Tribhuvan University
Institute of Science and Technology
2065

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Bachelor Level/First Year/ Second Semester/ Science	Full Marks: 60
Computer Science and Information Technology (STA. 159)	Pass Marks: 24
(STATISTICS II)	Time: 3hours

Candidates are required to give their answers in their own words as far as practicable.
The figures in the margin indicate full marks.

All notations have the usual meanings.

<u>**Group A**</u>   **(2 x 10 = 20)**

<u>Answer any two questions</u>

1. Describe a situation where multistage sampling is an appropriate method of drawing a random sample. Clearly state the procedure of drawing random sample in two stage sampling plan. In two stage sampling with random sampling without replacement at both stages obtain an expression for an unbiased estimator of the population total and derive the expression for the unbiased estimator. Hence, in particular case (when $M_i = M$ and $m_i = m$ for all i), obtain the simplified version of unbiased estimator and variance of unbiased estimator.

2. What do you mean by Latin Square Design (LSD)? Write and explain the statistical model for m x m LSD. Give the statistical analysis of m x m LSD with one observation per cell.

3. (a) What is questionnaire? What are the requisites of a good questionnaire?
    (b) Explain the effect model $y_{ij} = \mu + \tau_i + e_{ij}$, i = 1, 2, ······, a and j = 1, 2, ······, n with the assumptions made on y_{ij}. Why the assumptions are required?

<u>**Group B**</u>
<u>Answer any eight questions</u>   **(8 x 5 = 40)**

1. The following table summarizes population size (N_h) and population variance (S_h^2) of four strata. Compute the variance of the stratified estimator $\bar{y}_{st}$ of the population mean for proportional allocation of a total sample of size 100.

h	1	2	3	4
N_h	14000	3000	1500	1500
S_h^2	34	94	175	319

2. Describe the procedure of drawing a linear systematic sample of size n from a population consisting of N units when N = n x k where k is a positive integer. Write down the problem of drawing a linear systematic sample of size 4 from a population consisting of 17 units, numbered from 1 to 17.

3. In pps with replacement sampling, show that an unbiased estimator of population total Y is $\hat{Y}_{pps} = \frac{1}{n}\sum_{i=1}^{n}\frac{y_i}{p_i}$. Derive the expression for the variance of $\bar{Y}_{pps}$.

4. Clearly state the procedure of drawing a random sample in cluster sampling plan. In a simple random sampling without replacement of n clusters from a population of N clusters each containing M element, derive an unbiased estimator of the parameter $\bar{\bar{Y}}$, population mean per element.

5. Describe census and sample survey. Write down the advantages of sample survey over the census. Write down the major steps involved in a sample survey.

6. Explain the terms – factor, experimental units, treatment and experimental error with suitable examples.

7. In a single factor model $y_{ij} = \mu + \tau_i + e_{ij}$, show that
$$\sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y})^2 = n\sum_{i=1}^{a}(\bar{y}_i - \bar{y})^2 + \sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_i)^2.$$
What is significance of this result in experimental design?

8. State the mathematical model with the hypothesis to be tested in a two way ANOVA. Write down the ANOVA table for a two way ANOVA.

9. Consider the partially completed ANOVA table below. Complete the ANOVA table and answer the followings. What design was employed? How many treatments were compared? How many observations were analyzed? At the 0.05 level of significance can one conclude that the treatments have different effects? Why?

Source	SS	df	MS	F
Treatments	231.50	2		
Blocks		7		
Error	573.75			
Total	903.75	23		

10. The results of 2^2 experiments with 36 replications are presented below. Estimate the main effects, interaction effects, SS_A, SS_B, and SS_{AB}. Which effects appear to be large?

Treatment Combination	Replication		
	I	II	III
(1)	22	30	25
A	32	42	29
b	35	33	50
ab	55	45	46

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<u>**Group A**</u>   **(2 x 10 = 20)**

<u>**Answer any two questions**</u>

1. Describe a situation where probability proportion to size (pps) sampling in an appropriate method for drawing a random sample. Clearly state the procedure of drawing a random sample in pps sampling plan. In pps sampling with replacement derive an unbiased estimator of the parameter Y, population total, and also derive the variance of the estimator.

