Midterm 2 Question Bank

Stat 218

Your exam questions will be randomly selected from this bank of questions. There **will not** be a solution key posted. It is your responsibility to discuss your ideas with your group members and / or with Dr. Theobold during office hours prior to the exam.

Golden Ticket

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 $Q1 - (1.5 \times IQR)$

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

$$Residual = y - \hat{y}$$

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

$$SE(\mu) = \frac{\sigma}{\sqrt{n}}$$

$$SE(\mu_1 - \mu_2) = \sqrt{\frac{\sigma_1}{n_1} + \frac{\sigma_2}{n_2}}$$

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 grassland butterflies similar to those sampled.

(iii) Sex causes a difference in average step distance for grassland butterflies similar to those sampled.

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

Q2[8 points] Is insomnia related to education level? Researchers at the University of Memphis, in Tennessee investigated this question in the *Journal of Abnormal Psychology* (February, 2005). Eight hundred (800) adults living in Tennessee were selected to participate in the study, using a random-digit telephone dialing procedure. Responses were collected from a total of 575 adults. Two variables measured were level of education and insomnia status (normal sleeper or chronic insomniac). The researchers discovered that the lower the level of education, the more likely the person was to have chronic insomnia.

(a)[2 points] What are the observational units in this study?

(b)[3 points] Fill in the blanks with one of the options provided in parentheses to identify and explain the study design.

This is a(n) (observational study / randomized experiment) _____
because (level of education / insomnia status) _____ (was / was
not) _____ randomly (assigned / sampled) _____.

(c)[3 points] Which types of sampling bias may be present in this study? Select **all** that are present, or if there is no bias present, select No bias.

  (i) Selection bias

 (ii) Response bias

(iii) Non-response bias

 (iv) No bias

Q3[24 points] In 2004, the state of North Carolina released to the public a large dataset containing information on births recorded in this state. This data set has been of interest to medical researchers who are studying the relation between habits and practices of expectant mothers and the birth of their children. This analysis will focus on a random sample of 1,000 observations from the published dataset.

(a)[3 points] Hospital administration at Duke University Hospital are interested in the difference in the mean baby birth weight between mothers who smoke and mothers who do not smoke. Using the table below, report the observed statistic for this comparison. Indicate in your answer what notation should be used for this statistic.

Answer:

Notation:


```
##       habit  min     Q1 median    Q3   max      mean       sd   n missing
## 1 nonsmoker 1.19 6.5700   7.35 8.060 10.42 7.269873 1.232846 867       0
## 2    smoker 0.75 5.9525   7.03 7.805  9.25 6.677193 1.596645 114       0
```


4
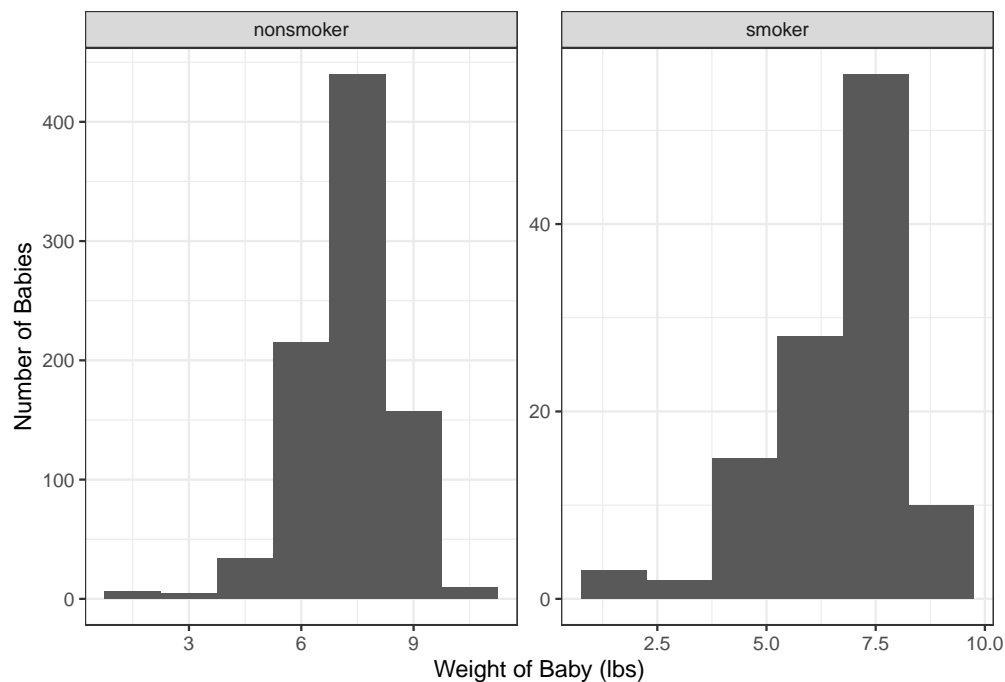
(b)[4 points] These hospital administrators are interested in estimating the true difference in mean birth weight between mothers who smoke and mothers who do not smoke. The administrators learned in their Statistics class how obtain a confidence interval for a difference in means using a t-distribution. Using the plots above and your knowledge of how the data were collected evaluate whether it would be appropriate for the administrators to use a t-distribution to obtain a confidence interval for the true difference in means.

