**Math 326 – Experimental Design**

**Exam 1 (98 Points)**

**Instructions:**

* Treat this exam as if you were taking it at the Testing Center, but don't go to the testing center.
* Do not look at the exam until you are ready to start.
* Before starting the test, be sure to open up R and close all your script and Markdown files so you are not tempted to look at them during the test.
* **Record your start and stop times on the exam**. Take the exam in one sitting.
* You cannot use your class notes, homework solutions, your book, or anything (or anyone) else (so don't take them with you when you take the exam). You can use one formula sheet that you prepare (8.5x11 – both sides). Once you start reading the test, you cannot update your notes. **Upload a picture of your notes. If you did not use notes, please state on the exam “DID NOT USE NOTES.”**
* Once you have finished taking the exam, you will not change your answers (imagine leaving the Testing Center). For example, if 20 minutes after you finish the exam (leave the Testing Center), you realize that you forgot something on one of the problems or made a mistake, you agree to not go back and change your answer.
* You must upload this exam and accompanying files by the Test 1 submission folder end date. Please be neat and organized in what you submit.
* Once you have taken the exam, you will not talk to anyone about the contents of the exam (except Brother Palmer).
* **For problem #15, you will be using Excel. For problems #16-17 you will be using R.**
* You may use the following: a calculator, your page of notes, scratch paper, R and Excel data files that are linked to in I-Learn Test 1 submission folder description.
* Upload this file all filled out (including copy and pasted images from R as necessary). For 15a you may also wish to copy and paste an image of the Excel spreadsheet or upload the Excel file itself. You are encouraged/welcomed to upload any R scripts you generate (though there is no guarantee of partial credit, especially for messy/confusing coding).
  + If want to use R markdown files instead of copying and pasting output for part or all of the test and submit it in I-Learn, you are welcome to do so.
* By submitting the test you agree to the terms of this test, and vouch that you followed the rules.

Start Date/Time: \_\_\_\_\_\_\_\_7:46 pm\_\_\_\_\_\_\_\_\_\_\_

End Date/Time: \_\_\_\_\_\_\_9:00 pm\_\_\_\_\_\_\_\_\_\_\_\_

1. (2 points) Consider 109 single people in a class as if they were the **population** of interest. The mean ‘*number of different people dated in the last month*’ for these 109 people is 1.57. Also, a simple random sample of 10 of these values was drawn, and the mean of these 10 values was 1.40. The values 1.57 and 1.40 are, respectively, a \_\_\_\_\_\_\_ and a \_\_\_\_\_\_\_\_\_\_\_\_.
2. statistic, parameter
3. parameter, statistic
4. statistic, statistic
5. parameter, parameter

Answer:\_\_\_\_\_C.\_\_\_

**For problems 2-4, classify each test as one of the following. Some designs you may use more than once. Some design you may not use at all.**

1. One-way Randomized Basic Factorial Design (RBF [1])
2. One-way Complete Block Design (CB [2])
3. Two-way Basic Factorial Design (BF [2])
4. Split Plot/Repeated Measures Design (SP/RM)
5. There are two different types of indenters that a researcher wants to test when making indentations in a certain type of metal. She also wants to measure three levels of compression strength (low, medium and large). A sample of 54 pieces of the same metal are randomly assigned to each of the indenter/compression strength combinations and the indentation will be measured in millimeters (mm). Answer:\_\_\_C\_\_\_\_\_
6. Ninety BYU-Idaho students agreed to do a study comparing three different methods of teaching for the Book of Mormon class. Each of the students took a test. Based on the pre-test, students were put in groups of three based on comparable test scores, so that there were 30 groups of students of three each. Each student in a group of three were randomly put in a classroom where one student in the group got Method I, one student got Method II and one student got Method III. A standardized test was given after the semester to compare the three different methods. Answer:\_D.\_\_\_\_\_\_\_
7. An experiment is to compare the yield of three varieties of oats and four different levels of manure. Suppose 6 farmers agree to participate in the experiment and each will designate a farm field of equal size for the experiment. Since it is easier to plant one variety of oats in a large field, the experimenter randomly chooses two farm fields for each of the variety of oats. Each field is then divided into four equal parts and the four levels of manure are randomly assigned to the four equal parts. Answer:\_\_\_**B**\_\_\_\_\_
8. A student in an experimental design statistics class wanted to measure how well students do for an introductory statistics class. Which is the most appropriate response when doing this experimental design
9. The students GPA from the current semester
10. A measurement based on how well a student participates in class
11. A final test score based off of a standardized test
12. An attitude survey, based on how well they enjoyed the class and how well they feel that they did in the class

