DEPARTMENT OF STATISTICS
ASSAM UNIVERSITY, SILCHAR

AU/STAT/BUGS/Minutes/09 **Date: 6th March, 2024**

Minutes of the **9th** meeting of the Board of Under Graduate Studies (BUGS), Department of Statistics, Assam University, Silchar held on 6th March, 2024 at Assam University, Silchar from 11.30 am onwards.

Following members were present:

1.	Prof. Dibyojyoti Bhattacharjee	Chairman
2.	Dr. Rama Shanker	Member
3.	Dr. Jonali Gogoi	Member
4.	Gopa Singha	Member
5.	Dr. Sankar Goswami	Member
6.	Mr. Debojyoti Bora	Member
7.	Ms. Chayanika Deka	Member
8.	Ms. Debarati Nath	Special Invitee
9.	Dr. Santanu Choudhury	Special Invitee

At the very outset the Chairman welcomed all the members of BUGS to the 9th meeting of the BUGS Statistics present in the meeting.

The agenda of the discussion was circulated before the meeting. The discussions were held on the agenda items. The meeting resolved the following as per the agenda items.

Agenda 1: Finalizing the syllabus of 3rd semester onwards for the U.G Statistics program (NEP Mode)

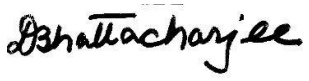
The Chairman presented before the house a draft syllabus of UG Statistics (NEP Format) from III Semester to the VIII Semester for in the 8th Metting of the BUGS conducted earlier, for futher modifications if any and finalization.
As per the resolution of the previous BUGS the Chairman tabled the Draft Syllabus prepared following incorporation of all the suggestions received from the teachers of the affiliated colleges and university department.
A detailed discussion among the members followed and accordingly it was decided that some minor modifications are required in some papers of the syllabus. The papers were once again

taken up one by one and after a thread bearing discussions, necessary modifications in some papers of the syllabus were done in front of all the members by displaying it in the smart board of the seminar hall of the department.

The house by the evening of that day agreed to the contents of the syllabus and are appended to this minutes.

Agenda 2: Any Other Matter

As there were no other matter to discuss so the meeting ended with thanks from and to the chair.



(Prof. Dibyojyoti Bhattacharjee)
Chairman BUGS,
Department of Statistics
Assam University

ASSAM UNIVERSITY: SILCHAR

DEPARTMENT OF STATISTICS

Curriculum

For

FYUG Programme (Draft 3rd semester onwards)

Under NEP-2020

w.e.f. 2023-24

[Syllabus Approved by BUGS dated 6th March, 2024]

Table 1: Semester-wise list of Statistics DSC Courses

Semester	Course Code	Title of Courses	Credits
I	STADSC101	Descriptive Statistics and Probability	3
	STADSC102	Calculus	3
II	STADSC151	Probability Distributions	3
	STADSC152 (P)	Descriptive Statistics and Probability Distributions	3
III	STADSC201	Algebra	4
	STADSC202	Limit Theorems and Sampling Distributions	4
IV	STADSC251	Statistical Inference	4
	STADSC252	Mathematical and Numerical Analysis	4
	STADSC253 (P)	Practical based on Test of Significance and Numerical Analysis	4
V	STADSC301	Applied Statistics	4
	STADSC302	Linear models and Designs of Experiments	4
	STADSC303(P)	Practical based on Applied Statistics and Designs of Experiment using Microsoft Excel	4
VI	STADSC351	Survey Sampling and Indian Official Statistics	4
	STADSC352	Stochastic Processes and Queuing Theory	4
	STADSC353	Multivariate Analysis and Nonparametric Methods	4
	STADSC354 (P)	Practical based on Sample Survey, Non-parametric and Multivariate Analysis	4
VII	STADSC401	Real Analysis and Linear Algebra	4
	STADSC402	Probability Theory	4
	STADSC403	Distribution Theory	4

Semester	Course Code	Title of Courses	Credits
	STADSC404 (P)	Practical based on Real Analysis, Linear Algebra, Probability Theory, Distribution Theory in R	4
VIII	STADSC451	Research Methodology	4
	STADSC452	Advanced Statistical Inference	4
	STADSC453	Operations Research	4
	STADSC454 (P)	Programming in Python	4
	STADSC455	Research Project/Dissertation *	12

*Students who prefer to take up Research Project/Dissertation shall study STADSC455 only in this semester along with STADSC451 i.e. all the papers of Group A. Students who do not like to take up Research Project/Dissertation shall study the papers STADSC451, STADSC452, STADSC453 and STADSC454 (P) i.e. all the papers of Group B.

- Group A: Research Methodology (STADSC451), Research Project/Dissertation (STADSC455)
- Group B: Research Methodology (STADSC451), Advanced Statistical Inference (STADSC452), Operations Research (STADSC453), Programming in Python (STADSC454(P))

Table 2: Semester-wise list of Statistic DSM Courses

Semester	DSM1/DSM2	Course Code	Title of Courses	Credits
I	DSM1	STADSM101	Basic Statistics and Probability	3
II	DSM2	STADSM151	Statistical Methods and Probability	3
III	DSM1	STADSM201	Random Variables and Probability Distributions	4
IV	DSM1	STADSM251 (P)	Practical based on Descriptive Statistics and Probability Distributions	3
	DSM2	STADSM252	Mathematical Statistics	3
V	DSM1	STADSM301	Statistical Inference and Applied Statistics	3
	DSM2	STADSM302	Statistical Inference and Applied Statistics	3
VI	DSM2	STADSM351 (P)	Statistical Methods and	4

			Probability Distributions	
VII	DSM1	STADSM401	Survey Sampling, Design of Experiments and Indian Official Statistics	4
VIII	DSM2	STADSM451	Survey Sampling, Design of Experiments and Indian Official Statistics	4

Table 3: Semester-wise list of Statistics SEC Courses

Semester	Course Code	Title of Courses	Credits
I	STASEC101	Data Analysis using Microsoft Excel	3
II	STASEC151	Statistical Data Analysis using R	3
III	STASEC201	Statistical Computing Using C	3
V	STASEC301	Community Engagement/Field Study	2

Table 4: Semester-wise list of IDC Courses

Semester	Course Code	Title of Courses	Credits
I	STAIDC101	Introduction to Statistics	3
II	STAIDC151	Index Number and Time Series	3
III	STAIDC201	Sampling and Elements of Hypothesis Testing	3

DETAILED SYLLABI

DISCIPLINE SPECIFIC CORE COURSE: STADSC-201
(Algebra)

Semester III
(Credits: 04)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) + Internal (30)]
Pass Marks = 40[End Semester Exam (28) + Internal (12)]

Learning Objectives:

- Develop a strong grasp of fundamental algebraic concepts, including the theory of equations and the fundamental theorem of algebra, to form a solid foundation for more advanced algebraic topics.
- Acquire a deep understanding of vector spaces, subspaces, and matrix operations, along with the ability to analyze and manipulate matrices using various properties and theorems.
- Gain proficiency in working with determinants, including their properties, applications, and transformations, and apply these skills to solve linear equations and evaluate matrix properties.
- Develop the ability to analyze matrix ranks, eigenvalues, and eigenvectors, along with understanding the significance of these concepts in various mathematical and real-world scenarios.
- Explore advanced algebraic concepts such as characteristic roots, the Cayley-Hamilton theorem, and quadratic forms, and apply these concepts to solve complex mathematical problems and real-world situations.

Learning Outcomes:

- Gain a strong theoretical foundation in algebra, enabling the understanding of algebraic relationships, equations, and concepts that serve as building blocks for advanced mathematical studies.
- Develop the ability to solve problems related to vector spaces, linear dependence, and dimension, allowing for effective analysis and representation of vectors in various dimensions and applications.
- Acquire the skills to manipulate matrices, evaluate their properties, and solve matrix equations, providing tools for solving systems of linear equations and applying matrix operations to real-world problems.

- Demonstrate competence in solving problems using determinants, including applications to linear independence, matrix properties, and solutions to linear equations, enhancing problem-solving abilities.
- Understand the concepts of matrix rank, apply rank theorems, and explore scenarios involving the sum and product of matrices, along with applying these concepts to fields such as engineering, physics, and computer science.
- Cultivate critical thinking skills by connecting abstract algebraic concepts to real-world problems, enabling students to approach challenges from multiple perspectives.
- Overall, the "Algebra" course aims to equip students with a broad range of algebraic skills, fostering problem-solving abilities, critical thinking, and a deep understanding of algebraic concepts that are applicable across various academic and professional fields.

UNIT-I

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties. (12 hours)

UNIT-II

Definition, properties and applications of determinants for 3rd and higher orders (without proof), evaluation of determinants of order 3 and more using transformations.

Row reduction, echelon forms and normal forms, Rank of a matrix, row-rank, column-rank, standard theorems and properties ranks (statements only) and their applications. Inverse of a matrix. (12 hours)

UNIT-III

Solution of both homogeneous and non-homogeneous system of linear equations. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector (Statement of theorems and properties) and applications, Cayley Hamilton theorem and Quadratic forms. (12 hours)

UNIT-IV

Concept and definition of Groups, Rings and Fields. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. (12 hours)

UNIT V

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. (12 hours)

SUGGESTED READING:

1. Lay, D. C. (2000). Linear Algebra and its Applications, Addison Wesley.

2. Krishnamurthy, V., Mainra, V. P.,& Arora, J. L. An Introduction to Linear Algebra (II, III, IV, V).

3. Jain, P. K.,& Khalil, A. (1973). Metric Spaces, Narosa Publishing House, New Delhi.

4. Biswas, S. (1997). A Textbook of Matrix Algebra, New Age International.

5. Gupta, S. C. (2008). An Introduction to Matrices. Sultan Chand & Sons (Reprint).

6. Artin, M. (1994). Algebra. Prentice Hall of India.

7. Hadley, G. (2002). Linear Algebra. Narosa Publishing House (Reprint).

8. Searle, S. R. (1982). Matrix Algebra Useful for Statistics. John Wiley & Sons.

9. Sharma & Vasistha. (2014). Matrices. Krishna Prakashan.

10. Sharma & Vasistha. (2010). Linear Algebra. Krishna Prakashan.

11. Sharma & Vasistha. (2014). Modern Algebra. Krishna Prakashan.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-202
(Limit Theorems and Sampling Distributions)

Semester III
(Credits: 04)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) + Internal (30)]
Pass Marks = 40 [End Semester Exam (28) + Internal (12)]

Learning Objectives:

- Develop a solid grasp of various limit laws, including convergence in probability, almost sure convergence, mean square convergence, and convergence in distribution. Explore the relationships between these concepts and their significance in statistics.
- Gain a comprehensive understanding of the Central Limit Theorem and its applications in real-world scenarios. Learn how the CLT enables the approximation of various distributions by the normal distribution, enhancing the ability to work with large sample sizes.
- Acquire a deep understanding of the sampling distribution of statistics, such as sample mean, sample variance, and sample proportion. Explore the concept of parameter estimation, the role of standard errors, and the calculation of confidence intervals.
- Learn the principles of hypothesis testing, including null and alternative hypotheses, significance levels, Type I and Type II errors, and critical regions. Develop the ability to conduct large sample tests and apply the Central Limit Theorem to test proportions, means, and variances.
- Delve into exact sampling distributions such as the chi-squared distribution, Student's t-distribution, and the F-distribution. Understand their properties, derive their probability density functions, and learn how these distributions are used in tests of significance and confidence interval construction.

Learning Outcomes:

- Develop strong mathematical skills in understanding and applying various limit theorems, enabling the analysis of the behaviour of random variables and their distributions as sample sizes increase.
- Acquire the ability to make informed inferences about population parameters from sample statistics. Understand the concept of point estimation, interval estimation, and the role of confidence intervals in quantifying uncertainty.
- Develop critical thinking skills in formulating hypotheses, determining appropriate significance levels, and calculating probabilities of Type I and Type II errors. Apply these skills to real-world scenarios to draw valid conclusions from data.
- Gain hands-on experience in applying statistical techniques to analyze real data. Learn to choose appropriate tests, calculate test statistics, and make sound decisions based on the results.

- Overall, this paper provides students with a strong foundation in the principles of limit theorems, sampling distributions, and hypothesis testing, enabling them to make informed statistical inferences and contribute effectively to data-driven decision-making processes.