2. What do you mean by Completely Randomized Design (CRD)? Write and explain the statistical model for CRD. Give the statistical analysis of CRD with one observation per cell.

3. (a) Write down the major steps of a sample survey and state the major sources of errors in a sample survey.

    (b) Write down the basic principles of experimental designs and explain the term experimental errors.

<u>**Group B**</u>
<u>**Answer any eight questions**</u>   **(8 x 5 = 40)**

4. The following table summarizes information related to four strata. Compute the variance of the stratified estimator $\bar{y}_{st}$ of the population mean assuming proportional allocation of a total sample of size 100.

h	1	2	3	4
N_h	200	400	300	100
S_h^2	9	4	4	9

5. Describe the situation where the systematic sampling is useful. Write down the problems of drawing as linear systematic sample of size 4 from a population consisting of 17 units, numbered from 1 to 17.

6. In two stage sampling with simple random sampling without replacement at both stages, an unbiased estimator of Y is

$$\bar{Y} = \frac{N}{n} \sum_{i=1}^{n} \frac{M_i}{j=1} y_{ij}$$

Derive the variance of the above estimator.

7. Clearly state the procedure of drawing a sample random sampling without replacement of n clusters from a population of N clusters each containing M elements, derive an unbiased estimator of the parameter $\bar{\bar{Y}}$, population mean per element.

8. Describe census and sample survey. Write down the advantages of sample survey over census. Write down the major steps involved in a sample survey.

9. Explain the terms – factor, experimental units, treatment and experimental error with suitable examples.

10. Write down (a) layout of two way ANOVA with its assumptions, (b) effect model and (c) ANOVA table.

11. In a single factor model $y_{ij} = \mu + \tau_i + e_{ij}$, show that

$$\sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y})^2 = n \sum_{i=1}^{a}(\bar{y}_i - \bar{y})^2 + \sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_i)^2.$$

What is the significance of this result in experimental design?

12. Fill in the (_____) in the following ANOVA table of Latin Square Design.

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-Value
Rows	_____	72	_____	2
Columns	_____	_____	36	_____
Treatments	_____	180	_____	_____
Error	6	_____	12	_____
Total	_____	_____	_____	_____

13. The results of 2^2 experiment with 3 replications are presented below. Estimate the main effects, interaction effects, SS_A, SS_B and SS_{AB}. Which effects appear to be large?

Treatment Combination	Replication		
	I	II	III
(1)	22	30	25
A	32	42	29
B	35	33	50
ab	55	45	46

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Candidates are required to give their answers in their own words as far as practicable.
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All notations have the usual meanings.

Group A   **(2 x 10 = 20)**

Answer any two questions

1. Describe a situation where cluster sampling is appropriate for drawing random sample. Clearly state the procedure of drawing a random sampling in cluster sampling plan. In a sampling without replacement of n clusters from a population of N clusters each containing M elements, derive an unbiased estimator of the parameter $\bar{\bar{Y}}$, population mean per element and also derive the variance of the estimator.

2. (a) Explain the terms: a random sample, sampling frame, sampling error and non-sampling error.
    (b) Explain the terms: factor, experimental units, treatment and experimental error.

3. What do you mean by Randomized Block Design (RBD)? Write and explain the statistical model for RBD. Give the statistical analysis of RBD with one observation per cell.

Group B

Answer any eight questions   **(8 x 5 = 40)**

4. The following table summarizes population size (N_h) and population variance (S_h^2) related to four strata. If the required sample size is 4000, what are the sample sizes that would be drawn from each stratum for (a) proportional allocation and (b) optimum allocation assuming the survey cost per unit is same in each stratum.

h	1	2	3	4
N_h	14000	3000	1500	1500
S_h^2	34	94	175	319

5. Describe the procedure of drawing a linear systematic sample of size n from a population consisting of N units when N = n x k where k is a positive integer. Write down the problem of drawing a linear systematic sample of size 4 from a population consisting of 17 units, numbered from 1 to 17.

6. In pps with replacement sampling, show that an unbiased estimator of population total Y is

$$\hat{Y}_{pps} = \frac{1}{n} \sum_{i=1}^{n} \frac{y_i}{p_i}.$$

Derive the expression for the variance of $\hat{Y}_{pps}$.

