



THE CATHOLIC UNIVERSITY OF EASTERN AFRICA
A. M. E. C. E. A

P.O. Box 62157
00200 Nairobi – Kenya
Telephone: 891601-6
Fax: 254-20-891084
e-mail: academics@cuea.edu

GABA CAMPUS - ELDORET

MAIN EXAMINATION

SEPTEMBER – DECEMBER 2021 TRIMESTER

FACULTY OF SCIENCE

BACHELOR OF SCIENCE

DEPARTMENT OF MATHEMATICS AND ACTUARIAL SCIENCE

MAT 363: DESIGN AND ANALYSIS OF EXPERIMENTS

Date: December 2021

Duration: 2 Hours

Instructions: Answer Question **ONE** and any other **TWO** Questions

QUESTION ONE

- a) Define the following terms.
- i) Experimental error. [1 mark]
 - ii) Replication. [1 mark]
 - iii) Block. [1 mark]
 - iv) Blocking. [1 mark]
 - v) Randomization. [1 mark]
- b) When does confounding occur? [1 mark]
- c) When is an experimental design said to be orthogonal? [1 mark]
- d) Differentiate between crossed and nested factors. [2 marks]
- e) A researcher wants to know the effect of four different types of fertilizers on the mean number of tomatoes produced. He wants to estimate the treatment means μ_1 , μ_2 , μ_3 and μ_4 such that he will be 90% confident that the estimates are within five tomatoes of the true mean number of tomatoes. What is the necessary number of replications to achieve this goal? It is known from previous experiments that the numbers of tomatoes per plant have ranged from 20 to 60. [5 marks]
- f) Give two advantages of a CRD. [2 marks]

g) How is the randomization procedure for the CRD different from the RCBD?

[2 marks]

h) When are two factors A and B said to interact?

[1 mark]

i) Using the following data calculate

a) SSA **[2 marks]**

b) SSB **[2 marks]**

c) $SSAB$ **[2 marks]**

	R1	R2
$a_0b_0c_0$	7	9
$a_0b_0c_1$	12	11
$a_0b_1c_0$	13	16
$a_0b_1c_1$	18	20
$a_1b_0c_0$	15	19
$a_1b_0c_1$	22	20
$a_1b_1c_0$	24	27
$a_1b_1c_1$	33	29

j) Why is the error term of a Randomized Block Design usually smaller than that of a completely randomized design? **[1 mark]**

k) Assume you have a 2^3 factorial, with treatments arranged in a Latin square. What would be the size of the Latin square? **[1 mark]**

l) Give conditions that a design must satisfy in order to be called a Balanced Incomplete Block Design. **[3 marks]**

QUESTION TWO

a) Give three reasons for randomization. **[3 marks]**

b) The management of a grocery store observes various employees for work productivity. The table below gives the number of customers served by each of its four checkout lanes per hour.

i) Construct an analysis-of-variance table. **[13 marks]**

ii) Test whether there is a difference between the mean number of customers served by the four employees at the 0.05 level. Assume that the conditions of completely randomized design are met. **[2 marks]**

iii) Calculate Coefficient of Variation (CV). **[2 marks]**

Lane 1	Lane 2	Lane 3	Lane 4
16	11	8	21
18	14	12	16
22	10	17	17
21	10	10	23
15	14	13	17
	10	10	

QUESTION THREE

a) Prove that for a BIBD (v, b, r, k, λ) design.

i. The number of times each pair of treatments appears in the same block is

$$\lambda = \frac{k(k-1)}{(v-1)}. \quad \textbf{[5 marks]}$$

ii. $bk = vr.$ **[5 marks]**

b) Suppose you have the following data from a Randomized complete block design.

Estimate the value of the missing value. **[6 marks]**

Rep	Treatment			
	A	B	C	D
1	3.1	3.3	3.6	4.15
2	3.1		3.4	4.0
3	3.0	3.2	3.6	4.2

c) Write the linear additive model for the RCBD, and then define each term and give the standard assumptions about the errors in an experimental design?

[4 marks]

QUESTION FOUR

a) Consider an investigation into the effect of the concentration of the reactant and the amount of the catalyst on the conversion (yield) in a chemical process. The objective of the experiment was to determine if adjustments to either of these two factors would increase the yield. Let the reactant concentration be factor A and let the two levels of interest be 15 and 25 percent. The catalyst is factor B, with the high level denoting the use of 2 pounds of the catalyst and the low level denoting

the use of only 1 pound. The experiment is replicated three times, so there are 12 runs. The order in which the runs are made is random, so this is a completely randomized experiment. The data obtained are as follows:

Treatment combination	Replicate		
	I	II	III
A low, B low	28	25	27
A high, B low	36	32	32
A low, B high	18	19	23
A high, B high	31	30	29

i) Main effect of A and B and interpret the results. **[4 marks]**

ii) Analyze the data and conclude whether there is a significant effect.

[16 marks]

QUESTION FIVE

a) Give two disadvantages of a Latin Square. **[2 marks]**

b) An investigator wants to determine which of four movies, to be released soon, should have the greatest audience appeal. These movies are (A) mystery, (B) sci fi, (C) comedy and (D) drama. Movies are shown to audiences of 50 viewers at each showing, four times a day, and over a period of four days. It was thought that time of day and day of the week may influence the results of the study. The response is the number of people out of 50, who recommend the movies to a friend.

Time of Day	Day			
	Mon	Tue	Wed	Thur
Morning	C 32	D 23	B 36	A 40
Early Afternoon	B 33	A 36	C 31	D 22
Late Afternoon	D 17	C 37	A 34	B 41
evening	A 35	B 37	D 18	C 31

i) Is there a difference in the mean response of the four movies?

[15 marks]

ii) Which movies was most recommended?

[3 marks]

END