**Roll No. .....**

| Question Booklet Number |
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**O. M. R. Serial No.**

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# M. Sc. (Second Semester)
# (NEP) EXAMINATION, 2025-26
## STATISTICS
## (Design of Experiments)

| Paper Code | | | | | | | |
|---|---|---|---|---|---|---|---|
| B | 0 | 6 | 0 | 8 | 0 | 2 | T |

| Questions Booklet Series |
|---|
| D |

*Time : 1:30 Hours* ] [ *Maximum Marks : 75*

**Instructions to the Examinee :**

1. Do not open the booklet unless you are asked to do so.

2. The booklet contains 100 questions. Examinee is required to answer 75 questions in the OMR Answer-Sheet provided and not in the question booklet. All questions carry equal marks.

3. Examine the Booklet and the OMR Answer-Sheet very carefully before you proceed. Faulty question booklet due to missing or duplicate pages/questions or having any other discrepancy should be got immediately replaced.

**परीक्षार्थियों के लिए निर्देश :**

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।

2. प्रश्न-पुस्तिका में 100 प्रश्न हैं। परीक्षार्थी को 75 प्रश्नों को केवल दी गई OMR आन्सर-शीट पर ही हल करना है, प्रश्न-पुस्तिका पर नहीं। सभी प्रश्नों के अंक समान हैं।

3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR आन्सर-शीट को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका जिसमें कुछ भाग छपने से छूट गए हों या प्रश्न एक से अधिक बार छप गए हों या उसमें किसी अन्य प्रकार की कमी हो, तो उसे तुरन्त बदल लें।

**(Remaining instructions on the last page)** **(शेष निर्देश अन्तिम पृष्ठ पर)**

*(Only for Rough Work)*

1. The main disadvantage of fractional factorial design is :

   (A) Large cost

   (B) Increased aliasing

   (C) Too many runs

   (D) No confounding

2. In fractional replication, generators are used to :

   (A) Increase block size

   (B) Define which treatment combinations to include

   (C) Estimate error variance

   (D) Remove interaction

3. The number of two-factor interactions in a $2^k$ design is :

   (A) $k$

   (B) $\binom{k}{2}$

   (C) $2^k$

   (D) $k^2$

4. In unreplicated $2^k$ designs, Lenth's method is used for :

   (A) Estimating blocks.

