SLR-MM – 523

Seat No.	

M.Sc. (Part – II) (Semester – III) Examination, 2015
STATISTICS (Paper – XIII)
Planning and Analysis of Industrial Experiments (New CGPA)

Day and Date : Friday, 20-11-2015 Total Marks : 70

Time : 2.30 p.m. to 5.00 p.m.

Instructions : *1) Attempt **five** questions.*
*2) Q. No. (**1**) and Q. No. (**2**) are **compulsory**.*
*3) Attempt **any three** from Q. No. (**3**) to Q. No. (**7**).*
*4) Figures to the **right** indicate **full** marks.*

1. A) Choose the correct alternative : **5**

1) Smaller the experimental error _____ efficient the design.
   a) less b) more
   c) not d) none of the above

2) If AB and BC are confounded with incomplete block in 2^n experiment, then automatically confounded effect is
   a) ABC b) AC c) A d) B

3) The degrees of freedom corresponding to error in single replicate design is
   a) 0 b) 1
   c) 2 d) None of above

4) Confounding is necessary to reduce
   a) Block size b) No. of blocks
   c) No. of factors d) All of above

5) Fractional factorial experiment reduces
   a) factors b) levels of factors
   c) both a) and b) d) neither a) nor b)

P.T.O.

B) Fill in the blanks : **5**

1) In factorial experiment one can estimate _____ and _____ effects.

2) The shortest word length in defining relation is called as _____

3) Variables which are hard to control are called _____

4) In 3^3 experiment with factors A, B and C the interaction AB has _____ d.f.

5) Preferably _____ interaction is chosen for confounding.

C) State whether the following statements are **true** or **false** : **4**

1) In 2^3 design, generally we choose ABC as confounding factor.

2) Experimental error is due to experimenter's mistake.

3) For 2^k design the complete model would contain 2^{k-2} effects.

4) In Response Surface Study the factors must be quantitative.

2. a) Define with one example : **6**

i) Minimum aberration design.

ii) Resolution of factorial design.

b) Write short notes on the following : **8**

i) Yates table for 2^3 factorial experiments.

ii) Central Composite Design.

3. a) Describe the random effect model of one-way classification.

b) Describe Taguchi arrays. **(7+7)**

4. a) Explain $\frac{1}{4}$ fraction of 2^k design with suitable example.

b) Write down lay-out of 2^4 confounded design with higher order interaction is confounded. **(8+6)**

5. a) Explain advantages and disadvantages of confounding.

b) Explain partial confounding with illustration. **(7+7)**

6. a) Explain Response Surface methodology.

   b) Define :

      i) Principle fraction

      ii) Aliases sets

      iii) Clearly estimate effects. **(7+7)**

7. a) Explain analysis of 2^n factorial experiment in 'r' replicates.

   b) Describe basic principles of Design of Experiments. **(7+7)**

SLR-MM – 517

Seat No.	

M.Sc. (Part – I) (Sem. – II) Examination, 2015
(Old – CGPA)
STATISTICS (Paper – VII)
Linear Models and Design of Experiments

Day and Date : Thursday, 19-11-2015 Total Marks : 70

Time : 10.30 a.m. to 1.00 p.m.

Instructions : *1) Attempt **five** questions.*

*2) Q. No. **1** and Q. No. **2** are **compulsory**.*

*3) Attempt **any three** from Q. No. **3** to Q. No. **7**.*

*4) Figures to the **right** indicate **full** marks.*

1. A) Select the correct alternative : **5**

1) Let $E(Y_1) = \theta_1 + \theta_2$, $E(Y_2) = \theta_1 - \theta_2$, $E(Y_3) = \theta_1$, $V(Y_i) = \sigma^2$; $i = 1, 2, 3$. Let $\hat{\theta}_i$ be the least square estimator of θ_i. Which of the following statement is correct ?

a) $\hat{\theta}_1 = \dfrac{Y_1 + Y_2 + Y_3}{2}$ b) $\hat{\theta}_2 = \dfrac{Y_1 + Y_2 + Y_3}{2}$

c) $V(\hat{\theta}_1) = \dfrac{3\sigma^2}{4}$ d) $V(\hat{\theta}_2) = \dfrac{\sigma^2}{2}$

2) An experimenter wishes to compare 8 treatments in blocks of size 4, using BIBD with 14 blocks, then any pair of treatments appear together in _____ blocks.

a) 4 b) 3 c) 2 d) 1

3) In a connected block design with v treatments and b blocks, rank of D matrix is

a) v – 1 b) b – 1 c) v + 1 d) b + 1

P.T.O.

4) In the linear model $y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$, i = 1, 2, 3, j = 1, 2, 3, 4, the number of linearly independent estimable parametric functions is

a) 12 b) 3 c) 4 d) 7

5) From an RBD with 4 treatments and 5 blocks one block is removed, then the resulting design is

a) CRD b) BIBD c) LSD d) RBD

B) Fill in the blanks : **5**

1) In a general linear model, the covariance between any linear function belonging to the error space and any BLUE is _____

2) The BLUE of a treatment contrast $\sum_i c_i\alpha_i$ in one-way ANOVA model is _____

3) The degrees of freedom of error SS in two-way without interaction ANOCOVA model with p rows, q columns, 1 observation per cell and 1 covariate is _____

4) In a general block design, covariance between adjusted treatment totals and block totals is _____

5) In a general linear model, $\underline{y} = X\underline{\beta} + \underline{\varepsilon}$, a linear parametric function $\underline{\lambda}'\underline{\beta}$ is estimable if and only if $\underline{\lambda}'$ = _____

C) State **true** or **false** : **4**

1) In a general linear model, the normal equations are always consistent.