UNIT-I

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapounov's Theorem (without proof). (12 hours)

UNIT-II

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean (single, difference of two means), standard errors of sample mean (single and difference of two means), sample variance and sample proportion. (12 hours)

UNIT-III

Order Statistics: Introduction, distribution of the r^{th} order statistic, smallest and largest order statistics. Joint distribution of r^{th} and s^{th} order statistics, distribution of sample median and sample range and their applications. (12 hours)

UNIT-IV

Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f., mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on $\chi 2$ distribution. (12 hours)

UNIT V

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., moments and limiting form of t distribution.

Snedecore's F-distribution: Derivation of p.d.f., moments and mode. Distribution of 1/F(n1,n2). Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions. (12 hours)

SUGGESTED READING:

1. Goon, A.M., Gupta, M.K.,& Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I (4^{th} Edition). World Press, Kolkata.

2. Rohatgi, V. K.,& Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2^{nd}Edition. (Reprint) John Wiley and Sons.

3. Hogg, R.V.,& Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.

4. Johnson, R.A.,& Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4th Edition. John Wiley and Sons.

5. Mood, A.M., Graybill, F.A.,&Boes, D.C. (2007). Introduction to the Theory of Statistics (3rd Edition, Reprint). Tata McGraw-Hill Pub. Co. Ltd.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-251

(Statistical Inference)

Semester IV
(Credits: 4)

Contact Hours: 60

Full Marks = 100 [End Semester Exam (70) +Internal (30)]

Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Develop a solid foundation in statistical inference concepts, including estimation and hypothesis testing. Gain a deep understanding of unbiasedness, sufficiency, consistency, and efficiency, along with their practical implications in real-world statistical analysis.
- Master the principles of different estimation methods, such as method of moments and maximum likelihood estimation. Understand how to calculate point estimates of parameters, assess their properties, and apply them in various statistical scenarios.
- Acquire expertise in the principles of hypothesis testing, encompassing null and alternative hypotheses, Type-I and Type-II errors, critical regions, and significance levels. Learn to design hypothesis tests and make informed decisions based on statistical evidence.
- Explore advanced concepts like Minimum Variance Unbiased Estimators (MVUE), Cramer-Rao inequality, Rao-Blackwell theorem, Neyman-Pearson Lemma, and Likelihood Ratio Test. Understand how to construct optimal estimators and tests, ensuring efficiency and power.
- Develop the skills to construct confidence intervals for various distribution parameters. Learn the pivotal quantity method for creating confidence intervals and understand how to apply them in different situations, including large sample scenarios.

Learning Outcomes:

- Gain the ability to analyze complex statistical problems using estimation and hypothesis testing techniques. Apply these methods to real-world datasets to draw meaningful conclusions and make data-driven decisions.
- Acquire proficiency in estimating population parameters using diverse methods. Understand the strengths and limitations of each method, and select the most appropriate estimation technique based on the nature of data and research objectives.

- Develop expertise in designing hypothesis tests and interpreting their results. Learn to manage the trade-off between Type-I and Type-II errors, and construct tests with optimal power using concepts like the Neyman-Pearson Lemma.
- Gain familiarity with advanced statistical concepts such as MVUE, Cramer-Rao inequality, and Likelihood Ratio Test. Apply these techniques to solve complex problems, enhancing analytical and problem-solving skills.
- Acquire skills in constructing confidence intervals and interpreting their meaning in real-world contexts. Understand the nuances of large sample intervals and their applications in diverse statistical scenarios.
- By achieving these course objectives and outcomes, students will emerge well-equipped to handle a wide range of statistical inference challenges, providing valuable insights into estimation, hypothesis testing, and confidence interval construction in various fields of research and decision-making.

UNIT-I

Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete sufficient statistic. (12 hours)

UNIT-II

Cramer-Rao inequality and MVB estimators (statement and applications), Rao-Blackwell theorem with applications, Minimum variance unbiased estimator (MVUE). Methods of Estimation: Method of moments, method of maximum likelihood estimation-their properties and applications. (12 hours)

UNIT-III

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations. Concept of p-value. (12 hours)

UNIT-IV

Neyman-Pearson Lemma and its applications to construct most powerful test). Likelihood ratio test and relevant problems, properties of the likelihood ratio tests (without proof). (12 hours)

UNIT V

Interval estimation - Confidence interval for Binomial proportion, Confidence interval for population correlation coefficient for Bivariate Normal distribution, Pivotal quantity method of constructing confidence interval, Large sample confidence intervals. (12 hours)

SUGGESTED READING:

1. Goon, A.M., Gupta, M.K., &Das, G.B. (2005). Fundamentals of Statistics, Vol. I. World Press, Calcutta.

2. Rohatgi, V. K., & Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics (2nd Edition, Reprint). John Wiley and Sons.

3. Miller, I.,& Miller, M. (2002). John E. Freund's Mathematical Statistics (6th addition, low price edition). Prentice Hall of India.

4. Dudewicz, E. J., & Mishra, S. N. (1988). Modern Mathematical Statistics. John Wiley & Sons.
5. Mood, A.M., Graybill, F.A.,&Boes, D.C. (1973). Introduction to the Theory of Statistics. McGraw Hill.

6. Bhat, B.R, Srivenkatramana, T.& Rao, M. K.S. (1997). Statistics: A Beginner's Text, Vol. I. New Age International (P) Ltd.

7. Snedecor, G.W. & Cochran,W.G. (1967). Statistical Methods. Lowa State University Press.

8. Bhattacharjee,D. & Das, K. K. (2008). A Treatise on Statistical Inference and Distributions. Asian Books, New Delhi.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-252

(Mathematical and Numerical Analysis)

Semester IV
(Credits: 4)

Contact Hours: 60

Full Marks = 100 [End Semester Exam (70) +Internal (30)]

Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives: .

- Familiarize with neighborhoods, limit points, supremum, and infimum, and apply them in mathematical analysis..
- Analyze sequences and their convergence, and understand the limits of special sequences
- Master the principles of Cauchy's general convergence and apply them to analyze convergence in sequences.
- Analyze monotonic sequences and understand their behavior.
- Apply various convergence tests, including the Comparison test, D'Alembert's ratio test, and Raabe's test, for series analysis.
- Understand Cauchy's nth root test and its applications in determining convergence.
- Apply Leibnitz's test for the convergence of alternating series.
- Explore and apply Rolle's and Lagrange's Mean Value Theorems in calculus.
- Understand and apply Cauchy's Mean Value Theorem in calculus.
- Grasp Taylor's theorem with Lagrange's form of remainder (without proof).
- Master Taylor's and Maclaurin's series expansions of (1+x)n, log (1+x) and ex.
- Explore numerical analysis concepts including factorial, finite differences, and interpolation..
- Master Newton's forward, backward, and divided differences interpolation formulae.
- Explore central differences and the interpolation formulae of Gauss and Stirling.
- Master common numerical integration methods.
- Grasp the solution of Polynomial Equations using the Newton-Raphson method.

Learning Outcomes:

- Competence in working with neighborhoods, limit points, suprimum, and infimum.
- Competent analysis of sequences and their convergence, with a focus on special sequences.
- Skill in applying Cauchy's general convergence principle in sequence analysis.
- Capability to apply Cauchy's first theorem on limits in mathematical analysis.
- Competence in analyzing infinite series and positive-termed series.

- Ability to apply various convergence tests for series analysis.
- Ability to apply Rolle's, Cauchy's Mean Value Theorem and Lagrange's Mean Value Theorems in calculus problems.
- Proficiency in applying Taylor's theorem and its applications in series expansions.
- Capability to apply numerical analysis concepts, including factorial, finite differences, and interpolation.
- Proficiency in applying different interpolation formulae in numerical analysis.
- Competence in understanding and applying central differences and interpolation formulae of Gauss and Stirling.
- Proficiency in using numerical integration methods.
- Capability to solve Polynomial Equations using the Newton-Raphson method in numerical analysis.

UNIT-I

Concepts of Bounded and unbounded sets, neighborhoods and limit points, Supremum and infimum, derived sets, open and closed sets .

Sequences and their convergence, limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences. (12 hours)

UNIT-II

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test (statements and examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series. (12 hours)

UNIT-III

Rolle's and Lagrange's Mean Value theorems. Cauchy's Mean Value Theorem. Taylor's theorem with Lagrange's form of remainder (without proof). Taylor's and Maclaurin's series expansions of $(1+x)^n$, $log\ (1+x)$ and e^x (12 hours)

UNIT-IV

Numerical Analysis: Factorial, finite differences and interpolation. Operators- Δ, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. (12 hours)

UNIT-V

Central differences: Gauss and Stirling's interpolation formulae. Numerical integration: Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Solution of difference equations of first order, Solution of Polynomial Equations by Newton-Raphson method. (12 hours)

SUGGESTED READING

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern

Limited, New Age International Limited, New Delhi, 1994.

2. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis,

Narosa Publishing House, New Delhi, 1987.

3. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi,

1987.

4. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.)

Ltd., New Delhi, 1987.
5. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.

DISCIPLINE SPECIFIC CORE COURSE: DSC-253 LAB
(Practical Based on Test of Significance and Numerical Analysis)

Semester IV
(Credits: 04)
Contact Hours: 120
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Develop practical skills in applying statistical tests and confidence interval methods to various scenarios involving proportions, means, standard deviations, and correlations. Understand how to choose and execute the appropriate test for a given problem.
- Gain a deep understanding of the theoretical foundations of different statistical tests, confidence intervals, and interpolation methods. Learn the underlying assumptions, significance levels, and critical values associated with each technique.
- Equip students with the ability to analyze real-world data using the techniques covered in the course. Learn how to interpret results, draw meaningful conclusions, and make informed decisions based on statistical evidence.
- Develop proficiency in using interpolation methods like Newton's forward and backward difference formulas, divided differences, and Lagrange's interpolation. Understand how to approximate values between data points and apply these methods to practical problems.
- Gain hands-on experience with numerical integration techniques such as the Trapezoidal Rule, Simpson's one-third rule, Simpson's three-eighth rule, and Weddle's rule. Learn to apply these methods for approximating definite integrals and integrating functions.

Learning Outcomes:

- Acquire practical skills in conducting hypothesis tests and constructing confidence intervals for different scenarios involving proportions, means, standard deviations, correlations, and more. Apply these skills to draw valid statistical conclusions.
- Develop the ability to make informed decisions based on statistical analyses. Understand how to choose the appropriate test or interval estimation method to address specific research questions or practical problems.
- Gain a strong foundation in mathematical techniques such as interpolation and numerical integration. Apply these methods to approximate values, interpolate missing data points, and estimate definite integrals.
- Apply statistical and mathematical techniques to real-world datasets. Understand the practical implications of statistical tests and interval estimates, and effectively communicate findings to a non-technical audience.

- Enhance problem-solving skills by applying interpolation and numerical integration methods to solve mathematical and statistical problems. Develop the ability to work with complex datasets and utilize appropriate techniques to obtain meaningful results.
- Studying this paper students will be well-prepared to handle practical statistical and mathematical challenges, and they will be equipped with valuable skills for data analysis, decision-making, and research in various fields.

List of Practical

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness of fit (Chi-square test of frequencies)
7. Testing of independence of attributes.
8. Testing of significance and confidence intervals of an observed sample correlation coefficient.
9. Testing and confidence intervals of equality of two population variances
10. Newton's Gregory forward difference interpolation formula
11. Newton's backward difference interpolation formula.
12. Newton's divided difference and Lagrange's interpolation formula
13. Gauss forward, Gauss backward central difference interpolation formula
14. Stirling's central difference interpolation formula
15. Trapezoidal Rule, Simpson's one-third rule, Simpson's three-eighth rule
16. Finding the roots of polynomial equation using Newton-Raphson method

DISCIPLINE SPECIFIC CORE COURSE: STADSC-301
(Applied Statistics)

Semester V
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40 [End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a comprehensive understanding of quality control principles, including the distinction between chance and assignable causes of variation, and the significance of statistical control charts in maintaining consistent process and product quality.
- Learn how to construct and interpret various control charts for both variables and attribute data. Understand the rationale behind subgrouping, and gain the ability to identify and react to quality variations effectively using control charts.
- Gain insight into acceptance sampling plans, their principles, and their practical applications. Understand the concepts of Operating Characteristic (OC) curves, Average Outgoing Quality (AOQ), and other key performance measures related to acceptance sampling.
- Acquire the ability to analyze time series data, including identifying the different components such as trend, seasonality, cyclic variations, and random fluctuations. Learn methods to decompose time series and estimate these components.
- Develop proficiency in constructing and interpreting index numbers. Learn about various index number formulas, including weighted and unweighted indices, and their application in measuring changes in price levels, with a focus on consumer price index numbers.