   (B) Identifying active effects

   (C) Calculating sample size

   (D) Testing normality

5. In testing factorial effects, the denominator of F-ratio is :

   (A) Treatment mean square

   (B) Block mean square

   (C) Error mean square

   (D) Total mean square

6. Orthogonal contrasts in factorial experiments ensure :

   (A) Dependent estimates

   (B) Minimum variance and independent estimation

   (C) Larger bias

   (D) Confounding

7. In symmetric factorial $s^k$, "$s$" represents :

   (A) Sample size

   (B) Number of factors

   (C) Number of levels of each factor

   (D) Blocks

8. In Resolution IV design :

   (A) Main effects are aliased with main effects

   (B) Main effects are aliased with two-factor interactions

   (C) Main effects are clear of two-factor interactions

   (D) All effects are confounded

9. The defining relation in fractional factorial design determines :

(A) Sample size

(B) Alias structure

(C) Block size

(D) Error variance

10. A half-fraction of a $2^4$ design contains :

(A) 4 runs

(B) 8 runs

(C) 16 runs

(D) 2 runs

11. Fractional replication is mainly used to :

(A) Increase precision

(B) Reduce number of runs

(C) Eliminate blocking

(D) Increase replications

12. In a $3^2$ symmetric factorial design, the total treatment combinations are :

(A) 6

(B) 9

(C) 8

(D) 12

13. The primary reason for confounding is to :

(A) Increase error variance

(B) Accommodate blocking when block size is smaller than total treatments

(C) Reduce sample size

(D) Increase interaction

14. Partial confounding differs from complete confounding because :

(A) Effect is confounded in some replicates but not all

(B) No confounding exists

(C) All effects are confounded

(D) Blocks are absent

15. In complete confounding of a $2^3$ design in two blocks, the confounded effect is usually :

(A) Main effect

(B) Lowest order interaction

(C) Highest order interaction

(D) Mean

16. Complete confounding occurs when :

(A) All effects are clear

(B) A treatment effect is totally aliased with a block effect

(C) Sample size doubles

(D) No interaction exists

17. In unreplicated factorial experiments, significance of effects may be tested using :

(A) *t*-test with pure error

(B) Normal probability plot of effects

(C) Chi-square test

(D) Paired test

18. Testing significance of factorial effects is generally done using :

(A) Z-test

(B) F-test

(C) Chi-square test

(D) Sign test

19. The variance of an estimated main effect in a replicated $2^k$ design is proportional to :

(A) Error variance divided by number of replications

(B) Treatment mean

(C) Block size

(D) Interaction effect

20. The best estimate of a factorial effect in a replicated experiment is obtained using :

(A) Median

(B) Least squares estimator

(C) Maximum likelihood under non-normality

(D) Sample variance

21. The factorial effect in a $2^2$ design is estimated as :

(A) Sum of treatment means

(B) Difference between high and low level averages

(C) Block mean

(D) Residual mean square

22. In a $2k$ factorial experiment, the total number of effects (including interaction and mean) is :

(A) $2^k$

(B) $k$

(C) $2k$

(D) $k + 1$

23. In a $2^k$ factorial design, the number of main effects is :

(A) 2

(B) $k$

(C) $2k$

(D) $2^k$

24. The main effect of a factor is defined as :

(A) Difference between maximum and minimum response

(B) Average change in response due to change in factor level

(C) Interaction between two factors

(D) Block effect

25. In a general $a \times b$ factorial experiment, the total number of treatment combinations is :

(A) $a + b$

(B) $ab$

(C) $a^b$

(D) $b^a$

26. The main advantage of lattice design over RCBD is :

(A) Simpler analysis

(B) Higher precision for large number of treatments

(C) No confounding

(D) No replication needed

27. A necessary condition for existence of BIBD is :

(A) $\lambda(v - 1)$ divisible by $(k - 1)$

(B) $v = k$

(C) $r = 1$

(D) $b = 1$

28. The expected mean square for treatments in BIBD contains :

(A) Only error variance

(B) Treatment variance component

(C) Block variance only

(D) No variance

29. Recovery of inter-block information is possible when blocks are considered :

(A) Fixed effects

(B) Random effects

(C) Absent

(D) Constant

30. In BIBD, treatment concurrence matrix shows :

(A) Number of blocks

(B) Pairwise occurrences of treatments

(C) Block sizes

(D) Error variance

31. The analysis of lattice design involves adjustment for :

(A) Rows only

(B) Columns only

(C) Incomplete blocks

(D) Interaction

32. In triple lattice design the number of replications is :

(A) 1

(B) 2

(C) 3

(D) $k$

33. Lattice designs are especially useful when :

(A) Number of treatments is small

(B) Number of treatments is large

(C) No blocking required

(D) Only two treatments exist

34. In a simple lattice design, number of replications is usually :

(A) 1

(B) 2

(C) 3

(D) $k$

35. A simple lattice design is suitable when number of treatments equals :

(A) $k$

(B) $k^2$

(C) $2k$

(D) $v - 1$

36. In symmetric BIBD :

(A) $v = b$

(B) $r = k$

(C) Both (A) and (B)

(D) $\lambda = 0$

37. If $\lambda = 1$ in BIBD, the design is called :

(A) Simple BIBD

(B) Pairwise balanced

(C) Symmetric design

(D) Lattice design

38. The information matrix of BIBD is :

(A) Diagonal

(B) Singular

(C) Symmetric with special structure

(D) Zero matrix

39. Efficiency factor in BIBD compares it with :

(A) CRD

(B) Latin square design

(C) RCBD

(D) Split plot design

40. The variance of adjusted treatment mean in BIBD depends on :

(A) $v$ only

(B) $r$, $k$ and $\lambda$

(C) $b$ only

(D) Error degrees of freedom only

41. In BIBD, treatment effects are estimated using :

(A) Ordinary means only

(B) Adjusted treatment means

(C) Median

(D) Mode

42. Recovery of inter-block information improves :

(A) Bias

(B) Precision of treatment estimates

(C) Block size

(D) Number of treatments

43. Inter-block information refers to information obtained from :

(A) Within-block comparisons

(B) Between-block variation

(C) Treatment replication only

(D) Error variance only

44. Intra-block analysis in BIBD primarily uses :

(A) Block totals

(B) Within-block contrasts

(C) Treatment totals only

(D) Overall mean only

45. A BIBD becomes a complete block design when :

(A) $k = v$

(B) $\lambda = 0$

(C) $r = 1$

(D) $b = 1$

46. In BIBD, total number of experimental units is :

(A) $v + b$

(B) $vr$

(C) $bk$

(D) Both (B) and (C)