2) Individual parameters are not estimable in one-way and two-way ANOVA models.

3) A connected design is necessarily balanced.

4) BIBD is not orthogonal.

2. a) Define BIBD and show that it is connected, non-orthogonal and balanced.

b) Show that for BIBD with parameters (v, b, r, k, λ), $b \geq v$. **(7+7)**

3. Consider $E(Y_1) = \theta_1 + \theta_2 + \theta_3$, $E(Y_2) = E(Y_4) = \theta_1 - \theta_4$, $E(Y_3) = \theta_1 + \theta_2$ and $cov(\underline{Y}) = \sigma^2 I_n$.

a) Check whether the above model is full-rank model.

b) Obtain rank of the estimation space and rank of the error space.

c) Obtain one solution of normal equations and hence obtain BLUE of $\theta_1 + \theta_2$ if it is an estimable parametric function. **(4+4+6)**

4. a) Explain Tukey's method of comparison of k different individual means.

   b) Prove or disprove BLUE is unique.

   c) For the linear model, $\underline{y} = x\underline{\beta} + \underline{\varepsilon}$, explain conditional and unconditional sum of squares of error. **(4+4+6)**

5. a) Given below is the incidence matrix N_A of design A. Check whether the design is connected.

$$N_A = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 2 \\ 2 & 2 & 2 \end{bmatrix}$$

   b) In a general block design, show that row sums and column sums of C matrix are all zero.

   c) Obtain BLUE of $\sum_i l_i \alpha_i$, $\sum_i l_i = 0$ in the one-way ANOCOVA model with single covariate. **(3+3+8)**

6. A) Write the linear model for one-way classification with one concomitant variable. Obtain the least square estimates of its parameters. **14**

   B) Derive the test for testing the hypothesis of the equality of row effects in two-way ANOVA without interaction model with one observation per cell.

7. a) Explain the following terms :

      i) Estimation space

      ii) BIBD and its properties.

   b) In a general linear model $\underline{y} = x\underline{\beta} + \varepsilon$, develop a test for testing $H_0 : \wedge\underline{\beta} = \underline{0}$. **(8+6)**

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SLR-ES-379

Seat No.		Set	P

M.Sc. (Semester - III) (CBCS) Examination March/April-2019
Statistics
PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Day & Date: Tuesday, 30-04-2019 Max. Marks: 70
Time: 03:30 PM To 06:00 PM

Instructions: 1) All questions are compulsory.
2) Figures to the right indicate full marks.

Q.1 Choose Correct Alternative from the following. **14**

1) Confounding is necessary to reduce _____.
   a) Block size b) No. of blocks
   c) No. of factors d) All of these

2) For a 2^{6-2} experiment with defining relation I=ABCD=CDEF=ABEF is a _____ design.
   a) Resolution IV b) Resolution II
   c) Resolution III d) Resolution V

3) RBD is _____ orthogonal.
   a) Always b) Not
   c) Sometimes d) All of these

4) If there are five factors each at two levels and are conducted in two replications, then error degrees of freedom are _____.
   a) 0 b) 31
   c) 32 d) 63

5) In the field experimentation, when experimental material is heterogeneous, we use _____.
   a) CRD b) RBD
   c) LSD d) All of these

6) In one half fraction with I = +ABC is called _____ fraction.
   a) Principal b) Alternate
   c) Complementary d) Both b and c

7) The local control helps to _____.
   a) Reduce the number of treatments
   b) Maintain greater homogeneity of experiment
   c) Increase the number of plots
   d) None of these

8) If AB and BC are confounded with incomplete block in 2^n experiment, then automatically confounded effect is _____.
   a) ABC b) AC
   c) A d) B

9) The shortest word length in a defining relation is called as _____.
   a) Generator b) Alias
   c) Resolution d) All of these

10) In 3^3 factorial experiment with factors A and B, the interaction AB has _____ d.f.'s.
   a) 8 b) 4
   c) 1 d) depending on the experiment

11) For 2^k design the complete model would contain _____ effects.
   a) 2^{k-1} b) 2^k
   c) 2^k-1 d) infinitely many

12) Consider the two statements
   P: A connected design always orthogonal,
   Q: An orthogonal design is always connected.
   Which of the statement is true?
   a) Only P b) Only Q
   c) Both P and Q d) Neither P or Q

13) For error degrees of freedom to be non zero in 2^k experiment, we have _____ replicates.
   a) 1 b) At least 2
   c) Both a and b d) None of these

14) If there are four factors each at two levels and are conducted in two replications, then error degrees of freedom are _____.
   a) 0 b) 13
   c) 12 d) 16

Q.2 A) Answer the following (Any four) **08**

1) Define BIBD and Symmetric BIBD.
2) Write one way ANOVA model with its assumptions.
3) Define interaction effect and its graphical representation in factorial design.
4) Shortly discuss the 3^2 factorial experiments with 2 replications.
5) Define generator and defining contrast subgroup in fractional factorial design.

B) Write Notes on (Any two) **06**

1) Minimum Aberration Design
2) Total confounding
3) a) Resolution III b) Resolution IV in Design

Q.3 A) Answer the following (Any two) **08**

1) Define ANOCOVA model in general. State ANOCOVA model in one way case.
2) Define Single replicate design. What is the need of single replicate design?
3) Describe 2^3 factorial experiment with 2 replications. Give suitable example of it.

