MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2023/2024

THIRD YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN STATISTICS

SMS 3352: DESIGN AND ANALYSIS OF EXPERIMENTS I

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Briefly explain the following terms as used in design and analysis of experiments; (6 Marks)

i. treatment
ii. factorial experiment
iii. extraneous factors

b) For a complete randomised design, show that $SSE = SS_{Total} - SS_{Treatment}$ (4 Marks)

c) Discern between Duncans multiple range test and least significant difference as used in analysis of variance. (5 Marks)

d) The data in Table 1 represent the number of hours of relief provided by five different brands of headache tablets administered to 25 subjects experiencing fevers of 38^0C or more. Perform the analysis of variance, and test the hypothesis at the 0.05 level of significance that the mean number of hours of relief provided by the tablets is the same for all five brands. (8 Marks)

Table 1: Tablet and relief

Tablet				
A	B	C	D	E
5	9	3	2	7
4	7	5	3	6
8	8	2	4	9
6	6	3	1	4
3	9	7	4	7

e) Estimate the missing value in the RCBD in Table 2. (4 Marks)

Table 2: Missing values

Treatments	1	2	3	4
A	13.2	19.5	16.1	17.4
B	15.3	20.2	17.3	19.7
C	12.8		19.5	13.2
D	18.8	112.6	18.1	16.8
E	100.0	101.6	20.8	110.3

f) Explain randomization as a principle of design and analysis of experiments. (3 Marks)

QUESTION TWO (20 MARKS)

a) Briefly explain a Latin square design, highlighting its analysis of variance model. (4 Marks)

b) Outline the steps in Duncan's Multiple Range Test. (4 Marks)

c) A manufacturing firm wants to investigate the effects of five colour additives on the setting time of a new concrete mix. Variations in the setting times can be expected from day to day changes in temperature and humidity and also from the different workers who prepare the test molds. To eliminate the extraneous sources, the following design was used with setting times in hours for the twenty-five molds recorded as in

Table 3:

Table 3: Setting times

Worker	Day				
	1	2	3	4	5
1	$D_{10.7}$	$E_{10.3}$	$B_{11.2}$	$A_{10.9}$	$C_{10.5}$
2	$E_{11.3}$	$C_{10.5}$	$D_{12.0}$	$B_{11.5}$	$A_{10.3}$
3	$A_{11.8}$	$B_{10.9}$	$C_{10.5}$	$D_{11.3}$	$E_{7.5}$
4	$B_{14.1}$	$A_{11.6}$	$E_{11.0}$	$C_{11.7}$	$D_{11.5}$
5	$C_{14.5}$	$D_{11.5}$	$A_{11.5}$	$E_{12.7}$	$B_{10.9}$

A the 0.05 level of significance, can we say that the colour additives have any effect on the setting time of the concrete mix? (12 Marks)

QUESTION THREE (20 MARKS)

a) Explain the advantages of a randomised complete block design (RCBD) over a completely randomised design (CRD). (4 Marks)

b) Discriminate between fixed and random effect models. (4 Marks)

c) Table 4 represent the percnts of foreign additives measured by five analysts for three similar brands of strawberry jam; A, B and C:

Table 4: Foreign additives

Analyst 1	Analyst 2	Analyst 3	Analyst 4	Analyst 5
$B_{2.7}$	$C_{7.5}$	$B_{2.8}$	$A_{l.7}$	$C_{8.1}$
$C_{3.6}$	A 1.6	$A_{2.7}$	$B_{l.9}$	$A_{2.0}$
$A_{3.8}$	$B_{5.2}$	$C_{6.4}$	$C_{2.6}$	$B_{4.8}$

Perform the nalysis of variance and test the hypothesis, at the 0.05 level of significance, that

i. there is no difference in the percents of foreign additives due to different analysis; (6 Marks)

ii. the percent of foreign additives is the same for all three brands of jam. (6 Marks)

QUESTION FOUR (20 MARKS)

a) Highlighting the analysis of variance model, explain a completely randomised design (CRD). (4 Marks)

b) Explain the advantages of a balanced CRD. (6 Marks)

c) Part of the study "Serum Inorganic Phosphorus Levels with Seizure Disorders Taking Anticonvulsant Drugs, " concluded at the Meru University of Science and Technology in 2020, was designed to measure serum alkaline phosphatase activity levels in children with seizure disorders who were receiving anticonvulsant therapy under the care of a private physian. Forty-five subjects were found for the study and categorized into four groups:

G-1: control (not receiving anticonvulsants and having no history of seizure disorders)

G-2: phenobarbital, G-3: carbamazepine and G-4: other anticonvulsants.

From blood samples collected on each subject the serum alkaline phosphatase activity level was determined and recorded in Table 5.

Table 5: Serum Alkaline Phosphatase Activity

Drug Group				
49.20	97.50	97.07	62.10	110.60
44.54	105.00	73.40	94.95	57.10
45.80	58.05	68.50	142.50	117.60
95.84	86.60	91.85	53.00	77.71
30.10	58.35	106.60	175.00	150.00
36.50	72.80	0.57	79.50	82.90
82.30	116.70	0.79	29.50	111.50
87.85	45.15	0.77	78.40	
105.00	70.35	0.81	127.50	
95.22	77.40			

Test the hypothesis at the 0.05 level of significance that the average serum alkaline phosphatase activity level is the same for the four drug groups. (10 Marks)

QUESTION FIVE (20 MARKS)

a) Define level of a factor as used in factorial experiments. (2 Marks)

b) Explain the justification for a factorial experiment in design and analysis of sample surveys. (5 Marks)

c) An experiment was conducted to study the effect of temperature and type of oven on the life of a particular component being tested. Four types of ovens and three temperature levels were used in the experiment. Twenty-four pieces were assigned randomly, two to each combination of treatments, and the following results were recorded as in Table 6.

Table 6: Temperature and Oven

Temperature(0C)	Oven			
	0_1	0_2	0_3	0_4
500	227	214	225	260
	221	259	236	229
550	187	181	232	246
	208	179	198	273
600	174	198	178	206
	202	194	213	219

Using a 0.05 level of significance test the hypothesis that;

i. different temperatures have no effect on the life of the component; (4 Marks)

ii. different ovens have no effect on the life of the component; (4 Marks)

iii. the type of oven and temperature do not interact. (5 Marks)

Table 7: $F_{0.05}(d_1, d_2)$

F Values for $\alpha = 0.05$

d_2	d_1 1	2	3	4	5	6	7	8	9
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
2	18.51	19.00	19.16	19.25	19.3	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21