You are permitted to use a calculator on all portions of this test. You are not allowed to use any textbook, notes, cell phone, or laptop on any portion of this test. All devices must be turned off while you are in the testing room.

During this test, any communication with any person (other than the instructor or test proctor) in any form, including written, signed, verbal, or digital, is understood to be a violation of academic integrity.

No part of this test may be removed from the testing room.

Read each question very carefully. In order to receive full credit for the free response portion of the test, you must:

1. Show legible and logical (relevant) justification which supports your final answer.
2. Use complete and correct mathematical notation.
3. Include proper units, if necessary.

You have 90 minutes to complete the entire test.

On my honor, I have neither given nor received inappropriate or unauthorized information at any time before or during this test.

Student’s Signature: ___________________________

\[\begin{array}{|c|c|c|}
\hline
\text{Free Response Problem} & \text{Points Possible} & \text{Points Earned} \\
\hline
1 & 13 & \\
\hline
2 & 9 & \\
\hline
3 & 12 & \\
\hline
4 & 5 & \\
\hline
\text{Free Response Total} & 39 & \\
\hline
\text{Multiple Choice} & 60 & \\
\hline
\text{Correct Scantron} & 1 & \\
\hline
\text{Test Total} & 100 & \\
\hline
\end{array}\]
Part I: Multiple Choice. There are 20 multiple choices questions. Solve each question using the available space for scratch work. Decide which is the best of the choices given and fill in the corresponding oval on the provided scantron using a #2 pencil. For your own record, also circle your choice on your test since the scantron will not be returned to you. Only the responses recorded on your scantron sheet will be graded. Each multiple choice question is worth 3 points.

1. A sample of size 32 was used to test the hypotheses $H_0: \mu = 25$ versus $H_a: \mu \neq 25$. The calculated test statistic value was 1.55. Which range of values contains the $p$-value for this test?
   (A) $.0010 < p$-value < $.0025$
   (B) $.0020 < p$-value < $.0050$
   (C) $.0500 < p$-value < $.1000$
   (D) $.1000 < p$-value < $.2000$

2. A Food Science major wanted to know if an energy drink consumed before a STAT 2300 exam resulted in a difference in average scores. She randomly selected 28 students to drink a 16-ounce Double Uber-Charged energy beverage and randomly selected another 28 students to drink a placebo beverage before the STAT 2300 exam. The average score for those who had the actual energy drink was 81.6 with a standard deviation of 12.6 points. The average score for those who did not have the energy drink was 84.8 with a standard deviation of 7.4 points.

Which of the following expressions gives a 95% confidence interval for the difference in average exam scores between the energy drink group and the placebo beverage group?

(A) \[
\frac{84.8 - 81.6}{\sqrt{\frac{7.4^2}{28} + \frac{12.6^2}{28}}} \]

(B) \[(84.8 - 81.6) \pm 2.05183 \sqrt{\frac{7.4^2}{28} + \frac{12.6^2}{28}} \]

(C) \[(84.8 - 81.6) \pm 1.70329 \sqrt{\frac{7.4^2}{28} + \frac{12.6^2}{28}} \]

(D) \[3.2 \pm 2.05 \sqrt{\frac{3.2^2}{28}} \]
Use the following information to answer questions 3 – 5.

A researcher conducted a paired samples study to investigate whether local car dealers tend to charge women more than men for the same car model. Using information from the county tax collector’s records, the researcher randomly selected one man and one woman from among everyone who had purchased the same model of an identically equipped car from the same dealer. The process was repeated for a total of 6 randomly selected car models. The purchase prices and the differences, \( d = \text{woman} - \text{man} \), are shown in the table below. Selected summary statistics are also shown.