47. The fundamental relation in BIBD is :

(A) $vr = bk$

(B) $r = \lambda(v - 1)$

(C) $r(k - 1) = \lambda(v - 1)$

(D) $b = v$

48. The parameter $\lambda$ in BIBD represents :

(A) Number of blocks

(B) Replications per treatment

(C) Number of times each pair of treatments occurs together

(D) Block size

49. In a BIBD, each block contains :

(A) All $v$ treatments

(B) $k$ ($< v$) treatments

(C) $r$ treatments

(D) $\lambda$ treatments

50. A Balanced Incomplete Block Design (BIBD) is characterized by :

(A) Equal block sizes with all treatments in each block

(B) Unequal block sizes

(C) Equal block sizes with incomplete treatment sets

(D) No replication

51. The main purpose of extending block designs to row-column designs is to :

(A) Increase treatments

(B) Control two sources of nuisance variation

(C) Eliminate replication

(D) Reduce sample size

52. In analysis of general block design, error sum of squares is obtained after removing :

(A) Treatment effects only

(B) Block effects only

(C) Both treatment and block effects

(D) Mean only

53. A design is equireplicate if :

(A) All blocks have equal size

(B) All treatments have equal replication

(C) $\lambda = 1$

(D) $v = b$

54. The rank of the design matrix in a connected block design (with mean) is :

(A) $v$

(B) $v - 1$

(C) $b$

(D) $r$

55. In row-column designs, treatment effects are orthogonal to :

(A) Error only

(B) Row and column effects

(C) Interaction only

(D) Mean only

56. In row-column design with $r$ rows and c columns, total experimental units are :

(A) $r + c$

(B) $rc$

(C) $r - c$

(D) $r^2$

57. Latin Square Design is a special case of :

(A) General block design

(B) Row-column design

(C) PBIBD

(D) CRD

58. A row-column design controls variation in :

(A) One direction only

(B) Two perpendicular directions

(C) Three directions

(D) Treatments only

59. Efficiency of a block design is measured relative to :

(A) CRD

(B) RCBD

(C) BIBD

(D) Latin square

60. The adjusted treatment effects in block designs are obtained by eliminating :

(A) Mean only

(B) Block effects

(C) Error term

(D) Interaction

61. In general block design, the normal equations are derived using :

(A) Median method

(B) Least squares principle

(C) Chi-square test

(D) Sign test

62. Association scheme in PBIBD helps in :

(A) Determining sample size

(B) Describing concurrence relationships

(C) Eliminating blocks

(D) Estimating mean only

63. In PBIBD, treatments are classified according to :

(A) Blocks

(B) Associate classes

(C) Error variance

(D) Rows only

64. A partially balanced incomplete block design (PBIBD) involves :

(A) Only one associate class

(B) More than one associate class

(C) Complete blocks

(D) No replication

65. In Balanced Incomplete Block Design, concurrence matrix has :

(A) Unequal off-diagonal elements

(B) Equal off-diagonal elements

(C) Zero diagonal elements

(D) Only diagonal elements

66. Balanced block design ensures :

(A) Equal replication and equal concurrence

(B) Unequal replication

(C) No concurrence

(D) Only one block

67. In an orthogonal block design, treatment sums of squares are :

(A) Correlated with block sums of squares

(B) Independent of block sums of squares

(C) Zero

(D) Undefined

68. Orthonormality in block designs implies :

(A) Dependent treatment contrasts

(B) Orthogonal and normalized treatment effects

(C) Confounded effects

(D) Singular matrix

69. The trace of the information matrix equals :

(A) Total number of blocks

(B) Sum of treatment replications

(C) Number of treatments

(D) $\lambda$

70. If a design is not connected, then :

(A) All contrasts are estimable

(B) Some treatment contrasts are not estimable

(C) Error variance is zero

(D) Blocks are equal

71. The necessary and sufficient condition for connectedness is that :

(A) All treatments have equal replication

(B) Rank of information matrix $= v - 1$

(C) $b = v$

(D) $r = k$

72. A block design is said to be connected if :

(A) Every treatment appears in every block

(B) The information matrix is of full rank except for mean

(C) Blocks are complete

(D) $\lambda = 1$

73. The information matrix for treatment effects in a block design is given by :

(A) NN'

