

THE OPEN UNIVERSITY OF SRI LANKA  
 B.Sc/B.Ed Degree Programme, Continuing Education Programme  
 APPLIED MATHEMATICS - LEVEL 04  
 PSU2182 – EXPERIMENTAL DESIGN  
 FINAL EXAMINATION 2006/2007



DURATION: TWO AND HALF-HOURS

DATE: 11 – 06 – 2007

TIME: 1.30pm -4.00pm

Statistical Tables are provided. Non-programmable calculators are permitted.

ANSWER FOUR QUESTIONS ONLY.

1. An experiment was designed to study the effects of 4 diets on the milk production of cows. The 4 diets (A, B, C and D) were each fed to 4 cows in 4 different time periods and at the end of each period total yield of milk (lbs) from each cow was recorded. The experimenter used a  $4 \times 4$  Latin Square design with 4 time periods and 4 cows representing the rows and columns respectively.

- (i) Explain how you would use the random number table to do the randomization in this experiment.
- (ii) The total yield of milk (lbs) recorded at the end of each time period is as follows. (The English letters within brackets are the corresponding treatment received)

		Cow				Total
		1	2	3	4	
Period	1	192(A)	195(B)	292(C)	249 (D)	928
	2	190 (B)	203 (D)	218 (A)	210 (C)	821
	3	214 (C)	139(A)	245(D)	163 (B)	761
	4	221(D)	152(C)	204(B)	134 (A)	711
Total		817	689	959	756	3221

Total uncorrected sum of squares =  $\sum x^2 = 674315$

Construct an Analysis of Variance (ANOVA) table and test whether there is a significant difference between the effects of 4 diets. Use 5% significance level.

- (iii) Find the Least Significant Difference (LSD) for comparing any two treatment means. (Use 5% significance level)
- (iv) Using LSD found in part (iii) above, carryout a pairwise mean comparison to find out which treatment means are significantly different. Clearly explain your answer.

2. A  $2^2$  factorial experiment was carried out to study the effect of Nitrogen and Potassium on the yield of Soya bean. Two levels (0mg and 50mg) of a fertilizer (A) containing Nitrogen and Two levels (0mg and 50mg) of a fertilizer (B) containing Potassium was used for this study. Each treatment combination was allocated to 12 Soya bean plots using Randomized Complete Block Design (RCBD) with 3 blocks. The yield of Soya bean measured after 1 month was as follows.

		Treatment Combination				Total
		(1)	a	b	ab	
Block	1	18	72	65	119	274
	2	15	79	73	127	294
	3	32	81	60	73	246
Total		65	232	198	319	814

**Total uncorrected sum of squares =  $\sum x^2 = 68332$**

- (i) Construct an Analysis of Variance (ANOVA) table and test whether there is any significant difference between treatment combinations. Use 5% significance level.
  - (ii) Compute all main effects and interaction along with their standard errors.
  - (iii) Extend the ANOVA table constructed in part (i) above to test the significance of Main effects and Interaction. Use 5% significance level.
  - (iv) Summarize your findings in a meaningful way. Clearly explain you conclusions.
3. An experiment needs to be designed to compare the effects of four drugs P, Q, R and S (here S is a placebo or inactive substance) on the blood sugar level of mice. Suppose the experimenter has 5 litters and each litter contains 4 mice. You are called to assist the experimenter with the designing of this experiment.
- (i) Explain what type of design you would use if
    - (a) all mice are of same age.
    - (b) within each litter mice are of same age, but between litters mice are different in age.
 In each case give reasons for you answer.
  - (ii) Explain how you use random number table to allocate each treatment to the experimental units for each case given in parts (a) and (b). In each case how many replicates are there?
  - (iii) What are the advantages and disadvantages of using the design structures you suggested in parts (a) and (b)?

4. An experiment is being planned to investigate whether the water uptake of amphibian is affected by a certain hormone. Two types of species, frogs and toads (16 from each type) and two environmental conditions (moist and dry) are available for this experiment. Before the experiment half of the animals will be kept in moist conditions while the other half will be kept in dry conditions for 1 hour. Then half of the animals that kept in the moist condition will be injected with water containing the hormone and the other half will be injected with normal water. Same process will be applied for the animals that kept in the dry condition. After 2 hours the increase in weight will be measured. The experimenter wishes to allocate all possible treatment combinations using a Completely Randomized Design.

- (i) In relation to the above experiment explain the following terms.
  - (a) Treatment Structure
  - (b) Replicate
  - (c) Experimental Units
- (ii) How many treatments are there and what are they?
- (iii) What is the response variable in this experiment?
- (iv) Explain how you would use the random number table to allocate treatment combinations to experimental units.
- (v) What are the Advantages and Disadvantages of using a Completely Randomized Design in this experiment?

5. A  $2^3$  factorial experiment was carried out to investigate the effects of three factors on the hardness of biscuits. The factors considered were Baking Temperature (A), Baking Time (B), and Water content before baking (C). Each factor was applied at two levels (low and high) and 24 batches of biscuits were prepared under the 8 treatment combinations using a completely randomized design with equal number of replicates. The hardness of the biscuits was measured by finding the minimum weight (lbs) need to shatter a biscuits. The treatment total for each treatment combination is given below.

Treatment Combination	(1)	<i>a</i>	<i>b</i>	<i>c</i>	<i>ab</i>	<i>ac</i>	<i>bc</i>	<i>abc</i>
Hardness	59	91	90	124	121	209	138	241

A part of the analysis of variance (ANOVA) table related to this study is given below.

Source of Variation	d.f	S.S
Trt. S.S.	7	8923
Error S.S	16	332
Total S.S	23	9255

- (i) Using Yate's algorithm compute all the main effects and interactions.
- (ii) Extend the given analysis of variance (ANOVA) table to test the significance of all the Main effects and Interaction. Use 5% significance level. Clearly explain you conclusions.

6. In an experiment to study the effect of fertilizer on the yield of certain type of paddy, two amounts of fertilizer (5lbs and 10lbs) in dry and wet conditions along with the control (that is no fertilizer) were applied to 24 plots using Randomized Complete Block Design (RCBD) so that there were 4 replicates for each treatment. After 3 months total yield (kg) from each plot was measured. The results are as follows. (Here W5 and W10 denote the treatments corresponding to 5lbs and 10lbs of fertilizer applied in wet condition and D5 and D10 denote the treatments corresponding to 5lbs and 10lbs of fertilizer applied in dry condition .)

		Treatment					Total
		Control	W5	W10	D5	D10	
Block	1	18	38	42	28	31	157
	2	23	41	40	27	24	155
	3	15	39	37	32	30	153
	4	23	43	44	30	28	168
Total		79	161	163	117	113	633

A part of the analysis of variance (ANOVA) table related to this study is given below.

Source of Variation	Sum of squares
Trt. S.S.	1263
Block S.S	27
Error S.S	105
Total S.S	1395

- (i) Complete the ANOVA table and test whether there is a significant difference between treatment effects at 5% significance level.
- (ii) Suggest a meaningful independent comparisons to compare the effects between
  - (a) Fertilizer and Control
  - (b) Wet and Dry conditions
  - (c) the two levels of fertilizer
- (iii) Extend the ANOVA table you constructed in part (i), to test the significance of the comparisons suggested in part (ii). Clearly state your conclusions. Use 5% significance level.

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