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UNIVERSITY EXAMINATIONS 2021/2022

FOURTH YEAR, FIRST SEMESTER SPECIAL SUPPLEMENTARY EXAMINATION
FOR DEGREE OF BACHELOR OF SCIENCE IN STATISTICS

SMS 3454: DESIGN AND ANALYSIS OF EXPERIMENTS II

DATE: JANUARY 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Briefly explain the following terms; (6 Marks)
   i. Treatment
   ii. Confounding
   iii. Fractional factorial experiments

b) Explain randomization as used in design and analysis of experiment. (6 Marks)

c) Suppose A, B and C factors, each at two levels; low and medium, enumerate all the treatment combinations. (4 Marks)

d) Suppose a model is given as $y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ show that

$$E\left[MS_{Treatments}\right] = \sigma^2 + \frac{\sum_{i=1}^{t} T_i^2}{(b-1)(t-1)}$$ (4 Marks)

e) The factors temperature (A), Pressure (B), concentration of reactants (C) and stirring rate (D) are studied in a pilot plant of determine the effect of product filtration rate. The 2^4=16 treatment combinations cannot all be run on the same day. The experimenter can run 8 treatment combinations in one day. So a 2^4 design confounded in 2 blocks seems appropriate. Its logical to confound the highest order interaction ABCD with blocks. The defining contrast in $L = X_1 + X_2 + X_3 + X_4$. and it is easy to verify that blocks are

Block 1(+)	Block II(-)
(1) = 45	*a = 71*
ab = 65	*b = 48*
ac = 60	*c = 68*
bc = 80	*d = 43*
ad = 100	*abc = 65*
bd = 45	*bcd = 70*
cd = 75	*acd = 86*
abcd = 96	*abd = 104*

Test all main effects for significance at $\alpha = 0.05$. (7 Marks)

f) Giving relevant examples, describe a lattice design. (3 Marks)

QUESTION TWO (20 MARKS)

a) Explain contrast as used in design of experiments. (3 Marks)

b) Explain the merits of lattice designs. (4 Marks)

c) An experiment was conducted to study the effects of two factors on the quality of pancakes. The two factors used were the amount of whey and supplement or no supplement was used. There are 4 levels of whey (0%, 10%, 20%, 30%) and two levels of supplement (used or not used) giving a total of 4 x2 treatment combination. The higher the rating the better the quality. The results were tabulated as follows.

	Whey			
	0%	10%	20%	30%
No Supplement	4.4	4.6	4.5	4.6
	4.5	4.5	4.8	4.7
	4.3	4.8	4.8	5.1
Applied Supplement	3.3	3.8	5.0	5.4
	3.2	3.7	5.3	5.6
	3.1	3.6	4.8	5.3

At $\alpha = 0.05$ level of significance test whether there is interaction between whey and supplement. (13 Marks)

QUESTION THREE (20 MARKS)

a) Explain a 3^k factorial experiment. (3 Marks)

b) Discuss how error is controlled in blocking of experimental materials? (4 Marks)

c) The sum of squares and products for a one way analysis of covariance are shown below. Complete the analysis and draw appropriate conclusions.

Source	*df*	SS_{XX}	SP_{XY}	SS_{YY}
Treatments	3	1500	1000	650
Error	12	6000	1200	550
Total	15	7500	2200	1200

QUESTION FOUR (20 MARKS)

a) Briefly describe a split plot design as used in design and analysis of experiments. (3 Marks)

b) Write down a comprehensive statistical model for a split-split plot design. (4 Marks)

c) Four strains of perennial grass were grown as swards at each of two fertilizer levels. The four strains were; S23, N2, Kent and X. the experiment was laid out as four whole plots for the varieties each split into two for the application of fertilizers. The dirty matter yield were as follows;

		Blocks				
Strain	Manure	1	2	3	4	Total
S23	H	299	318	284	279	1180
	A	247	202	171	183	803
N_z	H	315	247	289	307	1158
	A	257	175	188	174	794
X	H	403	439	355	324	1521
	A	222	170	192	176	760
Kent	H	382	353	383	310	1428
	A	233	216	200	143	792
		2358	2120	2062	1896	8436

i. Give an appropriate model for this experiment. (4 Marks)

ii. Perform appropriate F-tests at 95% level of confidence and draw desirable conclusions. (9 Marks)

QUESTION FIVE (20 MARKS)

a) Briefly explain an incomplete block design as used in design and analysis of experiments. (3 Marks)

b) Write down a comprehensive statistical model for a PBIBD. (4 Marks)

c) A large group of plants were assigned at random to pots, three pots per treatment. All pots were completely randomised with respect to location during the time spent in day light.

Hours	Hours of day light								
	8			12			16		
Pots	1	2	3	1	2	3	1	2	3
1	3.5	2.5	3.0	5.0	3.5	4.5	5.0	5.5	5.5
2	4.0	4.5	3.0	5.5	3.5	4.0	4.5	6.0	4.5
3	3.0	5.5	2.5	4.0	3.0	4.0	5.0	5.0	6.5
4	4.5	5.0	3.0	3.5	4.0	5.0	4.5	5.0	5.5
Pot totals = y_{ij}	15.0	17.5	11.5	18.0	14.0	17.5	19.0	21.5	22.0
Treatment y_{ij}	44.0			49.5			62.5		

At $\alpha = 0.05$, test whether;

i. There are significant differences between hours of daylight. (6 Marks)

ii. There significant differences between the pots. (7 Marks)