# Chapter 9

## Section 9.1

***Check Your Understanding, page 532:***

1. (a) The parameter of interest is $p =$ proportion of students at Jannie's high school who get less than 8 hours of sleep at night. (b) The hypotheses are: $H_0: p = 0.85$ and $H_a: p \neq 0.85$.

2. (a) The parameter of interest is $\mu =$ mean amount of time that it takes to complete the census form. (b) The hypotheses are: $H_0: \mu = 10$ and $H_a: \mu > 10$.

***Check Your Understanding, page 539:***

1. A Type I error in this setting would be to say that the new batteries last longer than 30 hours when, in fact, their average lifetime is 30 hours.
2. A Type II error in this setting would be to say that the new batteries do not last longer than 30 hours when, in fact, they do last longer than 30 hours.
3. The result of a Type I error would be that the company spends the extra money to produce these new batteries when they aren't any better than the older, cheaper, type. The result of a Type II error would be that the company would not produce the new batteries, even though they were better. Arguments could be made for either of the errors being worse. For example, with a Type I error, the company would be wasting its money producing a new battery that wasn't any better. With a Type II error the company would be losing out on potential profits by not producing the new, better, battery.

***Exercises, page 546:***

9.1 $H_0: p = 0.12$; $H_a: p \neq 0.12$ where $p$ is the proportion of lefties in his school.

9.2 $H_0: p = 0.72$; $H_a: p \neq 0.72$ where $p$ is the proportion of teens in Yvonne's school who rarely or never fight with their friends.

9.3 $H_0: \mu = 115$; $H_a: \mu > 115$ where $\mu$ is the average score on the SSHA for students at least 30 years of age at the teacher's college.

9.4 $H_0: \mu = 12$; $H_a: \mu < 12$ where $\mu$ is the average amount of hemoglobin in Jordanian children.

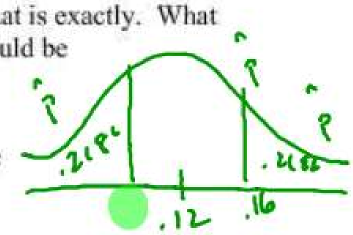
9.5 $H_0: \sigma = 3$; $H_a: \sigma > 3$ where $\sigma$ is the standard deviation of the temperature in the cabin.

9.6 $H_0: \sigma = 10$; $H_a: \sigma > 10$ where $\sigma$ is the standard deviation of the distance jumped by the ski jumpers.

9.7 The null hypothesis always gives the value of the current situation. In the hypotheses given, the alternative gives the current situation. The alternative is supposed to give what we are looking for evidence for. The hypotheses should be $H_0: p = 0.37$; $H_a: p > 0.37$.

9.8 We do not need to test hypotheses about the sample statistic. We know what that is exactly. What we need to test are hypotheses about the population parameter. Also, we are only interested in whether the situation has improved, so we need a one-sided alternative hypothesis. The hypotheses should be $H_0: p = 0.37$; $H_a: p > 0.37$.

9.9 We do not need to test hypotheses about the sample statistic. We know what that is exactly. What we need to test are hypotheses about the population parameter. The hypotheses should be $H_0: \mu = 1000$ grams; $H_a: \mu < 1000$ grams.




9.10 The values in both hypotheses need to be the same. The hypotheses should be $H_0: \mu = 1000$ grams; $H_a: \mu < 1000$ grams.

9.11 (a) If the proportion of lefties at Simon's school is really 0.12, there is a 21.84% chance of finding a sample of 100 people with a value of $\hat{p}$ that is as far from 0.12 as the sample value in either direction. (b) No. An outcome that would occur so often just by chance (more than 1 in every 5 random samples of 16 students) when $H_0$ is true is not convincing evidence against $H_0$. There is not enough evidence to say that the proportion of left-handed students at Simon's school is different than the national proportion.

9.12 (a) If the proportion of students at Yvonne's school who say they rarely or never argue with friends is really 0.72, there is a 2.91% chance of finding a sample of 150 students with a value of $\hat{p}$ that is as far from 0.72 as the sample value in either direction. (b) Yes. This outcome was fairly rare (only 2.91% chance of happening) so we would likely reject the null hypothesis. It appears that the percent of students at Yvonne's school is different from the national percent.

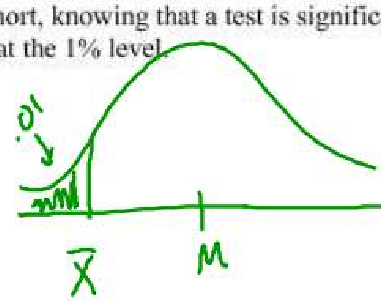
9.13 (a) If the mean score on the SSHA for older students at this school is really 115, there is a 1.01% chance of finding a sample of 45 older students with a mean score of at least 125.7. (b) Since the P-value is less than 0.05, we would reject the null hypothesis if $\alpha = 0.05$. Technically the P-value is larger than 0.01 so we would fail to reject the null hypothesis if $\alpha = 0.01$. However, we note that the P-value is very close to this $\alpha$.

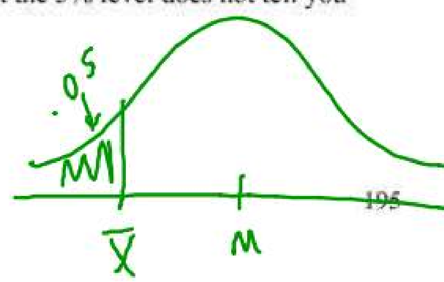
9.14 (a) If the mean hemoglobin level of Jordanian children is really 12, there is a 0.16% chance of finding a sample of 50 children with a mean level of 11.3 or lower. (b) Since the P-value is less than both 0.05 and 0.01, we would reject the null hypothesis in both cases. It appears that Jordanian children have an average hemoglobin level that is less than 12 mg/dl.

9.15 The explanation is not correct. Either $H_0$ is true (in which case the probability that $H_0$ is true is 1) or $H_0$ is false (in which case the probability that $H_0$ is true is 0). A *P*-value of 0.01 means that if $H_0$ is true, then the chance of observing a test statistic with the value we obtained or with a value more extreme is 1%.

9.16 The explanation is not correct. Either $H_0$ is true (in which case the probability that $H_0$ is true is 1) or $H_0$ is false (in which case the probability that $H_0$ is true is 0). Statistically significant at the $\alpha = 0.05$ level means that if $H_0$ is true, then the chance of observing a test statistic of the value we obtained or something more extreme is less than 5%.

9.17 Significance at the 1% level means that the *P*-value for the test is less than 0.01. If the *P*-value is less than 0.01, then it must also be less than 0.05. If a test is significant at the 5% level, then we know that the *P*-value is less than 0.05. However, we don't know how much smaller than 0.05 it is, so it may or may not be less than 0.01. In short, knowing that a test is significant at the 5% level does not tell you anything about its significance at the 1% level.



9.18 Both P-values (0.0101 and 0.0016) are likely to lead us to reject the null hypothesis because they are both less than 0.05 – the typically chosen value of $\alpha$. However, the *P*-value from Exercise 14 (0.0016) is much stronger evidence against the null hypothesis than the one from Exercise 13 (0.0101).

9.19 (a) Let $\mu$ represent the average response time for all accidents involving life-threatening injuries in the city. Then the hypotheses are: $H_0: \mu = 6.7$; $H_a: \mu < 6.7$. (b) A Type I error would be to reject the null hypothesis when it is really true. In this case that would mean that the city concludes that the response time has improved when it really hasn't. A Type II error would be to fail to reject the null hypothesis when it is really false. In this case that would mean concluding that the response time has not improved when it really has. (c) In this setting a Type I error would be worse because the city may stop trying to improve its response times because they think they have met the goal, when in fact they haven't. More people could die.

9.20 (a) Let $p$ represent the proportion of calls in which first responders are arriving within 8 minutes. Then the hypotheses are: $H_0: p = 0.78$; $H_a: p > 0.78$. (b) A Type I error would be to reject the null hypothesis when it is really true. In this case that would mean that the city concludes that the proportion of accidents with an appropriate response time has increased when it really hasn't. A Type II error would be to fail to reject the null hypothesis when it is really false. In this case that would mean concluding that the proportion of accidents with an appropriate response time has not increased when it really has. (c) In this setting a Type I error would be worse because the city may stop trying to improve its response times because they think they have met the goal, when in fact they haven't. More people could die. (d) Answers may vary.

9.21 (a) $H_0: \mu = \$85{,}000$ versus $H_a: \mu > \$85{,}000$ where $\mu$ = the mean income of residents near the restaurant. (b) A Type I error is committed if you conclude that the local mean income exceeds \$85,000 when in fact it does not. The consequence is that you will open your restaurant in a location where the residents will not be able to support it. A Type II error is committed if you conclude that the local mean income does not exceed \$85,000 when in fact it does. The consequence of this error is that you will not open your restaurant in a location where the residents would have been able to support it. (c) The smallest significance level, $\alpha = 0.01$, is the most appropriate, because it would minimize your probability of committing a serious Type I error.

