Post Graduate School
Indian Agricultural Research Institute, New Delhi

Examination for Admission to Ph.D. Programme 2013-2014

Discipline : Agricultural Statistics

Discipline Code : 06

Roll No. | | | | | | | |

Please Note:

(i) This question paper contains **13** pages. **Please check whether all the pages are printed in this set.** Report discrepancy, if any, **immediately** to the invigilator.

(ii) ***There shall be NEGATIVE marking for WRONG answers in the Multiple Choice type questions (No. 1 to 95) which carry one mark each. For every wrong answer 0.25 mark will be deducted.***

PART – I (General Agriculture)

Multiple choice questions (No. 1 to 30). Choose the correct answer (*a, b, c* or *d*) and enter your choice in the circle (by shading with a pencil) on the OMR - answer sheet as per the instructions given on the answer sheet.

1. Who is the present Chairman of Protection of Plant Varieties and Farmers' Right Authority (PPV&FRA)?
a) Dr. R.R. Hanchinal
b) Dr. P.L. Gautam
c) Dr. S. Nagarajan
d) Dr. Swapan K. Datta

2. Which among the following is another name for vitamin B_{12}?
a) Niacin
b) Pyridoxal phosphate
c) Cobalamin
d) Riboflavin

3. The largest share in India's farm export earning in the year 2011-12 was from
a) Basmati rice
b) Non-basmati rice
c) Sugar
d) Guar gum

4. The National Bureau of Agriculturally Important Insects was established by ICAR in ________, was earlier known as _______.
a) Bangalore; PDBC
b) New Delhi; National Pusa Collection
c) Ranchi; Indian Lac Research Institute
d) New Delhi; NCIPM

5. The most important sucking pests of cotton and rice are respectively
a) *Nilaparvata lugens* and *Aphis gossypii*
b) *Aphis gossypii* and *Thrips oryzae*
c) *Amrasca biguttula biguttula* and *Scirtothrips dorsalis*
d) *Thrips gossypii* and *Orseolia oryzae*

6. Which of the following microorganism causes fatal poisoning in canned fruits and vegetables?
a) *Aspergillus flavus*
b) *Penicillium digitatum*
c) *Clostridium botulinum*
d) *Rhizoctonia solani*

7. The cause of the great Bengal Famine was
a) Blast of rice
b) Brown spot of rice
c) Rust of wheat
d) Karnal bunt of wheat

8. Actinomycetes belong to
a) The fungi
b) Eukaryote
c) *Mycelia sterilia*
d) None of the above

9. A virus-free clone from a virus infected plant can be obtained by
a) Cotyledonary leaf culture
b) Axenic culture
c) Stem culture
d) Meristem tip culture

10. Which of the following is not an objective of the National Food Security Mission?
a) Sustainable increase in production of rice, wheat and pulses
b) Restoring soil fertility and productivity at individual farm level
c) Promoting use of bio-pesticides and organic fertilizers
d) Creation of employment opportunities

11. Agmarknet, a portal for the dissemination of agricultural marketing information, is a joint endeavour of
a) DMI and NIC
b) DMI and Ministry of Agriculture
c) NIC and Ministry of Agriculture
d) DMI and Directorate of Economics and Statistics

12. The share of agriculture and allied activities in India's GDP at constant prices in 2011-12 was
a) 14.1%
b) 14.7%
c) 15.6%
d) 17.0%

13. The average size of land holding in India according to Agricultural Census 2005-06 is
a) 0.38 ha
b) 1.23 ha
c) 1.49 ha
d) 1.70 ha

14. 'Farmers First' concept was proposed by
a) Paul Leagans
b) Neils Rolling
c) Robert Chamber
d) Indira Gandhi

15. In the year 2012, GM crops were cultivated in an area of
a) 150 million hectare in 18 countries
b) 170 million hectare in 28 countries
c) 200 million hectare in 18 countries
d) 1.70 million hectare in 28 countries

16. The broad-spectrum systematic herbicide glyphosate kills the weeds by inhibiting the biosynthesis of
a) Phenylalanine
b) Alanine
c) Glutamine
d) Cysteine