Answer:\_\_\_\_\_\_\_C\_

1. A researcher would like to see effects from different fertilizers in the growth for a type of plant, and after two months, check to see the increased growth in inches. Out of 30 for this type of plant, 10 are randomly selected in Fertilizer I group, 10 are randomly selected in Fertilizer II group, and 10 are randomly selected in Fertilizer III group. The \_\_\_\_\_\_\_\_ is/are the response, the \_\_\_\_\_\_\_\_\_ is/are the material, and the \_\_\_\_\_\_\_\_\_\_\_ is/are the conditions.
2. Increased growth, 30 plants, three types of fertilizer
3. Increased growth, three types of fertilizer, 30 plants
4. three types of fertilizer, Increased growth, 30 plants
5. three types of fertilizer, 30 plants, Increased growth
6. 30 plants, three types of fertilizer, Increased growth
7. 30 plants, Increased growth, three types of fertilizer

Answer:\_\_\_\_\_\_\_\_A

**For problems 7-8, classify each response based off of Stevens’ four types of responses. (1 point each).**

1. Nominal
2. Ordinal
3. Interval
4. Ratio
5. Student’s test scores from a standardized test

Answer:\_\_\_\_\_\_\_D\_

1. Religious Preference

Answer:\_\_\_\_\_\_\_A\_

9. Consider the BF[1] model:

1. (4 points) List the 4 assumptions about the errors () in the BF[1] model.

Constant variance.

Population mean of Zero.

All variables are independent and uncorrelated.

The error term is normally distributed.

10. An engineer is designing a battery for use in a device that will be subjected to some extreme variations in temperature. Each battery was randomly assigned to one of three plate material types (material A, material B, and material C), and to one of three temperature levels (15, 70 and 125º F). The lifetime in hours was measured for each of the batteries.

(a) (4 points) What is/are the factor(s) in the study, and what are the levels of each factor?

Material- Material A, B, and C.

Temperature-15,70,125 degrees F

1. (1 points) How many factor level combinations are there in this experiment?

9

(c) (2 points) What is the response variable?

Battery for use in a device that is subjected to some extreme variations in temperature.

(d) (2 points) What is the experimental unit?

Lifetime in hours

(e) (3 points) Give a 1-to-2 sentence interpretation for the interaction effect in this study. (Assume that the interaction is statistically significant.)

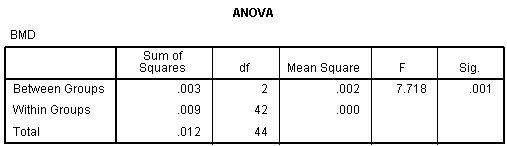
We have sufficient evidence to deny the null that there is no interaction. We have sufficient evidence there is a correlation between material and temperature.

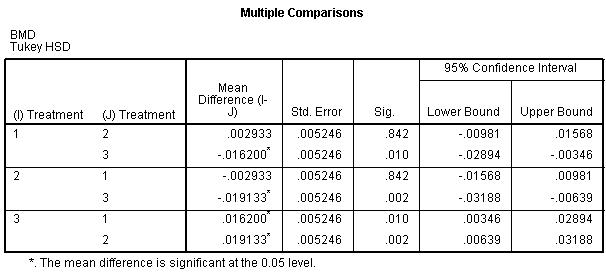
11. (4 points) What are the two main reasons we want to use replication (more than one unit per treatment group) in a study like this?

