MULTIPLE CHOICE (5 pts each)  Exam is worth 200 points

(1) The t distribution is wider than the Z distribution because:
(A) It includes the uncertainty in our estimate of the sample mean.
(B) It includes the uncertainty in our estimate of the sample variance.
(C) It includes the uncertainty in our estimate of the population mean.
(D) It includes the uncertainty in our estimate of the population variance.
(E) Larger sample sizes cause it to be wider than the Z distribution.

(2) Which of the following is NOT correct?
(A) Heteroscedastic t tests have a complicated df equation.
(B) Homoscedastic t tests have a simple df equation.
(C) Homoscedastic t tests can be done with any two samples.
(D) Paired t tests have a simple df equation.
(E) Paired t tests can only be done with samples in which data values are paired.

(3) The best description of what a p value represents is:
(A) The probability of obtaining the test statistic if H₀ is true.
(B) The probability of obtaining the test statistic if Hₐ is true.
(C) The probability that Hₐ is true.
(D) The probability of obtaining the test statistic if H₀ is false.
(E) The probability of obtaining the test statistic if Hₐ is false.

(4) Which of the following is the best description of what a 95% confidence interval represents?
(A) A region roughly one standard error above and below the sample mean.
(B) A region within which 95% of the sample's data values lie.
(C) A region within which 95% of the population's data values lie.
(D) A region within which there is a 95% probability the sample's mean value lies.
(E) A region within which there is a 95% probability the population's mean value lies.

(5) A researcher is interested in whether a drug alters the pH of blood in users. She takes blood samples from a set of individuals before and after taking the experimental medication. Unfortunately a small number of the sample jar labels in the "after" treatment got mislabeled. Although she has all the samples, she cannot guarantee which samples are from the same individuals in a few cases. What option below best explains her next step.
(A) Because only a few labels are incorrect she can still do a paired t test, she should just use a smaller p value threshold in her analysis.
(B) She cannot do a paired t test, but since the same people are in both samples she can analyze the data with a homoscedastic t test.
(C) She cannot do a paired t test, but since the same people are in both samples she can analyze the data with a heteroscedastic t test.
(D) She cannot do a t test, but she can analyze the data with an F ratio test to answer her overall question.
(E) Since the labels are not correct she cannot do a paired t test and she must redo the whole experiment.
(6) Which of the following is the correct equation for a data set Q described by $Q \sim N(4, 25)$:

(a) $f(x) = \frac{1}{5\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-2}{5}\right)^2}$  
(b) $f(x) = \frac{1}{25\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-2}{25}\right)^2}$

(c) $f(x) = \frac{1}{5\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-4}{5}\right)^2}$  
(d) $f(x) = \frac{1}{25\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-4}{25}\right)^2}$

(e) $f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2} x^2}$

(7) Which of the following statements is FALSE?
(A) A confidence interval becomes narrower as the standard error increases.
(B) A statistically significant result generally leads us to reject a null hypothesis.
(C) For the sample sizes, a homoscedastic t test is more powerful than an heteroscedastic t test.
(D) The F ratio test is prone to inaccurate results when conducted on non-normal distributions.
(E) The distribution of means for samples taken from a population will be normal.

(8) The bias introduced into science by the selective publishing of results that are statistically significant and clear and therefore easier to publish is best described as:
(A) Beavis effect.  
(B) Confirmation bias.  
(C) Cherry-picking.  
(D) Shifting baselines phenomenon.  
(E) The file drawer problem.

(9) Which of the following is TRUE regarding one and two tailed tests?
(A) One tailed tests are for when you have one sample, two tailed tests are for when you have two samples.
(B) Two tailed tests are more likely to give you type I error than type II error.
(C) Two tailed tests will look suspicious unless you provide a convincing reason why you are not doing a one tailed test.
(D) When doing a one tailed test, the critical t values you use would typically be larger in magnitude than if you were doing a two tailed test.
(E) You cannot use your sample data values to help you decide whether to do a one or two tailed test.