Learning Outcome

- Gain practical skills in applying statistical techniques to manage and control the quality of processes and products. Learn to distinguish between random and assignable variations and use control charts to maintain consistent quality standards.
- Acquire the ability to analyze and interpret data using statistical tools. Understand how to identify trends, patterns, and irregularities in time series data and make informed decisions based on the analysis.
- Develop the skills to make informed decisions about acceptance sampling plans based on factors such as lot quality, production processes, and desired quality levels. Understand the trade-offs between different sampling strategies.
- Understand the components of time series data and their importance in various fields. Gain the ability to decompose time series and estimate trend, seasonality, and other variations, enabling better forecasting and planning.

- Acquire proficiency in constructing and interpreting index numbers, a crucial tool for measuring economic and price-level changes. Understand the application of index numbers in real-world scenarios and their significance in economic analysis.
- By studying these course students will be well-equipped with the skills necessary to manage quality, analyze time series data, make informed decisions about acceptance sampling, and understand the principles and applications of index numbers in various sectors, contributing to effective decision-making and data analysis.

UNIT-I

Statistical Quality Control: Concepts and applications, introduction to Process and Product Controls. Chance and assignable Causes of quality variation. Statistical Control Charts-Construction and Statistical basis of 3-σ Control charts, Rational sub-group. Control charts for variables: X-bar & R-chart. Control charts for attributes: np-chart, p-chart, c-chart.

(12 hours)

UNIT-II

Rates and Ratios of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates. Life Tables: types, assumptions, description, construction and uses. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR). (12 hours)

UNIT-III

Introduction to times series data, application of time series in various fields. Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting of various mathematical curves (linear, exponential, polynomial), Method of moving averages. (12 hours)

UNIT-IV

Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method. Cyclic Component: Harmonic Analysis (concept only). Random Component: Variate difference method.

(12 hours)

UNIT-V

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain-based index numbers and vice-versa. Consumer price index numbers-its use and limitations. (12 hours)

SUGGESTED READING:

1. Montogomery, D. C. (2009). Introduction to Statistical Quality Control (6th Edition). Wiley India Private Ltd.

2. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I a.& II (8th Edition). The World Press, Kolkata.
3. Mukhopadhyay, P. (2011). Applied Statistics (2nd edition, revised reprint). Books and Allied(P) Ltd.
4. Montogomery, D. C. &Runger, G.C. (2008). Applied Statistics and Probability for Engineers (3rd Edition,Reprint). Wiley India Pvt. Ltd.
5. Gupta, S.C.,& Kapoor, V.K. (2007). Fundamentals of Applied Statistics (4th Edition). Sultan Chand and Sons., New Delhi.
6. Kendall, M.G. (1976). Time Series, Charles Griffin.
7. Chatfield, C. (1980). The Analysis of Time Series –An Introduction. Chapman & Hall.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-302
(Linear Models and Design of Experiments)

Semester V
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40 [End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a comprehensive understanding of linear estimation theory within the Gauss-Markov framework. Learn about estimability of linear parametric functions, the method of least squares, and the Gauss-Markov theorem. Understand how to estimate error variance effectively.
- Gain expertise in analyzing variance and covariance in different types of classified data using fixed, random, and mixed effect models. Understand the principles behind one-way and two-way classified data analysis, and their applications in various contexts.
- Learn the fundamental principles of experimental design, including terminology, sources of experimental error, and the basics of uniformity trials. Understand how to choose plot and block sizes and shapes for different designs, and grasp the concepts of efficiency and randomization.
- Acquire knowledge of different experimental designs, starting from Completely Randomized Design (CRD) and moving to more complex designs like Randomized Block Design (RBD) and Latin Square Design (LSD). Understand their layouts, models, and statistical analyses.
- Develop a deep understanding of factorial experiments, their advantages, and notations. Learn about the design and analysis of 2^2, 2^3, and 2^n factorial experiments, including the concept of confounding. Understand the principles of fractional factorial experiments and their utility.

Learning Outcome

- Acquire practical skills in estimating linear parametric functions using the method of least squares. Understand the assumptions underlying linear estimation and how the Gauss-Markov theorem ensures the best linear unbiased estimators.
- Develop the ability to analyze classified data using analysis of variance and covariance techniques for different types of effect models. Learn to interpret the results and draw valid conclusions based on the analyses.
- Gain proficiency in designing experiments with a focus on randomization and control of experimental error. Learn how to apply different designs like CRD, RBD, and LSD to address specific research questions.

- Acquire skills in designing and analyzing factorial experiments, including the ability to recognize and handle confounding. Understand how to extract valuable information from factorial designs with the least number of experiments using fractional factorials.
- Develop critical thinking skills to choose appropriate experimental designs based on research objectives and available resources. Understand the trade-offs between different designs and their implications for statistical analysis and inference.
- By achieving these course objectives and outcomes, students will be well-prepared to handle complex experimental design and analysis challenges, apply statistical techniques in various research contexts, and make informed decisions based on experimental results.

UNIT-I

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.
Analysis of variance: Definitions of fixed, random and mixed effect models. Analysis of variance in one-way classified data for fixed effect models. Analysis of variance in two-way classified data with one observation per cell for fixed effect models. (12 hours)

UNIT-II

Experimental designs: Terminology, experimental error, basic principles, uniformity trials, choice of size and shape of plots and blocks, Completely Randomized Design (CRD). Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency. (12 hours)

UNIT-III

Factorial experiments: advantages, notations and concepts, 2^2, 2^3, 2^4 and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 4$). (12 hours)

UNIT-IV

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties. Definitions of Symmetric BIBD. Concept of fractional factorial experiment. (12 hours)

UNIT-V

Missing plot technique: RBD with one and two missing observations, LSD with one missing observation. Analysis of covariance of one-way and two-way classified data. (12 hours)

SUGGESTED READING:

1. Cochran, W.G. & Cox, G.M. (1959). Experimental Design. Asia Publishing House.

2. Das, M.N. & Giri, N.C. (1986). Design and Analysis of Experiments. Wiley Easter Ltd.

3. Goon, A.M., Gupta, M.K.,&Dasgupta, B. (2005). Fundamentals of Statistics. Vol- II (8^{th}Edition).World Press, Kolkata.

4. Kempthorne, O. (1965). The Design and Analysis of Experiments. John Wiley.

5. Montgomery, D. C. (2008). Design and Analysis of Experiments, John Wiley.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-303 LAB
(Practical on Applied Statistics and Design of Experiments)

Semester V
(Credits: 4)
Contact Hours: 120
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40 [End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Enable students to draw and interpret the control charts for variables.
- Develop the ability of the participating students to draw and interpret the control charts for variables.
- Teach the students to compute the different types of Index numbers and interpret the values.
- To computationally induce the concepts of trend analysis in time series using method of moving average and fitting of linear and non-linear functions.
- Identifying seasonal variation in the time series data using ratio to method of moving averages method, ratio to trend method and method of link relatives.
- Perform computations of One-way and Two-way ANOVA.
- Equip students with the skills to perform the Designs of Experiments computation for CRD and RBD.
- Foster an understanding and perform the analysis of variance of Latin Square Design (LSD).
- Develop proficiency of performing ANOVA of LSD and RBD in case of missing observation.
- To learn how to handle the computational aspects leading to the identification of the significant factors in case of factorial experiment both in case of complete and confounded experiments.
- To learn about the different measures of mortality and fertility
- To understand the measures of population growth and get exposure to life tables.

Learning Outcomes:

- Students will effectively interpret and create control charts of quality control and can tell when the system of production has earned an assignable cause of variation both for variables and attributes.
- Perform routine analysis of time series data to study trends using the method of moving average and curve fitting (both linear and non-linear)
- Students shall be exposed to identification of the impact of seasonal variation in time series data using the ratio to trend method, moving average method and link relatives
- Learners will perform ANOVA in Excel and shall also interpret the results effectively.

- Participants will demonstrate proficiency in extending one-way and two-way ANOVA to designing Completely Randomized Design (CRD) and Randomized Block Design (RBD) experiments.
- Performing Latin Square Design (LSD) experiments and hence interpret the results.
- Students will estimate missing observations and hence perform ANOVA for RBD and LSD
- Mastering factorial experiments layout and analysis both for complete and confounded cases.
- To get accustomed to computing different measures of mortality and fertility

List of Practicals

1. Computing control limits and drawing control charts for mean and range and interpreting the state of control.
2. Computing control limits and drawing control charts for number of defects per unit and interpreting the state of control.
3. Computing control limits and drawing control charts for number of defectives and interpreting the state of control.
4. Computation of Index Numbers using different formulae and their interpretation
5. Perform Time Reversal Test and Factor Reversal Test of different Index Number formulae.
6. To prove empirically that Fisher's Index number is the ideal index number.
7. Computation of Cost of Living Index number.
8. Fitting of trend equation to time series data- linear and non-linear equations and obtain forecast and detrended values.
9. Identifying seasonal variation in the time series data using ratio to method of moving averages
10. Identifying seasonal variation in the time series data using ratio to trend method and method of link relatives.
11. Performing one-way ANOVA
12. Performing two-way ANOVA with single observation
13. Performing two-way ANOVA with multiple observations per cell
14. Performing ANOVA for CRD, RBD and LSD
15. Performing ANOVA for RBD and LSD following estimation of the value of missing observation.
16. To perform the ANOVA for 2^2 and 2^3 full factorial experiments
17. To perform the ANOVA for 2^2 and 2^3 confounded factorial experiments (complete and partial)
18. Computation of mortality and fertility rates
19. Computation of different growth rates
20. Life tables

Suggested Reading:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. II), 8th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.

3. N. G. Das (2008) *Statistical Methods*, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Bhattacharjee D. and Bhattacharjee D. (2008) B. Sc Statistics Vol-II, Kalyani Publishers, Ludhiana.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-351
(Survey Sampling and Indian Official Statistics)

Semester VI
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a comprehensive understanding of population and sample, the distinction between complete enumeration and sampling, and the various types of sampling techniques. Learn the principles of probability and non-probability sampling methods, including simple random sampling (with and without replacement), stratified random sampling, and systematic sampling.
- Gain proficiency in estimating population parameters such as mean and total using different sampling techniques. Understand how to compute estimates, variances of estimates, and the factors influencing the precision of these estimates.
- Learn the importance of determining an appropriate sample size and the concept of pilot surveys. Understand the significance of conducting preliminary surveys to assess feasibility and refine survey methodologies.
- Understand the landscape of official statistics in India, including the methods of data collection, their reliability, and limitations. Familiarize oneself with key government agencies such as the Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and the National Statistical Commission.
- Gain knowledge of advanced sampling methods like cluster sampling, double sampling, ratio estimation, regression estimation, multistage sampling, multiphase sampling, and PPS sampling. Understand the principles behind these techniques and their applications.

Learning Outcome

- Acquire practical skills in selecting and implementing different sampling techniques, understanding their strengths and limitations, and making informed choices based on research objectives.
- Develop the ability to estimate population parameters using various sampling techniques, calculate estimates of variances, and evaluate the precision of these estimates. Understand the principles of unbiased estimation.
- Gain proficiency in determining appropriate sample sizes based on desired precision levels and available resources. Understand the significance of pilot surveys in refining survey methodologies.

- Acquire an in-depth understanding of the official statistical system in India, the roles of key government agencies, and the methods used to collect and publish official statistics on topics such as population, industry, and finance.
- Develop the ability to apply advanced sampling methods to real-world scenarios, enhancing the accuracy and efficiency of survey results. Understand the situations in which cluster sampling, ratio estimation, and other advanced techniques are most appropriate.
- By achieving these course objectives and outcomes, students will be well-prepared to design, conduct, and analyze survey sampling techniques, make informed decisions regarding sample size and methodology, and understand the intricacies of the official statistical system in India.