(c)[5 points] The administrators contacted the Department of Statistics at Duke and requested a consultation. The Statistician they spoke with suggested they use bootstrapping instead of a t-distribution to obtain a confidence interval. Fill in the blanks below to explain to the administrators how one bootstrap (re)sample is found.

On (#) _____ cards, write _____ on the cards.

Generate a new sample by:

Calculate and plot the _____ from each bootstrap (re)sample.

(d)[3 points] The Statistician carried out a simulation with 1000 bootstrap resamples using the order (**nonsmoker - smoker**) and obtained the bootstrap distribution below.

Where is the bootstrap distribution centered? Why is the distribution centered at that value?
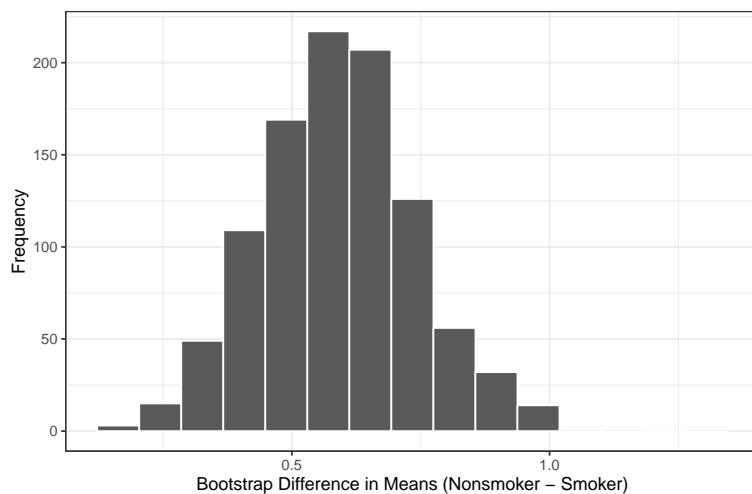
(e)[3 points] The table below presents percentiles for the bootstrap distribution shown above. Circle the two values which will construct a 99% confidence interval.

Quantile	Value
0.5%	0.3446
1%	0.2672
2.5%	0.3014
5%	0.3446
90%	0.7783
95%	0.8518
97.5%	0.9187
99.5%	0.8518

(f)[4 points] Interpret the 99% confidence interval found in part (f) **in the context of this study**.

(g)[2 points] Based on your confidence interval in (f), which of the following is the most likely p-value for a two-sided hypothesis test? Circle one.

(i) 0.20   (ii) 0.10   (iii) 0.05   (iv) 0.01   (v) 0.005

Q4[21 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 points] 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 points] 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 points] 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 points] 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 points] Using `R`, Dr. Hagobian obtained the following table.

statistic	p_value	estimate	lower_ci	upper_ci
0.2626	0.7982	0.1067	-0.6297	0.8431

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 points] 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**

(g)[2 points] If instead Dr. Hagobian had 100 subjects (50 in each group), the chance of the error described in part (f) would

increase   **decrease**   **stay the same**

(h)[2 points] 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.

Q5[24 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	3801	102.7	9
Hydroponic A	4657	90.34	12
Hydroponic B	3837	80.44	13

(a)[2 points] 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	____	5418766	2709383	____	1.087e-21
Residuals	31	251836	8124	NA	NA

(b)[3 points] 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 points] Rewrite the null hypothesis above to use notation for the parameters that are being tested.

(d)[2 points] 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 point] What are the degrees of freedom associated with `Growing Method`?

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

(g)[2 points] The value of the F-statistic would be larger if the nitrate standard deviations were smaller for each group. Circle one.

True   **False**

(h)[2 points] The value of the F-statistic would be larger if the nitrate means were more different across the groups. Circle one.

True   **False**

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

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

(j)[4 points] 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 points] 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?

Group 1	Group 2	p.value
Hydroponic B	Hydroponic A	< 0.000001
Soil	Hydroponic A	< 0.000001
Soil	Hydroponic B	0.3687