7. In two stage sampling with simple random sampling without replacement at both stages, show that an unbiased estimator of Y is

$$\hat{Y} = \frac{N}{n} \sum_{i=1}^{n} \frac{M_i}{m_i} \sum_{j=1}^{m_i} y_{ij}.$$

What would be the above expression if $M_i = M$ and $m_i = m$ for all i?

8. What is questionnaire? Explain. Write down the pre-requisites of a good questionnaire?

9. Write down the principles of experimental design.

10. In a single factor model $y_{ij} = \mu + \tau_i + e_{ij}$, show that

$$\sum_{i=1}^{a} \sum_{j=1}^{n} (y_{ij} - \bar{y})^2 = n \sum_{i=1}^{a} (\bar{y}_i - \bar{y})^2 + \sum_{i=1}^{a} \sum_{j=1}^{n} (y_{ij} - \bar{y}_i)^2.$$

What is the significance of this result in experimental design?

11. Consider the partially completed ANOVA table below. Complete the ANOVA table and answer the followings. What design was employed? How many treatments were compared? How many observations were analyzed? At the 0.05 level of significance, can one conclude that the treatments have different effects? Why?

Source	SS	df	MS	F
Treatments	231.50	2		
Blocks		7		
Error	573.75			
Total	903.75	23		

12. Write down statistical model for a Latin Square Design (LSD) and explain it. Also, write down the ANOVA table for LSD.

13. Write down the four treatment combinations of 2^2 experiment using standard notations. Write down the expressions for computing main effects, interaction effect, SS_A, SS_B and SS_{AB} if experiment is replicated r times.

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Bachelor Level/ First Year/ Second Semester/ Science   Full Marks: 60
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(Stat - II)   Time: 3hours
Candidates are required to give their answers in their own words as for as practicable.
The figures in the margin indicate full marks.

All notation have usual meanings.

Group A

Answer any two questions   (2 x 10 = 20)

1. Under which situation probability proportion to size (pps) sampling is an appropriate method for drawing a random sample. Explain the procedure of drawing a random sample in pps sampling plan. In pps sampling with replacement, derive an unbiased estimator of the parameter Y, population total and also derive the variance of the estimator.

2. What do you mean by factorial design? Discuss its role in design of experiment. Obtain main effect and interaction effect in 2^2 factorial design.

3.
    a) What do you mean by ANOVA? Explain the underlying assumptions of ANOVA.
    b) Explain the term-sampling error and non-sampling error.

Group B

Answer any eight questions   (8 x 5 = 40)

4. Suppose it is required to estimate the average value of output of a group of 5000 factories in an industrial area so that one sample estimate lies within 10% of the true value with a confidence of 95%. Determine the minimum sample size required. It is also known that the population coefficient of variation is 60%.

5. Derive the expression of the sample mean in case of cluster sampling, each cluster containing equal number of element.

6. The following table summarizes population size (N_h) and population variance (S_h^2) of four strata. Calculate the variance of the stratified estimator $\bar{y}_{st}$ of the population mean for proportional allocation of a total sample size 100.

h	1	2	3	4
N_h	14000	3000	1500	1500
S_h^2	34	94	175	319

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7. In two stage sampling with simple random sampling without replacement(SRSWOR) at both stage, an unbiased estimator of Y is

$$\hat{y} = \frac{N}{n} \sum_{i=1}^{n} \frac{M_i}{m_i} \sum_{j=1}^{m_i} y_{ij} = \frac{N}{n} \sum_{i=1}^{n} M_i \bar{Y}_i$$

Also derive the variance of the above estimator.

8. In simple random sampling without replacement (N, n), show that the bias of the ratio estimator $\hat{R}$ is approximately equal to:

$$B(\hat{R}) \sim \frac{1-f}{n\,\bar{X}^2} \, (RS_x^2) - \rho\, S_y S_x) = Rcv(\bar{X})[cv(\bar{X}) - \rho\, cv(\bar{y})].$$

.