UNIT-I

Concept of population and sample, complete enumeration versus sampling, sampling and non sampling errors, pilot survey. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling (SRS) with and without replacement, definition and procedure of selecting a sample, estimates of population mean and total, estimates and variances of these estimates, estimates of their variances. (12 hours)

UNIT-II

Sample size determination (for mean and proportion), Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. (12 hours)

UNIT-III

Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N = nk$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend. Concept of cluster sampling and double sampling. (12 hours)

UNIT-IV

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances. Concept of multistage, multiphase and Probability Proportional to Size (PPS) sampling. (12 hours)

UNIT V

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance. (12 hours)

SUGGESTED READING:

1. Cochran, W.G. (1984). Sampling Techniques(3rd Edition). Wiley Eastern.
2. Sukhatme,P.V., Sukhatme, B. V.,Sukhatme, S., &Asok,C.(1984). Sampling Theories of Survey with Application. IOWA State University Press and Indian Society of Agricultural Statistics.
3. Murthy, M.N. (1977). Sampling Theory & Statistical Methods. Statistical Pub, Society, Calcutta.
4. Des, R.,&Chandhok, P. (1998). Sample Survey Theory.Narosa Publishing House.
5. Goon, A.M., Gupta, M.K. &Dasgupta, B. (2001). Fundamentals of Statistics, Vol.2. World Press.
6. Guide to Current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
7. Website of the Ministry of Statistics and Program Implementation (http://mospi.nic.in/)

DISCIPLINE SPECIFIC CORE COURSE: STADSC-352
(Stochastic Processes and Queuing Theory)

Semester VI
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a strong foundation in probability distributions and generating functions. Understand their applications in modeling and analyzing various stochastic processes.
- Gain a comprehensive understanding of stochastic processes, including stationary processes. Learn how to analyze and interpret random processes over time.
- Acquire expertise in Markov chains, including their definitions, transition probability matrices, and order. Understand the graphical representation of Markov chains and their classification.
- Develop skills in working with Poisson processes, understanding their properties, and analyzing inter-arrival times. Gain an overview of branching processes and their significance.
- Understand the fundamental concepts of queuing systems, including steady-state distributions, queuing models, and waiting time distributions. Learn how to analyze and model real-world queuing scenarios.

Learning Outcome

- Acquire practical skills in using probability distributions and generating functions to model random processes. Understand how to apply these concepts to various real-world scenarios.
- Develop the ability to analyze stochastic processes, including identifying stationary processes and interpreting their behavior over time.
- Gain proficiency in analyzing and interpreting Markov chains using transition probability matrices. Understand the classification of states and chains and their implications for stability.
- Acquire skills in working with Poisson processes, understanding their postulates, properties, and inter-arrival times. Apply these concepts to solve problems related to random events.
- Develop the ability to analyze queuing systems, calculate steady-state distributions, and model waiting time distributions. Understand how queuing theory is applied in scenarios involving waiting lines and service processes.
- From this course students will be well-prepared to work with various stochastic processes, analyze Markov chains, Poisson processes, and queuing systems, and apply these concepts to real-world situations involving randomness and uncertainty.

UNIT-I

Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process. (12 hours)

UNIT-II

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, diagrammatic representation of Markov Chain. (12 hours)

UNIT-III

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, Second order Poisson Process, relevant problems. Branching process (Overview only) (12 hours)

UNIT-IV

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite system capacity, waiting time distribution (without proof) and relevant problems. (12 hours)

UNIT V

Gambler's Ruin Problem: Classical ruin problem, expected duration of the game. Simple birth process and simple death process- relevant deduction and applications. (12 hours)

SUGGESTED READING:

1. Medhi, J. (2009). Stochastic Processes. New Age International Publishers.
2. Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B. R. (2000). Stochastic Models: Analysis and Applications. New Age International Publishers.
4. Taha, H. (1995). Operations Research: An Introduction. Prentice- Hall India.
5. Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I (3rd Edition). Wiley International.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-353
(Multivariate Analysis and Nonparametric Methods)

Semester VI
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a comprehensive understanding of bivariate normal distribution, including its probability density function (p.d.f), properties, and marginal and conditional distributions. Extend this knowledge to multivariate data, covering random vectors, their probability mass/density functions, mean vectors, and dispersion matrices.
- Acquire expertise in the multivariate normal distribution, its properties, and how it is used to model multivariate data. Understand the sampling distribution of the mean vector and variance-covariance matrix in multivariate scenarios.
- Gain a deep understanding of correlation coefficients in multivariate data, including multiple and partial correlation coefficients. Learn about their properties and how they measure the relationships among variables.
- Learn the fundamentals of sequential analysis, including the sequential probability ratio test (SPRT) for comparing simple hypotheses. Understand the relationships among significance levels, power, average sample numbers, and error probabilities.
- Develop proficiency in nonparametric methods, including tests for randomness, Kolmogorov-Smirnov tests, sign tests, Wilcoxon signed rank tests, and Mann-Whitney U tests. Understand the concepts behind these tests and how they are applied.

Learning Outcome

- Acquire practical skills in analyzing multivariate data, understanding distributions, and calculating properties of multivariate distributions, leading to a deeper understanding of data patterns.
- Develop the ability to model multivariate data using the multivariate normal distribution. Understand how to estimate and interpret mean vectors and variance-covariance matrices.
- Gain expertise in interpreting correlation coefficients in multivariate scenarios, including multiple and partial correlation coefficients. Understand their roles in capturing relationships between variables.
- Acquire skills in applying sequential analysis techniques, especially the SPRT, to make informed decisions regarding hypotheses. Understand how to balance significance levels, power, and sample sizes for efficient decision-making.

- Develop practical skills in applying nonparametric tests to data. Understand how to choose and perform appropriate tests for randomness, distribution comparisons, and paired/unpaired samples, even when parametric assumptions are not met.
- The course shall teach the student to analyze and interpret multivariate data, understand the principles of sequential analysis, and apply nonparametric methods in various statistical scenarios, enhancing their ability to work with diverse types of data and make informed statistical decisions.

UNIT-I

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN and related problems. (12 hours)

UNIT-II

Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions. Multinomial distribution (12 hours)

UNIT-III

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient- concept, properties (statements only) and applications. (12 hours)

UNIT-IV

Sequential Analysis: Sequential probability ratio test (SPRT) for simple null vs simple alternative hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions. (12 hours)

UNIT V

Nonparametric Tests: Introduction and Concept

One Sample Tests: Kolmogrov-Smirnov test, Sign tests, Wilcoxon signed rank test, Test for randomness based on total number of runs

Two sample Tests: Sign Test, Wilcoxon matched pair signed rank test, Mann-Whitney U test, Wald-Wolfowitz run test. (12 hours)

SUGGESTED READING:

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis (3rdEdition). John Wiley
2. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory. John Wiley.
3. Kshirsagar, A.M. (1972). Multivariate Analysis (1stEdition). Marcel Dekker.
4. Johnson, R.A.,&Wichern, D.W. (2007). Applied Multivariate Analysis (6thEdition). Pearson & Prentice Hall.

5. Goon, A.M., Gupta, M.K. &Dasgupta, B. (2005). An Outline ofStatistical Theory, Volume II,World Press.
6. Rao, C. R. (2000). Linear Statistical Inference. Wiley.
7. Mukhopadhyay, P. Mathematical Statistics. Books and Allied, Kolkata
8. Gibbons, J. D. &Chakraborty, S. (2003). Nonparametric Statistical Inference (4th Edition). Marcel Dekker, CRC.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-354 LAB
(Practical based on Sample Survey, Non-parametric and Multivariate Analysis)

Semester VI
(Credits: 4)
Contact Hours: 120
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Develop practical skills in selecting SRS with and without replacement, estimating population mean, population mean square and population variance of SRS.
- Gain a deep understanding of the practical foundations of different method of sample selection. Learn to estimate the gain in precision in stratified sampling technique.
- Learn how to determine the sample size, allocate samples in strata, interpret results, draw meaningful conclusions, and make informed decisions based on statistical evidence.
- Develop proficiency in methods like Multiple Correlation, Partial Correlation and apply these methods to practical problems. Understand how to fit Bivariate Normal Distribution, Multivariate Normal Distribution.
- Gain hands-on experience with non-parametric techniques such as Kolmogrov Smirnov test for one sample, Sign test, Wilcoxon signed rank test for one sample and two samples and Mann-Whitney U-test.

Learning Outcomes:

- Acquire practical skills in selecting simple random sample with and without replacement and stratified sample. Apply these skills to draw simple random and stratified sample.
- Develop the ability to make informed decisions based on statistical analyses. Understand how to choose the appropriate allocation techniques method for drawing stratified sample or in practical sample selection problems.
- Gain a strong foundation in mathematical techniques such as Multiple Correlation, Partial Correlation. Apply these methods to approximate value and the relationship between the variables.
- Apply statistical techniques to real-world datasets. Understand the practical techniques of sample size determination and estimation of population mean, population mean square and population variance.
- Enhance problem-solving skills by applying non-parametric methods to solve different problems. Develop the ability to work with complex datasets and utilize appropriate techniques to obtain meaningful results.

- Studying the paper students will be well-prepared to handle practically challenges and they will be equipped with valuable skills for data analysis, decision-making, and research in various fields.

List of Practical

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Multiple Correlation.
7. Partial Correlation.
8. Parameter estimation of Bivariate Normal Distribution.
9. Parameter estimation of Multivariate Normal Distribution.
10. Test for randomness based on total number of runs
11. Kolmogrov Smirnov test for one sample.
12. Sign test: one sample, two samples, large samples.
13. Mann-Whitney U-test
14. Wilcoxon signed rank test-one sample and two samples.
15. Wald-Wolfowitz Run test for two samples

SUGGESTED READING:

- Gardener,M. (2012). Beginning R: The Statistical Programming Language. Wiley Publications.
- Braun, W.J.,& Murdoch, D.J. (2007). A First Course in Statistical Programming with R. Cambridge University Press. New York
- Moore, D.S., McCabe, G.P., &Craig, B.A. (2014). Introduction to the Practice of Statistics. W.H. Freeman
- Cho,M.J.,Martinez,W.L.(2014). Statistics in MATLAB: A Primer. Chapman and Hall/CRC

DISCIPLINE SPECIFIC CORE COURSE: STADSC-401
(Real Analysis and Linear Algebra)

Semester VII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Understand the basic concepts of real analysis including completeness of set, supremum, infimum, sequence and series and their convergence, real-valued function, continuous function, uniform continuity and convergence, power series, Fourier series.
- Also to learn about unconstrained and constrained optimization problems with several variables, double and multiple integrals, uniform convergence in improper integrals and differentiation under the sign of integral.
- To learn those concepts of real analysis are necessary in the study of probability theory, distribution theory, statistical inference, stochastic process, Bayesian inference, linear and non-linear models, optimization techniques, multivariate statistics and other topics of statistics.
- The paper helps in understanding the basic concepts of linear algebra including matrices, vector space, linear dependence, basis and dimension of vector space, norms and orthogonality, orthogonal projections, Gram-Schmidt orthogonalization process,
- To learn about Eigen values and Eigen vectors, generalized inverse, quadratic forms and solution of system of linear equations.

Learning Outcome

- On studying this paper the students are expected to develop a mathematical foundation that is necessary for understanding various advanced topics of statistics.
- The concepts of linear algebra shall help the student in the study of multivariate analysis, time series, linear models and regression, design of experiments, stochastic process, bivariate and multivariate distributions, Statistical inference, stochastic process, Bayesian inference, linear and non-linear models, optimization techniques, and several other topics of statistics they shall encounter in other courses of the same program.
- This, paper lays the foundation of the student in further understanding of the subject.