9.22 (a) $H_0: \mu = 130$ versus $H_a: \mu > 130$ where $\mu$ represents the mean blood pressure of the individual. (b) A Type I error is committed by telling an individual that they have a high systolic blood pressure when in fact they do not. A Type II error is committed by failing to notify an individual who has high blood pressure. (c) You obviously want to make the chance of a Type II error as small as possible. While it is inconvenient to send some people for further testing when their blood pressure is OK (a Type I error), death could result from a Type II error.

9.23 The probability of a Type I error is 0.05 and the probability of a Type II error is $1 - 0.78 = 0.22$.

9.24 The power of the test is $1 - 0.14 = 0.86$.

9.25 (a) If $p = 0.08$, the probability of (correctly) rejecting the null hypothesis is 0.64. (b) To increase the power we need more information. Therefore we need to increase the number of measurements taken. (c) If we decrease the likelihood of one type of error, then we increase the likelihood of the other type of error. Since we reduced the probability of a Type I error, that means that we have increased the probability of a Type II error. That, in turn, means that the power has been reduced. (d) Since 0.07 is

2. When a law firm represents a group of people in a class action lawsuit and wins that lawsuit, the firm receives a percentage of the group's monetary settlement. That settlement amount is based on the total number of people in the group—the larger the group and the larger the settlement, the more money the firm will receive.

A law firm is trying to decide whether to represent car owners in a class action lawsuit against the manufacturer of a certain make and model for a particular defect. If 5 percent or less of the cars of this make and model have the defect, the firm will not recover its expenses. Therefore, the firm will handle the lawsuit only if it is convinced that more than 5 percent of cars of this make and model have the defect. The firm plans to take a random sample of 1,000 people who bought this car and ask them if they experienced this defect in their cars.

(a) Define the parameter of interest and state the null and alternative hypotheses that the law firm should test.

(b) In the context of this situation, describe Type I and Type II errors and describe the consequences of each of these for the law firm.

a) p = proportion of cars with defect

$H_0: p = .05$ $H_a: p > .05$

b) Type I - Accept Ha (But Ha False)

Firm takes case when it shouldn't; firm loses money

Type II - "Accept" Ho (But Ho False)

Firm does not take case; firm misses out on billions of dollars ?

**3.** As a construction engineer for a city, you are responsible for ensuring that the company that is providing gravel for a new road puts as much gravel in each truckload as they claim to. It has been estimated that it will take 500 truckloads of gravel to complete this road, so you plan to measure the volume of gravel in an SRS of 25 trucks to make sure that the company isn't delivering less gravel per truckload than they claim. Each truckload is supposed to have 20 m$^3$ of gravel, so you will test the hypotheses $\boxed{H_0 : \mu = 20}$ *versus* $\boxed{H_a : \mu < 20}$ at the $\alpha$ = 0.05 level.

(a) Describe what a Type I error would be in this context.

Type I - Conclude average volume is less than 20 m$^3$ when it really equals 20 m$^3$

(b) Describe what a Type II error would be in this context.

Type II - conclude average volume equals 20 m$^3$ when it is really less than that

(c) Which error—Type I or Type II—is a more serious problem for the city? Explain.

Probably Type II since company would pay for underweighted trucks

(d) You have determined that the power of this test (when $\alpha$ = 0.05) against the alternative $\mu = 19.2$ is 0.38. Explain what this means in context.

The probability of rejecting the null (when the true mean volume is actually 19.2) is .38

(e) Describe two ways you can increase the power of this test.

1) Increase significance level (from .05 to .10)

2) Increase sample size (from 25 to 50)

9.1 AP Statistics Name:

1. For each of the following settings, define the parameter of interest and write the appropriate null and alternative hypotheses for the test that is described.

(a) The mean time needed for college students to complete a certain paper-and-pencil maze is 30 seconds. You wish to see if this is changed by vigorous exercise, so you have a randomly selected group of 25 students from a particular college exercise vigorously for 30 minutes and then complete the maze.

$\mu$ = mean time to complete maze

$H_0: \mu = 30$ sec  $H_a: \mu \neq 30$ sec

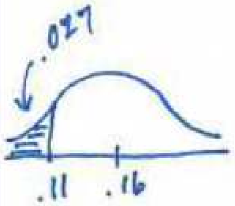
(b) Lumber companies dry freshly-cut wood in kilns before selling it. As a result of the drying process a certain percentage of the boards become "checked," which means that cracks develop at the ends of the boards. The current drying procedure for 1" x 4" red oak boards is known to produce cracks in 16% of the boards. The drying supervisor at a lumber company wants to test a new method to determine if fewer boards crack.

p = proportion of boards that are checked

$H_0: p = .16$  $H_a: p < .16$

2. Consider the lumber problem in question 1(b). Suppose the drying supervisor uses the new method on an SRS of boards and finds that the sample proportion of checked boards is 0.11, which produces a *P*-value of 0.027.

(a) Interpret the *P*-value in the context of the problem.




If the true proportion of checked boards is really .16, the probability of getting a sample proportion of .11 or lower is .027

(b) What conclusion would you draw at the $\alpha$ 0.05 level? At the $\alpha = 0.01$ level?

At $\alpha = .05$, reject Ho and conclude proportion of checked boards is less than .16

At $\alpha = .01$, fail to reject Ho and conclude that the proportion of cracked boards is not less than .16

selected. Normal: The expected number of successes $np_0 = 250(0.2) = 50$ and failures $n(1-p_0) = 250(0.8) = 200$ are both at least 10. Independent: There were 250 in the sample and 2800 in the school, so the sample is less than 10% of the population. All conditions have been met. *Do*: The sample proportion is $\hat{p} = \frac{63}{250} = 0.252$. The corresponding test statistic is $z = \frac{0.252 - 0.20}{\sqrt{\frac{0.20(0.80)}{250}}} = 2.06.$

Since this is a one-sided test the *P*-value is $P(z > 2.06) = 0.0197$. *Conclude*: Since our *P*-value is less than 0.05, we reject the null hypothesis. It appears that the counselor's concerns are valid and that more than 20% of the teens in her school would say they have electronically sent or posted sexually suggestive images of themselves.

### *Check Your Understanding, page 558:*

1. *State*: We want to perform a test at the $\alpha = 0.05$ significance level of $H_0: p = 0.75$ versus $H_a: p \neq 0.75$ where $p$ is the actual proportion of restaurant employees who say that work stress has a negative impact on their personal lives. *Plan*: If conditions are met, we should do a one-sample $z$ test for the population proportion $p$. Random: The sample was randomly selected. Normal: The expected number of successes $np_0 = 100(0.75) = 75$ and failures $n(1-p_0) = 100(0.25) = 25$ are both at least 10. Independent: There were 100 in the sample and since this is a large restaurant chain, it is very likely that there are more than 1000 workers in the population, so the sample is less than 10% of the population. All conditions have been met. *Do*: The sample proportion is $\hat{p} = \frac{68}{100} = 0.68$. The corresponding test statistic is $z = \frac{0.68 - 0.75}{\sqrt{\frac{0.75(0.25)}{100}}} = -1.62$. Since this is a two-sided test the *P*-value is $2P(z < -1.62) = 2(0.0526) = 0.1052$. *Conclude*: Since our *P*-value is greater than 0.05, we fail to reject the null hypothesis. We do not have enough evidence to conclude that the proportion of restaurant employees at this large restaurant chain who say that work stress has a negative impact on their personal lives is different from the national proportion of 0.75.

### *Check Your Understanding, page 561:*

1. In the previous Check Your Understanding, we failed to reject the null hypothesis that the proportion of restaurant employees at this chain who say that work stress has a negative impact on their personal lives is the same as the national proportion of 0.75. The confidence interval given in the output includes 0.75 which means that 0.75 is a plausible value for the population proportion that we are seeking. So both the hypothesis test (which didn't rule out 0.75 as the proportion) and the confidence interval (which gave 0.75 as a plausible value) give the same conclusion. The confidence interval, however, gives more information in that it gives a whole range of plausible values whereas the hypothesis test concentrates only on the one value as a possibility for the population proportion (0.75 here).

### *Exercises, page 562:*

✓

9.33 Random: The sample was randomly selected. Normal: The expected numbers of successes $np_0 = 100(0.12) = 12$ and failures $n(1-p_0) = 100(0.88) = 88$ are both at least 10. Independent: There were 100 in the sample, and since this is a large public high school, it is very likely that there are more than 1000 students in the population, so the sample is less than 10% of the population. All conditions have been met.

9.34 Random: The sample was randomly selected. Normal: The expected numbers of successes $np_0 = 150(0.72) = 108$ and failures $n(1-p_0) = 150(0.28) = 42$ are both at least 10. Independent: There were 150 in the sample, and since this is a large public high school, it is very likely that there are more than 1500 students in the population, so the sample is less than 10% of the population. All conditions have been met.

9.35 The expected number of successes $np_0 = 10(0.5) = 5$ and failures $n(1-p_0) = 10(0.5) = 5$ are both less than 10 so the Normal condition will not be met.

9.36 The expected number of failures is less than 10. $n(1-p_0) = 2$, so the Normal condition will not be met.

9.37 (a) In this case $\hat{p} = 0.16$ so $z = \dfrac{0.16 - 0.12}{\sqrt{\dfrac{0.12(0.88)}{100}}} = 1.23$. (b) Since this is a two-sided test, the P-value is $2P(z > 1.23) = 2(0.1093) = 0.2186$. The graph is given below.