9. State the mathematical model with the hypothesis to be tested in a two way ANOVA and prepare ANOVA table.

10. Carry out the statistical analysis if m x m Latin Square Design (LSD) with one observation per cell.

11. Explain the terms – experimental units, treatments, blocking in design of experiment.

12. Introduce Randomized Complete Block Design (RCBD). Prepare an Analysis of Variance (ANOVA) table for RCBD.

13. The following is partially completed ANOVA table.

Source of Variation	Sum of squares	Degree of freedom	Mean square	F
Treatments	901.9	5		
Blocks	219.43	3		
Error	229.63	-		
Total	1350.25	23		

Complete the ANOVA table and answer the followings.

What design was employed? How many treatments were compared? What about the total number of observations? At 5% level of significance, can we conclude that the treatments have different effects? Are the blocks homogeneous? Explain.

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Bachelor Level/ First Year/ Second Semester/ Science   Full Marks: 60
Computer Science and Information Technology (STA. 159)   Pass Marks: 24
(Statistics - II)   Time: 3hours
Candidates are required to give their answers in their own words as for as practicable.
The figures in the margin indicate full marks.

All notation have usual meanings.

Group A   (2 x 10 = 20)

Answer any two questions

1. Explain the situation when stratified random sampling is a suitable method of drawing a random sample. Derive expressions for estimation of population mean and population total. Also obtain an unbiased estimator of variance in stratified random sampling with simple random sampling without replacement (srswor) in each stratum.

2. What is the basic concept of Latin Square Design (LSD)? State and explain the statistical model for p x p LSD with one observation per cell.

3.
    a) Distinguish between census and sample survey.
    b) Write down the basic principles of design of experiment and explain the term experimental errors.

Group B

Answer any eight questions   (8 x 5 = 40)

4. It is known that certain disease affects at least 1.5% of individuals in a large population. An epidemiologist is interested to estimate the total number of cases of such disease with a coefficient of variation not exceeding 30%. Find the size of the simple random sample needed, assuming that the presence of the disease can be detected without mistakes.

5. What is questionnaire? What are the requisites of a good questionnaire?

6. In probability proportion to size sampling (pps), show that an unbiased estimator of population total y is

$$\hat{Y}_{PPS} = \frac{1}{n} \sum_{i=1}^{n} \frac{Y_i}{P_i}$$

. Also obtain the expression for the variance of $\hat{Y}_{PPS}$

7. Describe sampling and non-sampling errors. Discuss the requisites of a good questionnaire.

8. Describe the procedure of drawing a linear systematic sample of size n from a population consisting of N units (N = n x k, where k is a positive integer). Write down the problem of drawing a linear systematic sample of size 4 from a population consisting of 17 units, numbered from 1 to 17.

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9. Prepare an analysis of variance 1able for Randomized Complete Block Design (RCBD) for which the statistical model is:

$$y_{ij} = \mu + \tau_i + \beta_j + e_{ij}, \quad i = 1, 2, \dots, a; \quad j = 1, 2, \dots, b$$

10. Write down the main effect and interaction effect in 2^2 factorial design.

11. In a single factor model, $y_{ij} = \mu + \tau_i + e_{ij}$, show that

$$\sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_{..})^2 = n\sum_{i=1}^{a}(\bar{y}_i - \bar{y}_{..})^2 + \sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_i)^2$$

How this model works in design of experiment?

12. The following is partially completed ANOVA table.

Source of variation	Sum of squares	Degrees of freedom	Mean Square	F
Treatments	38.50	3		
Blocks	82.50	3		
Error	8.00			
Total	129.00	15		

Complete the ANOVA table and answer the followings:

What design was employed? How many treatments were compared? What about the total number of observations? At 5% level of significance, can we conclude that the treatments have different effects? Explain.

13. Explain the terms -factor, experimental units, treatments and confounding.

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(Statistics - II)   Time: 3hours
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<u>**Group A**</u>   **(2 x 10 = 20)**

Answer any two questions
1. Describe the advantages of carrying out a sample survey in preference to a complete enumeration survey. Under what circumstances can complete enumeration be recommended in preference to a sample survey?
2. What is meant by Randomized block design? Give the analysis of variance of the design. What are the usual assumption mode in the analysis of a Randomized block design?
3.
    a) What is questionnaire? What are requisites of a good questionnaire?
    b) What is Latin Square Design? Under what conditions this design can be used?