UNIT-I

Sequences: Convergent sequences, bounded sequences, Cauchy's general principle of convergence. Infinite series, different tests of convergence of series (without proof).Continuous functions and their properties, uniform continuity. (12 hours)

UNIT-II

Mean value theorems, Taylor's theorem and their applications. Functions of several variables: continuity and differentiability. Maxima-minima of functions of one real variable. Maxima-minima of functions of several variables, constrained maxima-minima of functions and their applications. (12 hours)

UNIT-III

Double and multiple integrals (triple integral only), evaluation of multiple integrals by repeated integration (triple integral only), change of variables in multiple integration. Improper integrals, differentiation under the sign of integral. (12 hours)

UNIT-IV

Linear transformations, Rank and nullity of a linear transformation, rank-nullity theorem. Matrix representation of linear transformations. Inner product spaces, norms and orthogonality, orthogonal projections. Gram-Schmidt orthogonalization process. (12 hours)

UNIT V

Eigenvalues and eigenvectors of a matrix, Diagonalizable matrices, Similarity with triangular matrices, Matrix polynomials, Cayley-Hamilton theorem, Generalized inverse of a matrix, Moore and Penrose inverse, Quadratic forms (12 hours)

SUGGESTED READING:

1. T.M. Apostol (1974), Mathematical Analysis, 2nd edition, *Narosa Book Distributors Pvt. Ltd.*
2. R. G. Bartle and D. R. Sherbert (2000) Introduction to Real Analysis, 4th edition, *Wiley India Pvt. Ltd.*
3. S. C. Malik and S. Arora (2017) Mathematical Analysis, 5th edition, *New Age International Publishers.*
4. A. Kumar and S. Kumaresan, (2014) A Basic Course in Real Analysis, 1st edition, *CRC Press.*
5. Royden HL and Fitzpatrick PM (2015) Real Analysis, 4th Edition, Pearson.
6. Mapa S.K. (2019) Introduction to Real Analysis, 8th Edition, Sarat Book House.
7. Kunze Ray, Hoffman Kenneth (2008) LinearAlgebra, 2nd Edition, PHI Learning Pvt. Ltd.
8. Seymour Lipschutz, Marc Lipson (2005) LinearAlgebra 3rd Edition, Tata McGraw Hill.
9. Seymour Lipschutz, Marc Lipson (2017) Schaum's Outlines of Linear Algebra, Third Edition, McGrow Hills Inc.
10. Biswas, S. (2012). Textbook of Matrix Algebra, PHI, New Delhi.
11. Bhimasanaram P., A. Ramachandra Rao (2010) Linear Algebra (Texts and Readings in Mathematics) 2nd Revised edition, HinduStatn Book Agency.
12. Banerjee, S., Roy, A. (2014). Linear Algebra and Matrix Analysis for Statistics, First Edition, CRC Press.
13. Dasgupta A. (2014) Abstract and Linear Algebra, AshokePrakashan, Kolkata.

14. Khanna, V. K. and Bhambri, S. K. (2016). A Course in Abstract Algebra, Fifth Edition, Vikas Publishing House.

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DISCIPLINE SPECIFIC CORE COURSE: STADSC-402
(Probability Theory)

Semester VII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- This paper shall give the students' knowledge about the basic concepts of measure theory, measurable function, integrability of functions.
- Students shall also learn about probability space, theorems of probability and functions of random variables.
- They shall also go into the details of distribution function, convergence of sequence of random variables, generating function and their convergence
- Theorems, proofs and problems concerning law of large numbers, central limit theorems and urn models shall also be dealt with

Learning Outcome

- Knowledge of probability is the basis of understanding the other domains of statistics.

- The knowledge of other subfields of statistics that depends on the concept of probability includes stochastic process, statistical inference, time series, regression analysis, multivariate analysis and other areas of statistical modeling.
- In addition to all these the students learn how to quantify the chance of an outcome in the midst of uncertainty.

UNIT-I

Classes of Sets, Fields, sigma-fields, minimal sigma-field, Borel field, Sequence of sets, limits of a sequence of sets, Probability measure, Integration with respect to measure.
(12 hours)

UNIT-II

Probability space, Basic terminologies and theorems on probability, theorem of total probability, conditional probability, theorems on compound probability and Bayes theorem, Independence of events and its difference from mutually exclusive events, Borel zero-one criterion. (12 hours)

UNIT-III

Random Variable and its properties, mathematical expectation and inequalities involving random variables viz. Markov's, Holder's, Minkowski's and Jenson's Inequalities, Probability distribution (discrete and continuous), Distribution function, two-dimensional and

Multi-dimensional random variables, Marginal and conditional distributions and stochastic independence. (12 hours)

UNIT-IV

Generating functions, probability generating function, moment generating function characteristic functions, factorial moment generating functions, Uniqueness theorem, inversion theorem, Joint characteristic function. (12 hours)

UNIT V

Law of large numbers, Chebychev's and Khinchin's weak law of large numbers, Kolmogorov's theorem, Strong law of large numbers., Central limit theorem, De-Moivre's Laplace central limit theorem, Liapounov's central limit theorem, Statement of Lindeberg- Feller's central limit theorem. (12 hours)

SUGGESTED READING

1. Ash, Robert B. (2000). Probability and Measure Theory, Second Edition, Academic Press, New York.
2. Feller, W. (1985). Introduction to Probability Theory and its Applications, Wiley Eastern, New Delhi
3. Bhatt, B.R. (1999). Modern Probability Theory, 3rd Edition, New Age International Publishers.
4. A. K. Md. Ehsanes Saleh and Vijay K. Rohatgi (2010) An Introduction to Probability and STATistics, Wiley India Pvt. Ltd.
5. Das K. K. and Bhattacharjee D. (2008). An Introduction to Probability Theory, Asian Books, New Delhi.
6. Capinski, M. and ZaStatwniah (2001). Probability through problems, Springer.
7. Cramer, H. (1992). Mathematical Methods of Statistics, Princeton University Press.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-403
(Distribution Theory)

Semester VII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Understand the derivation, properties, and applications of binomial, multinomial, Poisson, negative binomial, geometric, hypergeometric distributions, and power series distribution.
- Explore the exponential families of distributions and the Pitman family of distributions.
- Derive, comprehend, and apply properties of normal, exponential, gamma, beta, Weibull, Cauchy, and lognormal distributions.
- Derive and understand properties and applications of the bivariate normal distribution.
- Derive, understand, and establish the interrelationship of Chi-square, t, and F-distributions.
- Derive and comprehend properties and applications of non-central Chi-square, t, and F distributions.
- Explore compound distributions, including Neyman's Type A distribution, Polya-Eggenberger distribution, and Inverse Polya-Eggenberger distribution.
- Understand the truncation of basic discrete and continuous distributions and their properties.
- Understand distributions of r-th order statistics and joint density of two order statistics.
- Explore special joint distributions resulting from order statistics, distribution of range, and other systematic statistics.
- Understand moments, recurrence relations, and identities for moments of order statistics from arbitrary distributions.
- Study mixture distributions, including finite mixtures, zero-modified distributions, mixture of binomial distribution, and extreme value distributions.

Learning Outcome

- Gain a comprehensive understanding of discrete probability distributions and their real-world applications.
- Develop the ability to apply power series distribution in various contexts.
- Acquire a deep understanding of continuous probability distributions and their significance.
- Apply various continuous distributions to solve practical problems.
- Develop the ability to analyze and model relationships between two variables using bivariate distributions.
- Understand the importance and interconnections of different sampling distributions.
- Develop proficiency in analyzing distributions with non-central characteristics.
- Understand the principles and applications of compound distributions and truncation in statistical modeling.
- Develop advanced statistical modeling skills using order statistics and joint distributions.

- Apply mixture distributions and extreme value distributions in diverse contexts.

UNIT-I

Derivation, properties and advanced applications of multinomial, Poisson, negative binomial, geometric, hyper geometric distribution, power series Distribution, Exponential families of Distributions, Pitman family of distributions. (12 hours)

UNIT-II

Derivation, properties and applications of extreme value distributions (Type I, Type II and Type III). Mixture distribution- finite mixture, zero-modified distributions, mixture of binomial distribution. (12 hours)

UNIT-III

Derivation, properties and applications of bivariate normal distribution, Derivation, properties and applications of Chi-square, t and F-distributions and their interrelationship. (12 hours)

UNIT-IV

Derivation, properties and applications of non-central chi-square, t and F distributions. Compound distribution- Neyman's Type A distribution, Polya-Eggenberger distribution, Inverse Polya-Eggenberger distribution, Truncation of basic discrete and continuous distributions with their properties. (12 hours)

UNIT V

Distributions of r^{th} order statistics, joint density of two order statistics, some special joint distributions resulting from order statistics, Distribution of range and other systematic statistics, moments of order statistics, recurrence relations and identities for moments of order statistics from an arbitrary distributions. (12 hours)

SUGGESTED READING:

1. Johnson, N.L., Kemp, A.W., and Kotz, S.. (2005): Univariate Discrete Distributions, 5th edition, Wiley Interscience, John Wiley & Sons
2. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 1, John Wiley
3. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 2, John Wiley
4. Hogg, R. V., Craig, A., and Mckean, J.W. (2019): Introduction to Mathematical Statistics, 8th edition , Pearson
5. Freund, J.E. (1998): Mathematical Statistics, Prentice Hall of India, New Delhi
6. Biswas, S. (2002): Topics in Statistical Methodology, New Age International Publishers, New Delhi
7. Wilks, S.S. (2007): Mathematical Statistics, Buck Press
8. Das, K.K. and Bhattacharjee, D. (2008): A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi

DISCIPLINE SPECIFIC CORE COURSE: STADSC-404 LAB
(Practical Based on Linear Algebra and Probability Distribution using R)

Semester VII
(Credits: 4)
Contact Hours: 120
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Enable students to compute adjoint and inverse of a matrix using R.
- Develop the ability to reducing a Quadratic Form to its canonical form and finding its rank and index using R.
- Teach the students to establish a quadratic form whether it is positive or negative definite using R.
- Develop proficiency of finding the product of two matrices by considering partitioned matrices using R.
- To learn how to find the inverse of a matrix by using Cayley Hamilton theorem using R.
- Fitting of common discrete and continuous distributions and draw random sample from such distributions.

Learning Outcomes:

- Students will effectively compute adjoint and inverse of a matrix using R.
- Perform analysis to reducing a Quadratic Form to its canonical form and finding its rank and index using R.
- Students shall be able to establish a quadratic form whether it is positive or negative definite using R.
- Students will find the product of two matrices by considering partitioned matrices using R.
- Mastering in find the inverse of a matrix by using Cayley Hamilton theorem using R.

List of Practical:

1. Computation of adjoint and inverse of a matrix
2. Computation of Determinants of matrix
3. Inverses of a matrix by partitioning
4. Rank of a matrix
5. Solutions of matrix equations
6. Characteristic roots and vectors of a matrix
7. Reducing a Quadratic Form to its canonical form and finding its rank and index
8. Proving that a quadratic form is positive or negative definite
9. Finding the product of two matrices by considering partitioned matrices
10. Finding inverse of a matrix by using Cayley-Hamilton theorem

11. Distribution Fitting and checking the goodness of fit of Binomial distribution
12. Distribution Fitting and checking the goodness of fit of Poisson distribution
13. Distribution Fitting and checking the goodness of fit of Normal distribution
14. Distribution Fitting and checking the goodness of fit of Lognormal distribution
15. Distribution Fitting and checking the goodness of fit of Beta distribution
16. Goodness of Fit of distribution with Known Parameters, Testing Independence
17. Random number generation and Simulations.

SUGGESTED READING:

1. Schmuller, J. (2017). *Statistical Analysis with R For Dummies*. John Wiley & Sons.
2. Mailund, T. (2017). *Beginning Data Science in R: Data Analysis, Visualization, and Modelling for the Data Scientist*. Apress.
3. Gardener M. (2010) Beginning R : The Statistical Programming Language, Wiley India Pvt. Ltd., New Delhi.
4. Teetor, Paul (2011) R Cookbook, O'Really.
5. Braun, W. J. and Murdoch, D. J. (2007) A First Course on Statistical Programming with R, Cambridge University Press.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-451
(Research Methodology)

Semester VIII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop an understanding of the meaning, objectives, and motivations in research. Explore different types of research and comprehend research approaches and the significance of research in various domains.
- Learn the process of defining, selecting, and understanding the necessity of research problems. Gain skills in identifying research gaps and framing clear objectives, research questions, and hypotheses.
- Understand the principles of survey methodology, covering topics such as data collection, inference, and errors in surveys. Explore concepts like target populations, sampling frames, coverage errors, and methods of data collection.
- Review various data analysis techniques from core statistics papers. Learn techniques for processing, analyzing data, and interpreting results. Understand precautions in data interpretation to ensure accurate conclusions.
- Apply theoretical knowledge by developing a questionnaire, collecting survey data related to real-world problems (e.g., gender discriminations, unemployment rates), and interpret results to draw meaningful inferences.