<table>
<thead>
<tr>
<th>Car Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>$20,100</td>
<td>$17,400</td>
<td>$32,500</td>
<td>$17,710</td>
<td>$29,600</td>
<td>$46,300</td>
<td>$27,268.33</td>
<td>$11,270.69</td>
</tr>
<tr>
<td>Men</td>
<td>$19,580</td>
<td>$17,500</td>
<td>$32,300</td>
<td>$17,720</td>
<td>$28,300</td>
<td>$45,630</td>
<td>$26,838.33</td>
<td>$11,028.37</td>
</tr>
<tr>
<td>Difference</td>
<td>$520</td>
<td>$-100</td>
<td>$200</td>
<td>$-10</td>
<td>$1,300</td>
<td>$670</td>
<td>$430.00</td>
<td>$519.62</td>
</tr>
</tbody>
</table>

3. Which of the following is the extraneous variable in this study?
   (A) The researcher conducting the study
   (B) Gender
   (C) Car model
   (D) Price difference

4. Which of the following is the appropriate alternative hypothesis for a matched pairs \( t \)-test to address the researcher’s question of interest?
   (A) \( \mu_d > 0 \)
   (B) \( \bar{x}_d > 0 \)
   (C) \( \mu_d < 0 \)
   (D) \( \bar{x}_d < 0 \)

5. Which of the following expressions gives the value of the test statistic for a matched pairs \( t \)-test to address the researcher’s question of interest?
   (A) \( \frac{430 - 0}{\sqrt{6}} \frac{519.62}{\sqrt{6}} \)
   (B) \( \frac{0 - 430}{\sqrt{6}} \frac{519.62}{\sqrt{6}} \)
   (C) \( \frac{430 - 0}{\sqrt{12}} \frac{519.62}{\sqrt{12}} \)
   (D) \( \frac{27,268.33 - 26,838.33 - 0}{\sqrt{11,270.69^2 + 11,028.37^2}} \frac{6}{6} \frac{6}{6} \)
6. If JMP were being used to perform a lower tail hypothesis test for one population mean and the following output were obtained, what should the conclusion be?

<table>
<thead>
<tr>
<th>Hypothesized Value</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Estimate</td>
<td>17.4118</td>
</tr>
<tr>
<td>DF</td>
<td>16</td>
</tr>
<tr>
<td>Std Dev</td>
<td>2.73995</td>
</tr>
<tr>
<td><strong>t Test</strong></td>
<td></td>
</tr>
<tr>
<td>Test Statistic</td>
<td>-3.8948</td>
</tr>
<tr>
<td>Prob &gt;</td>
<td>t</td>
</tr>
<tr>
<td>Prob &gt; t</td>
<td>0.9994</td>
</tr>
<tr>
<td>Prob &lt; t</td>
<td>0.0006*</td>
</tr>
</tbody>
</table>

(A) There is sufficient evidence to conclude that the mean of the population from which the data was taken is 20.

(B) There is sufficient evidence to conclude that the mean of the population from which the data was taken is less than 20.

(C) There is sufficient evidence to conclude that the mean of the population from which the data was taken is greater than 20.

(D) There is sufficient evidence to conclude that the mean of the population from which the data was taken is 17.41.

7. Which of the following statements about the t-distribution is NOT correct?

(A) The t-distribution has a mean of 0.

(B) The t-distribution is symmetric.

(C) The t-distribution has less variability than the standard normal distribution.

(D) As the degrees of freedom increases, the t-distribution approaches the standard normal distribution.

8. Last year Clay’s lawn and landscaping service, The Cutting Edge, earned on average $250 per day, and he thinks he is already making more this year. To test his hunch, he randomly selects 10 days from this year and performs a hypothesis test. What parameter is Clay testing?

(A) The true proportion of The Cutting Edge’s customers who returned this year.

(B) The true mean difference in daily revenue for The Cutting Edge, this year versus last year.

(C) The true mean daily revenue that The Cutting Edge is generating this year.

(D) The true mean daily revenue that The Cutting Edge generated last year.
9. To estimate the mean increase in heart rate after running one mile, 15 individuals that regularly exercise were randomly selected and their heart rates were measured (in beats per minute) both before and after running one mile. Which of the following is the appropriate degrees of freedom if this sample data is used to construct a 95% confidence interval for the true mean difference in heart rate (before – after) due to running one mile?