B) Answer the following (Any one) **06**

1) Write down the incidence matrix in case of BIBD with usual notations. Prove that in a BIBD number of blocks is greater than or equal to number of treatment.
2) Explain Main effect and interaction effect in a factorial experiments with special reference to 2^2 design. Give graphical representation of both effects.

Q.4 A) Answer the following (Any two) **10**

1) Describe stepwise procedure of construction and analysis of 2^{4-1} experiment

2) Describe one way ANOVA model and obtain the least square estimates of its parameters
3) Define BIBD. What is symmetric BIBD? Prove that in case of BIBD $r(k-1)=\lambda(v-1)$.

B) Answer the following (Any one) **04**

1) Give Yates table for 2^3 factorial experiments. State the uses of Yates table.
2) Write down layout of 2^4 confounded design in two blocks with higher order interaction is confounded.

Q.5 Answer the following (Any two) **14**

a) Discuss
1) Randomization
2) Replication
3) Local control in Design of Experiments

b) Explain full analysis of 2^3 factorial experiment with 3 replications. Give the Hypothesis under study, ANOVA table and test criterion.

c) What are fractional factorial experiments? Give its uses with suitable example.

SLR-BP – 489

Seat No.	

M.Sc. (Part – II) (Semester – III) Examination, 2015
STATISTICS (Paper – XIII)
Planning and Analysis of Industrial Experiments

Day and Date : Monday, 20-4-2015 Total Marks : 70
Time : 3.00 p.m. to 6.00 p.m.

Instructions *: 1) Attempt* ***five*** *questions.*
2) Q. No. ***1*** *and Q. No.* ***2*** *are* ***compulsory****.*
3) Attempt ***any three*** *from Q. No.* ***3*** *to Q. No.* ***7****.*
4) Figures to the ***right*** *indicate* ***full*** *marks.*

1. A) Choose the correct alternative : **5**

1) In the field experimentation, when experimental material is heterogeneous, we use _____

a) CRD b) RBD c) LSD d) None of these

2) The aliased defining relation of 2^{k-1} design is I = ABCD, then alias of A is _____

a) BCD b) ACD c) ABD d) ABC

3) The selection of p generator of 2^{k-p} fractional factorial design is in such a way that _____

a) it has lowest possible resolution
b) it has minimum aberration
c) it has highest possible resolution
d) it has maximum aberration

4) If all effects of same order are confounded with incomplete block difference, then it is said to be _____

a) complete confounding b) partial confounding
c) balanced confounding d) none of these

5) The objects which are to be compared in comparative experiment are called _____

a) blocks b) treatment
c) randomization d) all the above

P.T.O.

B) Fill in the blanks : **5**

1) In one-half fraction with I = + ABC is called _____

2) Replication reflects source of variability both _____ runs and _____ runs.

3) Residual can be check by using formula e_{ij} = _____

4) Each contrast among k treatments has _____ degrees of freedom.

5) The shortest word length is called _____

C) State whether the following statements are **True** and **False** : **4**

1) Factorial design is necessary when interaction may be present to avoid the misleading result.

2) Fractional Factorial design reduces the number of levels of size.

3) The procedure for moving sequentially along in the direction of maximization then it is said to be steepest descent.

4) In randomization the treatments are allocated to the experimental units has with equal probability.

2. a) Answer the following : **6**

i) Define orthogonal array. Give its example.

ii) What is location and dispersion modeling ?

b) Write short notes on the following : **8**

i) Total confounding.

ii) Control composite design.

3. a) Obtain a complete replicate with block size 8 for 2^5 factorial design having ABC and ADE interactions confounded simultaneously.

b) Describe a 3^2 factorial experiment with factors A and B. Give complete procedure of analysis along with the ANOVA table. **(7+7)**

4. a) Explain Taguchi in design of experiment in terms of mode and layout of the experiment.

   b) Find 2_{III}^{6-2} fraction having different aberrations. Use these fractions to state advantages of a fraction with less aberration over the other fractions. **(7+7)**

5. a) Write a short note on Response Surface Methodology (RSM). What are response surface designs ? Write a note on design for fitting the first order modes.

   b) Explain main effects and interactions in a factorial experiment with special reference to a 2^2 design. Give graphical representation to interaction in it. **(7+7)**

6. a) Explain the one quarter fraction of 2^k experiment.

   b) Describe the random effect model of one way classification. **(7+7)**

7. a) Define resolution of a design. What is resolution III, IV and V design ?

   b) Explain in brief about design of experiments. Also state the advantages and disadvantages of the same. **(7+7)**

SLR-BP – 489

Seat No.	

M.Sc. (Part – II) (Semester – III) Examination, 2015
STATISTICS (Paper – XIII)
Planning and Analysis of Industrial Experiments

Day and Date : Monday, 20-4-2015 Total Marks : 70
Time : 3.00 p.m. to 6.00 p.m.