17. At harvest, the above ground straw (leaf, sheath and stem) weight and grain weight of paddy crop are 5.5 and 4.5 tonnes per hectare, respectively. What is the harvest index of paddy?
a) 45%
b) 50%
c) 55%
d) 100%

18. Crossing over between non-sister chromatids of homologous chromosomes takes place during
a) Leptotene
b) Pachytene
c) Diplotene
d) Zygotene

19. The term 'Heterosis' was coined by
a) G.H. Shull
b) W. Bateson
c) T.H. Morgan
d) E.M. East

20. When a transgenic plant is crossed with a non-transgenic, what would be the zygosity status of the F_1 plant?
a) Homozygous
b) Heterozygous
c) Hemizygous
d) Nullizygous

21. The highest per capita consumption of flowers in the world is in
a) The USA
b) India
c) Switzerland
d) The Netherlands

22. Which of the following is a very rich source of betalain pigment?
a) Radish
b) Beet root
c) Carrot
d) Red cabbage

23. Dog ridge is
a) Salt tolerant rootstocks of mango
b) Salt tolerant rootstocks of guava
c) Salt tolerant rootstocks of grape
d) Salt tolerant rootstocks of citrus

24. Which of the following micronutrients are most widely deficient in Indian soils?
a) Zinc and boron
b) Zinc and iron
c) Zinc and manganese
d) Zinc and copper

25. Which of the following fertilizers is not produced in India?
a) DAP
b) Urea
c) Muriate of potash
d) TSP

26. What is the estimated extent of salt affected soils in India?
a) 5.42 mha
b) 7.42 mha
c) 11.42 mha
d) 17.42 mha

27. Which of the following is not a feature of watershed?
a) Hydrological unit
b) Biophysical unit
c) Socio-economic unit
d) Production unit

28. Correlation coefficient 'r' lies between
a) 0 and 1
b) -1 and 1
c) -1 and 0
d) 0 and ∞

29. For the data 1, -2, 4, geometric mean is
a) 2
b) 4
c) $-\frac{7}{3}$
d) -2

30. The relationship between Arithmetic mean (A), Harmonic mean (H) and Geometric mean (G) is
a) $G^2=AH$
b) $G=\sqrt{A+H}$
c) $H^2=GA$
d) $A^2=GH$

PART – II (Subject Paper)

Multiple choice questions (No. 31 to 95). Choose the correct answer (*a, b, c* or *d*) and enter your choice in the circle (by shading with a pencil) on the OMR - answer sheet as per the instructions given on the answer sheet.

31. If A and B are two events such that P(A) = 1/2, P(B) = 1/4 and $P(A \cup B)$ = 1/2, then $P(A \cap \bar{B})$ is equal to
a) 1/4
b) 1/6
c) 1/2
d) 1/3

32. Three balls are drawn successively with replacement from a box containing 6 red, 4 white and 5 blue balls. The probability that the balls are of different colours is
a) 8/75
b) 8/225
c) 16/75
d) 16/225

33. A number is selected randomly from each of the two sets
Set I: 1, 2, 3, 4, 5, 6, 7, 8
Set II: 2, 3, 4, 5, 6, 7, 8, 9
The probability that the sum of the numbers is equal to 9 is
a) 8/81
b) 7/64
c) 7/81
d) 8/64

34. Let X and Y be jointly distributed as f(x,y) = 4xy, 0<x<y<1, the conditional p.d.f $f(x|Y = y)$ is
a) 2x
b) 4x
c) x/2
d) x/4

35. Let X be a random variable with moment generating function $M(t) = (1-t)^{-2}$, t<1, then V(X) will be
a) 8
b) 6
c) 4
d) 2

36. Let X be a random variable giving the number obtained when a fair dice is tossed. The value of 'θ' given by Chebychev's inequality $P\{|X - E(X)|>2.5\} \leq \theta$ will be
a) 0.40
b) 0.47
c) 1.7
d) 2.5