(i) The more replications you have the closer your error term is to the true term.

(ii) To find out if your evidence is really significant based on variation within each factor.

12. Kudzu is a plant that was imported to the United States from Japan and now covers over seven million acres in the South. The plant contains chemicals called isoflavones that have been shown to have beneficial effects on bones. One study used three groups of rats to compare a control group with rats that were fed either a low dose or a high dose of isoflavones from kudzu. One of the outcomes examined was the bone mineral density in the femur (in grams per square centimeter). You would like to test if any of the mean bone mineral densities in the femur are different for the three different groups. Use α = 0.05 level of significance. There are two tables below: a one-way ANOVA table and multiple comparisons table. Note: Treatment 1 = Control, Treatment 2 = Low Dose, and Treatment 3 = High Dose.





1. (2 pts.) TRUE or FALSE : Because we are simultaneously evaluating pairwise differences among the 3 treatment levels using Tukey’s HSD, the pairwise comparisons shown on this page will inflate the family-wise Type I error rate beyond the desired rate of α = 0.05.

FALSE

(b) (2 pts.) TRUE or FALSE : The mean bone mineral density of the low dose group is significantly different from the mean bone mineral density of the high dose group.

TRUE

13. (6 pts.) Write in the most appropriate multiple-comparison approach for each scenario below. Your choices are: (i) Fisher's LSD, (ii) Tukey's HSD, (iii) Scheffe', or (iv) Bonferroni.

(a) You are interested in conducting an exploratory analysis by comparing group means, then choosing a contrast that seems likely to be significant.

Approach:\_\_\_\_\_\_\_\_\_\_\_\_\_Tukey’s HSD\_\_\_\_\_\_\_\_\_\_

(b) You would like to test 3 comparisons that you have chosen in advance (based on natural groupings among the factor levels).

Approach:\_\_\_\_\_\_\_\_\_\_\_\_Sheffe\_\_\_\_\_\_\_\_\_\_\_

(c) You would like to look at all pairwise comparisons among 8 different levels of a factor of interest and you would like to have a greater chance of catching a real difference, but it would be increasing your family-wise Type I error.

Approach:\_\_\_\_\_\_\_\_\_\_Fishers\_\_\_\_\_\_\_\_\_\_\_\_\_

14. Consider a study in which a 6-year-old used car is taken to 36 different car lots to obtain a cash offer for the car. For each car lot visited, an “owner” is assigned with one of three ages (young, middle, or old) and one of two genders. What follows is an ANOVA for the car offers received (in 100's of dollars). For all assessments, use α = 0.05.



Note: There is no information on the grand mean or total, but it does not affect the rest of the results.

1. (2 pts.) TRUE or FALSE : Given the nature of the interaction effect, we must be extremely cautious when trying to interpret the main effects for age and gender.

True

1. (2 pts.) TRUE or FALSE : There is at least one significant difference in mean car offer when comparing the 3 levels of age.

True

1. (2 pts.) TRUE or FALSE : There is a significant difference in mean car offer when comparing the 2 levels of gender.

False

15. Consider a BF[2] experiment when comparing noise level of a car using Type of Car Filter (2 factor levels), Size of Car (3 factor levels), and the interaction between Type of Filter & Size of Car. The two levels for the type of filter factor are Octel and Standard. The three levels for the Size of Car factor are large, medium and small. For each of the 6 treatments in the factorial design, there are 4 replications. Thus, the experimental design can be illustrated with the following diagram:



(a) (12 points) The ANOVA decomposition of the total of 24 observations is shown in the diagram below. The same display below is in the “Test 2 decomposition” excel file. Complete the decomposition below by filling **in all 24 cells** for each of the factors of the model. Use the excel file to help you complete the table on the test. Transfer your work from the excel file to this page. **Either input all numbers below in the spaces or submit the Excel document in I-Learn.**



[This problem is continued on the next page.]