Instructions *: 1) Attempt* ***five*** *questions.*
2) Q. No. ***1*** *and Q. No.* ***2*** *are* ***compulsory****.*
3) Attempt ***any three*** *from Q. No.* ***3*** *to Q. No.* ***7****.*
4) Figures to the ***right*** *indicate* ***full*** *marks.*

1. A) Choose the correct alternative : **5**

1) In the field experimentation, when experimental material is heterogeneous, we use _____

a) CRD b) RBD c) LSD d) None of these

2) The aliased defining relation of 2^{k-1} design is I = ABCD, then alias of A is _____

a) BCD b) ACD c) ABD d) ABC

3) The selection of p generator of 2^{k-p} fractional factorial design is in such a way that _____

a) it has lowest possible resolution
b) it has minimum aberration
c) it has highest possible resolution
d) it has maximum aberration

4) If all effects of same order are confounded with incomplete block difference, then it is said to be _____

a) complete confounding b) partial confounding
c) balanced confounding d) none of these

5) The objects which are to be compared in comparative experiment are called _____

a) blocks b) treatment
c) randomization d) all the above

P.T.O.

B) Fill in the blanks : **5**

1) In one-half fraction with I = + ABC is called _____

2) Replication reflects source of variability both _____ runs and _____ runs.

3) Residual can be check by using formula e_{ij} = _____

4) Each contrast among k treatments has _____ degrees of freedom.

5) The shortest word length is called _____

C) State whether the following statements are **True** and **False** : **4**

1) Factorial design is necessary when interaction may be present to avoid the misleading result.

2) Fractional Factorial design reduces the number of levels of size.

3) The procedure for moving sequentially along in the direction of maximization then it is said to be steepest descent.

4) In randomization the treatments are allocated to the experimental units has with equal probability.

2. a) Answer the following : **6**

i) Define orthogonal array. Give its example.

ii) What is location and dispersion modeling ?

b) Write short notes on the following : **8**

i) Total confounding.

ii) Control composite design.

3. a) Obtain a complete replicate with block size 8 for 2^5 factorial design having ABC and ADE interactions confounded simultaneously.

b) Describe a 3^2 factorial experiment with factors A and B. Give complete procedure of analysis along with the ANOVA table. **(7+7)**

4. a) Explain Taguchi in design of experiment in terms of mode and layout of the experiment.

   b) Find 2_{III}^{6-2} fraction having different aberrations. Use these fractions to state advantages of a fraction with less aberration over the other fractions. **(7+7)**

5. a) Write a short note on Response Surface Methodology (RSM). What are response surface designs ? Write a note on design for fitting the first order modes.

   b) Explain main effects and interactions in a factorial experiment with special reference to a 2^2 design. Give graphical representation to interaction in it. **(7+7)**

6. a) Explain the one quarter fraction of 2^k experiment.

   b) Describe the random effect model of one way classification. **(7+7)**

7. a) Define resolution of a design. What is resolution III, IV and V design ?

   b) Explain in brief about design of experiments. Also state the advantages and disadvantages of the same. **(7+7)**

SLR-JS-380

Seat No.	

Set P

M.Sc. (Semester - III) (CBCS) Examination Oct/Nov-2019
Statistics
PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Day & Date: Thursday, 07-11-2019 Max. Marks: 70
Time: 03:00 PM To 05:30 PM

Instructions: 1) All questions are compulsory.
2) Figures to the right indicate full marks.

Q.1 Fill in the banks by choosing correct alternatives given below. **14**

1) If there are six factors each at two levels and are conducted in two replications, then error degrees of freedom are _____.
   a) 0 b) 39
   c) 64 d) 128

2) In the field experimentation, when experimental material is heterogeneous, we use _____.
   a) CRD b) RBD
   c) LSD d) All of these

3) Smaller the experimental error _____ efficient the design.
   a) less b) more
   c) not d) none of these

4) In 3^2 factorial experiment with factors A and B, the interaction AB has _____ d.f.'s.
   a) 8 b) 4
   c) 1 d) depending on the experiment

5) In one half fraction with I=+ABC is called _____ fraction.
   a) principal b) alternate
   c) complementary d) both b and c

6) The rank of the incidence matrix in case of BIBD with v-1 treatment in b block is _____.
   a) b-1 b) v-1
   c) v d) bv-1

7) The aliased defining relation of 2^{k-1} design is I=ABCD, then a alias of AB is _____.
   a) ACD b) BCD
   c) ABD d) CD

8) The objects which are to be compared in comparative experiment are called _____.
   a) treatment b) blocks
   c) unit d) none of these

9) If ABC and BCD are confounded with incomplete block in 2^n experiment, then automatically confounded effect is _____.
   a) ABC b) AC
   c) AD d) B

10) For 2^4 design the complete model would contain _____ effects.
a) 16 b) 14
c) 15 d) 32

11) BIBD is _____ orthogonal.
a) Always b) Not
c) Sometimes d) All of these

12) Preferably _____ interactions is chosen for confounding.
a) low order b) middle order
c) higher order d) none of these

13) Confounding is necessary to reduce _____.
a) Block size b) No. of blocks
c) No. of factors d) All of these

14) In the design matrix of Randomized block design all entries are _____.
a) One b) zero
c) zero and one d) any value between-1 and +1

Q.2 A) Answer the following questions. (Any Four) **08**

1) Define main effect and interaction effect in factorial design.
2) Define Balancedness in design.
3) Write down two way ANOVA without interaction model with its assumptions.
4) Show that the Randomized Block Design is orthogonal design.
5) Write down aliases structure for 2^{3-1} design with generator as a higher order interaction.

B) Write short notes. (Any Two) **06**

1) 2_{III}^{6-2} fractional factorial design
2) Complete confounding
3) i) Resolution IV
ii) Resolution V in Design

Q.3 A) Answer the following questions. (Any Two) **08**

1) Define half fraction of 2^4 design with ABCD as g defining generator. Write a alias structure of it.
2) Discuss the use of confounding. State and describe the types of confounding.
3) Define BIBD. Obtain the determinant of incidence matrix in case of symmetric BIBD.