37. If two discrete random variables X and Y have the joint distribution : P[X=1,Y=1] = 2/9, P[X=1,Y=2] = P[X=2, Y=1] = 1/9 and P[X=2, Y=2] = 5/9, then
a) X and Y are independent
b) X and Y are not identically distributed
c) P[Y<X] = 1/5 P[XY>2]
d) P[X-Y=0] + P[X-Y=1] = 1

38. If X is a random variable with a Binomial distribution with n=5, p=0.2, then the most probable value (value taken with the highest probability) of X is
a) 1
b) 2
c) 3
d) 4

39. If X has a Poisson distribution with $E(X^2)=2$, then P(X=0) is equal to
a) P[X=1]
b) P[X=2]
c) P[X=3]
d) P[X=4]

40. Let X follows a Binomial distribution with n=10 and p=$\frac{3}{5}$. Let Y be a new random variable obtained by deleting X=0. Then E(Y) is equal to
a) $6\left[1-\left(\frac{2}{5}\right)^{10}\right]$
b) $6\left[1-\left(\frac{2}{5}\right)^{10}\right]^{-1}$
c) $4\left[1-\left(\frac{3}{5}\right)^{10}\right]$
d) $4\left[1-\left(\frac{3}{5}\right)^{10}\right]^{-1}$

41. A random variable X is distributed as F(4,7), the mode of the distribution is
a) 7/6
b) 7/18
c) 21/10
d) 8/21

42. The regression line of Y on X is Y=0.95X + 7.25 and $\overline{Y}$=13.14, the value of $\overline{X}$ is
a) 5.9
b) 6.2
c) 12.5
d) 21.5

43. Let X has a uniform distribution in [0,1] and Y=-2$\log_e$X, then which of the following statement is false?
a) Y has an exponential distribution with parameter θ=1/2
b) Y has a chi-square distribution with 2 degrees of freedom
c) E(Y)=1/2
d) V(Y)=4

44. In order to test the hypothesis H_0 : p = 0.5 against H_1 : p = 0.6, H_0 is rejected if there are 7 or more heads in 10 trials. The size of the test is
a) 0.050
b) 0.156
c) 0.172
d) 0.901

45. If X_i can have any two values i^{α}, $i^{-\alpha}$, then the law of large numbers can be applied to X_1, X_2, …, if
a) $\alpha = 1$
b) $\alpha > \frac{1}{2}$
c) $\alpha < \frac{1}{2}$
d) $\alpha = \frac{1}{2}$

46. A coin is tossed three times. If heads appear in all the three tosses or if tails appear in all the three tosses, the hypothesis, H_0: Coin is unbiased, is rejected, then the probability of type I error is
a) 1/4
b) 1/8
c) 1/2
d) 1/64

47. Let **X** = (X_1,X_2, ...,X_{25}) denote a random sample of size 25 from a normal distribution with mean=μ and variance σ^2=100. If $\overline{X}$=67.53, then a 95% confidence interval for μ is
a) (61.20, 69.48)
b) (64.73, 72.51)
c) (62.61, 70.31)
d) (63.61, 71.45)

48. Let the random variable X takes values 0 and 1 with probability
$P_\theta(X=1)=\theta$ and $P_\theta(X=0)=1-\theta$ and let $1/3 \le \theta \le 2/3$.
The maximum likelihood estimator of θ on the basis of X is
a) X
b) $\frac{1+X}{3}$
c) $\frac{1-X}{3}$
d) 1-X

49. If $\overline{X}$ is the mean of a random sample of size n from a normal population N(μ,9), then the value of n such that
$P(\overline{X}-1 < \mu < \overline{X}+1) = 0.95$ is
a) 16
b) 25
c) 35
d) 49

50. If X and Y are two independent random variables, X has a Poisson distribution with mean 1 and Y has the geometric distribution $P(Y=y) = (1-p).p^y$; y=0,1,2,...; then P[X=Y] is equal to
a) $(1-p)e^{-1}$
b) $1-p+e^{-1}$
c) $(1-p)e^{(p-1)}$
d) pe^{-p}