(A) 14
(B) 15
(C) 28
(D) 29

Use the following information to answer questions 10 – 11.
Rainwater on the east coast of the US has an average pH of 5.5. An average pH significantly lower than 5.5 can indicate the presence of an excessive amount of pollutants that form sulfuric acid and nitric acid. An ecologist is collecting samples of rainwater on Mt. Mitchell in North Carolina to determine if the rain there is more acidic, on average, than in other places in the eastern US. In testing the hypotheses $H_0: \mu = 5.5$ versus $H_a: \mu < 5.5$, the ecologist obtained an average pH of 4.4 and a $p$-value of .0244.

10. Which of the following is the best interpretation of this $p$-value?

(A) If the average pH on Mt. Mitchell is really 5.5, the probability of obtaining a sample average pH of 4.4 or lower is .0244.
(B) If the average pH on Mt. Mitchell is really less than 5.5, the probability of obtaining a sample average pH of 4.4 or lower is .0244.
(C) The probability is .0244 that the average pH on Mt. Mitchell is equal to 5.5.
(D) The probability is .0244 that the average pH on Mt. Mitchell is less than 5.5.

11. At the 1% significance level, what should the ecologist conclude?

(A) There is sufficient evidence to conclude that the average pH of rainwater on Mt. Mitchell is lower than 5.5.
(B) There is sufficient evidence to conclude that the average pH of rainwater on Mt. Mitchell is equal to 5.5.
(C) There is insufficient evidence to conclude that the average pH of rainwater on Mt. Mitchell is lower than 5.5.
(D) There is insufficient evidence to conclude that the average pH of rainwater on Mt. Mitchell is equal to 5.5.
Use the following information to answer questions 12 – 13.
A 90% confidence interval for the mean age (in weeks) at which a baby first crawls was reported to be (32, 46).

12. The margin of error for this confidence interval is:
   (A) 46
   (B) 32
   (C) 14
   (D) 7

13. Suppose the same sample data used to construct the 90% confidence interval of (32, 46) was used to construct a 98% confidence interval. Which of the following intervals could possibly represent that result?
   (A) (34, 44)
   (B) (32, 46)
   (C) (30, 48)
   (D) Cannot be determined from the given information.

14. A dog food company wishes to test a new high-protein formula for puppy food to determine whether it promotes faster weight gain than the existing formula for puppy food. Two puppies were selected from each of seven different litters of Labrador puppies for this experiment. One puppy from each litter was randomly assigned to the high-protein formula puppy food and the other puppy from the same litter to the existing formula puppy food. The weight gains (in pounds) after six months are shown in the following table.

<table>
<thead>
<tr>
<th>Litter</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Protein Formula</td>
<td>32</td>
<td>29</td>
<td>27</td>
<td>32</td>
<td>28</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Existing Formula</td>
<td>28</td>
<td>32</td>
<td>22</td>
<td>25</td>
<td>29</td>
<td>25</td>
<td>31</td>
</tr>
</tbody>
</table>

Which of the following best describes this experiment?
   (A) This experiment involved only one sample.
   (B) This experiment involved paired samples.
   (C) This experiment involved two independent samples.
   (D) This experiment involved both paired samples and independent samples.
15. Two hundred female students who graduated from Clemson in 2013 were surveyed. They were found to have jobs with salaries that pay on average $53,230 per year. The same number of male students who graduated that year also responded to the survey and were found to have jobs that paid $45,520 per year on average. The margin of error for a 95% confidence interval for the difference in mean salaries for the females and males was found to be $3,412 per year. Can we conclude that there is an actual difference in average salaries between the male and female graduates?

(A) Cannot be determined from the given information.
(B) Yes; the 95% confidence interval for the true difference in mean salaries does not contain 0.
(C) No; the 95% confidence interval for the true difference in mean salaries does not contain 0.
(D) No; the 95% confidence interval for the true difference in mean salaries contains 0.

16. *Laptop* magazine conducted an experiment to determine which of two smartphone models, the Samsung Galaxy S5 or the Apple iPhone 6 Plus, had the longer battery life. They obtained a random sample of 8 of the Samsung phones and a random sample of 8 of the Apple phones. They subjected each of the 16 phones to their battery test, which involves continuous web surfing over 4G LTE. The results are summarized in the table below, with battery lifetimes given in hours.

