(50)

(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS

2021/2022 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: 17/05/2022 **TIME:** 9:00 AM - 11:00 AM

INSTRUCTIONS TO CANDIDATES

Answer Question One and Any other TWO Questions

TIME: 2 Hours

This Paper Consists of 5 Printed Pages. Please Turn Over.

QUESTION ONE (30 MARKS)

a)

(i) When is an incomplete block design said to be connected?

(ii) Draw the connectivity graph for the block design with field plan

Bl_1 1,3,5 Bl_2 2,4,6 Bl_3 3,5,8
Bl_4 4,6,7 Bl_5 5,7,1 Bl_6 6,8,2
Bl_7 7,1,3 Bl_8 8,2,4

and state whether the design is connected or not. (5 Marks)

b) Define the following terms used in factorial experiments:

(i) Factor

(ii) Levels of the factor

(iii) Treatment

(3 Marks)

c)

(i) What is the purpose of confounding in factorial experiments?

(ii) Distinguish between partial and complete confounding.

(iii) We wish to run a 2^4 factorial experiment using blocks of size 2^3. For this purpose ABCD is confounded with blocks. Give the field plan for the experiment. (9 Marks)

d)

(i) Explain clearly what is meant by a split plot design. (2 Marks)

(ii) List three occasions when a split plot design is desired. (3 Marks)

For a balanced incomplete block (B.I.B) design, with parameters v, b, r, k and (usual notation) show that:

(i) $bk = vr$
(ii) $(v-1) = r(k-1)$
(iii) $b \geq v$ (8 Marks)

QUESTION TWO (20 MARKS)

a) Give an analysis of a B.I.B design with parameters v, b, r, k, (using usual notation). Obtain a test for the hypothesis.

H_0: All treatment effects are equal versus

H_1: Anything different from H_0. (6 Marks)

(b) Suppose that a chemical engineer thinks that the time of reaction for a chemical process is a function of the type of catalyst employed. Four catalysts are currently being investigated. The experimental procedure consists of selecting a batch of raw material, loading the pilot plant, applying each catalyst in a separate run of the pilot plant, and observing the reaction time. Because variations in the batches of raw material may affect the performance of the catalysts, the engineer decides to use batches of raw material as blocks. However, each batch is only large enough to permit three catalysts to be run. Therefore, a randomized incomplete block design must be used. The balanced incomplete block design for this experiment, along with the observations recorded, as shown in the table below The order in which the catalysts are run in each block is randomized

Balanced Incomplete Block Design for Catalyst Experiment

Treatment	Blocks (batches) of raw materials			
catalyst	1	2	3	4
1	73	74	---	71
2	----	75	67	72
3	73	75	68	---
4	75	----	72	75

Describe the BIBD, analyze the data and draw conclusions at $\alpha = 0.05$. [14 Marks]

QUESTION THREE (20 MARKS)

a) Define the following terms used in factorial experiments:

(i) Simple effect.

(ii) Main effect

(iii) Interaction effect between two factors. (6 Marks)

b) The following are the results for a 2^3 factorial experiment run in a randomized complete block design.

Blocks

Treatments	1	2	Total
(1)	2	3	5
a	6	14	20
b	10	15	25
c	6	9	15
ab	4	6	10
ac	15	25	40
bc	18	22	40
abc	8	12	20
Total	69	106	175

(i) Obtain the design matrix and the X matrix, for this design. (3 Marks)

(ii) Obtain estimates of the factorial effects. (3 Marks)

(iii) Give a complete analysis of the experiments and check which factorial effects are significant at 5% level of significance. (8 Marks)

(You are given Total S.S=690.9375)

QUESTION FOUR (20 MARKS)

a) Explain what is meant by nested classification and state the major difference between crossed and nested classifications. (5 Marks)

b) A chemist wanted to measure the ability of three chemicals to retard the spread of fire when used to treat plywood panels. He obtained 12 panels and sprayed four of the panels with each of the three chemicals. He then cut two small pieces from each panel and measure the time required for each to be completely consumed in a standard flame. He obtained the following results:

		Chemical		
Panel	Sample	A	B	C
1	1	103	4.4	3.1
	2	9.8	4.7	3.3
2	1	5.8	2.7	6.5
	2	5.4	1.6	5.4
3	1	8.7	4.6	5.1
	2	10.0	4.0	7.5
4	1	8.9	5.6	5.6
	2	9.4	3.4	4.2

(i) Identify the population structure and the population identify.
(ii) Obtain the analysis of variance table for this data.
(iii) Test whether there is any significant difference among the chemicals at 5% level of significance.

(You are given $\sum_{i=1}^{3}\sum_{j=1}^{4}\sum_{k=1}^{2} y_{ijk} = 140$ $\sum_{i=1}^{3}\sum_{j=1}^{4}\sum_{k=1}^{2} y_{ijk}^{2} = 962.74$ (15 Marks)

QUESTION FIVE (20 MARKS)

Assume that four replications were made for the human comfort study provided in Table below.

INDEPENDENT VARIABLES									DEPENDENT VARIBLES			
FACTOR A, (Temperature ^{0}F)				FACTOR B, (Humidity %)				Treatment Combinations	Response(Comfort)			
Coding system				Coding system					y1	y2	y3	y4
Low	-	-1	0	0	0	0	0	(1)	0	0	0	0
High	+	+1	6	6	7	7	0	a	6	6	7	7
Low	-	-1	0	2	0	1	35	b	0	2	0	1
High	+	+1	9	9	10	9	35	ab	9	9	10	9

a) Calculate the main and the interaction effects
b) Calculate the estimates for A, B, and AB
c) Write down the estimated regression equation
d) Calculate the Sum of Squares
e) Develop the ANOVA Table
f) Interpret the effects in the context of the problem
g) Which effects are likely to be significant based on the effect calculation? Why?