51. If X and Y are two independent variates with variances σ_X^2 and σ_Y^2 respectively, the correlation coefficient between X and X-Y is

a) $\dfrac{\sigma_{XY}}{\sqrt{\sigma_X^2 \ \sigma_Y^2}}$

b) $\dfrac{\sigma_X}{\sqrt{\sigma_X^2 + \sigma_Y^2}}$

c) $\dfrac{\sigma_Y}{\sqrt{\sigma_X^2 + \sigma_Y^2}}$

d) $\dfrac{\sigma_X \sigma_Y}{\sqrt{\sigma_X^2 + \sigma_Y^2}}$

52. The mean difference between 9 paired observations is 15.0 and the standard deviation of differences is 5.0. The value of statistic 't' is
a) 27
b) 9
c) 3
d) 0

53. On the basis of one observation drawn from a distribution with probability density function as

$$f(x; \theta) = \theta \exp(-\theta x), \text{ if } 0 \le x < \infty$$
$$= 0 \quad , \text{ otherwise,}$$

the critical region is defined by $x \ge 1$ for testing H_0: $\theta=1$ against H_1: $\theta=2$. The probability of type II error, β, is given by

a) $\int_1^\infty \exp(-x)\,dx$

b) $\int_1^\infty 2\exp(-2x)\,dx$

c) $\int_0^1 \exp(-x)\,dx$

d) $\int_0^1 2\exp(-2x)\,dx$

54. If X and Y are two independent random variables with probability density functions

$$f(x) = \frac{1}{\sqrt{2\pi}} \exp\{-\frac{1}{2} x^2\} \text{ and}$$

$$f(y) = \frac{1}{\sqrt{8\pi}} \exp\{-\frac{1}{8} (y-5)^2\}, \text{ respectively,}$$

$-\infty \le x$, $y \le \infty$, then the variance of the random variable Z = 2X+Y is
a) 4
b) 6
c) 8
d) 9

55. A random sample of five observations drawn from a population with probability density function as

$$f(x) = \frac{1}{b-a} \quad , \quad a<x<b$$
$$= 0 \quad , \text{ otherwise}$$

is (3.5, 0.6, 2.7, 0.9, 1.8).
The maximum likelihood estimates of a and b are
a) (0.6, 3.5)
b) (0.6, 0.9)
c) (1.9, 3.5)
d) (2.7, 3.5)

56. If X and Y are independent random variables having beta distribution with parameters (2, 4) and (6, 8), respectively, then the distribution of XY is
a) a beta distribution with parameters (2, 12)
b) a beta distribution with parameters (6, 12)
c) a beta distribution with parameters (8, 12)
b) a beta distribution with parameters (12, 32)

57. It is desired to test a simple hypothesis H_0: $\theta=2$ against the alternative H_1: $\theta=4$. A random sample X_1, X_2 of size n=2 is used and the test used has the critical region $C=\{(x_1, x_2); 9.5 \le x_1+x_2 < \infty\}$. The power of the test for $\theta=2$ is 0.05 and that for $\theta=4$ is 0.31, The significance level of this test is
a) 0.31
b) 0.18
c) 0.05
d) 0.01

58. Let (1,0,1,0,1,0) be a random sample of size 6 from a distribution with probability mass function as

$$f(x, \theta) = \theta^x (1-\theta)^{1-x}; \ x=0,1; \ 0<\theta<1.$$

The consistent estimator for $\theta(1-\theta)$ is
a) 0.25
b) 0.42
c) 0.50
d) 0.75

59. For sample size n, the lower bound to the variance of unbiased estimator of the parameter θ for the Cauchy distribution with probability density function

$$f(x, \theta) = \frac{1}{\pi[1 + (x-\theta)^2]}, -\infty < x < \infty$$

is

a) 1/n
b) 1/2
c) π/n
d) 2/n

60. Suppose that u ~ N_p ($\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$), $\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$ being unknown. For testing the null hypothesis H_0: $\boldsymbol{\mu}=\boldsymbol{\mu}_0$ (specified) against H_1: $\boldsymbol{\mu}\neq\boldsymbol{\mu}_0$, the test statistic used is