(10) Drugs and substances "approved" by the FDA have been intensively studied to demonstrate that they are:
(A) At least somewhat effective at improving a health condition and have no negative side-effects.
(B) At least somewhat effective at improving a health condition and any negative side-effects are less severe that the condition treated.
(C) 100% effective at improving a health condition and have no negative side-effects.
(D) 100% effective at improving a health condition and any negative side-effects are less severe that the condition treated.
(E) Natural, safe and don't cause poisoning or severe side-effects.

(11) If you are using a table of critical t values and you accidentally use the values for more degrees of freedom than you really have which of these is true:
(A) The risk of making a type I error is increased and the risk of type II error is increased.
(B) The risk of making a type I error is increased and the risk of type II error is decreased.
(C) The risk of making a type I error is decreased and the risk of type II error is increased.
(D) The risk of making a type I error is decreased and the risk of type II error is decreased.
(E) The risk of making a type I error is the same and the risk of type II error is the same.
(12) Which of the following most accurately describes the Tuskegee experiment?
(A) African-American and Caucasian soldiers were given different formulas of a syphilis vaccine and then compared to see which was more effective.
(B) Healthy African-American men were infected with syphilis to determine the rate of transmission of the disease to their spouses and offspring.
(C) Healthy African-American men were vaccinated against syphilis and then infected to determine the level of effectiveness of the vaccine.
(D) Pre-existing cases of syphilis were identified in African-American men and they were observed, but not treated.
(E) Pre-existing cases of syphilis were identified in African-American men and they were administered either antibiotics or a placebo to determine the effectiveness of antibiotics in combating syphilis.

(13) Which of the following most accurately describes the conclusion of Milgram experiment?
(A) People enjoy causing pain to others.
(B) Under the guidance of an authority figure, most people are willing to harm others.
(C) People have a remarkably high ability to resist peer pressure when the consequences are severe.
(C) Men are more likely than women to administer electric shocks to puppies when asked to.
(E) People are generally unwilling to harm others unless there is a reward offered.

Power analysis questions

(14) If we have data from two populations (the sample sizes and variances are equal) and the calculated t value for a one-tailed t test is 1.75, what is the minimum sample size of each sample in order for us to conclude that the populations are "significantly different"?
(A) 9
(B) 10
(C) 11
(D) 12
(E) 13

(15) Consider conducting a homoscedastic t test with two samples of size n=16 from two populations that differ. The standard deviations of the populations are 20% of the mean. Which of the following is closest to the minimum difference in population means that would result in a p value less than 0.05 and us correctly identifying that population means differ?
(A) 10%
(B) 12%
(C) 14%
(D) 16%
(E) 18%

(16) If you use a smaller pair of samples, what sort of statistical error are you likely to commit?
(A) Heteroscedastic error
(B) Homoscedastic error
(C) Type I error
(D) Type II error
(E) Sampling error

(17) Consider conducting a homoscedastic t test with two samples of equal size from two populations that differ by 8% of their mean. The standard deviations of the populations are 10% of the mean. What is the minimum sample size you would need to use in order to obtain a p value less than 0.05 and correctly identify the difference in the population means?
(A) \( n_1 = n_2 = 13 \)
(B) \( n_1 = n_2 = 15 \)
(C) \( n_1 = n_2 = 17 \)
(D) \( n_1 = n_2 = 19 \)
(E) \( n_1 = n_2 = 21 \)

(18) If you used a larger sample size what would tend to happen to your calculated t value and the critical t value you would use?
(A) Both values decrease
(B) Both values increase
(C) \( t_{calc} \) decreases, \( t_{crit} \) increases.
(D) \( t_{calc} \) increases, \( t_{crit} \) decreases.
(E) Values become equal.
The next 3 questions are based on the list of "misuses of statistics" that you were instructed to read for this exam.