Learning Outcomes

- Demonstrate the ability to choose appropriate research methods aligned with aims and objectives.
- Understand the limitations of research and effectively address them by framing clear research problems and objectives.
- Identify and discuss the role and importance of research in the social sciences, showcasing proficiency in reviewing relevant literature.
- Gain practical skills in survey methodology, covering data collection, inference, and error management in surveys.
- Develop the ability to process, analyze, and interpret data, ensuring students can derive meaningful insights and draw valid conclusions from survey results.

UNIT-I

Introduction: Meaning, objective and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems. (12 hours)

UNIT-II

Review of literature, identifying research gaps, framing of objectives of the survey, research questions and research hypothesis, need of Pilot survey and its implications of its result

(12 hours)

UNIT-III

Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys. (12 hours)

UNIT-IV

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

(12 hours)

UNIT V

Data collection process through the questionnaire, aspects of a questionnaire, essentials of a good questionnaire, schedule method of collecting data, difference between the questionnaire and schedule.

Report Writing: Types of report, its layout, steps in writing a report, precautions of report writing. (12 hours)

SUGGESTED READING:

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.
3. Malhotra Naresh, K. and Dash, S. (2015) Marketing Research, An Applied Orientation. 7th Edition, Pearson, India.
4. Panneerselvam, R. (2014) Research Methodology, PHI Learning.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-452
(Advanced Statistical Inference)

Semester VIII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Familiarize with the Neyman Factorization Criterion. Learn its application in determining sufficient statistics.
- Understand the concept of completeness in statistical inference. Recognize the importance of completeness in efficient estimation.
- Learn about the exponential family of distributions. Understand the properties and characteristics of this family.
- Explore families that are non-regular but admit complete sufficient statistics.
- Understand Rao-Cramer's inequality and its implications. Learn its role in determining lower bounds for variances of unbiased estimators.
- Grasp Chapman-Robin's inequality and its significance in statistical estimation.
- Understand Bhattacharya's Bound and its application in statistical inference.
- Learn the concept of Mean Square Error (MSE) as a measure of estimator performance. Understand the trade-off between bias and variance.
- Explore the criteria for an estimator to be the Best Linear Unbiased Estimator. Understand the concept of efficiency in the context of BLUE.
- Grasp Rao-Blackwell theorem and its application in improving estimators.
- Understand Lehmann-Scheffe theorem and its role in finding unique estimators.
- Learn the fundamentals of the method of Maximum Likelihood. Apply MLE to estimate parameters. Understand the asymptotic properties of Maximum Likelihood Estimators. Explore the application of MLE in censored and truncated distributions.
- Grasp the Method of Moments for parameter estimation. Learn to apply the method in practical scenarios.
- Understand the concept of the Method of Minimum Chi-Squares. Explore its application in statistical estimation.
- Familiarize with the Modified Minimum Chi-Square method and its significance.
- Learn the Pitman method of estimation for location and scale parameters.
- Grasp the Neyman-Pearson Lemma and its role in hypothesis testing.
- Understand the concepts of Most Powerful and Uniformly Most Powerful tests. Explore their applications in hypothesis testing.
- Learn to construct UMP tests for simple null hypotheses against one-sided alternatives.
- Understand the construction of UMP tests for one-sided null hypotheses in the exponential family.

- Learn the pivotal quantity method for constructing confidence intervals. Understand the general method of constructing confidence intervals.
- Explore the construction of confidence intervals in the context of large sample sizes.
- Understand the criteria for constructing the shortest expected length confidence interval.
- Learn about uniformly most accurate one-sided confidence intervals. Understand their relationship to UMP tests for one-sided null hypotheses against one-sided alternatives.

Learning Outcome

- Recognize the role of consistency in ensuring estimators converge to the true parameter value. Grasp the concept of efficiency and its connection to the precision of estimators. Understand the notion of sufficiency and its role in reducing data to its essential information.
- Familiarity with Neyman factorization criterion and its application in identifying sufficient statistics. Understand completeness and its significance in capturing all information about the parameter. Explore the exponential family of distributions and its key properties. Investigate non-regular families that admit complete sufficient statistics.
- Understand Rao-Cramer's inequality and its implications for the efficiency of estimators. Familiarity with Chapman-Robin's inequality and its use in bounding moments of distributions. Explore Bhattacharya's Bound and its application in measuring the difference between probability distributions. Grasp the concept of mean square error and its role in assessing the performance of estimators.
- Comprehend the concept of Best Linear Unbiased Estimator (BLUE) and its optimality properties. Explore the Rao-Blackwell theorem and its application in improving estimators. Understand Lehmann-Scheffe theorem and its role in obtaining unbiased estimators with minimal variance.
- Master the method of maximum likelihood for estimating parameters. Explore the asymptotic properties of Maximum Likelihood Estimators (MLE). Understand the application of MLE in censored and truncated distributions.
- Understand the method of minimum chi-squares and modified minimum chi-square for estimation. Familiarity with the Pitman method of estimation for location and scale.
- Recognize the concepts of most powerful (MP) and uniformly most powerful (UMP) tests. Explore UMP tests for simple null hypotheses against one-sided alternatives. Understand UMP tests for one-sided null hypotheses against one-sided alternatives in the one-parameter exponential family.
- Grasp the concept of pivotal quantity method for constructing confidence intervals. Explore large sample confidence intervals. Recognize the concept of uniformly most accurate one-sided confidence interval and its relation to UMP tests for one-sided null hypotheses against one-sided alternative hypotheses.

UNIT-I

Properties of estimators-Unbiasedness, consistency, efficiency, sufficiency, Neyman factorization criterion, Completeness, Exponential family of distributions and its properties, Non-regular families admitting complete sufficient statistics. (12 hours)

UNIT-II

Rao-Cramer's inequality, Chapman-Robin's inequality, Bhattacharya's Bound, Mean square error, Best linear unbiased estimator (BLUE), Rao-Blackwell theorem, Lehmann-Scheffe theorem (12 hours)

UNIT-III

Method of maximum likelihood, asymptotic properties of MLE, MLE in censored and truncated distributions, Method of moments, method of minimum chi-squares, modified minimum chi-square, Pitman method of estimation for location and scale (12 hours)

UNIT-IV

Neyman-Pearson lemma, most powerful (MP) and uniformly most powerful (UMP) tests, UMP tests for simple null hypothesis against one-sided alternatives and for one sided null against one-sided alternatives in one parameter exponential family (12 hours)

UNIT V

Pivotal quantity method and general method of constructing confidence interval, large sample confidence interval, construction of shortest expected length confidence interval
Uniformly most accurate one-sided confidence interval and its relation to UMP tests for one-sided null against one-sided alternative hypothesis. (12 hours)

SUGGESTED READING:

1. Hogg, R. V., Craig, A., and Mckean, J.W. (2019): Introduction to Mathematical Statistics, 8th edition , Pearson
2. Kale, B. K. (1999): A first course on Parametric Inference, Narosa Publishing House
3. Bartoszynski, R and Bugaj, M.N. (2007): Probability and Statistical Inference, John Wiley & Sons
4. Lehmann, E. L. (1986): Theory of Point Estimation, John Wiley & Sons
5. Lehmann, E.L. (1986): Testing Statistical Hypothesis, John Wiley & Sons
6. Dudewicz, E. J and Mishra, S.N. (1988): Modern mathematical Statistics, John Wiley & Sons
7. Rao, C. R. (1973): Linear Statistical Inference and Its Applications, 2nd edition, Wiley Eastern Limited, New Delhi
8. Wilks, S.S. (2007): Mathematical STATistics, Buck Press
9. Rohtagi, V.K and Saleh, A. K, Md, E. (2005): An Introduction to Probability and Statistics, 2nd Edition, John Wiley & Sons
10. Zacks, S. (1971): Theory of Statistical Inference, , John Wiley & Sons
11. Mishra, A. (2020): Theory of Statistical Estimation, Notion Press, Chennai
12. Mishra, A. (2020): Theory of Statistical Hypothesis Testing, Notion Press, Chennai.
13. Das, K.K. and Bhattacharjee, D. (2008): A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi.
14. Mood, A.M, Graybill, F. A. and Boes, D. C. (2017): Introduction to the Theory of statistics, Mc. Graw Hill Publishing Co. Ltd.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-453
(Operations Research)

Semester VIII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Familiarize students with the fundamental concepts of Operations Research (O.R.) and its various phases. Understand the role of O.R. in decision-making and problem-solving across different domains.
- Develop a strong foundation in linear programming (LP) by learning the mathematical formulation of LP problems and graphical solutions. Acquire proficiency in solving LP problems using the simplex method and understanding the significance of artificial variables.
- Gain insight into the concept of duality in LP problems and learn how to solve dual LP problems using the dual simplex method. Understand the relationship between primal and dual LP problems and their practical applications.
- Learn optimization techniques for solving transportation problems, including initial solutions using various methods like North West corner rule, Least cost method, and Vogel's approximation method. Acquire skills in using the MODI method to find optimal solutions.
- Understand the principles of game theory, including rectangular games, minimax-maximin principles, and solution methods using graphical approaches. Understanding the basics of critical path method (CPM) and program evaluation and review technique (PERT) for project management and network analysis.
- Learn about trade-off between replacement and maintenance.

Learning Outcome

- Develop the ability to model real-world problems as linear programming problems, understand their constraints and objectives, and apply the simplex method for optimization.
- Acquire practical skills in solving transportation problems and assignment problems using techniques like the Hungarian method. Understand how these methods are applied to real-world scenarios involving distribution and allocation.
- Learn to analyze and make informed decisions using the principles of duality in LP problems. Understand the economic interpretation of dual variables and the practical implications of solving both primal and dual LP problems.
- Gain proficiency in project scheduling using CPM and PERT techniques. Understand how to identify critical paths, calculate project completion times, and manage project uncertainties effectively.

- Develop a solid understanding of replacement and maintenance problems and shall be able to compute the depreciation cost in practical settings.
- From this course students will be well-prepared to apply operations research techniques to a variety of decision-making scenarios, optimize resource allocation, manage projects efficiently, and make informed choices in inventory management, contributing to effective problem-solving in various domains.

UNIT-I

Introduction to Operations Research, phases of O.R. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. (12 hours)

UNIT-II

Charne's M-technique for solving L.P.P. involving artificial variables. Concept of Duality in L.P.P: Dual simplex method. (12 hours)

UNIT-III

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, Assignment Problem – Hungarian method. (12 hours)

UNIT-IV

Game theory: rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix

Networking: CPM and PERT (Concept and applications). (12 hours)

UNIT V

Replacement and maintenance problems, methodology of replacement and maintenance problems, replacement of items that deteriorates with time (with and without change in money value), replacement of items that fail completely. (12 hours)

SUGGESTED READING:

1. Taha, H. A. (2007). Operations Research: An Introduction (8th Hall of India, Edition). Prentice
2. Kanti, S., Gupta, P.K.,& Manmohan, (2007). Operations Research (13th Edition). Sultan Chand and Sons.
3. Hadley, G. (2002). Linear Programming.Narosa Publications
4. Hillier, F.A.,& Lieberman, G.J. (2010). Introduction to Operations Research-Concepts and Cases (9th Edition). Tata McGraw Hill.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-454
(Programming in Python)

Semester VIII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- The course is designed to provide knowledge of Python to participants having little or no prior programming experience.
- The knowledge of Python language is essential for participants to develop their computational approaches to problem solving.
- Python programming is intended for software engineers, system analysts, program managers and user support personnel for solving problems from basic to advanced level.
- The main objective of the paper is to teach the participants programming skills in core Python and to acquire Object Oriented Skills.