a) Student's t
b) Hotelling T^2
c) Mahalanobis D^2
d) χ^2

61. Let $\mathbf{S_1}$ ~ W_p (k_1 , $\boldsymbol{\Sigma}$) and $\mathbf{S_2}$ ~ W_p (k_2 , $\boldsymbol{\Sigma}$) be independent, where $W_p(\cdot,\cdot)$ denotes a Wishart distribution. Then the distribution of $\mathbf{S_1}$ + $\mathbf{S_2}$ is

a) W_p (k_1+k_2, $\boldsymbol{\Sigma}$)
b) W_p (k_1+k_2, 2 $\boldsymbol{\Sigma}$)
c) W_{2p} (k_1+k_2, $\boldsymbol{\Sigma}$)
d) The distribution cannot be defined

62. Let $\mathbf{X}_1$, $\mathbf{X}_2$, …, $\mathbf{X}_5$ be mutually independent with $\mathbf{X}_j$, (j=1,2,…,5) distributed as N_{15} ($\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$). Then the distribution of $\mathbf{X}_1$+2$\mathbf{X}_2$+3$\mathbf{X}_3$+4$\mathbf{X}_4$+5$\mathbf{X}_5$ will be

a) N_5 ($\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$)
b) N_{15} (15 $\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$)
c) N_5 (15 $\boldsymbol{\mu}$, 15 $\boldsymbol{\Sigma}$)
d) N_{15} (15 $\boldsymbol{\mu}$, 55 $\boldsymbol{\Sigma}$)

63. Let $\mathbf{X}$ follows N_3($\mathbf{0}$, $\boldsymbol{\Sigma}$), $\boldsymbol{\Sigma} = \begin{pmatrix} 1 & \rho & 0 \\ \rho & 1 & \rho \\ 0 & \rho & 1 \end{pmatrix}$.

The value of ρ for which X_1+X_2+X_3 and X_1-X_2-X_3 will be independent is

a) 1.0
b) 0.5
c) -0.5
d) -1.0

64. Let $\mathbf{X}$ follows N_3($\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$) with $\boldsymbol{\mu}'$ = [-3,1,4] and

$$\boldsymbol{\Sigma} = \begin{pmatrix} 1 & -2 & 0 \\ -2 & 5 & 0 \\ 0 & 0 & 2 \end{pmatrix}.$$

Which of the following random variables are independent?

a) X_1 and X_2
b) (X_1, X_2) and X_3
c) (X_2, X_3) and X_1
d) X_2 and X_3

65. Let $\mathbf{X_1}$, $\mathbf{X_2}$, ..., $\mathbf{X_{10}}$ be a sample of size 10 drawn from N_{15} ($\boldsymbol{\mu}$, $\boldsymbol{\Sigma}$) then $\sum_{i=1}^{10} \mathbf{X}_i \mathbf{X}_i'$ will be

a) W_{10} (15, $\boldsymbol{\Sigma}$)
b) W_{15} (10, $\boldsymbol{\Sigma}$)
c) W_{15} (10, $\boldsymbol{\Sigma}$, •)
d) Distribution does not exist

66. If T_1 and T_2 are two unbiased estimators of population parameter θ having the same variance and ρ is the correlation coefficient between them (given the efficiency of each estimator is 0.64), then ρ must be

a) < 0.28
b) $\leq$ 0.28
c) $\geq$ 0.28
d) > 0.28

67. In an experiment with wheat crop conducted using randomized complete block design with 7 treatments and 4 replications, the standard error of the difference between two treatment means is

a) $\sqrt{s_e^2/2}$
b) $\sqrt{s_e^2/3}$
c) $\sqrt{s_e^2/4}$
d) $\sqrt{s_e^2/7}$

68. If in a Latin square design with v treatments, row degrees of freedom = column degrees of freedom = treatment degrees of freedom = error degrees of freedom, then v is equal to

a) 3
b) 8
c) 9
d) 16

69. An experimenter wishes to have 8 blocks per replicate in 2^6 factorial experiment. If the contents of all the blocks in each replicate is the same, then the number of degrees of freedom on which information cannot be obtained from the experiment is
a) 2
b) 6
c) 7
d) 8