B) Answer the following questions. (Any One) **06**

1) Describe two way ANOVA without interaction model with one observation per cell and obtain least square estimates of its parameter.
2) Define confounding. State its advantages and disadvantages.

Q.4 A) Answer the following questions. (Any Two) **10**

1) Explain $\frac{1}{4}^{th}$ fraction of 2^k experiment. Construct $\frac{1}{4}^{th}$ fraction of 2^6 design with suitable example.
2) Discuss the two way ANOVA without interaction and ANOCOVA in one way case.
3) Describe the 2^3 factorial experiments. Explain the Yates procedure in case of 2^3 designs.

B) Answer the following questions. (Any One) **04**

1) Write down layout of 2^4 confounded design in two blocks with higher order interaction is confounded.
2) Define
   i) Principle Fraction
   ii) Randomization in Design of Experiment

Q.5 Answer the following questions. (Any Two) **14**

a) Discuss the basic principles of Design of Experiments.

b) What are fractional factorial experiments? Illustrate with r = 1 and r = 2 one example.

c) State difference between analysis of 2^2 factorial experiments with r = 2. Explain full analysis of 2^2 factorial experiments for r = 1 and r = 2.

SLR-BP – 483

Seat No.	

M.Sc. (Part – I) (Semester – II) Examination, 2015
STATISTICS (Paper – VII) (Old)
Linear Models and Design of Experiments

Day and Date : Saturday, 18-4-2015 Total Marks : 70
Time : 11.00 a.m. to 2.00 p.m.

***Instructions** : 1) Attempt **five** questions.*
*2) Q. No. **1** and Q. No. **2** are **compulsory**.*
*3) Attempt **any three** from Q. No. **3** to Q. No. **7**.*
*4) Figures to the **right** indicate **full** marks.*

1. A) Select the correct alternative :

1) In general linear model, any linear function belonging to the error space and any BLUE are

a) Positively correlated b) Uncorrelated

c) Negatively correlated d) Correlated

2) The rank of the estimation space in one-way ANOVA model with *N* observations and *k* levels of treatment is

a) N – k b) k – 1 c) k d) N – k – 1

3) For a BIBD with usual notation, $\lambda(\nu - l)$ =

a) k (r – 1) b) k (r + 1) c) r (k + 1) d) r (k – 1)

4) In a connected block design with ν treatments and b blocks, rank of C matrix is

a) $\nu - 1$ b) $\nu + 1$ c) ν d) $\nu b - 1$

5) In a general linear model, the normal equation are

a) always consistent b) not always consistent

c) always inconsistent d) not always in consistent

P.T.O.

B) Fill in the blanks :

1) In general linear model $y = X\beta + \in$, a particular solution of the normal equations is _____

2) The rank of the estimation space in two-way ANOVA without interaction model with p rows and q columns and with one observation per cell is _____

3) A block design is _____ if and only if $CR^{-\delta} N = 0$.

4) The degrees of freedom of error SS in two-way ANOVA with interaction model with p rows and q columns and with r > 1 observation per cell is _____

5) The degrees of freedom of error SS in two-way without interaction ANOCOVA model with p rows, q columns, m observation per cell and m covariate is _____ **(1×5=5)**

C) State **True** or **False** :

1) In a general linear model, if S^- is g-inverse of $S = X'X$, its transpose is not in general g-inverse of S.

2) $\mu + \alpha_i$, i = 1, 2, ..., k, are estimable in one-way ANOVA model with k levels of treatment.

3) In a general linear model $y = X\beta + \in$, the quantity XS^-X' is invariant under the choice of g-inverse of $S = X'X$.

4) A balanced design is always connected. **(1×4=4)**

2. a) i) Show that any solution of normal equations minimizes residual sum of squares.

ii) Prove or disprove that a connected design is always balanced. **(3+3)**

b) Write short notes on the following :

i) Estimation space.

ii) Tuckey's procedure of multiple comparisons. **(4+4)**

3. a) Show that in general linear model $y = X\beta + \in$

   i) $H = H^2$

   ii) $SH = H$

   iii) rank (H) = trace (H) = rank (S) = rank (X), where $S = X'X$, $H = S^{-} S$, S^{-} being g-inverse of S. **(2+2+3)**

   b) Prove that in a general linear model $y = X\beta + \in$, the BLUE of every estimable linear parametric function is a linear function of the LHS of normal equations, and conversely, any linear function of the LHS of normal equations is the BLUE of its expected value. **7**

4. a) Describe one-way ANOVA model and obtain the least square estimates of its parameters.

   b) Derive the test for testing the hypothesis of the equality of row effects in two-way ANOVA without interaction model with one observation per cell. **(7+7)**

5. a) Show that in general block design, adjusted treatment totals and block totals are uncorrelated.

   b) State and prove a necessary and sufficient condition for orthogonality of a connected block design. **(7+7)**

6. a) Describe ANOCOVA model in general and obtain the least square estimates of its parameters.

   b) Describe two-way with interaction ANOVA model with $r > 1$ observations per cell and obtain the least square estimates of its parameters. **(7+7)**

7. a) State and prove Gauss-Morkoff theorem.

   b) Prove that in a BIBD, the number of blocks is greater than or equal to the number of treatments. **(7+7)**

SLR-BP – 483

Seat No.	