(B) N'N adjusted for replication

(C) Identity matrix

(D) Zero matrix

74. In a general block design with $v$ treatments and $b$ blocks, the incidence matrix N is of order :

(A) $b \times v$

(B) $v \times b$

(C) $v \times v$

(D) $b \times b$

75. A general block design consists of :

(A) Only treatments

(B) Only blocks

(C) Treatments arranged in blocks

(D) Rows only

76. The major disadvantage of split-plot design is :

(A) Simpler layout

(B) Complicated analysis and unequal precision

(C) No replication

(D) No interaction

77. The assumption underlying ANOVA includes :

(A) Heteroscedasticity

(B) Normality and independence

(C) Autocorrelation

(D) Multicollinearity

78. In general two-way ANOVA with replication, interaction degrees of freedom is :

(A) $(r-1)(c-1)$

(B) $rc-1$

(C) $r+c-2$

(D) $r+c$

79. If main plot factor has a levels and $r$ replications, its degrees of freedom is :

(A) $a$

(B) $a-1$

(C) $r-1$

(D) $ar-1$

80. The precision of sub-plot treatments in split-plot design is generally :

(A) Less than main plot

(B) Equal to main plot

(C) Greater than main plot

(D) Zero

81. In split-plot ANOVA table, interaction between main and sub-plot factors is tested using :

(A) Main-plot error

(B) Sub-plot error

(C) Block error

(D) No error term

82. Split-plot design is commonly used in :

(A) Laboratory experiments only

(B) Agricultural field experiments

(C) Surveys

(D) Case-control studies

83. The sub-plot factor is tested against :

(A) Main-plot error

(B) Sub-plot error

(C) Block mean square

(D) Total mean square

84. For testing main-plot factor in split-plot design, F-ratio uses :

(A) Sub-plot error

(B) Main-plot error

(C) Total error

(D) Interaction mean square

85. The experimental error in split-plot design is :

(A) Single error term

(B) Two different error terms

(C) No error term

(D) Three error terms

86. In split-plot design, main plots are used for :

(A) Sub-plot factor

(B) Hard-to-change factor

(C) Error estimation only

(D) Blocking

87. Split-plot design is characterized by :

(A) Single randomization

(B) No blocking

(C) Two-stage randomization

(D) No replication

88. The purpose of estimating missing plots is to :

(A) Bias the results

(B) Maintain orthogonality and balance

(C) Increase sample size

(D) Reduce treatments

89. In Latin Square Design with one missing value, estimation uses :

(A) Row total only

(B) Column total only

(C) Row, column and treatment totals

(D) Error mean square

90. In case of two missing observations in RCBD, estimation is generally done by :

(A) Direct substitution

(B) Iterative method

(C) Ignoring the values

(D) Median imputation

91. After estimating a missing value, the error degrees of freedom are :

(A) Increased by 1

(B) Decreased by 1

(C) Unchanged

(D) Doubled

92. Estimation of a single missing observation in RCBD is based on :

(A) Median value

(B) Row and column totals

(C) Overall mean only

(D) Random selection

93. Missing plot technique is used when :

(A) All data are complete

(B) Some observations are lost

(C) Interaction is significant

(D) Blocks are absent

94. The F-ratio for testing row effects is :

(A) MS(Row)/MS(Error)

(B) MS(Column)/MS(Error)

(C) MS(Row)/MS(Column)

(D) MS(Error)/MS(Row)

95. The error degrees of freedom in two-way classification (single observation per cell) is :

(A) $(r-1)(c-1)$

(B) $rc-1$

(C) $r+c-2$

(D) $rc$

96. In two-way classification ($r \times c$), total degrees of freedom is :

(A) $rc$

(B) $rc-1$

(C) $r+c-1$

(D) $(r-1)(c-1)$

97. In two-way classification, degrees of freedom for rows ($r$ rows) is :

(A) $r$

(B) $r-1$

(C) $r+1$

(D) $r^2$

98. In two-way ANOVA (one observation per cell), interaction cannot be estimated because :

(A) Sample size is large

(B) No replication exists

(C) Error variance is zero

(D) Blocks are absent

99. The linear model for two-way classification with one observation per cell is :

(A) $Y_{ij} = \mu + \in_{ij}$

(B) $Y_{ij} = \mu + \alpha_i + \beta_j + \in_{ij}$

(C) $Y_{ij} = \mu + \alpha_i \beta_j + \in_{ij}$

(D) $Y_{ij} = \alpha_i + \beta_j$

100. In a general two-way classification (without interaction), the model assumes :

(A) No main effects

(B) Only interaction effect

(C) Additivity of row and column effects

(D) Random sampling only

*(Only for Rough Work)*

4. Four alternative answers are mentioned for each question as—A, B, C & D in the booklet. The candidate has to choose the correct answer and mark the same in the OMR Answer-Sheet as per the direction :