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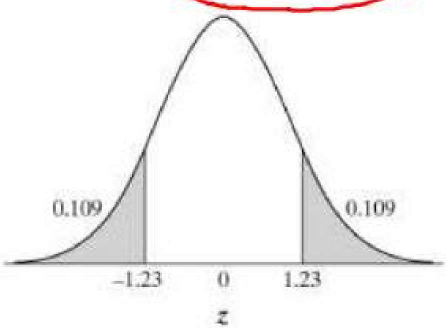


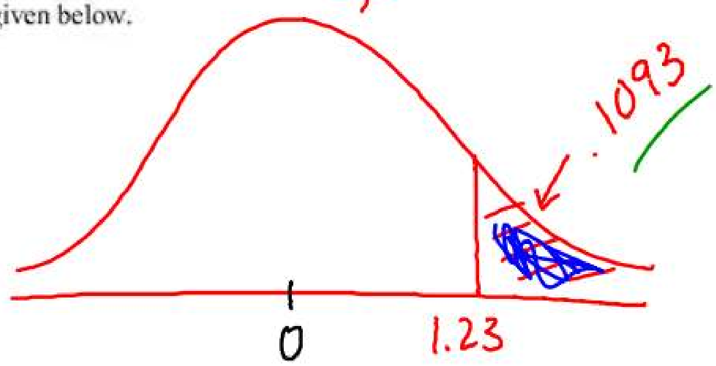


9.38 (a) In this case $\hat{p} = \dfrac{96}{150} = 0.64$ so $z = \dfrac{0.64 - 0.72}{\sqrt{\dfrac{0.72(0.28)}{150}}} = -2.18$. (b) Since this is a two-sided test, the P-value is $2P(z < -2.18) = 2(0.0146) = 0.0292$. The graph is given below.

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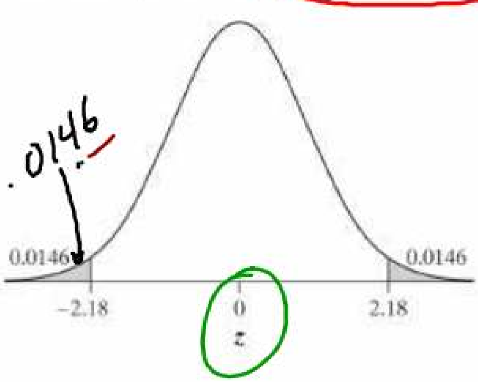



normalcdf (−10, −2.18)

9.39 (a) Since this is a one-sided test, the P-value is $P(z > 2.19) = 0.0143$. The P-value is less than 0.05 so we would reject the null hypothesis at the 5% significance level. ~~But the~~ P-value is greater than 0.01 so we would fail to reject the null hypothesis at the 1% significance level. (b) If the test were two-sided, that would change the P-value to $2P(z > 2.19) = 2(0.0143) = 0.0286$. This P-value is still less than 0.05 and greater than 0.01, so we would still reject at the 5% significance level but fail to reject at the 1% significance level.

9.40 Since this is a one-sided test, the P-value is $P(z < -1.78) = 0.0375$. The P-value is less than 0.05 so we would reject the null hypothesis at the 5% significance level. But the P-value is greater than 0.01 so we would fail to reject the null hypothesis at the 1% significance level. (b) If the test were two-sided, that would change the P-value to $2P(z < -1.78) = 2(0.0375) = 0.075$. This P-value is greater than both 0.05 and 0.01 so we would fail to reject the null hypothesis at ~~both the~~ 5% and the 1% significance levels.

9.41 *State*: We want to perform a test at the $\alpha = 0.05$ significance level of $H_0: p = 0.37$ versus $H_a: p > 0.37$ where $p$ is the actual proportion of students who are satisfied with the parking situation. *Plan*: If conditions are met, we should do a one-sample $z$ test for the population proportion $p$. Random: The sample was randomly selected. Normal: The expected number of successes $np_0 = 200(0.37) = 74$ and failures $n(1 - p_0) = 200(0.63) = 126$ are both at least 10. Independent: There were 200 in the sample and since there are 2500 students in the population, the sample is less than 10% of the population. All conditions have been met. *Do*: The sample proportion is $\hat{p} = \dfrac{83}{200} = 0.415$. The corresponding test statistic is $z = \dfrac{0.415 - 0.37}{\sqrt{\dfrac{0.37(0.63)}{200}}} = 1.32$. Since this is a one-sided test the *P*-value is $P(z > 1.32) = 0.0934$. *Conclude*: Since our *P*-value is greater than 0.05, we fail to reject the null hypothesis. We do not have enough evidence to conclude that the new parking arrangement increased student satisfaction with parking at this school.

9.42 *State*: We want to perform a test at the $\alpha = 0.05$ significance level of $H_0: p = 0.10$ versus $H_a: p < 0.10$ where $p$ is the actual proportion of Alzheimer's patients who would experience nausea while taking the new drug. *Plan*: If conditions are met, we should do a one-sample $z$ test for the population proportion $p$. Random: The sample was randomly selected. Normal: The expected number of successes $np_0 = 300(0.10) = 30$ and failures $n(1 - p_0) = 300(0.90) = 270$ are both at least 10. Independent: There were 300 in the sample and since there are 5,000 Alzheimer's patients in the population, the sample is less than 10% of the population. All conditions have been met. *Do*: The sample proportion is $\hat{p} = \dfrac{25}{300} = 0.0833$. The corresponding test statistic is $z = \dfrac{0.0833 - 0.10}{\sqrt{\dfrac{0.10(0.90)}{300}}} = -0.96$. Since this is a one-sided test the *P*-value is $P(z < -0.96) = 0.1680$. *Conclude*: Since our *P*-value is greater than 0.05, we fail to reject the null hypothesis. We do not have enough evidence to conclude that the proportion of Alzheimer's patients taking the new drug who would experience nausea is less than 0.10.

9.43 (a) A Type I error would be rejecting the null hypothesis when it is really true. In this case that

49) P $p$ = actual proportion of teens who pass their driving test on the first attempt

H $H_0: p = .60$ $H_a: p \neq .60$

A 1) Sample was randomly selected

2) Sampling distribution is normal:

$np_0 \geq 10$ $\quad$ $n(1-p_0) \geq 10$

$(125)(.60) \geq 10$ $\quad$ $(125)(.40) \geq 10$

$75 \geq 10$ ✓ $\quad$ $50 \geq 10$ ✓

3) # teens taking test > 10(125) > 1,250 ?

T $$Z = \frac{.688 - .60}{\sqrt{\frac{(.60)(.40)}{125}}} = 2.01$$

P-value = 2(.0222) = $\underline{.0444}$

One-Prop Z Test

S At $\alpha = .05$, I reject the null hypothesis and conclude the proportion of teens who pass their driving test on the first attempt is <u>not</u> .60

5(a) P $p$ = proportion of all teens who pass their driving test on their first attempt

A 1) Teens were randomly selected

2) Sampling distribution normal

$n\hat{p} \geq 10 \qquad n(1-\hat{p}) \geq 10$

$125\left(\frac{86}{125}\right) \geq 10 \qquad 125\left(\frac{39}{125}\right) \geq 10$

$86 \geq 10$ ✓ $\qquad 39 \geq 10$ ✓

3) # teens taking test > 10 (125) > 1,250

I $\quad 95\%\ CI = \hat{p} \pm z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

$= .688 \pm 1.96 \sqrt{\frac{(.688)(.312)}{125}}$

$= (.607, .769)$

1-Prop Z Int

S I am 95% confident that the interval from .61 to .77 captures the true proportion of all teens who pass their driving test on their first attempt

b) Since 60% is not captured in the interval I am 95% confident that DMV's claim is not correct (more than 60% pass)

**AP STATISTICS**
(Sec 9.2)

Name Frankum

**1.** Nationally, the proportion of red cars on the road is 0.12. A statistically-minded fan of the Philadelphia Phillies (whose team color is red) wonders if Phillies fans are more likely to drive red cars. One day during a home game, he takes an SRS of 210 cars parked at Citizens Bank Park (the Phillies home field) while a game is being played, and counts 35 red cars. (There are 21,000 parking spaces.) Is this convincing evidence that Phillies fans prefer red cars more than the general population? Support your conclusion with a test of significance.

P) p = proportion of red cars parked at Citizens Bank Park during a Phillies home game

H) $H_0: p = .12 \quad H_a: p > .12$

A) 1) Random (SRS) sample used

2) $\left.\begin{array}{l} np_0 = (210)(.12) = 25.2 > 10 \\ n(1-p_0) = (210)(.88) = 184.8 > 10 \end{array}\right\}$ Sampling Distribution Normal

3) Number of parked cars > 10(210) > 2100 ?

