

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

FOURTH YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN ECONOMICS & STATISTICS, BACHELOR OF ARTS & SCIENCE, BACHELOR OF ARTS

MATH 443: DESIGN AND ANALYSIS OF EXPERIMENTS I

STREAMS: BSC (ECON & STATS), BED (ARTS & SCI) & BA      TIME: 2 HOURS

DAY/DATE: FRIDAY 07 /12/2018      8.30 A.M. – 10.30 A.M.

INSTRUCTIONS: Attempt question ONE and any other TWO

QUESTION 1 (30 MARKS)

- (a) Briefly describe the fundamental principles of experimentations [6 marks]
- (b) Distinguish between the following terms/concepts as used in the design and analysis of experiments
- (i) Fixed effects model and the random effects model
  - (ii) Confounding and control
  - (iii) Measurement units and experimental units
  - (iv) Treatments and response [8 marks]
- (c) Consider a fixed effects model with  $k$  treatments. Let  $x_{ij} = \mu + t_i + \epsilon_{ij}$ ,

$$\begin{cases} i & \in 1 \dots k \\ j & \in 1, \dots, n_i \end{cases}$$

Where  $x_{ij}$  is the  $j^{\text{th}}$  observation of the  $i^{\text{th}}$  treatment effect,  $\mu$  is the overall mean,  $t_i$  is the treatment effect while  $\epsilon_{ij}$  is the random error assumed to be normally independent with a zero mean and variance  $\sigma^2$ .

**Required**

**MATH 443**

(i) Show that  $E(S.S.E) = (n-k)\sigma^2$  where  $n = \sum_{i=1}^k n_i$  and S.S.E is the sum of squares due to error

(ii) Hence or otherwise deduce the distribution of  $S.S.E / \sigma^2$  [10 marks]

(d) A Chuka University don thinks that the month of the semester affects the marks scored in the continuous assessment tests (CATs). In a semester long experiments, students were selected randomly during different months of the semester and we given impromptu CATs. The results are shown in the table below

September	4	3	6	7	5	3	4		
October	6	8	7	9	6	8	5	4	
November	7	11	12	8	13	6	5	4	7
December	7	5	6	4	4	3	4	7	

What would be the don's conclusion at 5% level significance [6 marks]

**QUESTION 2 (20 MARKS)**

- (a) Describe a randomized complete block design
- (b) Ten service stations are rated in terms of the overall quality and effectiveness by five different raters. The distributor of petroleum products of these service stations wishes to determine if the stations differ significantly in the mean rating score or whether the average ratings given by the five professional raters are significantly different. The results are presented below

Rater	Service stations									
	1	2	3	4	5	6	7	8	9	10
A	99	70	90	99	65	85	75	70	85	92
B	96	65	80	95	70	88	70	51	84	91
C	95	60	48	87	48	75	71	93	80	93
D	98	65	70	95	67	82	73	94	86	90
E	97	65	62	99	60	80	76	92	90	89

Carry out the analysis of variance at 1% significance level. What advice would you give the distributor?

**QUESTION 3 (20 MARKS)**

A baker is investigating the relationship between the quality of the bread she produces and the flour and the baking time used. He makes three loaves of bread for each treatment combination of flour and baking time. The loaves are graded according to quality/marketability index she has devised for the purpose. The values of the measurement in metric variables are:

Flour	Baking times (mins)			
	25	30	35	40
Exe	3.7	4.2	4.1	4.8
	4.2	3.8	4.3	5.5
	2.9	4.1	4.2	5.4
Chef	4.1	4.4	4.9	5.4
	4.5	4.6	4.4	5.2
	4.6	3.9	4.9	4.9
	4.1	4.4	4.7	4.8
	4.2	4.8	5.0	4.6
	3.8	4.0	5.2	5.1

Perform an analysis of variance to determine whether the various factors differ significantly at 1% level of significance

**QUESTION 4 (20 MARKS)**

- (a) The trusts produced by the rocket engines on five different fuels and five different injection systems were measured

Fuel	Injection rate (L/s)				
	1.2	1.5	1.6	1.9	2.5
Super	A (4.5)	B (4.7)	C (5.1)	D (4.3)	E (5.1)
Premium	C (5.3)	D (4.8)	E(5.1)	A (4.9)	B (5.2)
Diesel	E (4.4)	A (4.1)	B (4.6)	C (4.5)	D (5.1)
Spacegas	D (4.7)	E (4.4)	A (4.3)	B (4.6)	C (5.5)
Airflame	B (4.7)	C (5.2)	D (5.3)	E (4.7)	A (4.9)

The engines are denoted by the letters A, B, C, D and E. Analyze the data at 5% level of significance to investigate the effects of the fuel, injection rate and the engines.

**QUESTION 5 (20 MARKS)**

For a factorial design with three factors each at two levels, define the main effects, two factor effects and three factor interactions. Using the symbolic direct product method, obtain the estimates of the treatment effects clearly explaining each step

---