STAT 218 - Midterm Exam 2

Dr. Robinson

November 9, 2020

Name: _____

Section (circle one): 2:10am 4:10am

Read and Sign the Following Statement:

I understand that give or receiving help on this exam is a violation of academic regulations and is punishable by a grade of **F** in this course. This includes looking at other students' exams and / or allowing other students, actively or passively, to see answers on my exam. This also includes revealing, actively or passively, any information about the exam to any member of Professor Robinson's STAT 218 class who has not yet taken the exam. The use of cell phones is strictly prohibited.

I pledge not to do any of these things.

Signed: _____

Instructions.

- Read and sign the honesty pledge at the top of this page. Your exam will not be graded unless the honesty pledge is signed!
- You may use a calculator. You **may not** use your phone or any device that connects to the internet as a calculator.
- Show all work as clearly as possible. Point totals are shown in brackets next to each part. Formulas without values entered do not count as work.
- All answers should be reported in decimal form, rounded to three decimal places.
- For multiple choice and multi-select problems, circle your desired answer choice(s). If you change an answer, be sure to completely erase your initial selection.
- You have 50 minutes to complete this exam, so budget your time wisely.

Golden Ticket

Note you may need to think critically about how to extend some of this information to specific situations not listed.

Scenario	One Quantitative Response	Two Quantitative Variables	Quant. Response and Categ. Explanatory
Type of plot	Dot plot, Histogram, Boxplot	Scatterplot	Faceted Histograms, Side-by-side Boxplots
Summary measure	Mean	Slope or Correlation	Difference in Means
Parameter notation	μ	Slope: β_1; Correlation: ρ	$\mu_1 - \mu_2$
Statistic notation	$\bar{x}$	Slope: b_1; Correlation: r	$\bar{x}_1 - \bar{x}_2$

Provided Formulas

$$IQR = Q3 - Q1$$

1.5 IQR Rule: above $Q3 + (1.5 \times IQR)$ or below $Q1 - (1.5 \times IQR)$

$$\hat{y} = b_0 + b_1 \times x \qquad\qquad Residual = y - \hat{y}$$

t-based confidence interval: point estimate $\pm\, t^*_{df} \times SE$

$$SE(\bar{x}) = \frac{s}{\sqrt{n}} \qquad\qquad SE(\bar{x}_1 - \bar{x}_2) = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

$$F = \frac{\text{MSG}}{\text{MSE}} \qquad\qquad \alpha^* = \frac{\alpha}{\#\text{ of comparisons}}$$

Q1 [10 points] Researchers in Southern England collected data on grassland butterflies. They were interested in whether movement patterns varied across species and between male and female butterflies. Researchers observed 164 butterflies over the three-year length of this study, of which 28 were female and 136 were male. These 164 butterflies were considered to be representative of all grassland butterflies. The butterfly movements were observed by measuring how far they flew (in meters) from one landing site to the next, called step distance. This was done by placing a flag at each landing site and measuring the distance between the flags using a mapping software.

The researchers were interested in investigating if there was a difference between how far male and female butterflies travel, on average, between landing sites.

(a) [4 pts] Fill in each blank with one of the options in parentheses to best describe the variables collected.

Step distance is the (explanatory/response) _____ and it is (categorical/quantitative) _____.

Sex is the (explanatory/response) _____ and it is (categorical/quantitative) _____.

(b) [3 pts] Which visualizations would be most appropriate to display the relationship between step distance and sex of the butterfly? Select all that apply.

(i) Segmented Bar plot

(ii) Scatterplot

(iii) Side-by-side Boxplot

(iv) Faceted histograms

(c) [3 pts] Assuming a statistical difference in step distance is found between the male and female butterflies in the sample, what is the scope of inference for this study? Select one.

(i) Sex causes a difference in average step distance for all grassland butterflies.

(ii) Sex is associated with a difference in average step distance for the sample of grassland butterflies.

