RAJARATA UNIVERSITY OF SRI LANKA

FACULTY OF APPLIED SCIENCES, MIHINTALE

B.Sc. (4 year) Degree in Industrial Mathematics

Fourth Year - Semester II Examination – February / March 2019

Design of Experiments – MAT 4307

Instructions;

1. **Answer only four (04) questions.**
2. **Each question carries equal marks.**
3. **Statistical tables are provided on request and calculators are allowed.**

Duration: 03 hrs. **Total marks: 100**

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1) An experiment was conducted to compare three (03) new medicine types (X, Y, and Z) for their effectiveness with the standard medication (S). This was laid out on a randomized complete block design and replicated five times. The layout and the antibodies developed by the medicine (µg/ mL) are given below.

Block 1	55 **Y**	54 **S**	70 **X**	72 **Z**
Block 2	60 **Z**	50 **X**	55 **Y**	40 **S**
Block 3	70 **Z**	53 **S**	67 **X**	45 **Y**
Block 4	50 **S**	72 **X**	61 **Y**	70 **Z**
Block 5	62 **X**	57 **Y**	48 **S**	58 **Z**

a. Test the null hypothesis of "all medicines are same".
b. Compare the new medicine types with the standard medication.
c. Explain reasons for blocking and for not testing the significance of blocking criteria in a randomized complete block design.

2) An experiment was conducted to test the gas mileage of four (04) common fuel types (F1, F2, F3, and F4) available in Sri Lanka. Four (04) drivers (D1, D2, D3, and D4) were asked to drive four (04) cars (Toyota, Nissan, Honda, and Mazda) in a same terrain. Observed gas mileages are given in the table below:

a. What was the experimental design used in this experiment?
b. State an appropriate statistical model for the design given in part (a).
c. If the highest gas mileage is the best, select the best fuel type/s.
d. If the same experiment is to repeat in four (04) locations, state an appropriate experimental design and the ANOVA table (sources of variation and *df* only).

e. If it is difficult to take the same cars for four locations in part (d), state an appropriate experimental design to conduct the experiment and the ANOVA table (sources of variation and *df* only) for the particular analysis.

Car	*Fuel type*	*Driver*	*Gas mileage*	*Car*	*Fuel typeF*	*Driver*	*Gas mileage*
Toyota	F1	D3	16	***Toyota***	F3	D2	16
Nissan	F1	D2	11.6	***Nissan***	F3	D3	11.9
Honda	F1	D4	10.3	***Honda***	F3	D1	11.4
Mazda	F1	D1	14.5	***Mazda***	F3	D4	12.5
Toyota	F2	D4	14.5	***Toyota***	F4	D1	18
Nissan	F2	D1	10.4	***Nissan***	F4	D4	14.5
Honda	F2	D3	10.2	***Honda***	F4	D2	12.5
Mazda	F2	D2	12.3	***Mazda***	F4	D3	15

3) A researcher plans to conduct an experiment with four (04) factors A, B, C and D with two (02), two (02), three (03) and three (03) levels in each, respectively. The experimental design intended to be used is a RCBD with four (04) blocks.

a. Draw the layout of one (01) block, if four factors need small plots of the same size.

b. Provide the breakdown of ANOVA (sources of variation and *df* only) for part (a).

c. State the most appropriate design, if the factor A needs a large plot size.

d. Draw the layout of a single block for part (c).

e. Provide the breakdown of ANOVA (sources of variation and *df* only) for part (c).

f. State the most appropriate design, if factor A and factor B need large plots of equal size.

g. Draw the layout of a single block for part (f).

h. Provide the breakdown of ANOVA (sources of variation and *df* only) for part (f).

i. State the most appropriate design, if factor A and factor B need large plots but different sizes (large and medium).

j. Draw the layout of a single block for part (i).

k. Provide the breakdown of ANOVA (sources of variation and *df* only) for part (i).

4) An experiment was conducted to evaluate the effect of four (4) crop varieties (V1, V2, V3 and V4) on crop yield in a Randomized Complete Block Design (RCBD). During the study, these crops were by a pest. Observed yield (Y) in kilogram and pest damage (x) for each plot are given below.

Crop Variety	**V1**		**V2**		**V3**		**V4**	
Block	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**
B1	10	105	5	120	15	80	8	90
B2	25	85	20	100	5	98	8	88
B3	12	78	6	112	10	90	15	80

The formula used to calculate **Sum of Squares** for RCBD design is given in the following table:

BD
Treatment $= T_{yy} - \frac{(T_{xy} + E_{xy})^2}{T_{xx} + E_{xx}} + \frac{E_{xy}^2}{E_{xx}}$
Block $= B_{yy} - \frac{(B_{xy} + E_{xy})^2}{B_{xx} + E_{xx}} + \frac{E_{xy}^2}{E_{xx}}$

$$\text{Regression} = \frac{E_{xy}^2}{E_{xx}}$$

$$\text{Residual} = E_{yy} - \frac{E_{xy}^2}{E_{xx}}$$

$$\text{Total} = S_{yy}$$

a. Conduct an appropriate statistical test to find out whether there is a significant difference among crop varieties on crop yield using, 0.05 α level.

b. If there is a significant difference among crop varieties, recommend the best crop variety for cultivation.

5) An experiment was carried out using a randomized complete block design, to test effects of factors; P, W and N. Observations are summarized in the following table.

Block	P1				P2			
	W1		W2		W1		W2	
	N1	N2	N1	N2	N1	N2	N1	N2
1	110	160	180	250	180	240	180	250
2	180	240	260	400	210	280	230	290
3	100	160	170	240	130	200	150	220

a. Test the null hypothesis of "there is no interaction or main effects of tested factors"

b. Reconstruct the ANOVA of part (a), excluding the three-way interaction.

c. Assuming no interactions, find out the good/ effective level of P, N, and W. (Hint; higher means are preferable)