<u>**Group B**</u>

Answer any eight questions   **(8 x 5 = 40)**

4. A population of 800 is divided into 3 strator. Their sizes and standard deviations are given below:

	I	II	III
Number	300	300	300
Size	200	300	300
Standard deviation	6	8	12

   A stratified random sample of size 120 is to be drawn from the population. Determine the sizes of sample from the three strata in case of
    a) Proportional allocation
    b) Neyman's optimum allocation.

5. What do you understand by systematic sampling? What are the advantages of systematic sampling?

6. In PPS with replacement, show that an unbiased estimator of population total Y is

$$\hat{Y}_{PPS} = \frac{1}{n} \sum_{i=1}^{n} \frac{Y_i}{P_i}$$

   Derive the expression for the variance

7. Clearly state the procedure of drawing a random sample in cluster sampling plan. In a simple random sampling without replacement of x cluster from a population of N clusters each containing M elements. Derive an unbiased estimator of the parameter $\bar{Y}$, population mean per element.

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8. Explain the principles of replication, randomization and local control in experimental design pointing out the role of each one plays in the valid and accurate interpretation of data.

9. Write down (a) layout of two way ANOVA with it's assumption   (b) effect model   (c) ANOVA table

10. An agricultural research organization wants to study the effect of four types of fertilizers at random in 6 plots of land. Port of calculation are shown below:

Source of Variation	Sum of squares	Degrees of freedom	M.SS	F test
Between fertilizer	2940	-	-	-
Within samples	-	-	-	-
Total	6212			

   a) Fill in the blanks in the ANOV A table
   b) Test at 5% level of significance, whether fertilizers differ significantly.

11. In a single model, $y_{ij} = \mu + \tau_i + e_{ij}$, show that

$$\sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_{..})^2 = n\sum_{i=1}^{a}(\bar{y}_i - \bar{y}_{..})^2 + \sum_{i=1}^{a}\sum_{j=1}^{n}(y_{ij} - \bar{y}_i)^2$$

12. The results of 2^2 experiments with 3 replications are presented below. Estimate the main effects, interaction effects, SSA, SSB, SSAB. Which effects appear to be large?

Treatment Combination	Replication		
	I	II	III
(1)	22	30	25
a	32	42	29
b	35	33	50
ab	55	45	46

13. Write short notes on **any two**:
   a. Sampling and non-sampling errors.
   b. Probability proportion to size sampling.
   c. Factorial experiments.

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Group A   (2 x 10 = 20)

Answer any two questions

1. Explain the condition where simple random sampling is an appropriate method of drawing a random sample. Also derive the procedure the estimate the population mean, total and variance in simple random sampling. 10 households are selected from a cluster of 100 households by using simple random sampling method and the number of persons per household in the sample was observed as 2, 5, 6, 8, 10, 4, 5, 7, 6 and 5. Find the total population and variance.

2. What is the basic concept of Randomized Block Design (RBD)? State and explain the statistical model for RBD and also give the statistical analysis of RBD with one observation per cell.

3.
   a) Discuss the needs of sampling and differentiate between census and sample survey.
   b) Explain the 2^3 –experimental design, and also obtain the main and interaction effects.

Group B

Answer any eight questions   (8 x 5 = 40)

4. Write down the steps involved in sample survey and explain the procedures to determine the sample size.

5. What is questionnaire? Also state the requisite of a good questionnaire.

6. What do you understand about probability proportion to size sampling and state the procedure of drawing a random sample in probability proportion to size sampling plan.

7. Describe the situation where the systematic sampling is appropriate method for drawing a random sample. Explain the problem of drawing a linear systematic sample of size 5 from a population consisting of 23 units numbered from 1 to 23.

8. Compute the variance of stratified estimator $\bar{Y}_{st}$ of the population mean by assuming proportional allocation of a total sample of size 100 by using following information related to four strata.

H	1	2	3	4
N_h	200	400	300	100
S_h^2	7	3	3	7

9. Explain the analysis of variance and also write down the layout of one-way ANOVA with its assumptions and ANOVA table.

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10. Layout the two way analysis of variance by using the following information showing the quality of rating of service stations by three professional raters.