**Example :**

**Question :**

Q. 1 (A) ● (C) (D)
Q. 2 (A) (B) ● (D)
Q. 3 (A) ● (C) (D)

Illegible answers with cutting and over-writing or half filled circle will be cancelled.

5. Each question carries equal marks. Marks will be awarded according to the number of correct answers you have.
6. All answers are to be given on OMR Answer Sheet only. Answers given anywhere other than the place specified in the answer sheet will not be considered valid.
7. Before writing anything on the OMR Answer Sheet, all the instructions given in it should be read carefully.
8. After the completion of the examination candidates should leave the examination hall only after providing their OMR Answer Sheet to the invigilator. Candidate can carry their Question Booklet.
9. There will be no negative marking.
10. Rough work, if any, should be done on the blank pages provided for the purpose in the booklet.
11. To bring and use of log-book, calculator, pager and cellular phone in examination hall is prohibited.
12. In case of any difference found in English and Hindi version of the question, the English version of the question will be held authentic.

**Impt. :** On opening the question booklet, first check that all the pages of the question booklet are printed properly. If there is any discrepancy in the question Booklet, then after showing it to the invigilator, get another question Booklet of the same series.

4. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार सम्भावित उत्तर—A, B, C एवं D हैं। परीक्षार्थी को उन चारों विकल्पों में से सही उत्तर छाँटना है। उत्तर को OMR आन्सर-शीट में सम्बन्धित प्रश्न संख्या में निम्न प्रकार भरना है :

**उदाहरण :**

**प्रश्न :**

प्रश्न 1 (A) ● (C) (D)
प्रश्न 2 (A) (B) ● (D)
प्रश्न 3 (A) ● (C) (D)

अपठनीय उत्तर या ऐसे उत्तर जिन्हें काटा या बदला गया है, या गोले में आधा भरकर दिया गया, उन्हें निरस्त कर दिया जाएगा।

5. प्रत्येक प्रश्न के अंक समान हैं। आपके जितने उत्तर सही होंगे, उन्हीं के अनुसार अंक प्रदान किये जायेंगे।
6. सभी उत्तर केवल ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर ही दिये जाने हैं। उत्तर-पत्रक में निर्धारित स्थान के अलावा अन्यत्र कहीं पर दिया गया उत्तर मान्य नहीं होगा।
7. ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर कुछ भी लिखने से पूर्व उसमें दिये गये सभी अनुदेशों को सावधानीपूर्वक पढ़ लिया जाये।
8. परीक्षा समाप्ति के उपरान्त परीक्षार्थी कक्ष निरीक्षक को अपनी OMR Answer Sheet उपलब्ध कराने के बाद ही परीक्षा कक्ष से प्रस्थान करें। परीक्षार्थी अपने साथ प्रश्न-पुस्तिका ले जा सकते हैं।
9. निगेटिव मार्किंग नहीं है।
10. कोई भी रफ कार्य, प्रश्न-पुस्तिका के अन्त में, रफ-कार्य के लिए दिए खाली पेज पर ही किया जाना चाहिए।
11. परीक्षा-कक्ष में लॉग-बुक, कैलकुलेटर, पेजर तथा सेल्युलर फोन ले जाना तथा उसका उपयोग करना वर्जित है।
12. प्रश्न के हिन्दी एवं अंग्रेजी रूपान्तरण में भिन्नता होने की दशा में प्रश्न का अंग्रेजी रूपान्तरण ही मान्य होगा।

**महत्वपूर्ण :** प्रश्नपुस्तिका खोलने पर प्रथमतः जाँच कर देख लें कि प्रश्न-पुस्तिका के सभी पृष्ठ भलीभाँति छपे हुए हैं। यदि प्रश्नपुस्तिका में कोई कमी हो, तो कक्षनिरीक्षक को दिखाकर उसी सिरीज की दूसरी प्रश्न-पुस्तिका प्राप्त कर लें।