Learning Outcomes

- Learn Python language for expressing computations
- Learn a systematic approach to organizing, writing and debugging Python programs
- Learn how to utilize Python to apply statistical and visualization tools to model datasets

UNIT-I
The Python Environment, Basic elements of Python, Python Applications, Features of Python Programming Language
Python keywords or reserved words, Python Identifiers, class names, variable names, function names, method names, and Identifier naming rules. Implementations of Python, Modes of Programming in Python. (12 hours)

UNIT-II
Comments for Understanding Python code, Python Comment Syntax, Python Single line comment, Multiline comment in Python, and writing Python comments. (12 hours)

UNIT-III
Define Variables, Declaration of Variables, and Assigning Values to Variables, Initialization, Reading, Variable naming restrictions, and Types of Python Variables. (12 hours)

UNIT-IV

Define Data Type, Python Numbers, Python Strings, Python Set and Python Boolean data type. (12 hours)

UNIT V

Python Arithmetic, Comparison/Relational Operators, Increment Operators, Logical operators, Branching Programs, Python Identity Operators and Python Operators Precedence. (12 hours)

List of Programs to be practised in Python:

a) Use of print and input function in python
b) Simple Python program to perform Algebraic Computation
c) Finding the Maximum of Three Numbers in Python
d) Working with Strings
e) Computation of Descriptive Statistics in Python
f) Writing Python code for drawing of (i) Bar Graph (ii) Multiple Bar Diagram (iii) Line Diagram (iv) Scatter Diagram (v) Boxplot (vi) Pie Chart (vii) Histogram
g) Learning how to install Library in Python
h) Fitting of Regression Line in Python
i) Fitting of the following distributions in Python without the use of any Package (i) Bernoulli Distribution (ii) Binomial Distribution (iii) Poisson Distribution (iv) Normal Distribution
j) Filling the following distributions in Python using appropriate package (i) Bernoulli Distribution (ii) Binomial Distribution (iii) Poisson Distribution (iv) Normal Distribution

SUGGESTED READING:

1. McGrath M., (2013) *Python in Easy Steps*, McGraw Hill Education (India) Pvt. Ltd.
2. Guttag, J.V., (2016) *Introduction to Computation and Programming using Python,* PHI Learning Pvt. Ltd.
3. Madhavan S. (2015). Mastering Python for Data Science, Packt Publishing Limited.
4. Lutz M. (2013). Learning Python, O'Reilly, 5th Edition.
5. Urban M. and Murach J. (2016). Murach's Python Programming.
6. Baezly D M. (2009). Python Essential Reference, Fourth Edition. Addison-Wesley Professional.
7. Baezly D M. (2013). Python Cookbook, O'Reilly, Third Edition.

DISCIPLINE SPECIFIC CORE COURSE: STADSC-455
(Research Project/Dissertation)

Semester VIII
(Credits: 12)
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- The paper introduces to the students how to write a literature review of a topic of theoretical or applied statistics.
- The literature review shall not only be restricted to the problem but it shall be carried forward to the corresponding methodological concepts as well.
- The basic purpose of the project is to lay the foundation of understanding how to take up a Research Problem
- This project shall be an individual project. At the end of the project each student shall submit a write up (project report) in duplicate clearly stating the findings or research questions they reached following the literature review.
- Along with the report the project shall be presented by students before an external examiner.

Learning Outcome

- On studying this paper students shall learn how to perform literature review related to a researchable problem.
- Identification of research questions engrossing the research problem.
- The paper shall also enhance the presentation skills and learn to document a project report.

DISCIPLINE SPECIFIC MINOR: STADSM-201
(Random Variables and Probability Distributions)

Semester III
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Define and distinguish between discrete and continuous random variables.
- Explain the concept and significance of probability mass function (p.m.f.), probability density function (p.d.f.), and cumulative distribution function (c.d.f.) for random variables.
- Compute and interpret the expectation and variance of random variables, understanding their properties and applications.
- Demonstrate proficiency in deriving common results involving random variables, including moments and cumulants.
- Illustrate the application of bivariate probability distributions, understanding marginal and conditional distributions, and recognizing the concept of independence of variates.
- Learn about the common probability distributions and their applications.
- To get informed about law of large numbers and the central limit theorem.

Learning Outcomes:

- Construct and interpret tree diagrams for discrete random variables.
- Recognize and understand discrete probability distribution functions, including common distributions like Binomial, Poisson, Normal, and Exponential.
- Apply moment generating functions, cumulants generating functions, and characteristic functions to analyze random variables and their properties.
- Analyze bivariate probability distributions, understanding marginal and conditional distributions in practical scenarios.
- Interpret the independence of variates and its implications in statistical analysis.
- Solving problems involving some common probability distributions

UNIT-I
Random variables: Discrete and continuous random variables, Illustrations of random variables and its properties, concept of p.m.f., p.d.f. and c.d.f. and their properties. (12 hours)

UNIT-II
Expectation and variance of random variables and its properties. Moments and cumulants of random variables, moment generating function, cumulants generating function. (12 hours)

UNIT-III

Bivariate probability distributions, marginal and conditional distributions; independence of variates (only general idea to be given). (12 hours)

UNIT-IV

Common Discrete and Continuous Probability Distributions- Binomial, Poisson, Normal, Exponential. (12 hours)

UNIT V

Chebychev's inequality and its applications, Weak law of Large Numbers (WLLN), Bernoulli's law of large number, Central limit theorem (CLT)- concept only. (12 hours)

SUGGESTED READING:

1. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
2. R.V. Hogg, A.T. Craig, and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Ed. Pearson Education.
3. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. I), 8th Ed., World Press, Kolkata.
4. S.A. Ross (2007): *Introduction to Probability Models*, 9th Ed., Academic Press.

DISCIPLINE SPECIFIC MINOR: STADSM-251 LAB

(Practical based on Basic Statistics and Probability Distributions)

Semester IV
(Credits: 3)
Contact Hours: 90
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Enable students to interpret and construct graphical representations of data using histograms, frequency polygons, and ogive curves, with proficiency in handling equal and unequal class intervals.
- Develop the ability to compute measures of central tendency accurately from raw and grouped data, and demonstrate proficiency in adjusting for changes in origin and scale.
- Equip students with the skills to calculate measures of dispersion for raw and grouped data, and demonstrate competency in adjusting for changes in origin and scale when analyzing data variability.
- Foster an understanding of combined mean and variance, along with the coefficient of variation, allowing students to integrate multiple statistical measures for comprehensive data analysis.
- Develop proficiency in computing moments from raw and grouped data, and demonstrate the ability to adjust for changes in origin and scale, facilitating a deeper understanding of statistical moments and their applications.

Learning Outcomes:

- Students will effectively interpret and create graphical representations of data, facilitating enhanced visualization and communication of statistical information.
- Learners will accurately compute and interpret measures of central tendency, demonstrating the ability to summarize data distribution effectively.
- Participants will demonstrate proficiency in calculating measures of dispersion, enabling them to assess the spread of data and identify potential outliers.
- Students will integrate concepts of mean, variance, and coefficient of variation to analyze data variability comprehensively and draw meaningful insights.
- By mastering moments computation and adjustment for changes in origin and scale, learners will develop a deeper understanding of statistical moments and their significance in practical statistical analysis.

List of Practicals

1. Problems based on graphical representation of data: Histograms (equal class intervals and unequal class intervals), Frequency polygon, Ogive curve.

2. Problems based on measures of central tendency using raw data, grouped data and for change of origin and scale.
3. Problems based on measures of dispersion using raw data, grouped data and for change of origin and scale. Coefficient of Variation.
4. Problems based on Moments using raw data, grouped data and for change of origin and scale.
5. Problems based on skewness and kurtosis
6. Lines of regression and regression coefficients
7. Spearman rank correlation with /without ties
8. Fitting of polynomials and exponential curves
9. Fitting of Binomial distribution
10. Fitting of Poisson distribution
11. Fitting of Normal distribution

Suggested Readings:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. I), 8th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
3. N. G. Das (2008) *Statistical Methods*, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Bhattacharjee D. and Bhattacharjee D. (2008) B. Sc Statistics Vol-I, Kalyani Publishers, Ludhiana.

DISCIPLINE SPECIFIC MINOR: STADSM-252
(Mathematical Statistics)

Semester IV
(Credits: 3)
Contact Hours: 45
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Define and distinguish between discrete and continuous random variables.
- Explain the concept and significance of probability mass function (p.m.f.), probability density function (p.d.f.), and cumulative distribution function (c.d.f.) for random variables.
- Compute and interpret the expectation and variance of random variables, understanding their properties and applications.
- Demonstrate proficiency in deriving common results involving random variables, including moments and cumulants.
- Illustrate the application of bivariate probability distributions, understanding marginal and conditional distributions, and recognizing the concept of independence of variates.
- Learn about the common probability distributions and their applications.

Learning Outcomes:

- Construct and interpret tree diagrams for discrete random variables.
- Recognize and understand discrete probability distribution functions, including common distributions like Binomial, Poisson, Normal, and Exponential.
- Apply moment generating functions, cumulants generating functions, and characteristic functions to analyze random variables and their properties.
- Analyze bivariate probability distributions, understanding marginal and conditional distributions in practical scenarios.
- Interpret the independence of variates and its implications in statistical analysis.
- Solving problems involving some common probability distributions.

UNIT-I

Random variables: Discrete and continuous random variables, llustrations of random variables and its properties, concept of p.m.f., p.d.f. and c.d.f. and their properties. (9 hours)

UNIT-II

Expectation and variance of random variables and its properties. Deduction of common results involving random variables. (9 hours)

UNIT-III

Moments and cumulants of random variables, moment generating function, cumulants generating function and characteristic function. (9 hours)

UNIT-IV

Bivariate probability distributions, marginal and conditional distributions; independence of variates (only general idea to be given). (9 hours)

UNIT V

Common Discrete and Continuous Probability Distributions- Binomial, Poisson, Normal, Exponential. (9 hours)

SUGGESTED READING:

1. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
2. R.V. Hogg, A.T. Craig, and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Ed. Pearson Education.
3. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. I), 8th Ed., World Press, Kolkata.
4. S.A. Ross (2007): *Introduction to Probability Models*, 9th Ed., Academic Press.

DISCIPLINE SPECIFIC MINOR: STADSM-301
(Statistical Inference and Applied Statistics)

Semester V
(Credits: 3)
Contact Hours: 45
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a solid understanding of fundamental statistical concepts, including random samples, parameters, and statistics.
- Acquire proficiency in formulating null and alternative hypotheses, determining significance levels, and interpreting Type I and Type II errors.
- Master the concepts of sampling distributions, including those of the sample mean, and apply large sample tests for various parameters.
- Explore the properties and relationships between main sampling distributions like chi-square, t, and F distributions, applying them in significance tests.
- To understand about how to measure change in price/value of a basket of commodities using Index number
- To understand the concept of time series data and the components of time series analysis
- To determine the trend in time series analysis and to understand the process of measuring of seasonal impact on time series data.

Learning Outcome

- Demonstrate a solid understanding of fundamental statistical concepts, including random samples, parameters, and statistics.
- Apply parameter and sample space concepts in the estimation process, evaluating estimators for key properties.
- Acquire proficiency in formulating null and alternative hypotheses, determining significance levels, and interpreting Type I and Type II errors.
- Master the concepts of sampling distributions and apply large and small sample tests for various parameters.
- Understand the concept of inflation and measure the same applying Index numbers.
- Acquire knowledge about Time series data and measurement of trend
- To measure and eliminate seasonal fluctuation of time series data

UNIT-I
Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors and critical region (definition only). Concept of *p*- value. Sampling distribution of a statistic, unbiased estimator of sample mean and sample variance. Standard error of sample mean.

Large sample tests for single mean, difference of means**,** standard deviation and difference of standard deviations. (9 hours)

UNIT-II

Sampling distributions of chi-square, t and F: definitions, properties and relationships between them. Tests of Significance based on Chi-square (goodness of fit and independence of attributes), *t*-distribution and *F*- distribution. (9 hours)

UNIT-III

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher. Factor reversal and time reversal tests. Chain index numbers (definition only). Consumer price index numbers: Definition, construction and limitation. (9 hours)

UNIT-IV

Introduction to times series data, application of time series in various fields. Components of a times series. Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages. (9 hours)

UNIT V

Fitting of a various mathematical curves using method of least squares and Method of moving averages to understand trend. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Method of Link Relatives. (9 hours)

SUGGESTED READING:

1. A.M. Goon, M.K. Gupta and B. Dasgupta (2003): *An Outline of Statistical Theory* (Vol. I & II), 4th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
3. Mukhopadhyay P. (2011): *Applied Statistics*, 2nd ed. Revised reprint, Books and Allied.
4. Gupta, S.C. and Kapoor, V. K. (2008): *Fundamentals of Applied Statistics*, 4th Ed. (reprint), Sultan Chand and Sons.

