

(Time:3 hours)

[Total marks: 60]

**N.B.:** (1) Attempt any two questions from Question Nos. 1, 2 and 3, and any two from Question Nos. 4, 5 and 6.

(2) Figures to the right indicate full marks.

(3) Simple non-programmable calculator is allowed.

1. a Define Youden – square design .Obtain reduced normal equations for estimating treatment effects. 07
- b Define simple lattice design. Obtain the reduced normal equations for treatment effects in this design and find estimates of treatment effects. Illustrate with  $k = 4$ . 08

2. a Define PBIBD with  $m -$  associate classes. For the following PBIBD determine all its primary and secondary parameters and give the association scheme 07

Blocks	Treatments			
1	a	b	c	d
2	a	e	f	g
3	b	e	h	i
4	c	f	h	j
5	d	g	i	j

- b State and prove secondary parametric relations of PBIBD – with  $m$ - associate classes. 08
3. a Give an example of split plot design arranged in randomized blocks and obtain its ANOVA table showing the procedure to compute different sum of squares. 05
- b State mathematical model for two way design with  $u$  rows,  $u'$  columns and  $v$  treatments such that  $i^{\text{th}}$  treatment replicates  $r_i$  times. Derive normal equations for estimating parameters of this model. Hence obtain reduced normal equations for estimating treatment effects. 10
4. a For a  $3^2$  factorial design using appropriate set of equations produce the groups of treatment combinations compared to estimate the I and J components of interaction effect AB. Also give the sum of squares. 05
- b A one-quarter fraction of a  $2^5$  factorial design is given as: d, abd, ac, e, bc, abe, acde, bcde. Find the generators of this design and give alias structure. How many effects can you estimate? If higher order interactions are negligible give the name of the factor effects that can be estimated. 06



- c Find principal block using Das method when the  $3^5$  factorial design is to be grouped in  $3^3$  blocks allowing  $ABCD^2$ ,  $BCDE^2$  and  $AB^2CE^2$  to be confounded with blocks. 04
- 5 a Construct a  $3^{5-2}$  design with  $I=ABC$  and  $I=CDE$ . Write down the alias structure for main effects. What is the resolution of this design? 08
- b Explain 'Das method' of finding principal block for a  $(3^k, 3^p)$  confounding design. Illustrate for  $(3^4, 3)$  design if  $AB^2CD$  can be confounded with blocks. 07
- 6 Fit the second order response surface model  $y = b_0 + \sum_i b_i x_i + \sum_i b_{ii} x_i^2 + \sum_{i < j} b_{ij} x_i x_j + \varepsilon$  by making required appropriate assumptions. Give ANOVA table. 15

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