T) $z = \dfrac{\hat{p} - p_0}{\sqrt{\dfrac{p_0(1-p_0)}{n}}} = \dfrac{.166 - .12}{\sqrt{\dfrac{(.12)(.88)}{210}}} = \dfrac{.046}{.0224} = 2.05 \rightarrow$ P-value = .02

[1-Prop Z Test → $z = 2.08$, P-value = .0187]

S) At $\alpha = .05$ there is evidence to reject $H_0$ and conclude the proportion of red cars parked at a Phillies home game was more than 12%

***Check Your Understanding, page 577:***

1. No. The P-value is greater than 0.05.
2. We are 95% confident that the interval from 126.43 to 133.43 captures the true mean systolic blood pressure for the company's middle-aged male employees. The value of 128 is in this interval and therefore is a plausible mean systolic blood pressure for the males 35 to 44 years of age. This agrees with the hypothesis test which did not rule out a mean value of 128.

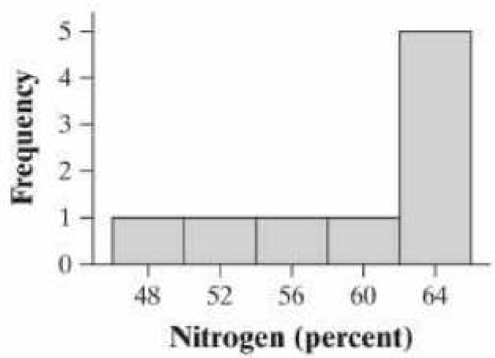
***Exercises, page 587:***

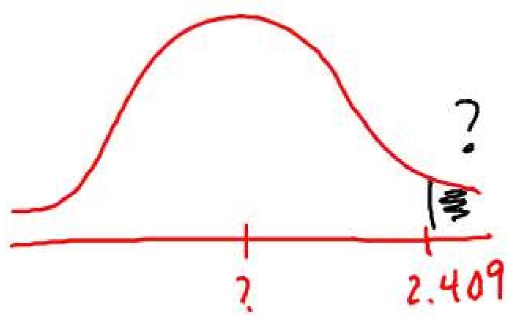
9.63 Random: The sample was randomly selected. Normal: The sample size is at least 30. Independent: The sample size was 45 which is less than 10% of the 1000 students at the college who are at least 30 years of age.

9.64 Random: The sample was randomly selected. Normal: The sample size is at least 30. Independent: The sample size was 50 and there are clearly more than 500 children in Jordan so the sample is less than 10% of the population.

9.65 The Normal condition for inference is not met here. The sample size is less than 30 and the sample values are clearly skewed to the left. This is seen in the histogram and also in the output since the third quartile is the same as the median (100%) but the 1st quartile is 68%. So there is no distance between the median and the third quartile but there is a distance of 32% between the median and the 1st quartile.

9.66 The Normal condition for inference is not met here. The sample size is less than 30 and the histogram below shows that the data are clearly skewed to the left.



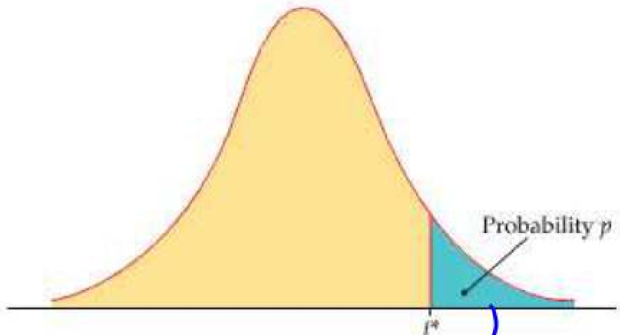

9.67 (a) The test statistic is $t = \frac{125.7-115}{29.8/\sqrt{45}} = 2.409$. (b) Using Table B and 40 df (there are no entries for 44 df), we find the following bounds on the *P*-value: $0.01 < P\text{-value} < 0.02$. Using technology the *P*-value is 0.0101.

tcdf (2.409, 100, 44) ≈ .0101

9.68 (a) The test statistic is $t = \frac{11.3-12}{1.6/\sqrt{50}} = -3.094$. (b) Using Table B and 40 df (there are no entries for 49 df), we find the following bounds on the *P*-value: $0.001 < P\text{-value} < 0.0025$. Using technology the *P*-value is 0.0016.

tcdf (-100, -3.094, 49)

Table entry for $p$ and $C$ is the critical value $t^*$ with probability $p$ lying to its right and probability $C$ lying between $-t^*$ and $t^*$.




## TABLE D

### $t$ distribution critical values

| | Upper-tail probability $p$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| df | .25 | .20 | .15 | .10 | .05 | .025 | .02 | .01 | .005 | .0025 | .001 | .0005 |
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 15.89 | 31.82 | 63.66 | 127.3 | 318.3 | 636.6 |
| 2 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 4.849 | 6.965 | 9.925 | 14.09 | 22.33 | 31.60 |
| 3 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 3.482 | 4.541 | 5.841 | 7.453 | 10.21 | 12.92 |
| 4 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 2.999 | 3.747 | 4.604 | 5.598 | 7.173 | 8.610 |
| 5 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 2.757 | 3.365 | 4.032 | 4.773 | 5.893 | 6.869 |
| 6 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 2.612 | 3.143 | 3.707 | 4.317 | 5.208 | 5.959 |
| 7 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.517 | 2.998 | 3.499 | 4.029 | 4.785 | 5.408 |
| 8 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.449 | 2.896 | 3.355 | 3.833 | 4.501 | 5.041 |
| 9 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.398 | 2.821 | 3.250 | 3.690 | 4.297 | 4.781 |
| 10 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.359 | 2.764 | 3.169 | 3.581 | 4.144 | 4.587 |
| 11 | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.328 | 2.718 | 3.106 | 3.497 | 4.025 | 4.437 |
| 12 | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.303 | 2.681 | 3.055 | 3.428 | 3.930 | 4.318 |
| 13 | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.282 | 2.650 | 3.012 | 3.372 | 3.852 | 4.221 |
| 14 | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.264 | 2.624 | 2.977 | 3.326 | 3.787 | 4.140 |
| 15 | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.249 | 2.602 | 2.947 | 3.286 | 3.733 | 4.073 |
| 16 | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.235 | 2.583 | 2.921 | 3.252 | 3.686 | 4.015 |
| 17 | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.224 | 2.567 | 2.898 | 3.222 | 3.646 | 3.965 |
| 18 | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.214 | 2.552 | 2.878 | 3.197 | 3.611 | 3.922 |
| 19 | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.205 | 2.539 | 2.861 | 3.174 | 3.579 | 3.883 |
| 20 | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.197 | 2.528 | 2.845 | 3.153 | 3.552 | 3.850 |
| 21 | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.189 | 2.518 | 2.831 | 3.135 | 3.527 | 3.819 |
| 22 | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.183 | 2.508 | 2.819 | 3.119 | 3.505 | 3.792 |
| 23 | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.177 | 2.500 | 2.807 | 3.104 | 3.485 | 3.768 |
| 24 | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.172 | 2.492 | 2.797 | 3.091 | 3.467 | 3.745 |
| 25 | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.167 | 2.485 | 2.787 | 3.078 | 3.450 | 3.725 |
| 26 | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.162 | 2.479 | 2.779 | 3.067 | 3.435 | 3.707 |
| 27 | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.158 | 2.473 | 2.771 | 3.057 | 3.421 | 3.690 |
| 28 | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.154 | 2.467 | 2.763 | 3.047 | 3.408 | 3.674 |
| 29 | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.150 | 2.462 | 2.756 | 3.038 | 3.396 | 3.659 |
| 30 | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.147 | 2.457 | 2.750 | 3.030 | 3.385 | 3.646 |
| 40 | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.123 | 2.423 | 2.704 | 2.971 | 3.307 | 3.551 |
| 50 | 0.679 | 0.849 | 1.047 | 1.299 | 1.676 | 2.009 | 2.109 | 2.403 | 2.678 | 2.937 | 3.261 | 3.496 |
| 60 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.099 | 2.390 | 2.660 | 2.915 | 3.232 | 3.460 |
| 80 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.088 | 2.374 | 2.639 | 2.887 | 3.195 | 3.416 |
| 100 | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.081 | 2.364 | 2.626 | 2.871 | 3.174 | 3.390 |
| 1000 | 0.675 | 0.842 | 1.037 | 1.282 | 1.646 | 1.962 | 2.056 | 2.330 | 2.581 | 2.813 | 3.098 | 3.300 |
| $z^*$ | 0.674 | 0.841 | 1.036 | 1.282 | 1.645 | 1.960 | 2.054 | 2.326 | 2.576 | 2.807 | 3.091 | 3.291 |
| | 50% | 60% | 70% | 80% | 90% | 95% | 96% | 98% | 99% | 99.5% | 99.8% | 99.9% |
| | Confidence level $C$ | | | | | | | | | | | |

9.69 (a) There are 19 df so using the table we find the following bounds on the $P$-value: $0.025 < P\text{-value} < 0.05$. Using technology the $P$-value is 0.043. Reject the null hypothesis at the 5% significance level. Fail to reject the null hypothesis at the 1% significance level. (b) If the alternative hypothesis is two-sided, the $P$-value gets doubled. So using the table we get $0.05 < P\text{-value} < 0.10$. Using technology the $P$-value is 0.086. Fail to reject the null hypothesis at both the 5% and the 1% level of significance.

