RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B. Sc. (Four Year) Degree in Industrial Mathematics
Fourth Year - Semester II Examination – June/July 2018
MAT 4307 – DESIGN OF EXPERIMENT

Time: Three (03) hours

Instructions;

1. **Answer 05 questions only.**
2. **Each question carries equal marks.**
3. **Statistical tables are provided on request and calculators are allowed.**
4. **Total marks 100.**

1. Following table shows the field layout and yields (kg/ha) obtained from an experiment completed with an objective of finding the best Nitrogen level.

	Nitrogen Level (kg/ha)					
Block	**0**	**25**	**50**	**75**	**100**	**125**
1	3.6	4.8	4.4	5.3	4.8	5.0
2	4.1	5.1	5.2	5.9	5.5	5.4
3	3.2	4.0	4.6	4.6	5.2	4.8
4	3.9	3.9	5.0	5.0	5.1	4.6

a. Find the best nitrogen level/s. **Note:** State hypothesis and conclusions clearly.

b. State the reasons for conducting this experiment on a blocked experiment.

2. This is a split-plot field layout of a sugar beetroot rot study. Each block contains 2 main plots, to which the inoculation treatment (A) levels were assigned (Inoculation, No Inoculation). Each main plot was split into 4 subplots, to which the in-row spacing levels (B) were assigned (4, 6, 12, and 18 inches). The yields of the subplots are shown in italics.

Block								
VI	4 *21.0*	12 *22.9*	18 *23.1*	6 *22.0*	6 *17.6*	12 *16.1*	4 *16.8*	18 *13.1*
	No inoculation				Inoculation			
V	18 *12.9*	6 *19.8*	4 *17.2*	12 *16.8*	6 *21.2*	4 *17.9*	12 *22.3*	18 *22.0*
	Inoculation				No inoculation			
IV	6 *21.1*	18 *21.4*	4 *18.4*	12 *22.8*	12 *16.1*	18 *14.7*	6 *16.3*	4 *16.8*
	No inoculation				Inoculation			
III	18 *19.3*	12 *18.6*	4 *18.2*	6 *20.8*	18 *12.5*	6 *19.1*	12 *16.6*	4 *16.5*
	No inoculation				Inoculation			
II	12 *14.9*	6 *17.0*	18 *12.1*	4 *16.4*	4 *17.9*	12 *21.1*	18 *20.1*	6 *19.6*
	Inoculation				No inoculation			
I	4 *17.4*	12 *16.3*	18 *12.5*	6 *17.3*	18 *20.0*	12 *21.8*	6 *20.2*	4 *20.1*
	Inoculation				No inoculation			

a. State reasons for using a split-plot layout for this experiment.

b. Respective analysis of variance table is given below, based on ANOVA, test relevant null hypotheses for this experiment.

c. Find out the best level of inoculation (A) and spacing (B). Assume interactions are not significant.

Dependent Variable: YIELD

Source	DF	SS
Model	17	388.5475
Error	30	23.5050
Corrected Total	47	412.0525

Source	DF	Type III SS
BLOCK	5	16.2500
A_INOC	1	256.6875
BLOCK*A_INOC	5	11.5350
B_SPACE	3	39.6375
A_INOC*B_SPACE	3	64.4375

Tests of Hypotheses using Type III

Source	DF	Type III SS
A_INOC	1	256.6875
BLOCK	5	16.2500

3. An experiment was conducted to evaluate the effect of three (03) different growth hormones (T1, T2 & T3) on poultry chicks using randomized complete block design (RCBD). Measurements on initial weight (x) and the weight after 10 days (y) were taken. The results are given in following table.

Block	Treatment					
	T1		T2		T3	
	X	Y	X	Y	X	Y
B1	32	48	30	45	23	48
B2.	26	31	28	39	25	50
B3	25	30	25	32	26	52

Using an analysis of covariance (ANCOVA), test significances of hormones and covariate (use 0.05 α level).

Note: Clearly indicate your null hypothesis, alternative hypothesis and conclusions

The sums of squares and cross products can be calculated using following formulas.

$$\text{Treatment} = T_{yy} - \frac{(T_{XY} + E_{XY})^2}{(T_{XX} + E_{XX})} + \frac{E_{xy}^2}{E_{xx}}$$

$$\text{Block} = B_{yy} - \frac{(B_{XY} + E_{XY})^2}{(B_{XX} + E_{XX})} + \frac{E_{xy}^2}{E_{xx}}$$

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

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

4. Four machines were tested (B, C, D, & E) against the standard machine (A), and their outputs were measured. Using the information given in the table, test the followings;

   a. Test whether there a significant difference between machines
   b. Test the following contrasts and make your conclusions,
      i. A versus the rest
      ii. B versus C, D, E
      iii. C versus D, E
      iv. D versus E

	A	B	C	D	E
Block 1	64	68	71	75	69
Block 2	66	64	69	74	71
Block 3	68	60	75	78	65
Block 4	59	61	68	72	60
Total	257	253	283	299	265
Mean	64.25	63.25	70.75	74.75	66.25

5. At planning of a study, four different drugs need to be tested to control a disease by increasing the red blood cells. Four people belong to four different weight classes are expected to be used and four days required to complete the experiment.
   a. Suggest the most appropriate experimental designs for the purpose.
   b. Provide the layout of the design.
   c. Provide the break-down of the ANOVA (Sources and degrees of freedom only)
   d. Suppose the study is expected to be repeated in three places, and the same weight classes are available in all three locations, suggest an appropriate experimental design.
   e. Give the break-down of the ANOVA for part (d) (Sources and degrees of freedom only)
   f. If the similar weight classes are unavailable, suggest and appropriate experimental design to replicate the experiment thrice.
   g. Provide the break-down of the ANOVA for part (f) (Sources and degrees of freedom only)

6. A researcher plans to conduct an experiment with three factors A, B and C with two, three and three levels in each, respectively. The experimental design intended to be used to RCBD with four blocks.
   a. Provide the layout of one block, if three factors need small plots of same size.
   b. Give the breakdown of ANOVA for part (a) (Sources and degrees of freedom only).
   c. Suppose factor A needs large plots, then what is the most appropriate design?
   d. Provide the layout, for a single block for part (c)
   e. Give the breakdown of ANOVA for part (c) (Sources and degrees of freedom only)
   f. Suppose that factor A and B need large plots of equal size, then what is the most appropriate design?
   g. Give the layout of a single block for part (g).
   h. Give the breakdown of ANOVA for part (g) (Sources and degrees of freedom only)
   j. Suppose A and B factors need large plots but different sizes, then what is the most appropriate design?
   k. Give the layout of a single block for part (j).
   l. Give the breakdown of ANOVA for part (j) (Sources and degrees of freedom only)