<table>
<thead>
<tr>
<th>Samsung Galaxy S5</th>
<th>10.70</th>
<th>10.65</th>
<th>10.00</th>
<th>11.00</th>
<th>10.65</th>
<th>10.25</th>
<th>10.35</th>
<th>10.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple iPhone 6 Plus</td>
<td>10.15</td>
<td>9.50</td>
<td>10.35</td>
<td>10.45</td>
<td>9.90</td>
<td>10.35</td>
<td>10.00</td>
<td>9.90</td>
</tr>
</tbody>
</table>

Which of the following best describes this experiment?

(A) This experiment involved only one sample.
(B) This experiment involved paired samples.
(C) This experiment involved two independent samples.
(D) This experiment involved both paired samples and independent samples.
17. In a survey conducted by the Gallup organization, 1100 randomly selected adult Americans were asked how many hours they worked in the previous week. Based on the results, a 95% confidence interval for the mean number of hours worked was (42.7, 44.5). Which of the following is the best interpretation of this confidence interval?

(A) There is a 95% probability the mean number of hours worked by all adult Americans in the previous week was between 42.7 hours and 44.5 hours.

(B) We are 95% confident that the mean number of hours worked by all adult Americans in the previous week was between 42.7 hours and 44.5 hours.

(C) Approximately 95% of adult Americans worked between 42.7 hours and 44.5 hours last week.

(D) We are 95% confident that the mean number of hours worked by adults in Idaho in the previous week was between 42.7 hours and 44.5 hours.

Use the following information to answer questions 18 – 19.

Twenty-five randomly selected owners of a Chevrolet Impala were asked to measure their fuel efficiencies for a tank of gas (in miles per gallon), which are known to follow a normal distribution. The summary statistics obtained from this study were: \( \bar{x} = 26.4 \) and \( s = 2.84 \).

18. Which of the following expressions would produce a 99% confidence interval for the fuel efficiency for all Chevrolet Impala cars?

(A) \( 26.4 \pm 2.48511 \left( \frac{2.84}{\sqrt{25}} \right) \)

(B) \( 26.4 \pm 2.49216 \left( \frac{2.84}{\sqrt{25}} \right) \)

(C) \( 26.4 \pm 2.78744 \left( \frac{2.84}{\sqrt{25}} \right) \)

(D) \( 26.4 \pm 2.79694 \left( \frac{2.84}{\sqrt{25}} \right) \)

19. The estimate of the standard error of the sample mean fuel efficiency is:

(A) 0.568

(B) 2.84

(C) 26.4

(D) Cannot be determined from the given information.
To test the claim that Clemson University (CU) students have higher IQs on average than University of South Carolina (USC) students, a random sample of 26 CU students was selected and a random sample of 19 USC students was selected and their IQ scores obtained. The following table summarizes the results.

<table>
<thead>
<tr>
<th></th>
<th>CU Students</th>
<th>USC Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>121.7</td>
<td>118.1</td>
</tr>
<tr>
<td>Std Dev</td>
<td>8.8</td>
<td>9.2</td>
</tr>
<tr>
<td>n</td>
<td>26</td>
<td>19</td>
</tr>
</tbody>
</table>

Which of the following expressions gives the appropriate test statistic for testing this claim?

(A) \[ \frac{121.7 - 118.1}{\sqrt{\frac{8.8^2 + 9.2^2}{26 + 19}}} \]

(B) \[ \frac{121.7 - 118.1}{\sqrt{\frac{8.8^2 + 9.2^2}{26 + 19}}} \]

(C) \[ \frac{3.6 - 0}{0.4/\sqrt{45}} \]

(D) Cannot be determined from the given information.
Part II: Free Response. Show all your work. Indicate clearly the methods you use, because you will be graded on the correctness of your methods as well as on the accuracy and completeness of your results and explanations. Answers with no justification will receive no credit.