70. In conducting a 2^4 experiment with four factors as A, B, C, D, if blocks of size 4 only are available and it is decided to confound the factorial effects ABC, BCD and AD totally, then the composition of the key block is
a) (1), bc, abd, acd
b) (1), ad, bc, abcd
c) (1), ad, cd, ac
d) (1), ab, cd, abcd

71. If **N** is a v×b incidence matrix of a Balanced incomplete block (BIB) design with parameters v,b,r,k,λ, then every row sum of **NN'** is
a) r
b) k
c) rk
d) λv

72. A BIB design with 4 treatments arranged in 6 blocks of size 2 each, has an efficiency factor equal to
a) 4/5
b) 3/4
c) 2/3
d) 1/2

73. For a BIB design with parameters v=4, b=6, r=3, k=2, λ=1, following are the four blocks:
(1,2) ; (3,1) ; (2,3) ; (4,2)
The remaining two blocks are
a) (1,4) ; (2,4)
b) (1,4) ; (2,3)
c) (1,4) ; (1,3)
d) (1,4) ; (3,4)

74. If two levels of main plot treatment are increased, then the degrees of freedom for main plot error in a split-plot design with three replications will be increased by
a) 10
b) 5
c) 4
d) 3

75. In a (3^5, 3^2) experiment, the total number of interaction effects confounded are
a) 3
b) 10
c) 13
d) 26

76. The maximum number of factors each at 3 levels that can be accommodated in a block of size 9 without confounding any main effect and two factor interactions are
a) 2
b) 3
c) 4
d) 5

77. The data pertaining to an experiment (along with treatment assigned) using Latin square design is given below, in which one observation (※) is missing.

29 (D)	19 (B)	29 (C)	6 (A)
16 (C)	10 (A)	21 (D)	19 (B)
5 (A)	※ (D)	24 (B)	37 (C)
25 (B)	42 (C)	10 (A)	29 (D)

The estimate of missing observation is
a) 33
b) 35
c) 37
d) 39

78. Three factors A, B and C each at two levels are tested in a confounded design with blocks of two plots. If the contents of one block is [(1), a], then which of the following set of effects are confounded in the design?
a) B, C, BC
b) A, B, AB
c) A, C, AC
d) C, AB, ABC

79. In which of the following crosses, linkage is expected?
a) AaBB × aabb
b) AaBb × aabb
c) aaBb × AABB
d) AAbb × aaBb

80. In Hardy-Weinberg law of equilibrium, the proportion of heterozygotes will never exceed
a) 0.2
b) 0.5
c) 0.6
d) 0.8

81. What percentage of a random-mating population showing 4 percent recessives is heterozygous?
a) 59.2
b) 40.6
c) 32.0
d) 17.2

82. Inbreeding coefficient of offspring in current generation is equal to the
a) coefficient of parentage of the succeeding generation
b) coefficient of parentage of the preceeding generation
c) coefficient of parentage of the current generation
d) panimictic index of the previous generation

83. Consider a population where the gene array of male parent is (p,q) and genotypic array of female parent is (r,2s,t), then the gene array of female offspring will be
a) (p,q)
b) (r+s, s+t)
c) $\left(\frac{p+r+s}{2}, \frac{q+s+t}{2}\right)$
d) $\left(\frac{p+r}{2}+s, \frac{q+s}{2}+t\right)$

84. The best method used for simultaneous selection of several traits is
a) Tandem selection
b) independent culling level method
c) selection index
d) indirect selection

85. The proportion of the three genotypes in the next generation for the population (0.25, 0.1, 0.65) is
a) (0.09, 0.42, 0.49)
b) (0.3, 0.42, 0.28)
c) (0.3, 0.0, 0.7)
d) (0.09, 0.1, 0.81)

86. When gene frequency of one allele is greater than twice the gene frequency of other allele, then the proportion of heterozygotes is
a) 0.1
b) 0.5
c) 0.9
d) Intermediate between two homozygotes

