

THE OPEN UNIVERSITY OF SRI LANKA

B.A./B.Ed. Degree Programme, Continuing Education Programme

APPLIED MATHEMATICS-LEVEL 04

PSU2182/PCU2142/PSZ4130/PSE4182- DESIGN AND ANALYSIS OF EXPERIMENTS

FINAL EXAMINATION 2011/2012

Duration: Two Hours.



Date: 20.11.2012

Time: 1.30p.m- 3.30 p.m

Programmable calculators are permitted. Statistical tables are provided.

Answer FOUR questions only.

- 1) (i) Briefly explain the importance of replication and randomization in experimental designs.
 - (ii) In what situations would you use Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD) and Latin Square Design?
 - (iii) A statistician suggests that CRD is more appropriate for lab experiments than field experiments. Comment on this statement.
- 2) A certain agricultural research institute conducted an experiment to compare the effects of five different insecticides (E1, E2, E3, E4 and E5) on the yield of tomato. To obtain sufficient amount of data, they had to use four plots which were in four different districts. The plots are different in soil fertility, drainage characteristics and different weather conditions. Tomatoes of same variety were planted in each plot and 5 different insecticides were randomly assigned to the tomato plants within all four plots. After a certain time period, tomato yields were recorded in each plot under each insecticide. The data are given in the following table.

Plot	Insecticide				
	E1	E2	E3	E4	E5
1	11	13	10	18	15
2	20	38	25	30	28
3	8	10	8	16	12
4	30	35	27	41	28

The data were given to student 'A' and asked to analyze. A part of the student's analysis is given below.

ANOVA: Yield versus Insecticide

Source of Variation	Degrees of freedom	Sum of Squares	Mean Squares	F value
Insecticide
Error
Total	2093		

- (i) What type of experimental design has been assumed by the student 'A' in analyzing the data?
- (ii) Complete the ANOVA table.

Output of the analysis of the above data done by another student 'B' is given below.

ANOVA: Yield versus Insecticide, Plot

Source of Variation	Degrees of freedom	Sum of Squares	Mean Squares	F value
Insecticide
Plot
Error
Total	2092.55		

- (iii) What type of experimental design has been assumed by the student 'B' in analyzing the data?
- (iv) Complete the ANOVA table.
- (v) Among the two analyses in the above, which is the most suitable analysis for these data? Justify your answer.
- (vi) Write down a suitable model for the yield of tomato under the above design. Define all the terms of the model.
- (vii) Test whether the Insecticides E1 and E4 are equally effective or not. (Use 5% significance level.)

3) The factors that influence the surface finish of a metal part are being studied. Two feed rates and two depths of cut are chosen. The results of the design are as follows.

Feed Rate (in/min)	Depth of Cut (in)					
	0.15			0.18		
0.20	74	64	60	79	68	73
0.25	92	86	88	98	104	88

- (i) Write down a suitable model for the experiment. Define all the terms of the model.
- (ii) A part of the analysis of data is given below. Construct the ANOVA table.

Source of Variation	Sum of Squares
Feed rate	1587
Depth of cut	176.33
Feed rate*Depth of cut	0.33
Total	2077.67

(iii) Interpret the results.

- 4) In an experiment to study the effects of different types of background music on the productivity of bank tellers, five types of music A, B, C, D and E were tested for five working days within five weeks. Following results were obtained.

Week	Day					Total
	Mon	Tue	Wed	Thu	Fri	
1	18(D)	17(C)	14(A)	21(B)	17(E)	87
2	13(C)	37(B)	21(E)	16(A)	15(D)	102
3	7(A)	29(D)	32(B)	27(E)	13(C)	108
4	17(E)	13(A)	24(C)	31(D)	25(B)	110
5	21(B)	26(E)	26(D)	31(C)	7(A)	111
Total	76	122	117	126	77	518

Total uncorrected sum of squares = $\sum y^2 = 12234$

Treatment	A	B	C	D	E
total	57	136	98	119	108

- (i) Construct the ANOVA table and test appropriate hypotheses. Interpret your results.
- (ii) Find the Least Significant Difference (LSD) for comparing any two treatment means. (Use 5% significance level)
- (iii) Using LSD found in part (ii) above, test whether music types A and B are equally effective. Use 5% level of significance. Clearly explain your answer.
- 5) A farmer who cultivates paddy wanted to study the effects of fertilizer and whether condition on the yield. Two amounts of fertilizer (4lbs and 8lbs) in dry and wet conditions along with the control (that is no fertilizer) were applied to 20 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 W4 and W8 denote the treatments corresponding to 4lbs and 8lbs of fertilizer applied in wet condition and D4 and D8 denote the treatments corresponding to 4lb and 8lbs of fertilizer applied in dry condition.)

		Treatment					Total
		Control	W4	W8	D4	D8	
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
Treatment S.S	1263
Block S.S	27
Total S.S	1395

- (i) Construct the ANOVA table and test whether there is a significant difference between treatment effects at 5% significance level.
 - (ii) Suggest 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.
- 6) A bacteriologist is interested in the effects of two different culture media and two different times on the growth of a particular virus. She performs six replicates of a factorial experiment in a CRD, making the runs in random order. The bacterial growth data are as follows.

Treatment Combination	Replicates						Total
	I	II	III	IV	V	VI	
(1)	21	23	20	22	28	26	140
a	37	38	35	39	38	36	223
b	25	24	29	26	25	27	156
ab	31	29	30	34	33	35	192

Total uncorrected sum of squares = $\sum y^2 = 21857$

- (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) Interpret your results.

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