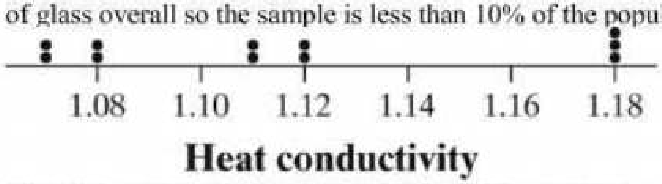
9.70 (a) There are 24 df so using the table we find the following bounds on the $P$-value: $2(0.1) < P\text{-value} < 2(0.15)$ or $0.20 < P\text{-value} < 0.30$. Using technology the $P$-value is 0.2738. Fail to reject the null hypothesis at both the 5% and the 1% significance level. (b) If the alternative hypothesis is one-sided, the $P$-value gets cut in half. So using the table we get $0.10 < P\text{-value} < 0.15$. Using technology the $P$-value is 0.1369. Fail to reject the null hypothesis at both the 5% and the 1% level of significance.

9.71 *State*: We want to perform a test of $H_0: \mu = 0$ versus $H_a: \mu > 0$ where $\mu$ is the actual mean amount of sweetness loss. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the population mean $\mu$. Random: The sample was randomly selected. Independent: There were 10 batches in the sample, so there need to be at least 100 batches of the new soda available. This is reasonable to assume, so all the conditions are met. Normal: Previous experience tells us that sweetness losses will be close to Normal. *Do*: The sample mean and standard deviation are: $\bar{x} = 1.02$ and $s_x = 1.196$. The corresponding test statistic is

$$t = \frac{1.02 - 0}{1.196/\sqrt{10}} = 2.70.$$ Since this is a one-sided test with df = 9, the $P$-value is $P(t > 2.70) = 0.0122$.

*Conclude*: Since our $P$-value is less than 0.05, we reject the null hypothesis. It appears that there is an average loss of sweetness for this cola.

9.72 *State*: We want to perform a test of $H_0: \mu = 1$ versus $H_a: \mu > 1$ where $\mu$ is the actual mean amount of heat conductivity for this type of glass. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the population mean $\mu$. Random: The sample was randomly selected. Normal: There were only 11 pieces sampled so we need to examine the sample data. The dotplot below indicates that there is not much skewness and no outliers. Independent: There were 11 pieces of glass in the sample. There are likely many more than 110 pieces of glass overall so the sample is less than 10% of the population. All conditions have been met.

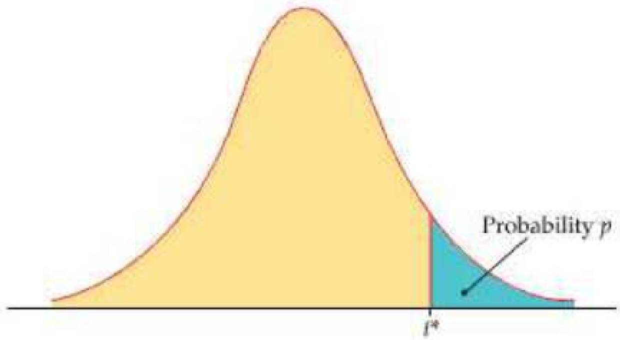



*Do*: The sample mean and standard deviation are: $\bar{x} = 1.1182$ and $s_x = 0.0438$. The corresponding test statistic is $t = \frac{1.1182 - 1}{0.0438/\sqrt{11}} = 8.95$. Since this is a one-sided test with df = 10, the $P$-value is

$P(t > 8.95) \approx 0$. *Conclude*: Since our $P$-value less than 0.05, we reject the null hypothesis. It appears that this glass has a mean heat conductivity greater than 1.

9.73 (a) First compute $IQR = 1090.5 - 632.3 = 458.2$. Outliers are points below $632.3 - 1.5(458.2) = -55$ or above $1090.5 + 1.5(458.2) = 1777.8$. The minimum is 374 so there are no

Table entry for $p$ and $C$ is the critical value $t^*$ with probability $p$ lying to its right and probability $C$ lying between $-t^*$ and $t^*$.




## TABLE D

### $t$ distribution critical values

| | Upper-tail probability $p$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| df | .25 | .20 | < .15 | .10 | .05 | .025 | .02 | .01 | .005 | .0025 | .001 | .0005 |
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 15.89 | 31.82 | 63.66 | 127.3 | 318.3 | 636.6 |
| 2 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 4.849 | 6.965 | 9.925 | 14.09 | 22.33 | 31.60 |
| 3 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 3.482 | 4.541 | 5.841 | 7.453 | 10.21 | 12.92 |
| 4 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 2.999 | 3.747 | 4.604 | 5.598 | 7.173 | 8.610 |
| 5 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 2.757 | 3.365 | 4.032 | 4.773 | 5.893 | 6.869 |
| 6 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 2.612 | 3.143 | 3.707 | 4.317 | 5.208 | 5.959 |
| 7 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.517 | 2.998 | 3.499 | 4.029 | 4.785 | 5.408 |
| 8 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.449 | 2.896 | 3.355 | 3.833 | 4.501 | 5.041 |
| 9 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.398 | 2.821 | 3.250 | 3.690 | 4.297 | 4.781 |
| 10 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.359 | 2.764 | 3.169 | 3.581 | 4.144 | 4.587 |
| 11 | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.328 | 2.718 | 3.106 | 3.497 | 4.025 | 4.437 |
| 12 | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.303 | 2.681 | 3.055 | 3.428 | 3.930 | 4.318 |
| 13 | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.282 | 2.650 | 3.012 | 3.372 | 3.852 | 4.221 |
| 14 | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.264 | 2.624 | 2.977 | 3.326 | 3.787 | 4.140 |
| 15 | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.249 | 2.602 | 2.947 | 3.286 | 3.733 | 4.073 |
| 16 | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.235 | 2.583 | 2.921 | 3.252 | 3.686 | 4.015 |
| 17 | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.224 | 2.567 | 2.898 | 3.222 | 3.646 | 3.965 |
| 18 | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.214 | 2.552 | 2.878 | 3.197 | 3.611 | 3.922 |
| 19 | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.205 | 2.539 | 2.861 | 3.174 | 3.579 | 3.883 |
| 20 | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.197 | 2.528 | 2.845 | 3.153 | 3.552 | 3.850 |
| 21 | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.189 | 2.518 | 2.831 | 3.135 | 3.527 | 3.819 |
| 22 | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.183 | 2.508 | 2.819 | 3.119 | 3.505 | 3.792 |
| 23 | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.177 | 2.500 | 2.807 | 3.104 | 3.485 | 3.768 |
| 24 | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.172 | 2.492 | 2.797 | 3.091 | 3.467 | 3.745 |
| 25 | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.167 | 2.485 | 2.787 | 3.078 | 3.450 | 3.725 |
| 26 | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.162 | 2.479 | 2.779 | 3.067 | 3.435 | 3.707 |
| 27 | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.158 | 2.473 | 2.771 | 3.057 | 3.421 | 3.690 |
| 28 | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.154 | 2.467 | 2.763 | 3.047 | 3.408 | 3.674 |
| 29 | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.150 | 2.462 | 2.756 | 3.038 | 3.396 | 3.659 |
| 30 | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.147 | 2.457 | 2.750 | 3.030 | 3.385 | 3.646 |
| 40 | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.123 | 2.423 | 2.704 | 2.971 | 3.307 | 3.551 |
| 50 | 0.679 | 0.849 | 1.047 | 1.299 | 1.676 | 2.009 | 2.109 | 2.403 | 2.678 | 2.937 | 3.261 | 3.496 |
| 60 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.099 | 2.390 | 2.660 | 2.915 | 3.232 | 3.460 |
| 80 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.088 | 2.374 | 2.639 | 2.887 | 3.195 | 3.416 |
| 100 | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.081 | 2.364 | 2.626 | 2.871 | 3.174 | 3.390 |
| 1000 | 0.675 | 0.842 | 1.037 | 1.282 | 1.646 | 1.962 | 2.056 | 2.330 | 2.581 | 2.813 | 3.098 | 3.300 |
| $z^*$ | 0.674 | 0.841 | 1.036 | 1.282 | 1.645 | 1.960 | 2.054 | 2.326 | 2.576 | 2.807 | 3.091 | 3.291 |
| | 50% | 60% | 70% | 80% | 90% | 95% | 96% | 98% | 99% | 99.5% | 99.8% | 99.9% |
| | Confidence level $C$ | | | | | | | | | | | |

73) low outliers and the maximum is 1425 so there are also no high outliers. (b) The P-value says that if the mean daily calcium intake for women 18 to 24 years of age is really 1200 mg, then the likelihood of getting a sample of 36 women with a mean intake of 856.2 or smaller is roughly 0. (c) *State*: We want to perform a test of $H_0: \mu = 1200$ versus $H_a: \mu < 1200$ where $\mu$ is the actual mean daily calcium intake of women 18 to 24 years of age. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the population mean $\mu$. Random: The sample was randomly selected. Normal: The sample size was 36 which is at least 30. Independent: There were 36 women in the sample. There are clearly many more than 360 women in the U.S. so the sample is less than 10% of the population. All conditions have been met. *Do*: The sample mean and standard deviation are: $\bar{x} = 856.2$ and $s_x = 306.7$. The corresponding test statistic is $t = -6.73$ (as given in the output). The *P*-value using df = 35 is given in the output as being approximately 0. *Conclude*: Since our *P*-value is less than 0.05, we reject the null hypothesis. It appears that women in this age range are getting less than 1200 mg of calcium daily, on average.