87. Let a sample of size n=16 is drawn from a population of size N=50 by simple random sampling without replacement (SRSWOR). Let $\sum_{i=1}^{n} Y_i = 32$ and $\sum_{i=1}^{n} Y_i^2 = 304$, then the standard error of the sample mean is
a) 4/5
b) 16/25
c) 17/5
d) $\sqrt{17}/5$

88. A population consisting of 1000 units is divided into four strata of sizes 100, 200, 300, 400 having standard deviation 4, 3, 2, 1 respectively. The allocation of a sample of size 200 into the above four strata under optimum allocation will be
a) 20, 40, 60, 80
b) 40, 60, 60, 40
c) 30, 50, 60, 60
d) 40, 50, 50, 60

89. If a stratified random sample of size 45 is to be selected by Neyman allocation from a population with $N_1=150$, $N_2=350$, $S_1^2=4$, $S_2^2=9$, then the number of units to be selected from the first stratum is
a) 10
b) 20
c) 35
d) 75

90. Let a population of size N=5 have its mean $\overline{X}_N=12$ and $S^2=100$. A sample of size n=2 is drawn without replacement. If the sample mean is $\overline{X}_n$, then $E(\overline{X}_n^2)$ is
a) 174
b) 144
c) 50
d) 30

91. Consider simple random sampling of n units from a population containing N units without replacement. Let V_1 be the variance of the sample mean and V_2, the large sample variance of the classical regression estimator based on a single auxiliary variable. If $\frac{V_1}{V_2}=\frac{4}{3}$, then the square of the correlation coefficient between the study and auxiliary variable is
a) 1/3
b) 2/3
c) 1/4
d) 1/2

92. If from a population of five units, a sample of three units is drawn using circular – systematic sampling with interval two, then the probability that the sample will include both the first and the third population units will be
a) 1/2
b) 1/3
c) 1/5
d) 2/5

93. Cluster sampling is better than simple random sampling if the intra-class correlation coefficient is
a) positive and less than one
b) negative
c) one
d) zero

94. If from a population of size 5, a sample of size 2 is drawn by using simple random sampling with replacement (SRSWR) and simple random sampling without replacement (SRSWOR) method of sampling, then the difference between the probability of selecting a sample in case of SRSWOR and SRSWR will be
a) greater than 0.5
b) equal to zero
c) positive and less than 0.05
d) equal to 0.06

95. In simple random sampling, the bias of the ratio estimator $\hat{R} = \overline{Y}/\overline{X}$ is given by
a) $\frac{Cor\,(\bar{y}, \bar{x})}{E(\bar{x})}$
b) $-\frac{Cor\,(\hat{R}, \bar{x})}{E(\bar{x})}$
c) $\frac{Cor\,(\hat{R}, \bar{y})}{E(\bar{y})}$
d) $-\frac{Cor\,(\hat{R}, \bar{y})}{E(\bar{y})}$

Note: ***In this paper there are no questions from Q. No. 96 to 130; leave OMR answer sheet blank against Q. No. 96 to 130.***

Matching type questions (No. 131 to 140); all questions carry equal marks. Choose the correct answer (*a, b, c, d* or *e*) for each sub-question (*i, ii, iii, iv* and *v*) and enter your choice in the circle (by shading with a pencil) on the OMR – answer sheet as per the instructions given on the answer sheet.

131.

i) Uniform distribution	a) Possesses no (integer order) moments
ii) Cauchy distribution	b) The k^{th} moment is $\frac{1}{(k+1)}$, k=0,1,2,...
iii) Binomial distribution	c) Mean=12, Variance=3
iv) Negative binomial distribution	d) Mean=1, Variance=1
v) Poisson distribution	e) Mean=3, Variance=4

132.

i) Rao-Blackwell theorem	a) MVB estimator
ii) Cramer-Rao inequality	b) Determination of sufficient statistic
iii) Koopman-Darmois form	c) Unique UMVU estimator
iv) Factorisation theorem	d) Characterisation of distributions having sufficient statistics
v) Complete, sufficient statistic	e) UMVU estimator

133.