1. The average national FICO (Fair, Isaac, & Co.) credit rating reached an all-time low of 686 in October 2009, just after the economic collapse of 2008. A recent sample of 41 people had an average credit rating of 695.6 with a standard deviation of 37.7. Perform a hypothesis test at the .05 significance level to determine if this sample provides sufficient evidence that the mean credit rating for all Americans is now higher than it was just after the economic collapse of 2008.

(a) Define the parameter of interest and state the null and alternative hypotheses. (3 pts)

Let \( \mu \) = current mean credit rating for all Americans.

\[
H_0: \mu = 686 \\
H_a: \mu > 686
\]

1 pt for correctly defining the parameter of interest
1 pt for using equals sign in \( H_0 \) and greater than sign in \( H_a \)
1 pt for using the correct value in the hypotheses

Note: In order to earn the point for correctly defining the parameter, the correct symbol must be used and the definition must reference the population.

(b) Calculate the test statistic. (2 pts)

\[
t_{\text{obs}} = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{695.6 - 686}{37.7/\sqrt{41}} \approx 1.6305
\]

1 pt for correctly filling in formula
1 pt for correct final answer

(c) Determine the approximate p-value. Give the degrees of freedom. (3 pts)

\[
df = n - 1 = 40
\]
\[
p-value = P(t > 1.6305)
\]
\[
.05 < p-value < .10
\]

1 pt for correct degrees of freedom
1 pt for correct lower bound
1 pt for correct upper bound

(d) What is the decision? Why? (2 pts)

Fail to reject \( H_0 \) because the p-value is greater than \( \alpha = .05 \).

1 pt for correct decision for p-value in (c)
1 pt for correct justification

(e) What is the conclusion? (3 pts)

There is insufficient evidence to conclude that the mean credit rating for all Americans is now higher than it was just after the economic collapse of 2008.

1 pt for stating conclusion in terms of \( H_a \)
1 pt for putting in context of problem
1 pt for stating (in)sufficient evidence (must be consistent with decision in part d)
2. Investigators at the U.S. Department of Agriculture wished to compare methods of determining the level of E. coli bacteria contamination in beef. Two different methods (A and B) of determining the level of contamination were used on each of ten randomly selected specimens of a certain type of beef. The data obtained, in millimicrobes/liter of ground beef, for each of the methods is shown in the table below. The differences, \( d = \text{Method A} - \text{Method B} \), are also shown along with selected summary statistics.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method A</td>
<td>22.7</td>
<td>23.6</td>
<td>24.0</td>
<td>27.1</td>
<td>27.4</td>
<td>27.8</td>
<td>34.4</td>
<td>35.2</td>
<td>40.4</td>
<td>46.8</td>
<td>30.94</td>
<td>8.0154</td>
</tr>
<tr>
<td>Method B</td>
<td>23.0</td>
<td>23.1</td>
<td>23.7</td>
<td>26.5</td>
<td>26.6</td>
<td>27.1</td>
<td>33.2</td>
<td>35.0</td>
<td>40.5</td>
<td>47.8</td>
<td>30.65</td>
<td>8.3442</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.3</td>
<td>0.5</td>
<td>0.3</td>
<td>0.6</td>
<td>0.8</td>
<td>0.7</td>
<td>1.2</td>
<td>0.2</td>
<td>-0.1</td>
<td>-0.1</td>
<td>0.29</td>
<td>0.6297</td>
</tr>
</tbody>
</table>

The investigators would like to report a 99% confidence interval for the true mean difference in the amount of E. coli bacteria detected by the two methods for this type of beef.

(a) What parameter are the investigators interested in estimating? Give the appropriate symbol and define in the context of this study. (2 pts)

\[ \mu_d = \text{the true mean difference in the amount of E. coli bacteria detected by the two methods } \]
\[ (d = \text{A} - \text{B}) \text{ for this type of beef} \]

(b) Find the 99% confidence interval. Round your final answer to two decimal places. (5 pts)

\[ 99\% \text{ CI for } \mu_d: \]
\[ \bar{d} \pm t_{\alpha/2, (n-1)} \left( \frac{s_d}{\sqrt{n}} \right) \]
\[ = 0.29 \pm 3.24984 \left( \frac{0.6297}{\sqrt{10}} \right) \]
\[ \approx 0.29 \pm 0.64714 \]
\[ \approx (-0.36, 0.94) \]

Note: If using the independent samples \( t \)-interval formula, at most 2 pts will be awarded if the critical value is correct.