9.74 (a) First compute $IQR = 1.543 - (-3.418) = 4.961$. Outliers are points below $-3.418 - 1.5(4.961) = -10.8595$ or above $1.543 + 1.5(4.961) = 8.9845$. The minimum is -10.27 so there are no low outliers, and the maximum is 7.34 so there are also no high outliers. (b) The P-value says that if the mean return for the broker's portfolios is really 0.95%, then the likelihood of getting a sample of 36 weeks with a mean return of -1.441% or smaller is roughly .3%. (c) *State*: We want to perform a test of $H_0: \mu = 0.95$ versus $H_a: \mu < 0.95$ where $\mu$ is the actual mean return on the broker's portfolios. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the population mean $\mu$. Random: The sample was randomly selected. Normal: The sample size was 36 which is at least 30. Independent: There were 36 weeks of returns in the sample. Over a 10-year period, there are at least 360 weeks of returns for the broker,so the sample is less than 10% of the population. All conditions have been met. *Do*: The sample mean and standard deviation are: $\bar{x} = -1.441$ and $s_x = 4.81$. The corresponding test statistic is $t = -2.98$ (as given in the output). The *P*-value using df = 35 is given in the output as being 0.003. *Conclude*: Since our *P*-value is less than 0.05, we reject the null hypothesis. It appears that the portfolios managed by this broker had a smaller mean return than the Standard and Poor's mean increase.

9.75 *State*: We want to perform a test of $H_0: \mu = 0$ versus $H_a: \mu > 0$ where $\mu$ is the actual mean difference in tomato yield. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the population mean $\mu$. Random: The data was the result of a randomized experiment. Normal: The sample size was 10 which is less than 30, but the problem states that a graph of the data is roughly symmetric with no outliers. Independent: There were 10 Variety A and 10 Variety B chosen in the sample,which is surely less than 10% of available plants of each variety.All conditions have been met. *Do*: The sample mean and standard deviation are: $\bar{x} = 0.34$ and $s_x = 0.83$. The corresponding test statistic is $t = \dfrac{0.34 - 0}{0.83/\sqrt{10}} = 1.295$. The *P*-value using df = 9 from technology is 0.1138. *Conclude*: Since our *P*-value is greater than 0.05, we fail to reject the null hypothesis. We do not have enough evidence to conclude that Variety A has a higher mean yield than Variety B.

9.76 *State*: We want to perform a test of $H_0: \mu = 150$ minutes versus $H_a: \mu < 150$ minutes where $\mu$ is the actual mean study time on weeknights of first-year students at this university. We will perform the test at the $\alpha = 0.05$ significance level. *Plan*: If conditions are met, we should do a one-sample $t$ test for the

73 c) P $\mu$ = actual mean calcium intake of all women (18-24)

H $H_0: \mu = 1200$ mg $H_a: \mu < 1200$ mg

A 1) Random sample used

2) Sample size > 30 → Sample Distribution Normal

3) Number of women (18-24) > 10(36) > 360

T From Minitab output:

$t = -6.73$, P-value $\approx 0.00$

S At $\alpha = .05$, we reject the null and conclude that women (18-24) get less than 1200 mg of calcium each day

80) P $\mu$ = average amount of cola in bottles

H $H_0: \mu = 300$ ml $H_a: \mu \neq 300$ ml

A 1) Random sample used

2) Sampling distribution Normal because population distribution Normal

3) Number of filled bottles > 10(6) > 60 ?

T
$$t = \frac{299.03 - 300}{\frac{1.5}{\sqrt{6}}} = -1.576 \quad \Big\} \text{ T Test}$$

$\downarrow$

P-Value = .1760

S At $\alpha = .05$, we fail to reject Ho... there is not enough evidence to conclude that bottles are being filled in an amount different than 300 ml

82) P $\mu$ = average amount of cola in bottles

A 1) Random sample used

2) Sampling distribution Normal because population distribution Normal

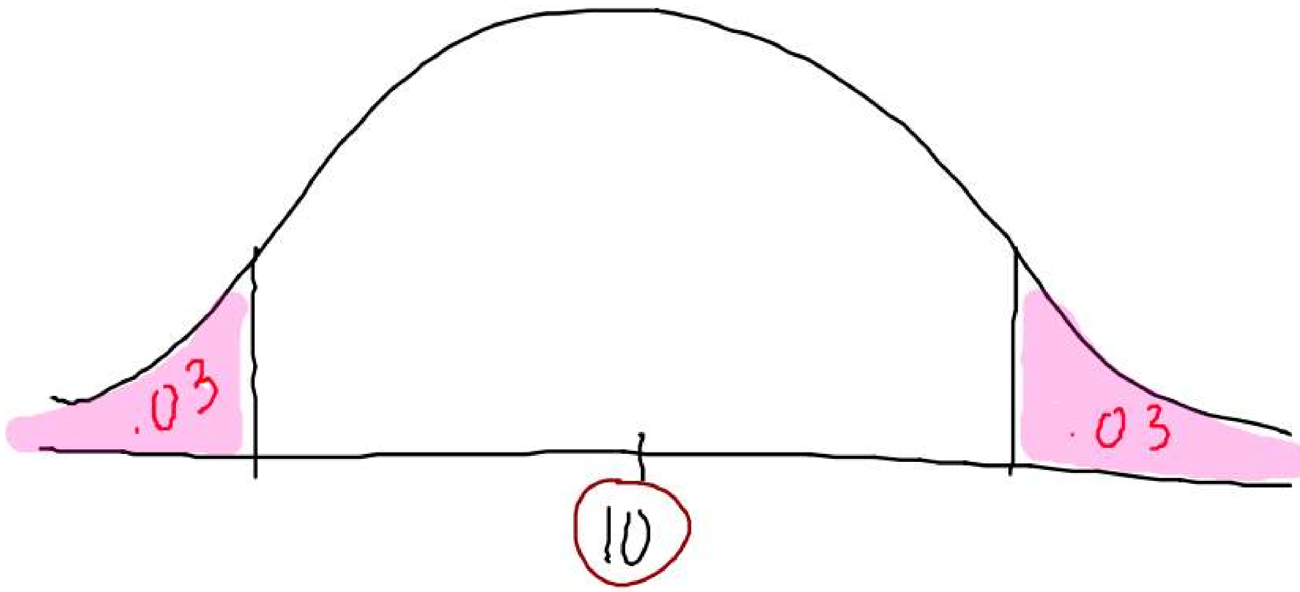
3) Number of filled bottles > 10 (6) > 60 ?

I
$$95\%\ CI = \bar{x} \pm t^*\left(\frac{s}{\sqrt{n}}\right)$$
$$= 299.03 \pm 2.571\left(\frac{1.5}{\sqrt{6}}\right)$$
$$= (297.456,\ 300.604)$$

T Interval

S We are 95% confident that the interval from 297.5 ml and 300.6 ml captures the true average amount of cola in each bottle (which agrees with previous hypothesis test)

85) $H_0: \mu = 10$ $\quad H_a: \mu \neq 10$ 1

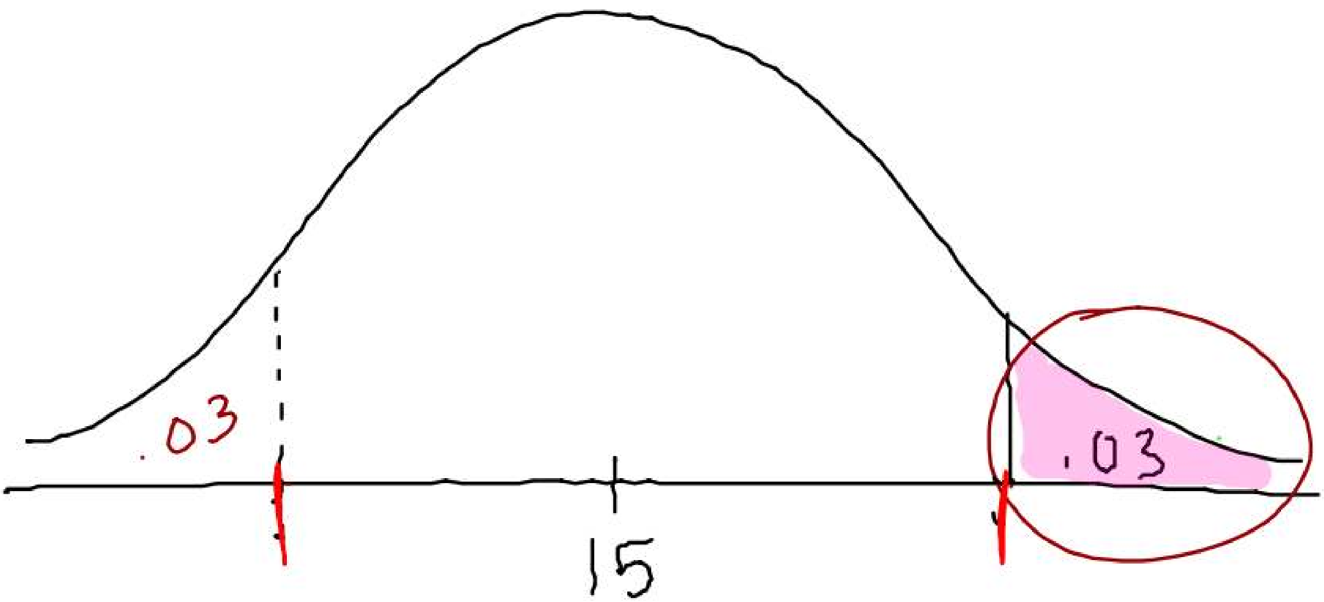



94%

a) 95% ✓

b) 90% X

86) $H_0: \mu = 15 \quad H_a: \mu > 15$




94%

a) 99%

b) 95%

89) $L_1$ = Right Times   $L_2$ = Left Times

P  $\mu$ = average difference in times to turn knobs (right - left)

