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**UNIVERSITY EXAMINATIONS  
2022/2023 ACADEMIC YEAR  
FOURTH YEAR FIRST SEMESTER  
MAIN EXAMINATION  
FOR THE DEGREE OF BACHELOR OF SCIENCE**

**COURSE CODE: STA 413**

**COURSE TITLE: EXPERIMENTAL DESIGN II**

**DATE: 25/04/2023**

**TIME: 9 AM -11 AM**

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**INSTRUCTIONS TO CANDIDATES**

- 1. Answer Question ONE and any other TWO Questions*
- 2. In each question, show your **working clearly***
- 3. There will be marks for proper working even if the answer is wrong*
- 4. Calculators and Statistical tables may be used*

TIME: 2 Hours

**QUESTION ONE (30 MARKS)**

- a. Briefly describe the fundamental principles of designing an experiment. (3 marks)
- b. There are 30 students in each experimental condition in a 5x4 between groups design. How many participants would be modeled in total? (2 marks)
- c. Using illustrations, explain the difference between a fixed effect and random effect model in the design of experiments. (3 marks)
- d. An experiment was conducted to compare the yields of five varieties of maize under rain-fed conditions in Northern Kenya. The experiment was conducted in a completely randomized design with each variety replicated four times. During the growing season, however goats broke through the fence and heavily grazed four plots along the edge of the experiment before they were detected. The yields in kg/acre from the remaining plots are given below:

Variety	Yields (Kgs)			
1	740	430	760	640
2	545	440	390	
3	325	290		
4	740	630	870	
5	605	505	430	540

At  $\alpha = 5\%$ , test whether or not the varieties differ significantly in the yields. (11 marks)

- c. The following table shows four varieties of potato each planted on five plots of the same size and type and each variety is treated with five different fertilizers.

Varieties	Fertilizers				
	A	B	C	D	E
1	1.9	2.2	2.6	1.8	2.1
2	2.5	1.9	2.3	2.6	2.3
3	1.7	1.9	2.2	2.0	2.1
4	2.1	1.8	2.5	2.3	2.4

At  $\alpha = 5\%$  test the following hypothesis:

- (i) The four varieties of potato differ in their yields.
- (ii) The fertilizers are significantly different.

(11 marks)

**QUESTION TWO (20 MARKS)**

- a. A randomize block experiment was carried out to compare the output of four machines producing nylon-fibre in a certain factory. The blocks were 10 shifts and response measured was the total length of fault-free material produced by each machine in each shift. Given that the Block,

Machines and Error sum of squares are 1500.2, 1427.4 and 2754.0 respectively. Complete the analysis of variance (ANOVA) table and calculate the efficiency of the design. (10 marks)

b.

- i. Explain what is meant by a symmetric balanced incomplete block design (BIBD). (2 mark)
- ii. Assuming any two (3 x 3) orthogonal latin squares, construct some BIBD design. Hence or otherwise construct a symmetric BIBD design. (8 marks)

**QUESTION THREE :( 20 MARKS)**

- a. A plant ecologist wishes to test the hypothesis that the height of plant species X depends on the type of soil it grows in and find out which soil differ significantly. He measures the height of 3 plants in each of 4 plots representing different soil types, all 4 plots being contained in an area two miles square. His results are tabulated below. (Height is in centimeters).

Observation Number	Plots			
	A	B	C	D
1	15	25	17	10
2	9	21	23	13
3	4	19	20	16

- (i) Analyze this result at  $\alpha = 0.01$ . Does your analysis support his hypothesis? (7 marks)
  - (ii) Find the estimates of the overall mean and the treatment effects (means). (3 marks)
  - (iii) Use any specific method to make comparison between pairs of treatment means. (3 marks)
- b. Suppose four different forms of a standardized test in statistics were given to each of the five students (selected one from each of the five I.Q. blocks) and the following are the scores which they obtained.

	Very low I.Q	Low I.Q	Average I.Q	High I.Q	Very high I.Q
	Student A	Student B	Student C	Student D	Student E
Form 1	82	67	57	71	73
Form 2	90	68	54	70	81
Form 3	86	73	51	69	84
Form 4	93	77	60	65	71

- i. Analyze the design and comment on your findings, taking  $\alpha = 0.05$ . (5 marks)
- ii. Obtain the efficiency of this design relative to the layout of completely randomized design. (2 marks)

**QUESTION FOUR (20 MARKS)**

- a) As an engineer for general motors, you suspect that the four machines producing parts for a wind screen wiper assembly are manufacturing parts with different mean diameters. Design a test to conform or disapprove this suspicion. (4 marks)
- b) Derive the formula of estimating one missing observation in a randomized block design. (6 marks)
- c) Hence or otherwise analyze the following RBD after estimating the missing value (10 marks)

Treatments	Blocks			
	B1	B2	B3	B4
T1	19	—	23	26
T2	26	28	27	33
T3	20	29	22	26

**X Missing**

**QUESTION FOUR (20 MARKS)**

- a. Decompose the total sum of squares  $\sum_{j=1}^k \sum_{i=1}^{n_j} (y_{ij} - \bar{y}_{\square})^2$  into the error sum of squares and treatment sum of squares. (5 marks)
- b. The following data are coded observations on the yield of a chemical process, using 5 batches of raw material selected randomly:

Batch	1	2	3	4	5
	9.7	10.4	15.9	8.6	9.7
	5.6	9.6	14.4	11.1	12.8
	8.4	7.3	8.3	10.7	8.7
	7.9	6.8	12.8	7.6	13.4
	8.2	8.8	7.9	6.4	8.3

- i. Write the appropriate model and list the assumptions being made. (3 marks)
- ii. Analyze the data and present the results in an ANOVA table. (6 marks)
- iii. Is there significant variation in yield from batch to batch? Use  $\alpha = 0.05$  (3 marks)
- iv. Compute the estimates of components of variance. (3 marks)