M.Sc. (Part – I) (Semester – II) Examination, 2015
STATISTICS (Paper – VII) (Old)
Linear Models and Design of Experiments

Day and Date : Saturday, 18-4-2015 Total Marks : 70
Time : 11.00 a.m. to 2.00 p.m.

***Instructions** : 1) Attempt **five** questions.*
*2) Q. No. **1** and Q. No. **2** are **compulsory**.*
*3) Attempt **any three** from Q. No. **3** to Q. No. **7**.*
*4) Figures to the **right** indicate **full** marks.*

1. A) Select the correct alternative :

1) In general linear model, any linear function belonging to the error space and any BLUE are

a) Positively correlated b) Uncorrelated

c) Negatively correlated d) Correlated

2) The rank of the estimation space in one-way ANOVA model with *N* observations and *k* levels of treatment is

a) N – k b) k – 1 c) k d) N – k – 1

3) For a BIBD with usual notation, $\lambda(\nu - l)$ =

a) k (r – 1) b) k (r + 1) c) r (k + 1) d) r (k – 1)

4) In a connected block design with ν treatments and b blocks, rank of C matrix is

a) $\nu - 1$ b) $\nu + 1$ c) ν d) $\nu b - 1$

5) In a general linear model, the normal equation are

a) always consistent b) not always consistent

c) always inconsistent d) not always in consistent

P.T.O.

B) Fill in the blanks :

1) In general linear model $y = X\beta + \in$, a particular solution of the normal equations is _____

2) The rank of the estimation space in two-way ANOVA without interaction model with p rows and q columns and with one observation per cell is _____

3) A block design is _____ if and only if $CR^{-\delta} N = 0$.

4) The degrees of freedom of error SS in two-way ANOVA with interaction model with p rows and q columns and with r > 1 observation per cell is _____

5) The degrees of freedom of error SS in two-way without interaction ANOCOVA model with p rows, q columns, m observation per cell and m covariate is _____ **(1×5=5)**

C) State **True** or **False** :

1) In a general linear model, if S^- is g-inverse of $S = X'X$, its transpose is not in general g-inverse of S.

2) $\mu + \alpha_i$, i = 1, 2, ..., k, are estimable in one-way ANOVA model with k levels of treatment.

3) In a general linear model $y = X\beta + \in$, the quantity XS^-X' is invariant under the choice of g-inverse of $S = X'X$.

4) A balanced design is always connected. **(1×4=4)**

2. a) i) Show that any solution of normal equations minimizes residual sum of squares.

ii) Prove or disprove that a connected design is always balanced. **(3+3)**

b) Write short notes on the following :

i) Estimation space.

ii) Tuckey's procedure of multiple comparisons. **(4+4)**

3. a) Show that in general linear model $y = X\beta + \in$

   i) $H = H^2$

   ii) $SH = H$

   iii) rank (H) = trace (H) = rank (S) = rank (X), where $S = X'X$, $H = S^{-} S$, S^{-} being g-inverse of S. **(2+2+3)**

   b) Prove that in a general linear model $y = X\beta + \in$, the BLUE of every estimable linear parametric function is a linear function of the LHS of normal equations, and conversely, any linear function of the LHS of normal equations is the BLUE of its expected value. **7**

4. a) Describe one-way ANOVA model and obtain the least square estimates of its parameters.

   b) Derive the test for testing the hypothesis of the equality of row effects in two-way ANOVA without interaction model with one observation per cell. **(7+7)**

5. a) Show that in general block design, adjusted treatment totals and block totals are uncorrelated.

   b) State and prove a necessary and sufficient condition for orthogonality of a connected block design. **(7+7)**

6. a) Describe ANOCOVA model in general and obtain the least square estimates of its parameters.

   b) Describe two-way with interaction ANOVA model with $r > 1$ observations per cell and obtain the least square estimates of its parameters. **(7+7)**

7. a) State and prove Gauss-Morkoff theorem.

   b) Prove that in a BIBD, the number of blocks is greater than or equal to the number of treatments. **(7+7)**

SLR-BP – 489

Seat No.	

M.Sc. (Part – II) (Semester – III) Examination, 2015
STATISTICS (Paper – XIII)
Planning and Analysis of Industrial Experiments

Day and Date : Monday, 20-4-2015 Total Marks : 70
Time : 3.00 p.m. to 6.00 p.m.

Instructions *: 1) Attempt* ***five*** *questions.*
2) Q. No. ***1*** *and Q. No.* ***2*** *are* ***compulsory****.*
3) Attempt ***any three*** *from Q. No.* ***3*** *to Q. No.* ***7****.*
4) Figures to the ***right*** *indicate* ***full*** *marks.*

1. A) Choose the correct alternative : **5**

1) In the field experimentation, when experimental material is heterogeneous, we use _____

a) CRD b) RBD c) LSD d) None of these

2) The aliased defining relation of 2^{k-1} design is I = ABCD, then alias of A is _____

a) BCD b) ACD c) ABD d) ABC

3) The selection of p generator of 2^{k-p} fractional factorial design is in such a way that _____

a) it has lowest possible resolution
b) it has minimum aberration
c) it has highest possible resolution
d) it has maximum aberration

4) If all effects of same order are confounded with incomplete block difference, then it is said to be _____

a) complete confounding b) partial confounding
c) balanced confounding d) none of these

5) The objects which are to be compared in comparative experiment are called _____

a) blocks b) treatment
c) randomization d) all the above

P.T.O.

B) Fill in the blanks : **5**

1) In one-half fraction with I = + ABC is called _____

2) Replication reflects source of variability both _____ runs and _____ runs.

