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B.E/B.Tech (FULL-TIME) DEGREE END SEMESTER EXAMINATIONS - NOV/DEC 2011

INDUSTRIAL ENGINEERING

SEVENTH SEMESTER

IE9401 – DESIGN OF EXPERIMENTS

(REGULATIONS 2008)

Time: 3 Hours Max.Marks:100

Answer ALL Questions

Use of STSTISTICAL TABLES permitted

Part-A (10 X 2 = 20 Marks)

1. How will you select sample size for attribute data?
2. What do you mean by complete randomization and Simple repetition? Under what circumstances each one is preferred?
3. Suppose you had an experiment with 6 blocks and 4 treatments. How to randomize treatments for a RCBD?
4. Why Duncan's Multiple Range test is more conservative than Newman- Keul's test?
5. What are the advantages of replication of Latin Squares? In what ways a Latin Square can be replicated?
6. State the advantage of the split-plot design over a completely randomized design
7. Give the general algorithm for determining the coordinates of a point on the PSA
8. What do you understand by the term Homoscedasticity? Why to check it?
9. What do you mean by Signal and Scaling factors?
10. State the methods used for multi-level factor OA designs

Part-B (5 X 16 = 80 Marks)

11. An experimenter is willing to study the impact of seven controlled factors (A to G) and three noise factors (I, J and K) all at two levels. The experimenter is interested in simultaneous optimisation of two responses[X (smaller the better) and Y (Larger the better)]. Based on the past experience, the experimenter gives a highest weight of 0.6 to X. The experimenter selected appropriate OA's for the design and sequentially assigns the factors to the selected OA to run optimal number of runs. The responses X and Y (the values for response Y is

given in italics) obtained by conducting the experiment is given below. Find the optimal levels.

Trial No						
1	175	*0.38*	177	*0.38*	165	*0.29*
2	144	*0.33*	142	*0.33*	139	*0.39*
3	162	*0.61*	162	*0.63*	159	*0.75*
4	136	*0.96*	132	*0.61*	125	*0.99*
5	88	*0.45*	99	*0.96*	91	*0.51*
6	85	*0.39*	83	*0.45*	99	*0.61*
7	68	*1.20*	66	*1.10*	88	*0.99*
8	72	*0.51*	59	*0.70*	100	*0.16*

12a. Four different designs for a digital computer circuit are being studied to compare the amount of noise present. The following results were obtained

Circuit Design	Noise Observed (in dB)					
1	29	26	27	30	32	25
2	36	34	33	35	30	33
3	36	41	35	39	34	37
4	42	38	37	41	45	43

i. Is the amount of noise the same for all four designs (state clearly the hypotheses and write down the ANOVA table and your conclusions

ii. Which circuit design would you choose?

iii. Are the basic assumptions of analysis of variance satisfied?

(OR)

12b. An engineer is studying the mileage performance characteristics of five types of gasoline additives. In the road test he wishes to use cars as block; however because of a time constraint, he must use an incomplete block design. He runs the balanced design with five blocks that follow. Analyze the data from this experiment and draw conclusions. Also construct a set of orthogonal contrasts.

	Car				
Additive	1	2	3	4	5
1		17	14	13	12
2	14	14		13	10
3	12		13	12	9
4	13	11	11	12	
5	11	12	10		8

13a. An engineer is interested in the effects of cutting speed (*A*), tool geometry (*B*), and cutting angle on the life (in hours) of a machine tool. Two levels of each factor are

chosen, and three replicates of a 2^3 factorial design are run. The results are given in the following table.

i. Estimate the factor effects. Which effects appear to be large?
ii. Analyze using ANOVA and verify (i).
iii. Write down the regression model to predict the response.

A	B	C	Treatment combination	Replication		
				I	II	III
-	-	-	(1)	22	31	25
+	-	-	a	32	43	29
-	+	-	b	35	34	50
+	+	-	ab	55	47	46
-	-	+	c	44	45	38
+	-	+	ac	40	37	36
-	+	+	bc	60	50	54
+	+	+	abc	39	41	47

(OR)

13b.

Consider the experiment described in Problem 13a. Analyze this experiment assuming that each replicate represents a block of a single production shift.

14a.

A chemical product is produced in a pressure vessel. A factorial experiment was carried out to study four factors temperature (A), pressure (B), concentration of reactor (C) and stirring rate (D). Each factor was studied at 2 levels and data are given below from a single replicate. Construct one – quarter fraction of the 2^4 design and perform the statistical analysis

	A_o				A_1			
	B_o		B_1		B_o		B_1	
	C_o	C_1	C_o	C_1	C_o	C_1	C_o	C_1
D_o	45	68	48	80	71	60	64	65
D_1	43	75	45	70	100	86	104	96

(OR)

14b.

The hexagon design that follows is used in an experiment that has the objective of fitting a second-order model.

i. Fit the second-order model.
ii. What operating conditions on x_1 and x_2 lead to the stationary point?
iii. Predicted Value of Y at the stationary point

x_1	x_2	y
1	0	68
0.5	$\sqrt{0.75}$	74
-0.5	$\sqrt{0.75}$	65
-1	0	60
-0.5	$-\sqrt{0.75}$	63
0.5	$-\sqrt{0.75}$	70
0	0	58
0	0	60
0	0	57
0	0	55
0	0	69

15a.

A study was performed to examine the use of emergency services. Of interest was variation among states and variation among district within a state. Three states were selected and four hospitals were chosen from each of two randomly selected districts from each state. The data is provided in the following table Conduct an ANOVA and draw conclusions.

State					
1		2		3	
District		District		District	
A	B	C	D	E	F
31	43	31	19	35	15
55	49	33	39	45	49
55	59	37	35	37	45
31	53	31	31	47	31

(OR)

15b.

An experiment was conducted to study the effects of irrigation, crop variety, and aerially sprayed pesticide on grain yield. There were two replicates. Within each replicate, three fields were chosen and randomly assigned to be sprayed with one of the pesticides. Each field was then divided into two east west strips; one of these strips was chosen at random to be irrigated, and the other was left un irrigated. Each east-west strip was split into north-south plots, and the two varieties were randomly assigned to plots.

Rep1			Rep2			Irrigation	Var
P1	P2	P3	P1	P2	P3		
53	54	55	46	57	57	Yes	1
53	56	58	51	56	60	Yes	2
58	60	62	49	61	57	No	1
59	64	64	51	66	62	No	2