

Name _____

Master's Comprehensive Exam:

Experimental Design and Analysis Fall 2021

Instructions: Do 5 problems out of the 7 problems given below.

Instructions: Circle five problems to be graded: 1 2 3 4 5 6 7

- **You are allowed to use any type of calculators. Use of cell phone or computer program is NOT allowed and will be treated as cheating.**
- **Make sure you write your name and “Page i of n” on each page. Please make sure that you include all pages of your work and your writing is clear and legible.**
- **Make sure you only write on ONE SIDE of the paper.**
- **Otherwise specified, the level of significance is 0.05.**

NOTE: Otherwise specified, the level of significance is 0.05.

1. For an evaluation of the breeding value of sires in pig-raising, each sire is mated to random group of dams, each mating producing a litter of pigs whose characteristics are the criteria. The data below were obtained by randomly selecting two pigs from each litter and using the average daily weight gain (g) of the pigs as the criterion for evaluation. Note that each dam is mated only to the selected sire. Assume that we are interested in the effects of these four sires specifically.

Sire	Dam	Pig Gains	
1	1	2.77	2.38
	2	2.58	2.94
2	1	2.98	2.82
	2	3.01	2.97
3	1	2.36	2.71
	2	2.72	2.74
4	1	2.27	2.46
	2	2.31	2.24

- a) Write the model with all the specification. Carefully justify the type of each factor (fixed or random) and explain why?
 - b) Give the ANOVA table and draw conclusions.
 - c) Perform a multiple comparison of the fixed factor using Tukey's MSD.
-
2. Consider a 2^3 factorial design with three replications.

Run	Coded Factors			Replication	
	A	B	C	I	II
1	-	-	-	8	11
2	+	-	-	12	23
3	-	+	-	15	14
4	+	+	-	35	22
5	-	-	+	22	25
6	+	-	+	20	17
7	-	+	+	40	30
8	+	+	+	19	31

- (a) Estimate the factor effects and perform ANOVA and draw conclusions.
- (b) Note that since only four treatment combinations can be done in a day, the experiment has been done over two days (block). Suppose that we had confounded AB in replicate I, and BC in replicate II in two blocks each replicate. Design the blocks for each replicate.
- (c) Redo the ANOVA for your design in (b). What can you conclude?

3. The Castle Bakery Company supplies wrapped Italian bread to a large number of supermarkets in a metropolitan area. An experimental study was made of the effects of height of the shelf display (factor A: bottom, middle, top) and the width of the shelf display (factor B: regular, wide) on sales of this bakery's bread during the experimental period (Y, measured in cases). Twelve supermarkets, similar in terms of sales volume and clientele, were utilized in the study. The six treatments were assigned at random to two stores each according to a completely randomized design, and the display of the bread in each store followed the treatment specifications for that store sales of the bread were recorded, and these results are presented in table below.

Display Height	Display Width	
	Regular	Wide
Bottom	47	46
	43	40
Middle	62	67
	68	71
Top	41	42
	39	46

- Specify the design and state the statistical model with all specifications.
 - Give the ANOVA table and carefully draw conclusions. Use $\alpha = 0.05$.
 - The manager of a supermarket similar in terms of sales volume and clientele to the supermarkets included in the Castle Bakery study has room only for the regular shelf display width, and wishes to obtain estimates of mean sales for the (1) middle shelf heights & regular shelf display width (2) top shelf heights & regular shelf display width. Obtain interval estimates using the Bonferroni procedure.
4. A leading energy company claims that its top-grade motor oil improves gasoline mileage. An independent testing organization conducts an experiment in which the company's brand A is compared to three other competing brands B, C, and D. To conduct the experiment, the testing organization will use these four motor oils in each of four different-size automobiles (subcompact, compact, intermediate, and SUV). The manufacturer is only interested in the differences in fuel efficiencies among the four different brands. The data of the experiment consist of the miles per gallon observed for a controlled combination of city and highway travel as follows:

Size	Brand			
	A	B	C	D
Subcompact	36	37	31	35
Compact	32	26	28	25
Intermediate	28	24	25	26
SUV	23	17	18	20

- Specify the design and state the statistical model with all specifications.
- Give the ANOVA table and carefully draw conclusions. Use $\alpha = 0.05$.
- There might be a potential driver effect. Unless the same driver is used for the entire experiment, there could be a substantial driver effect that has not been considered. What design would you use if this effect is to be considered?

5. An automotive engineer wished to evaluate the effects of four rubber compounds on the life of automobile tires. The manufacturing process permitted the use of up to three different compounds in a given tire. To do this, the tire is divided into three sections, and a different compound is used in each section. Because each segment of a tire would be subject to nearly identical road conditions, the investigator decided to use tires as blocks, with three of the four treatment (compounds) being applied to the three experimental units (tire segment) in each block. Four tires were tested. The response variable is a coded measure of wear.

	Compound			
Tire	A	B	C	D
1	238	238	279	
2	196	213		308
3	254		334	367
4		312	421	412

- Specify the design and state the statistical model with all specification. Is this a valid design?
- Give the ANOVA table and carefully draw conclusions.
- Use Fisher's LSD for pairwise comparisons of Compounds. Which one should be recommended?

6. Consider the experimental data below:

Replicate I		Replicate II	
Block 1	Block 2	Block 1	Block 2
a = 0	(1) = -3	(1) = -1	b = 0
b = -1	c = -1	a = 1	c = 0
ac = 2	ab = 2	bc = 1	ab = 3
bc = 1	abc = 6	abc = 5	ac = 1

- Identify the design. Which treatment combination is confounded in each replicate?
- Conduct the complete analysis. What conclusion can be drawn about the significance of the factors?
- How else can experimenters run this design? Give another pattern.

7. Consider an investigation to study the effects of two irrigation methods and two fertilizers on yield of a crop. There were three replicates. Within each replicate, each of the two irrigation methods is randomly assigned to one of the two fields. Each field is subdivided into three smaller areas, and the three fertilizers are then randomly assigned to the areas within each field. Measurements on yield of the crop are given below.

		Replicate I		Replicate II	
Irrigation Methods		1	2	1	2
Fertilizers	1	43	63	40	52
	2	48	70	43	53
	3	50	65	54	57

- Specify the design of this experiment and write the statistical model with all specifications.
- Give ANOVA table and draw a conclusion.
- Give Fisher's 95% CIs for the difference of the fertilizer effect and draw a conclusion.