3) Residual can be check by using formula e_{ij} = _____

4) Each contrast among k treatments has _____ degrees of freedom.

5) The shortest word length is called _____

C) State whether the following statements are **True** and **False** : **4**

1) Factorial design is necessary when interaction may be present to avoid the misleading result.

2) Fractional Factorial design reduces the number of levels of size.

3) The procedure for moving sequentially along in the direction of maximization then it is said to be steepest descent.

4) In randomization the treatments are allocated to the experimental units has with equal probability.

2. a) Answer the following : **6**

i) Define orthogonal array. Give its example.

ii) What is location and dispersion modeling ?

b) Write short notes on the following : **8**

i) Total confounding.

ii) Control composite design.

3. a) Obtain a complete replicate with block size 8 for 2^5 factorial design having ABC and ADE interactions confounded simultaneously.

b) Describe a 3^2 factorial experiment with factors A and B. Give complete procedure of analysis along with the ANOVA table. **(7+7)**

4. a) Explain Taguchi in design of experiment in terms of mode and layout of the experiment.

   b) Find 2_{III}^{6-2} fraction having different aberrations. Use these fractions to state advantages of a fraction with less aberration over the other fractions. **(7+7)**

5. a) Write a short note on Response Surface Methodology (RSM). What are response surface designs ? Write a note on design for fitting the first order modes.

   b) Explain main effects and interactions in a factorial experiment with special reference to a 2^2 design. Give graphical representation to interaction in it. **(7+7)**

6. a) Explain the one quarter fraction of 2^k experiment.

   b) Describe the random effect model of one way classification. **(7+7)**

7. a) Define resolution of a design. What is resolution III, IV and V design ?

   b) Explain in brief about design of experiments. Also state the advantages and disadvantages of the same. **(7+7)**

SLR-BP – 483

Seat No.	

M.Sc. (Part – I) (Semester – II) Examination, 2015
STATISTICS (Paper – VII) (Old)
Linear Models and Design of Experiments

Day and Date : Saturday, 18-4-2015 Total Marks : 70
Time : 11.00 a.m. to 2.00 p.m.

***Instructions** : 1) Attempt **five** questions.*
*2) Q. No. **1** and Q. No. **2** are **compulsory**.*
*3) Attempt **any three** from Q. No. **3** to Q. No. **7**.*
*4) Figures to the **right** indicate **full** marks.*

1. A) Select the correct alternative :

1) In general linear model, any linear function belonging to the error space and any BLUE are

a) Positively correlated b) Uncorrelated

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2) The rank of the estimation space in one-way ANOVA model with *N* observations and *k* levels of treatment is

a) N – k b) k – 1 c) k d) N – k – 1

3) For a BIBD with usual notation, $\lambda(\nu - l)$ =

a) k (r – 1) b) k (r + 1) c) r (k + 1) d) r (k – 1)

4) In a connected block design with ν treatments and b blocks, rank of C matrix is

a) $\nu - 1$ b) $\nu + 1$ c) ν d) $\nu b - 1$

5) In a general linear model, the normal equation are

a) always consistent b) not always consistent

c) always inconsistent d) not always in consistent

P.T.O.

B) Fill in the blanks :

1) In general linear model $y = X\beta + \in$, a particular solution of the normal equations is _____

2) The rank of the estimation space in two-way ANOVA without interaction model with p rows and q columns and with one observation per cell is _____

3) A block design is _____ if and only if $CR^{-\delta} N = 0$.

4) The degrees of freedom of error SS in two-way ANOVA with interaction model with p rows and q columns and with r > 1 observation per cell is _____

5) The degrees of freedom of error SS in two-way without interaction ANOCOVA model with p rows, q columns, m observation per cell and m covariate is _____ **(1×5=5)**

C) State **True** or **False** :

1) In a general linear model, if S^- is g-inverse of $S = X'X$, its transpose is not in general g-inverse of S.

2) $\mu + \alpha_i$, i = 1, 2, ..., k, are estimable in one-way ANOVA model with k levels of treatment.

3) In a general linear model $y = X\beta + \in$, the quantity XS^-X' is invariant under the choice of g-inverse of $S = X'X$.

4) A balanced design is always connected. **(1×4=4)**

2. a) i) Show that any solution of normal equations minimizes residual sum of squares.

ii) Prove or disprove that a connected design is always balanced. **(3+3)**

b) Write short notes on the following :

i) Estimation space.

ii) Tuckey's procedure of multiple comparisons. **(4+4)**

3. a) Show that in general linear model $y = X\beta + \in$

   i) $H = H^2$

   ii) $SH = H$

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   b) Prove that in a general linear model $y = X\beta + \in$, the BLUE of every estimable linear parametric function is a linear function of the LHS of normal equations, and conversely, any linear function of the LHS of normal equations is the BLUE of its expected value. **7**

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   b) Derive the test for testing the hypothesis of the equality of row effects in two-way ANOVA without interaction model with one observation per cell. **(7+7)**

5. a) Show that in general block design, adjusted treatment totals and block totals are uncorrelated.

   b) State and prove a necessary and sufficient condition for orthogonality of a connected block design. **(7+7)**

6. a) Describe ANOCOVA model in general and obtain the least square estimates of its parameters.

   b) Describe two-way with interaction ANOVA model with $r > 1$ observations per cell and obtain the least square estimates of its parameters. **(7+7)**

7. a) State and prove Gauss-Morkoff theorem.

   b) Prove that in a BIBD, the number of blocks is greater than or equal to the number of treatments. **(7+7)**

SLR-VB – 7

Seat No.	