(19) In class I described an exam I gave a few years ago in which I asked students to guess my age using two different treatments: "Ashley Carter" and "Dr. Carter". There was significant difference between the mean ages reported. This was an attempt to demonstrate the power of which of the following?
(A) Biased samples
(B) Data manipulation
(C) False causality
(D) Loaded questions
(E) Overgeneralization

(20) Over the past 20 years the number of diagnosed cases of autism have increased by approximately 300% (http://www.cdc.gov/ncbddd/autism/data.html) which is very close to the increase in the sales of natural and organic foods (http://ota.com/sites/default/files/indexed_files/StateOfOrganicIndustry_0.pdf). This close link between increased consumption of organic food and increased autism therefore clearly shows that eating organic food is a risk factor for autism. Which of the following is the misuse of statistics just demonstrated?
(A) Biased samples
(B) False causality
(C) Loaded questions
(D) Overgeneralization
(E) Proof of the null hypothesis

(21) Political season is upon us with Donald Trump and Bernie Sanders making big news for the attention they are getting from the press as newsworthy opponents of more established Republican and Democratic candidates. When they give speeches many people show up and they cite this fact as data that they have widespread and strong support. Which of the following misuse of statistics are they making?
(A) Data dredging.
(B) Data manipulation
(C) False causality
(D) Overgeneralization
(E) Loaded questions

(22) Which of the following is the best description of the way the technical term "statistically significant" is most commonly used?
(A) When the null hypothesis of a statistical test can be rejected at the $\alpha=5\%$ level.
(B) When the null hypothesis of a statistical test can be rejected at the $\alpha=1\%$ level.
(C) When the alternative hypothesis of a statistical test can be rejected at the $\alpha=5\%$ level.
(D) When the alternative hypothesis of a statistical test can be rejected at the $\alpha=1\%$ level.
(E) When the $t_{\text{crit}} > t_{\text{calc}}$

(23) If you do a statistical test and the p value is 0.04 what is your conclusion?
(A) Reject $H_0$ and accept $H_A$.
(B) Accept $H_0$ and reject $H_A$.
(C) The difference is significant.
(D) Accept both $H_0$ and $H_A$.
(E) Reject both $H_0$ and $H_A$.

(24) If we wish to know if two populations have different means we perform which of the following tests?
(A) $\chi^2$ test
(B) One sample t test
(C) Two sample t test
(D) Paired F test
(E) F ratio test

(25) If we wish to know if two populations have different variances we perform which of the following tests?
(A) $\chi^2$ test
(B) One sample t test
(C) Two sample t test
(D) Paired F test
(E) F ratio test
(26) Phenotypic plasticity is a phenomenon in which the same genotype can lead to dramatically different phenotypes. A well-known example of this is seen in several species of spadefoot toads (Spea sp.) in which some individuals develop into smaller omnivorous tadpoles while others develop into larger cannibalistic tadpoles (in the picture on the left and right respectively). Consider a field study in which researchers capture samples of tadpoles from four different ponds (a total of 100 tadpoles) and are interested in whether the relative proportions of the two morphs differ. Their data for the number of individuals of each morph is:

<table>
<thead>
<tr>
<th>Pond</th>
<th>Omnivore</th>
<th>Cannibal</th>
</tr>
</thead>
<tbody>
<tr>
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<td>11</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>4</td>
<td>18</td>
<td>12</td>
</tr>
</tbody>
</table>

Conduct a $X^2$ test of independence using these values. Report your value to the nearest 0.001.

(a, 3 pts) How many degrees of freedom will you use? (provide integer)

$$df = \underline{3}$$

(b, 15 pts) What is the $X^2$ value you obtain? (provide to closest 0.001)

$$X^2_{calc} = \underline{13.750}$$

(c, 6 pts) State the technical conclusion of your $X^2$ test in the box below. Use the grammar presented in lecture. State whether the conclusions are "significant" or not and be sure to include a statement about your degree of confidence with a range of $p$ values (using the table on this page). Remember that you are talking about "proportions of tadpole morphs". **Note:** no credit will be given for ANY text outside the box or hard to read answers and a lack of precision or unnecessary information and filler text will result in a loss of points.

The observed and predicted values are significantly different from one another ($0.001 < p < 0.01$) therefore the frequencies of the tadpole morphs and the pond in which the measurement was taken are not independent of one another.

(d, 2 pts) State the plain language version of your conclusion in the box below. Do the proportions of the tadpole morphs differ in the lakes or not?