10  20

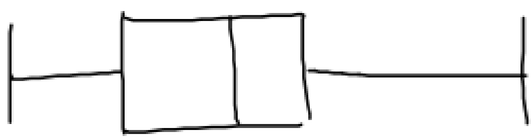
H  $H_0: \mu = 0$

$H_a: \mu < 0$

[ $H_a: \mu > 0$ for left - right difference ]

A

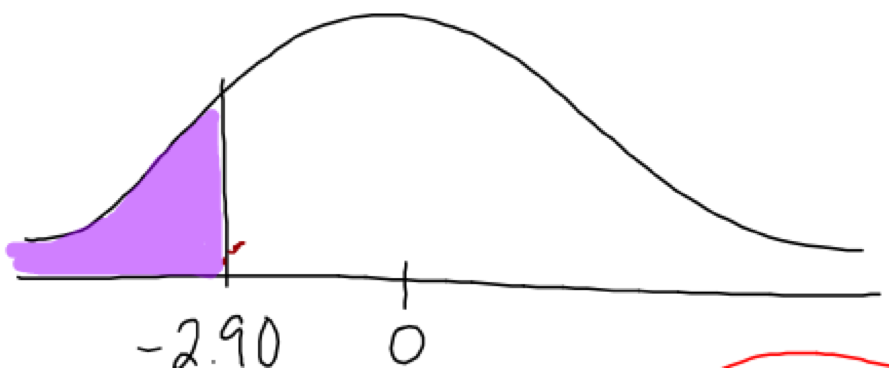
- Random order used
- Differences moderately skewed with no outliers



→ NPP ?

- Subjects' times independent

T $t = \frac{\bar{x} - 0}{\frac{s}{\sqrt{n}}} = \frac{-13.2}{\frac{22.94}{\sqrt{25}}} = -2.90$

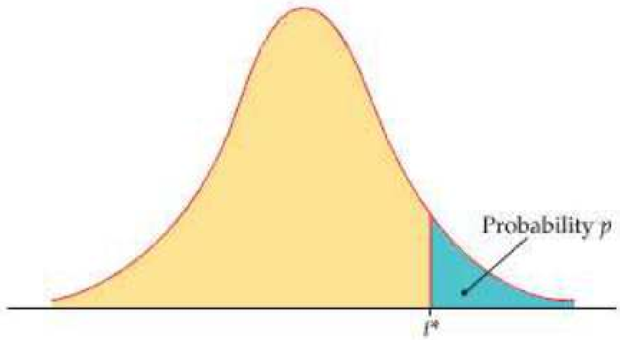



-10

From Table, P-value $< .005$

From Calculator, P-value $\approx .0039$

Table entry for $p$ and $C$ is the critical value $t^*$ with probability $p$ lying to its right and probability $C$ lying between $-t^*$ and $t^*$.




## TABLE D

### $t$ distribution critical values

| df | .25 | .20 | .15 | .10 | .05 | .025 | .02 | .01 | .005 | .0025 | .001 | .0005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper-tail probability $p$ | | | | | | | | | | | |
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 15.89 | 31.82 | 63.66 | 127.3 | 318.3 | 636.6 |
| 2 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 4.849 | 6.965 | 9.925 | 14.09 | 22.33 | 31.60 |
| 3 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 3.482 | 4.541 | 5.841 | 7.453 | 10.21 | 12.92 |
| 4 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 2.999 | 3.747 | 4.604 | 5.598 | 7.173 | 8.610 |
| 5 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 2.757 | 3.365 | 4.032 | 4.773 | 5.893 | 6.869 |
| 6 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 2.612 | 3.143 | 3.707 | 4.317 | 5.208 | 5.959 |
| 7 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.517 | 2.998 | 3.499 | 4.029 | 4.785 | 5.408 |
| 8 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.449 | 2.896 | 3.355 | 3.833 | 4.501 | 5.041 |
| 9 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.398 | 2.821 | 3.250 | 3.690 | 4.297 | 4.781 |
| 10 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.359 | 2.764 | 3.169 | 3.581 | 4.144 | 4.587 |
| 11 | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.328 | 2.718 | 3.106 | 3.497 | 4.025 | 4.437 |
| 12 | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.303 | 2.681 | 3.055 | 3.428 | 3.930 | 4.318 |
| 13 | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.282 | 2.650 | 3.012 | 3.372 | 3.852 | 4.221 |
| 14 | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.264 | 2.624 | 2.977 | 3.326 | 3.787 | 4.140 |
| 15 | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.249 | 2.602 | 2.947 | 3.286 | 3.733 | 4.073 |
| 16 | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.235 | 2.583 | 2.921 | 3.252 | 3.686 | 4.015 |
| 17 | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.224 | 2.567 | 2.898 | 3.222 | 3.646 | 3.965 |
| 18 | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.214 | 2.552 | 2.878 | 3.197 | 3.611 | 3.922 |
| 19 | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.205 | 2.539 | 2.861 | 3.174 | 3.579 | 3.883 |
| 20 | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.197 | 2.528 | 2.845 | 3.153 | 3.552 | 3.850 |
| 21 | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.189 | 2.518 | 2.831 | 3.135 | 3.527 | 3.819 |
| 22 | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.183 | 2.508 | 2.819 | 3.119 | 3.505 | 3.792 |
| 23 | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.177 | 2.500 | 2.807 | 3.104 | 3.485 | 3.768 |
| 24 | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.172 | 2.492 | 2.797 | 3.091 | 3.467 | 3.745 |
| 25 | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.167 | 2.485 | 2.787 | 3.078 | 3.450 | 3.725 |
| 26 | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.162 | 2.479 | 2.779 | 3.067 | 3.435 | 3.707 |
| 27 | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.158 | 2.473 | 2.771 | 3.057 | 3.421 | 3.690 |
| 28 | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.154 | 2.467 | 2.763 | 3.047 | 3.408 | 3.674 |
| 29 | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.150 | 2.462 | 2.756 | 3.038 | 3.396 | 3.659 |
| 30 | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.147 | 2.457 | 2.750 | 3.030 | 3.385 | 3.646 |
| 40 | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.123 | 2.423 | 2.704 | 2.971 | 3.307 | 3.551 |
| 50 | 0.679 | 0.849 | 1.047 | 1.299 | 1.676 | 2.009 | 2.109 | 2.403 | 2.678 | 2.937 | 3.261 | 3.496 |
| 60 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.099 | 2.390 | 2.660 | 2.915 | 3.232 | 3.460 |
| 80 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.088 | 2.374 | 2.639 | 2.887 | 3.195 | 3.416 |
| 100 | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.081 | 2.364 | 2.626 | 2.871 | 3.174 | 3.390 |
| 1000 | 0.675 | 0.842 | 1.037 | 1.282 | 1.646 | 1.962 | 2.056 | 2.330 | 2.581 | 2.813 | 3.098 | 3.300 |
| $z^*$ | 0.674 | 0.841 | 1.036 | 1.282 | 1.645 | 1.960 | 2.054 | 2.326 | 2.576 | 2.807 | 3.091 | 3.291 |
| | 50% | 60% | 70% | 80% | 90% | 95% | 96% | 98% | 99% | 99.5% | 99.8% | 99.9% |
| | Confidence level $C$ | | | | | | | | | | | |

$$\text{T-Test} \begin{cases} t(24) = -2.90 \\ p = .0038 \end{cases}$$

S At $\alpha = .05$, there is strong evidence ($p = .0038$) to reject the null and conclude that right-handed people turn clockwise knobs faster than they turn counterclockwise knobs

90) $L_1$ = Unscented Times $L_2$ = Scented Times

P $\mu$ = mean difference in times to complete maze (scented - unscented)

10 15

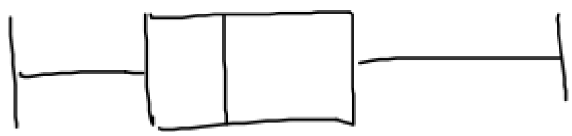
H $H_0: \mu = 0$

$H_a: \mu < 0$

[$H_a: \mu > 0$ for unscented - scented]

A

- Randomized experiment
- Differences in times moderately skewed with no outliers ⌣

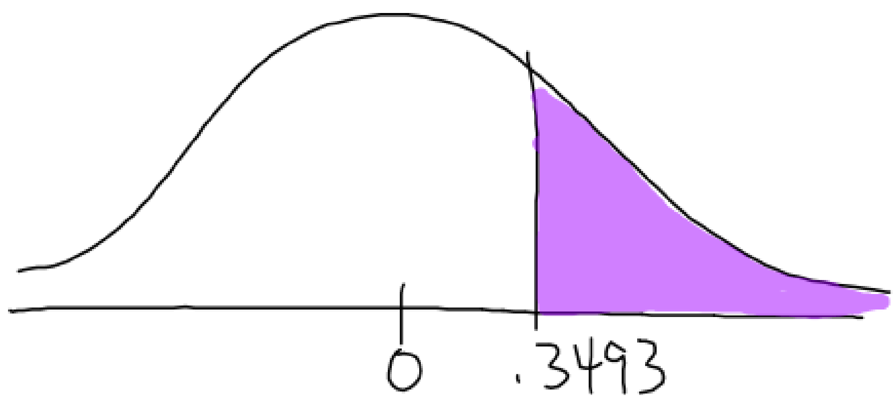


→ NPP ?