Rater	Service Stations						
	I	II	III	IV	V	VI	VII
A	2	3	4	5	6	7	8
B	4	5	6	7	8	9	10
C	6	7	8	9	10	11	12

11. Explain the statistical model for Completely Randomized Design (CRD) with one observation per cell.

12. Fill in the blanks (…) in the following analysis of variance table of the LSD.

Source of Variation	Degrees of freedom	Sum of squares	Mean sum of square	F value
Rows	3	243	…	3
Columns	…	…	108	…
Treatments	…	1215	…	…
Error	…	…	27	
Total	…	…		

13. Find the main effects, interaction effects, SS_a, SS_b and SS_{ab} in the following 2^2 –factorial experiment with 3 replications. Where notations have usual meaning. Explain which effects appear to be large?

Replication	Treatment Combination			
	(1)	a	b	ab
I	23	25	22	28
II	24	20	26	18
III	30	28	24	26

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TRIBHUVAN UNIVERSITY
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2072
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Bachelor Level/ First Year/ Second Semester/ Science   Full Marks: 60
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(Statistics II)   Time: 3 hours.

Candidates are required to give their answers in their own words as far as practicable.
The figures in the margin indicate full marks.

Group A

Attempt any TWO questions: (2x10=20)

1. Introduce the term 'Factorial Design' and describe its role in design of experiment. Obtain main effect and interaction effect in 2^2 factorial design.

2. Explain the situation when probability proportion to size (pps) sampling is a suitable method for drawing a random sample. Describe the procedure of drawing a random sample in pps sampling plan. Derive an unbiased estimator of the parameter Y, population total and also the variance of the estimator in pps sampling with replacement.

3. a) Explain the term- sampling error and non-sampling error.

    b) What do you mean by ANOVA? Describe the underlying assumptions of ANOVA.

Section B

Attempt any EIGHT questions: (8x5=40)

4. Obtain the expression of the sample mean in case of cluster sampling, each cluster containing equal number of element.

5. Suppose it is required to estimate the average value of output of a group of 5000 pharmaceutical industries in an industrial city so that the sample estimate lies within 10% of the true with a confidence coefficient of 95%. Determine the minimum sample size required. It is also known that the population coefficient of variation is 40%.

6. In two stage sampling with sample random sampling without replacement (srswor) at both stages, show that an unbiased estimator of Y is

$$\hat{Y} = \frac{N}{n} \sum_{i=1}^{n} \frac{M_i}{m_i} \sum_{j=1}^{m_i} y_{ij} = \frac{N}{n} \sum_{i=1}^{n} M_i \overline{Y}_i$$

   Also derive the variance of the above estimator.

7. The following table summarizes population size (N_h) and population variance (S_h^2) of four strata. Calculate the variance of the stratified estimator $\overline{y}_{st}$ of the population mean for proportional allocation of a total sample size 100.

h	1	2	3	4
N_h	14000	3000	1500	1500
S_h^2	24	84	1165	309

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8. In simple random sampling without replacement (N, n), prove that the bias of the ratio estimator $\hat{R}$ is approximately equal to: $B(\hat{R}) \sim \dfrac{1-f}{n\overline{X}^2}(RS_x^2) - \rho S_y S_x = Rcv(\overline{X})[cv(\overline{X}) - \rho cv(\overline{y})]$.

9. Explain the mathematical model with the hypothesis to be tested in a two way ANOVA and prepare ANOVA table.

10. Carry out the statistical analysis of p x p Latin Square Design (LSD) with one observation per cell.

11. The following is a partially completed ANOVA table.

Source of variation	Sum of squares	Degree of Freedom	Mean Square	F
Treatments	900	5	-----	---
Blocks	220	3	-----	---
Error	228	-----	-----	
Total	3148	23		

Complete the ANOVA table and answer the followings:

What design was adopted? How many treatments were compared? Give the total number of observations? Draw the conclusion whether the treatments have different effect at 5% level of significance. Are also the blocks homogeneous?

12. Explain the terms-experimental units, treatments and blocking in design of experiment.

13. What do you mean by Randomized Complete Block Design (RCBD)? Prepare an Analysis of Variance (ANOVA) table for RCBD.

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