(c) Based on the confidence interval in part (b), can we conclude that there is a true difference between the two methods? Explain. (2 pts)

No; the confidence interval contains 0 so it is plausible that there is no difference in the amount of E. coli bacteria detected by the two methods.

For the given \( d_i \): \( \bar{d} = 0.38 \), \( s_d = 0.46857 \) and the 99% CI is \((-0.10, 0.86)\)
3. A randomized experiment was performed to determine whether two fertilizers, A and B, give different yields of tomatoes. A total of 33 tomato plants were grown; 16 using fertilizer A, and 17 using fertilizer B. At the conclusion of the experiment, the number of tomatoes grown per plant was recorded. The JMP output below gives the results of a two sample \( t \)-test comparing fertilizer A and fertilizer B using the results of this experiment.

(a) Define the parameters and state the hypotheses that were tested. (4 pts)

Let \( \mu_A \) = true mean number of tomatoes per plant grown using fertilizer A & \( \mu_B \) = true mean number of tomatoes per plant grown using fertilizer B

\[
\begin{align*}
H_0 &: \mu_B - \mu_A = 0 \\
H_a &: \mu_B - \mu_A \neq 0
\end{align*}
\]

OR

\[
\begin{align*}
H_0 &: \mu_B = \mu_A \\
H_a &: \mu_B \neq \mu_A
\end{align*}
\]

Note: In order to earn the points for correctly defining the parameters, the correct symbols must be used and the definitions must reference the population.

(b) Give the value of the test statistic for this hypothesis test. (2 pts)

\[
t_{\text{obs}} = 3.50503
\]

(c) Give the \( p \)-value and degrees of freedom for this hypothesis test. (3 pts)

\[
\begin{align*}
df &= 26.60601 \\
p\text{-value} &= P(t > |3.50503|) = 0.0016
\end{align*}
\]

(d) At the 5% significance level, what conclusion can be drawn from this experiment? (3 pts)

There is sufficient evidence to conclude that the two fertilizers, A and B, give different yields of tomatoes.

\[
\begin{align*}
1 \text{ pt for stating (in)sufficient evidence for } H_a & \text{ (must be consistent with } p\text{-value in part c)} \\
1 \text{ pt for stating conclusion in terms of } H_a \\
1 \text{ pt for putting in context of problem}
\end{align*}
\]
4. Hoping to lure more shoppers downtown, a city builds a new public parking garage in the central business district. The city plans to pay for the structure through revenue generated from parking fees. During a two-month period (44 weekdays), daily revenue collected from fees averaged $126, with a standard deviation of $15. Determine a 90% confidence interval for the mean weekday daily revenue from this parking garage. Round your final answer to two decimal places. (5 pts)

Let $\mu = \text{true mean weekday daily revenue from this parking garage.}$

90% CI for $\mu$:

$$\bar{x} \pm t_{\alpha/2, (n-1)} \left( \frac{s}{\sqrt{n}} \right)$$

$$\alpha = .10 \rightarrow \frac{\alpha}{2} = .05$$

$$df = n - 1 = 43$$

$$t_{.05,43} = 1.68107$$

$$= 126 \pm 1.68107 \left( \frac{15}{\sqrt{44}} \right)$$

$$\approx 126 \pm 3.80147$$

$$\approx (\$122.20, \$129.80)$$

1 pt for substituting in correct point estimate
2 pts for finding correct critical value
1 pt for substituting values into SE formula correctly
1 pt for correct final answer

---

Did you correctly fill in your scantron? (1 pt)

☐ Did you write your name, lecture section #, and lecture instructor at the top of the form?
☐ Did you fill in your CUID with the C bubbled as a 0?
☐ Did you bubble in your Test Version?
☐ Are your bubbles filled in dark enough so that the form can be machine read?