(iii) Sex causes a difference in average step distance for the sample of grassland butterflies.

(iv) Sex is associated with a difference in average step distance for all grassland butterflies.

Q5 [20 points] The *Journal of Food and Agriculture* contained an article titled "Influence of hydroponic ad soil cultivation on quality and shelf life of ready-to-eat lamb's lettuce." In this article, researchers studied the effects of different hydroponic growing methods on the nitrate content of lettuce. In their study, the researchers randomly assigned 34 lettuce seedlings to one of three growing conditions: soil, hydroponic A, or hydroponic B. At the end of the growing period (60 days), nitrate measurements of the lettuce were taken (mg / kg).

Results from the study are presented in the table below.

Treatment Group	Mean Growth	Standard Deviation of Growth	Sample Size
Soil	3851	98.54	9
Hydroponic A	4705	119.1	12
Hydroponic B	3882	114.5	13

(a) [2 pts] One of the researcher's main questions was to determine whether the growing method affects nitrate concentration in lettuce. Considering how this study was executed, can they address this question? *Briefly justify your answer.*

Below is an incomplete ANOVA table, summarizing the data. You may use this information for the subsequent problems.

term	df	sumsq	meansq	statistic	p.value
Growing Method	____	5428428	2714214	____	<0.0001
Residuals	31	390916	12610	NA	NA

(b) [3 pts] In the context of the research and in plain English, what are the null and alternative hypotheses investigated in the ANOVA table above?

H_0**:**

H_A**:**

(c) [2 pts] Rewrite the null hypothesis above to use **notation** for the parameters that are being tested.

H_0**:**

H_A**:**

(d) [2 pts] The alternative hypothesis investigated in the ANOVA table above is H_A: $\mu_{\text{Soil}} \neq \mu_{\text{Hydroponic A}} \neq \mu_{\text{Hydroponic B}}$. Circle one.

True **False**

(e) [1 pts] What are the degrees of freedom associated with `Growing Method`?

(f) [2 pts] What is the value of the F-statistic?

(i) [1 pt] Which distribution was used to obtain the p-value presented in the table? Circle one.

Simulated / Permuted Null Distribution **F-distribution**

(j) [4 pts] Citing values from the ANOVA table to support your answer, what conclusions could be drawn regarding the hypotheses stated in (b) and (c)?

(k) [3 pts] The table below presents all comparisons of soil treatment. What value of α should the researchers use to determine which of these tests produced "significant" results, so that the overall Type I error rate for these tests is less than 5%?

Group 1	Group 2	p.value
Hydroponic B	Hydroponic A	<0.0001
Soil	Hydroponic A	<0.0001
Soil	Hydroponic B	0.5364

Extra Credit [3 pts] Based on the comparisons above, sketch what you would expect the side-by-side box-plots to look like. Be sure to label your x-axis and y-axis!

Q4 [19 points] As you may be aware, many individuals are concerned about the presence of BPA in plastics, especially plastics that make contact with food and drinks. Currently, these is an incomplete understanding of how exposure to BPA affects our ingestion. Last year Dr. Hagobian in the Kinesiology and Public Health carried out a study to investigate the role of Bisphenol A (BPA) in metabolism and endocrine disruption.

Dr. Hahobian recruited 11 subjects, each of whom ate two types of cookies on two separate visits, one visit in December and the second in February. On one visit they ate the BPA-laced cookie and, on a different day, a placebo cookie (with no BPA). Thirty minutes after eating the cookie on each occasion, they were given a glucose tolerance test to measure their glucose metabolism.

A summary of the glucose test results (mmol/L) after eating each type of cookie as well as the difference in glucose results for each subject is shown below.