i) Association	a) Comparison of group effects
ii) Analysis of variance	b) Most informative
iii) Unbiasedness	c) $E(g)=\theta$
iv) Sufficiency	d) Unique value
v) Completeness	e) Contingency tables

134.

i) Use of auxiliary information at the estimation stage	a) Sampling with probability proportional to size
ii) No use of the auxiliary information at the sample selection or estimation stage	b) Sample mean based on simple random sampling
iii) Selecting first unit randomly while remaining sample units follows a pre-determined pattern	c) Ratio estimator based on simple random sampling
iv) Selection of a group of elements as a sampling unit	d) Cluster sampling
v) Use of auxiliary information at the sample selection stage	e) Systematic sampling

135. Match the following designs for different effects with degrees of freedom for the test statistic

i) Latin square design with 't' treatments for testing row effects	a) t-1, t(r-1)
ii) Split-plot design with 'v' main plots and t subplots in 'r' replications for testing subplot treatments effects	b) (v-1)(t-1), (vt-v-t+1) (r-1)
iii) Completely randomized design in 't' treatments replicated 'r' times for testing treatment effects	c) t-1, tr-t-r+1
iv) Split-plot design with 't' main plots and 'v' subplots in 'r' replications for testing main plot effects	d) t-1, v(rt+1) – v(r+t)
v) Strip plot design with two factors at levels 'v' and 't' respectively, for testing interaction effects in 'r' replications	e) t-1, t(t-1) – 2(t-1)

136.

i) Square of path coefficient	a) Intra-sire regression of offspring on dam
ii) Heritability estimation	b) Large common environment
iii) Balanced polymorphism	c) Coefficient of determination
iv) Minor genes	d) Heterozygous superiority
v) Within family selection	e) Continuous distribution

137.

i) Linear discriminant function	a) S. Wright
ii) Inbreeding coefficient	b) J.B.S. Haldane
iii) Sequential probability ratio	c) K. Pearson
iv) Inverse sampling	d) R.A. Fisher
v) Goodness of fit	e) A. Wald

138.

i) $P(A/B) = P(A)$	a) $A \subset B$
ii) $P(AB) = 0$	b) A and B are mutually exclusive
iii) $P(A \cup B) = P(A)$	c) A and B are independent
iv) $P(A) - P(A \cap B)$	d) $A \supset B$
v) $P(A) \leq P(B)$	e) $P(A \cap \bar{B})$

139. Let X and Y be two independent standard normal variates. Match the following:

i) X^2	a) F-distribution
ii) X/Y	b) Normal distribution
iii) X^2/Y^2	c) t-distribution
iv) $1/X$	d) Chi-square distribution
v) $X+Y$	e) Cauchy distribution

140.

i) Sample mean vector	a) Hotelling's T^2
ii) Discriminant function	b) Multivariate generalization of χ^2
iii) Wishart distribution	c) Every linear function of it has a univariate normal distribution
iv) p-variate normal distribution	d) Independence of dispersion matrix
v) Mahalanobis D^2	e) $[\text{mean difference}]^2/$ variance is maximum

Short questions (No. 141 to 146); each question carries FIVE marks. Write answers, including computation / mathematical calculations if any, in the space provided for each question on the question paper itself.

141. Obtain an expression for covariance between two units under a simple random sampling without replacement sampling design.

142. The variables X and Y are related by the equation aX+bY+c = 0. Show that the correlation between them is -1 if the sign of 'a' and 'b' are alike and +1 if they are different.

143. Can the method used for testing linkage be efficiently used for estimation of linkage? Justify.

144. Explain the concept of confounding in factorial experiments. Develop the key block of a 3^3 partially confounded design in 3^2 plots per block in two replications.

145. Let p be the probability that a coin will fall head in a single toss. In order to test H_0: p=1/2 against H_1: p=3/4, the coin is tossed 5 times and H_0 is rejected if more than 3 heads are obtained. Find the probability of type I error and power of the test.

146. Given p-quantitative correlated trait responses on 'n' genotypes, construct an index score for selecting the genotypes. Explain the multivariate technique used for this purpose.