M.Sc. (Part – I) (Semester – II) Examination, 2014
STATISTICS (Paper – VII)
Linear Models and Design of Experiments

Day and Date : Thursday, 24-4-2014 Max. Marks : 70

Time : 11.00 a.m. to 2.00 p.m.

Instructions *: 1) Attempt* ***five*** *questions.*

*2) Q. No. (**1**) and Q. No. (**2**) are* ***compulsory****.*

3) Attempt ***any three*** *from Q. No. (**3**) to Q. No. (**7**).*

4) Figures to the ***right*** *indicate* ***full*** *marks.*

1. A) Choose correct alternative : **5**

1) Suppose $\hat{\beta}_1$ and $\hat{\beta}_2$ are two different solutions of normal equations $X'X\hat{\beta} = X'Y$ then which of the following statement is true ?

a) $X'X\hat{\beta}_1 = X'X\hat{\beta}_2$ b) $\hat{\beta}_1 = \hat{\beta}_2$

c) $V(\hat{\beta}_1) = V(\hat{\beta}_2)$ d) $E(\hat{\beta}_1) = E(\hat{\beta}_2)$

2) The degrees of freedom (d.f.) associated with error sum of squares for two-way classification without with one observation per cell when factor A is not at 'a' levels and factor B at 'b' are _____

a) $(a-1)(b-1)$ b) $b(a-1)$

c) $ab-1$ d) $a(b-1)$

3) If $X_1, X_2, X_3, ...X_n$ are iid then $\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$ and $\frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})^2$ are _____

a) iid b) independently distributed

c) identically distributed d) not idd

P.T.O.

4) Assume that $X_i \sim N(0, 1)$, i = 1, 2, ... and independently distributed then the quadratic form $X'AX$ is distributed as _____

   a) Chi-square with d.f. equal to R(A)

   b) Chi-square with d.f. equal to R(A) if A is idempotent

   c) Chi-square with d.f. equal to Rank (A^2)

   d) Chi-square with d.f. equal to trace (A)

5) The LSE of β in the full rank linear model $Y = \alpha + \beta X + \varepsilon$ is _____

   a) inconsistent b) biased

   c) unbiased d) none of these

B) Fill in the blanks : **5**

1) In the Gauss-Markov model $\left(Y_{n\times 1}, A\theta, \sigma^2 I_n\right)$, with rank (A) = m, E(RSS) is equal to _____

2) In Gauss-Markov model, the sampling distribution of the test statistic for testing a linear hypothesis is _____ distribution.

3) In the Gauss-Markov model, an unbiased estimated of the error variance is _____

4) If $l'\theta$ is an estimable linear parametric function in a Gauss-Markov model $\left(Y, A\theta, \sigma^2 I_n\right)$ with $l'\hat{\theta}$, Cov $(l'\hat{\theta}, Y - A\hat{\theta})$ = _____

5) The error space and estimation space are _____ of each other.

C) State whether the following statement are **true (T)** or **false (F)** : **4**

1) If columns of X matrix are mutually orthogonal then all linear parametric functions are estimable.

2) In two way classification with interaction and with one observation per cell, an estimate of σ^2 is always available.

3) The assumption of normality is required for testing hypothesis regarding the parameter in the usual linear model.

4) If $\underline{X} \sim N\left(\underline{0}, \sigma^2 I\right)$ $\underline{X}' A \underline{X}$ and $\underline{X}' B \underline{X}$ are independently distributed then $AB = 0$

2. a) Consider the following two full rank models :

i) $Y_i = \alpha + \beta (X_i - \overline{X}) + \varepsilon_i$, $i = 1, 2, ..., n$

ii) $Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$, $i = 1, 2, ..., n$.

1) Obtain LSE of the parameters of both models.

2) Show that the estimates $\hat{Y}_1$, $i = 1, 2, ..., n$ obtained from both the models are same.

b) Write short notes on the following :

1) Inter block analysis

2) Tukey's test for additivity. **(6+8)**

3. a) State and prove Gauss-Markov theorem.

b) Suppose $E(Y_1) = E(Y_2) = \theta$ and $V(Y_1) = 5\sigma^2$, $Cov(Y_1, Y_2) = \sigma^2$ and $V(Y_2) = 2\sigma^2$. Obtain BLUE of θ. **(8+6)**

4. a) Explain the following terms :

i) Error space

ii) Estimable parametric function

iii) Estimation space.

b) Explain the one-way ANOVA non full rank model. Write this model in matrix form. Examine which parametric functions are estimable under this model. Obtain the BLUE $\hat{\psi}$ if exists, of $\psi = \sum a_i \alpha_i$, where a_i are known constants and $\sum a_i = 0$. **(6+8)**

5. a) Obtain C-matrix of BIBD and show that all treatment contrasts are estimable. Obtain BLUE and its variance for treatment contrast.

   b) Write down ANOCOVA model with single covariate with assumptions. Obtain BLUE of contrast $\alpha_i - \alpha_u (i \neq u)$ and its variance, where α's are the parameters involved in the model. **(8+6)**

6. a) Obtain a condition for a connected design to be orthogonal.

   b) Explain Scheffe's multiple comparison procedure. **(6+8)**

7. a) State general block design model. Obtain reduced normal equations for estimating treatment effects.

   b) Develop a test for testing no interaction in two way ANOVA model with r > 1 observations per cell. **(6+8)**