Cookie	Mean	Standard Deviation	n
Placebo	5.259	0.762	11
BPA	5.355	1.462	11
Difference: Placebo - BPA	-0.095	1.153	11

(a) [4 pts] For simplicity, Dr. Hagobian could have given all subjects the BPA cookie on their first visit in December, and the Placebo cookie on the second visit in February, but he didn't. Instead, when a subject came for their first visit, he flipped a coin. If it was heads, they received BPA on that visit (and Placebo on their second visit). If it was tails they received the Placebo cookie first. Why did he add this extra coin flipping step instead of the simpler approach of just giving everyone one type of cookie in December and the other type in February?

(b) [2 pts] Dr. Hagobian is interested in testing whether BPA causes a shift in glucose levels. Which analysis would be more appropriate? Circle one.

Difference in Two Independent Means **Mean of the Paired Differences**

(c) [3 pts] Based on your answer to (b), write out the null and alternative hypotheses for Dr. Hagobian's test using **notation**. *Be sure to indicate the order of subtraction being used!*

H_0**:**

H_A**:**

(d) [3 pts] To perform the analyses you selected in (b), what conditions does Dr. Hagobian need to check before obtaining a p-value? Circle all that apply.

(i) Independence of the differences

(ii) Independence of the observations within each group

(iii) Independence of the observations between the groups

(iv) Independence of the variables

(v) Equal variance between the groups

(vi) Linear relationship between the variables

(vii) Normality of the differences

(viii) Normality of the observations within each group

(e) [3 pts] Using `R`, Dr. Hagobian obtained the following table.

statistic	p_value	estimate	lower_ci	upper_ci
0.7573	0.4663	0.2768	-0.3856	0.9392

Which of the following would be the best overall conclusion in the context of Dr. Hagobian's study? Your selection should reflect the hypotheses you wrote in part (c)!

(i) With such a large p-value, we have significant evidence to reject the null hypothesis. We conclude the true mean of the differences in glucose between eating a BPA cracker and a Placebo cracker is not 0.

(ii) With such a large p-value, we have insufficient evidence to reject the null hypothesis. We conclude the true mean of the differences in glucose between eating a BPA cracker and a Placebo cracker is 0.

(iii) With such a large p-value, we have insufficient evidence to reject the null hypothesis. We do not have evidence to suggest the mean of the differences in glucose between eating a BPA cracker and a Placebo cracker is different from 0.

(vi) With such a large p-value, we have significant evidence to reject the null hypothesis. We conclude the true mean glucose after eating a BPA cracker is different from the true mean glucose after eating a Placebo cracker.

(v) With such a large p-value, we have insufficient evidence to reject the null hypothesis. We conclude there is no difference in the true mean glucose after eating a BPA cracker and the true mean glucose after eating a Placebo cracker.

(vi) With such a large p-value, we have insufficient evidence to reject the null hypothesis. We do not have evidence to suggest the true mean glucose after eating a BPA cracker is different from the true mean glucose after eating a Placebo cracker.

(f) [2 pts] Based on the decision you reached in (e), what type of error could you have made? Circle one.

Type I Error **Type II Error** **No error was made**

(h) [2 pts] In a different study, Dr. Hagobian obtained a p-value of 0.0425 and a 95% confidence interval of (-1.129, 0.0437). Which of the following statements about these findings is true? Circle one.

(i) The results of the hypothesis test and the confidence interval tend to agree with each other at the 5% significance level. Four percent of the time we would obtain a statistic like the one we saw somewhere in the interval of -1.129 mmol/L to 0.0437 mmol/L.

(ii) The results of the hypothesis test and the confidence interval are conflicting at the 5% significance level. With a p-value of 0.0425 we have evidence to reject the null hypothesis, which would mean that our confidence interval would not contain 0.

(iii) The results of the hypothesis test and the confidence interval are conflicting at the 5% significance level. There's a 95of 0.0425 would be in the interval (-1.129, 0.0437).

(vi) The results of the hypothesis test and the confidence interval seem to agree with one another at the 5% significance level. With a p-value of 0.0425 we do not have evidence to reject the null hypothesis, thus indicating that 0 should be in our interval.

Points Earned: _____

Total Points: 49