- Subjects' times independent

T

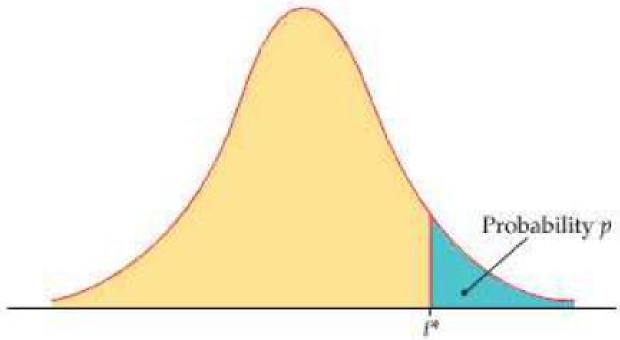
$$t = \frac{\bar{x} - 0}{\frac{s}{\sqrt{n}}} = \frac{.9566 - 0}{\frac{12.5478}{\sqrt{21}}} = .3493$$




From Table, P-value $> .25$

From Calculator, P-value $\approx .3652$

Table entry for $p$ and $C$ is the critical value $t^*$ with probability $p$ lying to its right and probability $C$ lying between $-t^*$ and $t^*$.




## TABLE D

### $t$ distribution critical values

| | Upper-tail probability $p$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| df | .25 | .20 | .15 | .10 | .05 | .025 | .02 | .01 | .005 | .0025 | .001 | .0005 |
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 15.89 | 31.82 | 63.66 | 127.3 | 318.3 | 636.6 |
| 2 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 4.849 | 6.965 | 9.925 | 14.09 | 22.33 | 31.60 |
| 3 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 3.482 | 4.541 | 5.841 | 7.453 | 10.21 | 12.92 |
| 4 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 2.999 | 3.747 | 4.604 | 5.598 | 7.173 | 8.610 |
| 5 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 2.757 | 3.365 | 4.032 | 4.773 | 5.893 | 6.869 |
| 6 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 2.612 | 3.143 | 3.707 | 4.317 | 5.208 | 5.959 |
| 7 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.517 | 2.998 | 3.499 | 4.029 | 4.785 | 5.408 |
| 8 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.449 | 2.896 | 3.355 | 3.833 | 4.501 | 5.041 |
| 9 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.398 | 2.821 | 3.250 | 3.690 | 4.297 | 4.781 |
| 10 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.359 | 2.764 | 3.169 | 3.581 | 4.144 | 4.587 |
| 11 | 0.697 | 0.876 | 1.088 | 1.363 | 1.796 | 2.201 | 2.328 | 2.718 | 3.106 | 3.497 | 4.025 | 4.437 |
| 12 | 0.695 | 0.873 | 1.083 | 1.356 | 1.782 | 2.179 | 2.303 | 2.681 | 3.055 | 3.428 | 3.930 | 4.318 |
| 13 | 0.694 | 0.870 | 1.079 | 1.350 | 1.771 | 2.160 | 2.282 | 2.650 | 3.012 | 3.372 | 3.852 | 4.221 |
| 14 | 0.692 | 0.868 | 1.076 | 1.345 | 1.761 | 2.145 | 2.264 | 2.624 | 2.977 | 3.326 | 3.787 | 4.140 |
| 15 | 0.691 | 0.866 | 1.074 | 1.341 | 1.753 | 2.131 | 2.249 | 2.602 | 2.947 | 3.286 | 3.733 | 4.073 |
| 16 | 0.690 | 0.865 | 1.071 | 1.337 | 1.746 | 2.120 | 2.235 | 2.583 | 2.921 | 3.252 | 3.686 | 4.015 |
| 17 | 0.689 | 0.863 | 1.069 | 1.333 | 1.740 | 2.110 | 2.224 | 2.567 | 2.898 | 3.222 | 3.646 | 3.965 |
| 18 | 0.688 | 0.862 | 1.067 | 1.330 | 1.734 | 2.101 | 2.214 | 2.552 | 2.878 | 3.197 | 3.611 | 3.922 |
| 19 | 0.688 | 0.861 | 1.066 | 1.328 | 1.729 | 2.093 | 2.205 | 2.539 | 2.861 | 3.174 | 3.579 | 3.883 |
| 20 | 0.687 | 0.860 | 1.064 | 1.325 | 1.725 | 2.086 | 2.197 | 2.528 | 2.845 | 3.153 | 3.552 | 3.850 |
| 21 | 0.686 | 0.859 | 1.063 | 1.323 | 1.721 | 2.080 | 2.189 | 2.518 | 2.831 | 3.135 | 3.527 | 3.819 |
| 22 | 0.686 | 0.858 | 1.061 | 1.321 | 1.717 | 2.074 | 2.183 | 2.508 | 2.819 | 3.119 | 3.505 | 3.792 |
| 23 | 0.685 | 0.858 | 1.060 | 1.319 | 1.714 | 2.069 | 2.177 | 2.500 | 2.807 | 3.104 | 3.485 | 3.768 |
| 24 | 0.685 | 0.857 | 1.059 | 1.318 | 1.711 | 2.064 | 2.172 | 2.492 | 2.797 | 3.091 | 3.467 | 3.745 |
| 25 | 0.684 | 0.856 | 1.058 | 1.316 | 1.708 | 2.060 | 2.167 | 2.485 | 2.787 | 3.078 | 3.450 | 3.725 |
| 26 | 0.684 | 0.856 | 1.058 | 1.315 | 1.706 | 2.056 | 2.162 | 2.479 | 2.779 | 3.067 | 3.435 | 3.707 |
| 27 | 0.684 | 0.855 | 1.057 | 1.314 | 1.703 | 2.052 | 2.158 | 2.473 | 2.771 | 3.057 | 3.421 | 3.690 |
| 28 | 0.683 | 0.855 | 1.056 | 1.313 | 1.701 | 2.048 | 2.154 | 2.467 | 2.763 | 3.047 | 3.408 | 3.674 |
| 29 | 0.683 | 0.854 | 1.055 | 1.311 | 1.699 | 2.045 | 2.150 | 2.462 | 2.756 | 3.038 | 3.396 | 3.659 |
| 30 | 0.683 | 0.854 | 1.055 | 1.310 | 1.697 | 2.042 | 2.147 | 2.457 | 2.750 | 3.030 | 3.385 | 3.646 |
| 40 | 0.681 | 0.851 | 1.050 | 1.303 | 1.684 | 2.021 | 2.123 | 2.423 | 2.704 | 2.971 | 3.307 | 3.551 |
| 50 | 0.679 | 0.849 | 1.047 | 1.299 | 1.676 | 2.009 | 2.109 | 2.403 | 2.678 | 2.937 | 3.261 | 3.496 |
| 60 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.099 | 2.390 | 2.660 | 2.915 | 3.232 | 3.460 |
| 80 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.088 | 2.374 | 2.639 | 2.887 | 3.195 | 3.416 |
| 100 | 0.677 | 0.845 | 1.042 | 1.290 | 1.660 | 1.984 | 2.081 | 2.364 | 2.626 | 2.871 | 3.174 | 3.390 |
| 1000 | 0.675 | 0.842 | 1.037 | 1.282 | 1.646 | 1.962 | 2.056 | 2.330 | 2.581 | 2.813 | 3.098 | 3.300 |
| $z^*$ | 0.674 | 0.841 | 1.036 | 1.282 | 1.645 | 1.960 | 2.054 | 2.326 | 2.576 | 2.807 | 3.091 | 3.291 |
| | 50% | 60% | 70% | 80% | 90% | 95% | 96% | 98% | 99% | 99.5% | 99.8% | 99.9% |
| | Confidence level $C$ | | | | | | | | | | | |

T-Test $\begin{cases} t = .3494 \\ p = .3652 \end{cases}$

S At $\alpha = .05$, we fail to reject $H_0$ ($p = .3652$) and must conclude there is no difference in the time to complete a maze using a scented mask versus an unscented mask