The tadpole morph frequencies seem to differ between the ponds.
(27) On this page we will look at how the same data set can be analyzed two different ways; with either the heteroscedastic or paired t test. Imagine that we are testing a new drug that may alter a health statistic we will call "NIN" for which lower values are better. A small pilot trial is conducted in which 9 individuals are given the drug - with their NIN values taken before and after administration of the drug. The data values obtained were:

<table>
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<th>After</th>
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</thead>
<tbody>
<tr>
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<td>34</td>
</tr>
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<td>35</td>
</tr>
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<td>3</td>
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</tr>
<tr>
<td>9</td>
<td>41</td>
<td>37</td>
</tr>
</tbody>
</table>

The mean NIN value is not significantly different before taking the drug and after taking the drug (0.05 < p < 0.1)

If one-tailed: The mean NIN value is significantly larger before taking the drug than after taking the drug (0.025 < p < 0.05)

Answer the following questions, report all calculated t values to the nearest 0.001 and df to the appropriate integer.

(a, 4 pts ea) Perform a heteroscedastic t test and fill in the blanks below with the values indicated.

\[ \text{df} = \underline{15} \quad \text{t}_{calc} = \underline{2.051} \]

(b, 4 pts) State the technical conclusion of your heteroscedastic test in the box below. Use the grammar presented in lecture. State whether the conclusions are "significant" or not and be sure to include a statement about your degree of confidence with a range of p values. **Note**: no credit will be given for ANY text outside the box or hard to read answers and a lack of precision or unnecessary information and filler text will result in a loss of points.

The mean NIN value is not significantly different before taking the drug and after taking the drug (0.05 < p < 0.1)

If one-tailed: The mean NIN value is significantly larger before taking the drug than after taking the drug (0.025 < p < 0.05)

(c, 4 pts ea) Perform a paired t test and fill in the blanks below as indicated.

\[ \text{df} = \underline{8} \quad \text{t}_{calc} = \underline{3.043} \]

(d, 4 pts) State the technical conclusion of your paired t test in the box below. Use the grammar presented in lecture. State whether the conclusions are "significant" or not and be sure to include a statement about your degree of confidence with a range of p values. **Note**: no credit will be given for ANY text outside the box or hard to read answers and a lack of precision or unnecessary information and filler text will result in a loss of points.

The mean NIN value is significantly larger before taking the drug than after taking the drug (0.01 < p < 0.02) If one-tailed: The mean NIN value is significantly larger before taking the drug than after taking the drug (0.005 < p < 0.01)
(28) The salinity of water often varies with depth, but the details can vary depending on ocean currents, temperatures, etc. Consider the following two hypothetical samples of 8 values taken from the Atlantic ocean- one from 800m and one from 2000m deep (these PPT values are close to typical salinities for such depths):

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<th>33.0</th>
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<th>34.0</th>
<th>36.0</th>
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<table>
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<tbody>
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<td>33.0</td>
<td>35.0</td>
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</tr>
</tbody>
</table>

Answer the following questions, report all calculated values to the nearest 0.001.

(a, 3 pts ea) If we were to perform an F test to compare the variances, what values would we get? Fill in the blanks below with the values indicated.

\[
F_{\text{calc}} = 5.000 \\
F_{\text{crit}} \text{ for } \alpha=0.05 = 4.99
\]

(b, 3 pts) State the plain language version of your conclusion in the box below. Do the variances of the salinity values differ or not? **Note:** no credit will be given for ANY text outside the box or hard to read answers and a lack of precision or unnecessary information and filler text will result in a loss of points.

Yes, the variances seem to differ

(c, 2 pts ea) Calculate the 95% confidence intervals for each data set.

800m: Upper bound = 35.095 \\
     Lower bound = 32.905 \\

3000m: Upper bound = 37.448 \\
       Lower bound = 32.552

(d, 3 pts) Based on the results above, would you expect the results of a t test to show a significant difference or not? Explain your reasoning. **Note:** no credit will be given for ANY text outside the box or hard to read answers and a lack of precision or unnecessary information and filler text will result in a loss of points.

The 95% confidence intervals overlap quite a bit so I would expect a t test to show that there is **NO SIGNIFICANT DIFFERENCE** between the means of the salinity values at these depths.
**TABLES OF $t_\alpha$ and $F_\alpha$ VALUES**

Table shows the $t$ values corresponding to the indicated critical $\alpha$ value.

<table>
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