



Strathmore
UNIVERSITY

STRATHMORE INSTITUTE OF MATHEMATICAL SCIENCES
MSC. STATISTICS
END OF SEMESTER EXAMS
STA 8204: DESIGN OF EXPERIMENTS

DATE: 7th September 2020

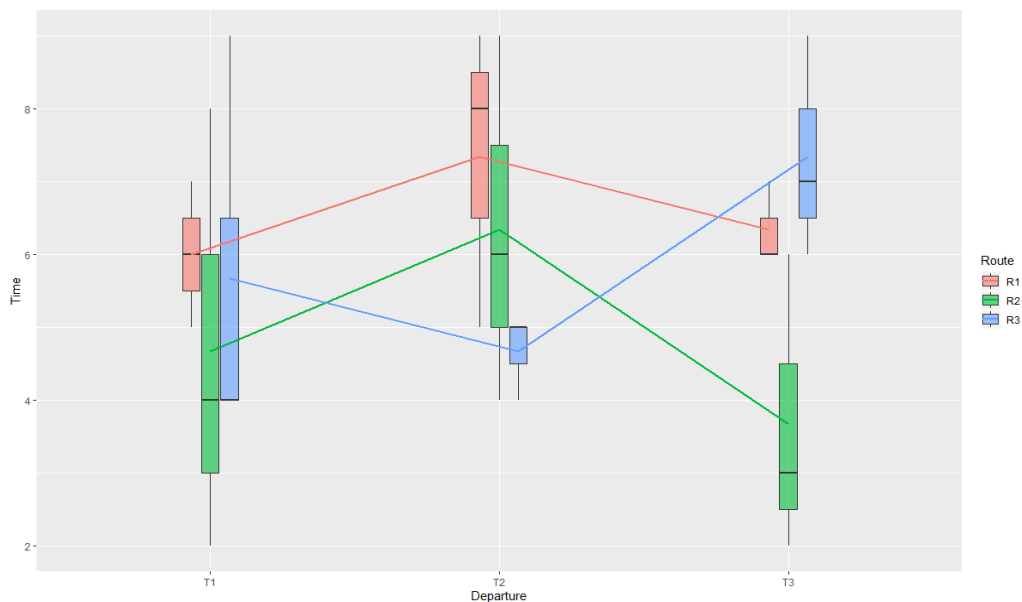
Time: 3 HOURS

Instructions:

Answer question one and any other 2 questions.

QUESTION ONE (30 MARKS)

- Giving elaborate example, differentiate between effect modifier, confounder, mediation variables (6 marks)
- The following is an interaction plot from ANOVA with interaction. Briefly describe it (3 marks)



- The effect of five different ingredients (*A, B, C, D, E*) on the reaction time of a chemical process is being studied. Each batch of new material is only large enough to permit five runs to be made. Furthermore, each run requires approximately hours, so only five runs

can be made in one day. The experimenter decides to run the experiment as a Latin square so that day and batch effects may be systematically controlled. She obtains the data that follow.

Day	Batch				
	1	2	3	4	5
1	A=8	B=7	D=1	C=7	E=3
2	C=11	E=2	A=7	D=3	B=8
3	B=4	A=?	C=10	E=1	D=5
4	D=6	C=8	E=6	B=6	A=10
5	E=4	D=2	B=3	A=8	C=8

Test the appropriate hypothesis at $\alpha = 0.05$ (13 marks)

- d. Illustrate the analysis of the single factor fixed effects model (4 marks)
- e. The following are results from ANOVA on a research on cassava yields.

```
Model = lm(Yields ~ fertilizer+treatment+seed, data=Cassava)
anova(Model)

Analysis of Variance Table

Response: Yield
      Df Sum Sq Mean Sq F value    Pr(>F)
fertilizer    4  17.760    4.440  0.7967 0.549839
treatment     4 109.360   27.340  4.9055 0.014105 *
seed          4 286.160   71.540 12.8361 0.000271 ***
Residuals    12  66.880    5.573
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Discuss the results (4 marks)

QUESTION TWO (15 MARKS)

- a. Seven different hardwood concentrations are being studied to determine their effect on the strength of the paper produced. However, the pilot plant can only produce three runs each day. As days may differ, the analyst uses the balanced incomplete block design that follows. Analyze the data from this experiment (use $\alpha = 0.05$) and draw conclusions.

Hardwood Concentration (%)	Days						
	1	2	3	4	5	6	7
2	114				120		117
4	126	120				119	
6		137	117				134
8	141		129	149			
10		145		150	143		
12			120		118	123	
14				136		130	127

(10 marks)

- b. For the above, write an R code to replicate the results above and exhaustively explain your answer (5 marks)

QUESTION THREE (15 MARKS)

Kenyans have just discovered that they can convert their vehicles to hybrid (partly use petrol/ diesel and partly use LPG). A student does experiment on the same model of vehicle that use Diesel-D, Petrol-P and hybrid-F(fuel and battery). The experiment is done on three different types of roads: Tarmac-T, gravel-GV and granite-GN. The data captured below were kilometres per litre of fuel.

	<i>D</i>		<i>P</i>		<i>F</i>	
<i>T</i>	25	14	40	22	21	16
	18	p	13	20	12	15
<i>GV</i>	15	18	13	15	21	16
	19	33	22	16	19	12
<i>GN</i>	22	11	17	10	14	20
	16	17	15	19	13	16

Test at $\alpha = 0.05$

- i. Whether there is significant variation due to seasons (4 marks)
- ii. Whether there is an interaction between season and location (4 marks)

- iii. Use Fisher's LSD test to perform multiple comparisons on seasons and locations (5 marks)

QUESTION FOUR (15 MARKS)

Two new COVID-19 drugs are being tested. The following table represents information collected. Number of days to recovery depends on the amount of dosage for each drug.

Drug 1		Drug 2	
Dosage(Mg)	Days to Recovery	Dosage(Mg)	Days to Recovery
15	16	25	17
22	10	18	12
17	12	12	9
30	6	35	22

- Test the hypothesis that the drugs differ on days to recovery at $\alpha = 0.05$ (10 marks)
- Test the appropriate hypothesis for β at 0.01 (5 marks)

QUESTION FIVE (15 MARKS)

A manufacturer suspects that the batches of raw material furnished by his supplier differ significantly in calcium content. There are five batches currently in the warehouse. A chemist makes five determinations on each batch and obtains the following data:

Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
23.46	23.59	23.51	23.28	23.29
23.48	23.46	23.64	23.40	23.46
23.56	23.42	23.46	23.37	23.37
23.39	23.49	23.52	23.46	23.32
23.40	23.50	23.49	23.39	23.38

- Use the Kruskal Wallis test to test the appropriate hypothesis at $\alpha = 0.05$ (10 marks)
- Use the normal F-test to test the hypothesis in a above and comment on your answer (5 marks)