[Parts (b), (c), and (d) refer to the experiment discussed on the previous page.]

(b) (2 points) What are the degrees of freedom for the F distribution used to test if Type of Filter is significant?

1

(c) (2 points) What are the degrees of freedom for the F distribution used to test if Size of Car is significant?

2

(d) (2 points) What are the degrees of freedom for the F distribution used to test if the Type of Filter X Size of Car interaction is significant?

**5**

16. Three Brands of batteries are under study. It is suspected that the lives (in weeks) of the three brands are different. Five randomly selected batteries of each brand are tested. Conduct your analysis in R with the data “BatteryLife”. Submit the graphs in I-Learn. Use a level of significance of α= 0.05. Don’t forget, if needed, to ensure that the factors are treated as factors in R.

a) (4 points) Get the QQ-plots, Boxplots and means plots and describe what you see with each of them.

b) (4 points) Check the assumption of equal variance and residuals being normally distributed. State whether each assumption was met.

Yes the assumptions were met.

c) (7 points) For this test: i) state the null and alternative hypotheses in mathematical terms, ii) give the test statistic, iii) give the degrees of freedom, iv) state the p-value, v) determine whether you should reject or not reject the null hypothesis, and vi) write a sentence which gives an appropriate conclusion.

Ho: Material 1=Material2=Material3

Ha: At least one material is different.

F: 38.338

P-value: 6.141e-06

DF: Numerator 2 denominator 12

Reject the null.

We have sufficient evidence that at least one material is different.

Analysis of Variance Table

Response: FailureTime

Df Sum Sq Mean Sq F value Pr(>F)

Material 2 1196.1 598.07 38.338 6.141e-06 \*\*\*

Residuals 12 187.2 15.60

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

17. An engineer suspects that the surface finish of a metal part is influenced by the feedrate and the depth of the cut. The engineer selects three feedrates (0.20, 0.25, and 0.30 in/min) and four depths of cut (0.15, 0.18, 0.20, and 0.25 in.). With all different combinations of feedrate and depths of cut, a score for surface finish was measured (The higher the number for surface finish, the smoother the finish). It desired to have a high number when combining the two factors. Conduct your analysis in R with the data “SurfaceFinish”. Submit the graphs in I-Learn. Use a level of significance of α= 0.05. Don’t forget, if needed, to check that the factors are treated as factors in R.

a) (4 points) Get an interaction plot, boxplots and means plot and describe what you see with each of them.

b) (4 points) Check the assumption of equal variance and residuals being normally distributed. State whether each assumption was met.

Yes they were.

c) (7 points) For each of the following main effects and interaction: i) state the null and alternative hypotheses, ii) give the test statistic, iii) give the degrees of freedom, iv) state the p-value, v) determine whether you should reject or not reject the null hypothesis, and vi) write a sentence which gives an appropriate conclusion.

Ho: Feed rate, .20 = .25 = .30

Ha: At least one is different

Ho: Depth of cut 0.15 = 0.18 = 0.20 = 0.25.

Ha: At least one is different.

Ho: Feed rate and depth of cut don’t have an interaction.

Ha: They have an interaction.

F:3.2324

P-Value: 0.1797

Degrees of freedom: 3,2,6,24

We reject the null

We have sufficient evidence that there is an interaction between Feed rate and Depth of Cut.

Analysis of Variance Table

Response: SurfaceFinish

Df Sum Sq Mean Sq F value Pr(>F)

DepthofCut 3 2125.11 708.37 24.6628 1.652e-07 \*\*\*

Feedrate 2 3160.50 1580.25 55.0184 1.086e-09 \*\*\*

DepthofCut:Feedrate 6 557.06 92.84 3.2324 0.01797 \*

Residuals 24 689.33 28.72

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1