DISCIPLINE SPECIFIC MINOR: STADSM-302
(Statistical Inference and Applied Statistics)

Semester V
(Credits: 3)
Contact Hours: 45
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Develop a solid understanding of fundamental statistical concepts, including random samples, parameters, and statistics.
- Acquire proficiency in formulating null and alternative hypotheses, determining significance levels, and interpreting Type I and Type II errors.
- Master the concepts of sampling distributions, including those of the sample mean, and apply large sample tests for various parameters.
- Explore the properties and relationships between main sampling distributions like chi-square, t, and F distributions, applying them in significance tests.
- To understand about how to measure change in price/value of a basket of commodities using Index number
- To understand the concept of time series data and the components of time series analysis
- To determine the trend in time series analysis and to understand the process of measuring of seasonal impact on time series data.

Learning Outcome

- Demonstrate a solid understanding of fundamental statistical concepts, including random samples, parameters, and statistics.
- Apply parameter and sample space concepts in the estimation process, evaluating estimators for key properties.
- Acquire proficiency in formulating null and alternative hypotheses, determining significance levels, and interpreting Type I and Type II errors.
- Master the concepts of sampling distributions and apply large and small sample tests for various parameters.
- Understand the concept of inflation and measure the same applying Index numbers.
- Acquire knowledge about Time series data and measurement of trend
- To measure and eliminate seasonal fluctuation of time series data

UNIT-I
Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors and critical region (definition only). Concept of *p*- value. Sampling distribution of a statistic, unbiased estimator of sample mean and sample variance. Standard error of sample mean.

Large sample tests for single mean, difference of means, standard deviation and difference of standard deviations. (9 hours)

UNIT-II

Sampling distributions of chi-square, t and F: definitions, properties and relationships between them. Tests of Significance based on Chi-square (goodness of fit and independence of attributes), t distribution and F- distribution. (9 hours)

UNIT-III

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher.Factor reversal and time reversal tests. Chain index numbers(definition only). Consumer price index numbers: Definition, construction and limitation. (9 hours)

UNIT-IV

Introduction to times series data, application of time series from various fields. Components of a times series. Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages. (9 hours)

UNIT V

Fitting of a various mathematical curve and Method of moving averages to understand trend. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Method of Link Relatives. (9 hours)

SUGGESTED READING:

1. A.M. Goon, M.K. Gupta and B. Dasgupta (2003): *An Outline of Statistical Theory* (Vol. I & II), 4th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
3. Mukhopadhyay P. (2011): *Applied Statistics,* 2nd ed. Revised reprint, Books and Allied.
4. Gupta, S.C. and Kapoor, V. K. (2008): *Fundamentals of Applied Statistics*, 4th Ed. (reprint), Sultan Chand and Sons.

DISCIPLINE SPECIFIC MINOR: STADSM-351 LAB
(Statistical Methods and Probability Distributions)

Semester VI
(Credits: 4)
Contact Hours: 120
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Enable students to interpret and construct graphical representations of data using histograms, frequency polygons, and ogive curves, with proficiency in handling equal and unequal class intervals.
- Develop the ability to compute measures of central tendency accurately from raw and grouped data, and demonstrate proficiency in adjusting for changes in origin and scale.
- Equip students with the skills to calculate measures of dispersion for raw and grouped data, and demonstrate competency in adjusting for changes in origin and scale when analyzing data variability.
- Foster an understanding of combined mean and variance, along with the coefficient of variation, allowing students to integrate multiple statistical measures for comprehensive data analysis.
- Develop proficiency in computing moments from raw and grouped data, and demonstrate the ability to adjust for changes in origin and scale, facilitating a deeper understanding of statistical moments and their applications.

Learning Outcomes:

- Students will effectively interpret and create graphical representations of data, facilitating enhanced visualization and communication of statistical information.
- Learners will accurately compute and interpret measures of central tendency, demonstrating the ability to summarize data distribution effectively.
- Participants will demonstrate proficiency in calculating measures of dispersion, enabling them to assess the spread of data and identify potential outliers.
- Students will integrate concepts of mean, variance, and coefficient of variation to analyze data variability comprehensively and draw meaningful insights.
- By mastering moments computation and adjustment for changes in origin and scale, learners will develop a deeper understanding of statistical moments and their significance in practical statistical analysis.

List of Practicals

1. Problems based on graphical representation of data: Histograms (equal class intervals and unequal class intervals), Frequency polygon, Ogive curve.

2. Problems based on measures of central tendency using raw data, grouped data and for change of origin and scale.
3. Problems based on measures of dispersion using raw data, grouped data and for change of origin and scale and computation of coefficient of variation
4. Problems based on Moments using raw data, grouped data and for change of origin and scale.
5. Problems based on Skewness and kurtosis
6. Lines of regression and regression coefficients
7. Spearman rank correlation with /without ties
8. Fitting of polynomials and exponential curves
9. Fitting of binomial distribution
10. Fitting of Poisson distribution
11. Fitting of Suitable distribution
12. Fitting of normal distribution

Suggested Reading:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. I), 8th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
3. N. G. Das (2008) *Statistical Methods*, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Bhattacharjee D. and Bhattacharjee D. (2008) B. Sc Statistics Vol-I, Kalyani Publishers, Ludhiana.

DISCIPLINE SPECIFIC MINOR: STADSM-401
(Sample Survey, Designs of Experiments and Indian Official Statistics)

Semester VII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Grasp the basic concepts of sample surveys, including the principles of sampling theory, planning, and organization of a sample survey.
- Master the definition, procedures, and properties of simple random sampling, along with the estimation of mean and sampling variance of the sample mean.
- Understand stratified random sampling, estimation of population mean and variance, and compare stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision.
- Learn the principles of linear systematic sampling and its applications.
- Comprehend the principles of design of experiments, including uniformity trials, completely randomized, randomized block, and Latin square designs. Understand the construction and analysis of 22 and 23 factorial experiments.
- Learn about the Indian Official Statistics system

Learning Outcome

- Demonstrate a solid understanding of the fundamental concepts of sample surveys, including the principles of sampling theory and Indian survey organization.
- Demonstrate mastery in applying simple random sampling, including the selection of samples and estimation of mean and sampling variance.
- Apply stratified random sampling techniques proficiently, including the estimation of population mean and variance under various scenarios.
- Apply systematic sampling techniques and conduct analysis of variance for different types of data classifications.
- Apply advanced principles of design of experiments, including the construction and analysis of factorial experiments and the use of different experimental designs.

UNIT-I
Sample Surveys: Basic concepts of sample survey: concept of sampling, need for sampling, complete enumeration v/s. sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors. (12 hours)

UNIT-II

Simple random sampling (srswr and srswor): definition and procedures of selecting a sample, properties of simple random sample, estimation of mean and sampling variance of sample mean.

Stratified random sampling: introduction, estimation of population mean and its variance, choice of sample sizes in different strata, comparison of stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision. (12 hours)

UNIT-III

Systematic sampling: introduction to linear systematic sampling, estimation of mean and its variance (N = nk).

Analysis of variance: one-way and two-way classified data with one observation per cell only. (12 hours)

UNIT-IV

Design of experiments: Principles of Design of experiments, uniformity trails, completely randomized, Randomized block and Latin square designs. (12 hours)

UNIT-V

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance. (12 hours)

SUGGESTED READING:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. II), 8th Ed., World Press, Kolkata.
2. A.M. Goon, M.K. Gupta and B. Dasgupta (2005): *An Outline of Statistical Theory* (Vol. II), 3rd Ed., World Press, Kolkata.
3. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
4. D.C. Montgomery (2001): *Designs and Analysis of Experiments*, John Wiley and Sons, New York.
5. P. Mukhopadhyay (1998): *Theory and Methods of Surveys Sampling*, Prentice Hall of India.
6. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok (1984): *Sampling Theory of Surveys with Applications*, Lowa State University Press, Lowa, USA.
7. Guide to current Indian Official Statistics, Central Statistical Office, GOI,New Delhi.
8. http://mospi.nic.in/

DISCIPLINE SPECIFIC MINOR: STADSM-451
(Sample Survey, Designs of Experiment and Indian Official Statistics)

Semester VIII
(Credits: 4)
Contact Hours: 60
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objective

- Grasp the basic concepts of sample surveys, including the principles of sampling theory, planning, and organization of a sample survey.
- Master the definition, procedures, and properties of simple random sampling, along with the estimation of mean and sampling variance of the sample mean.
- Understand stratified random sampling, estimation of population mean and variance, and compare stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision.
- Learn the principles of linear systematic sampling and its applications.
- Comprehend the principles of design of experiments, including uniformity trials, completely randomized, randomized block, and Latin square designs. Understand the construction and analysis of 22 and 23 factorial experiments.
- Learn about the Indian Official Statistics system

Learning Outcome

- Demonstrate a solid understanding of the fundamental concepts of sample surveys, including the principles of sampling theory and Indian survey organization.
- Demonstrate mastery in applying simple random sampling, including the selection of samples and estimation of mean and sampling variance.
- Apply stratified random sampling techniques proficiently, including the estimation of population mean and variance under various scenarios.
- Apply systematic sampling techniques and conduct analysis of variance for different types of data classifications.
- Apply advanced principles of design of experiments, including the construction and analysis of factorial experiments and the use of different experimental designs.

UNIT-I
Sample Surveys: Basic concepts of sample survey: concept of sampling, need for sampling, complete enumeration v/s. sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors. (12 hours)

UNIT-II

Simple random sampling (srswr and srswor): definition and procedures of selecting a sample, properties of simple random sample, estimation of mean and sampling variance of sample mean. Stratified random sampling: introduction, estimation of population mean and its variance, choice of sample sizes in different strata, comparison of stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision. (12 hours)

UNIT-III

Systematic sampling: introduction to linear systematic sampling, estimation of sample mean and its variance ($N = nk$). Analysis of variance: one-way and two-way classified data with one observation per cell only. (12 hours)

UNIT-IV

Design of experiments: Principles of Design of experiments, uniformity trails, completely randomized, Randomized block and Latin square designs. (12 hours)

UNIT-V

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance. (12 hours)

SUGGESTED READING:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. II), 8th Ed., World Press, Kolkata.
2. A.M. Goon, M.K. Gupta and B. Dasgupta (2005): *An Outline of Statistical Theory* (Vol. II), 3rd Ed., World Press, Kolkata.
3. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
4. D.C. Montgomery (2001): *Designs and Analysis of Experiments*, John Wiley and Sons, New York.
5. P. Mukhopadhyay (1998): *Theory and Methods of Surveys Sampling*, Prentice Hall of India.
6. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok (1984): *Sampling Theory of Surveys with Applications*, Lowa State University Press, Lowa, USA.
7. Guide to current Indian Official Statistics, Central Statistical Office, GOI,New Delhi.
8. http://mospi.nic.in/

SKILL ENHANCEMENT COURSES: STASEC-201T
(Statistical Computing Using C)

Semester III
(Credits: 3)
Contact Hours: 60
Full Marks = 70 [End Semester Exam (50)
Internal (20 = 14(Test)+6(Attendance))]
Pass Marks = 28 [End Semester Exam (20) +Internal (8)]

Learning Objective

- Familiarize with the components and basic structure of C programs, including character sets, tokens, keywords, and identifiers.
- Master the concepts of constants, variables, and symbolic constants, along with their declaration and assignment in C programs.
- Understand the precedence of operators in arithmetic, relational, and logical expressions to write efficient code.
- Learn about different looping constructs such as for, while, and do…while, and understand their applications in controlling program flow in C programming
- Understand the concept of arrays and their importance in storing and manipulating data efficiently.
- Gain proficiency in function prototypes and function calls to enable modular programming.

Learning Outcome

- Master the fundamentals of C++ programming language, including syntax, data types, control structures, and object-oriented programming concepts.
- Develop the ability to design and implement efficient algorithms using C, demonstrating logical thinking and problem-solving skills.
- Understand and utilize control structures effectively to manage program flow and make decisions within C programs.
- Learn to compile clean and error-free C programs, ensuring proper syntax and adherence to programming standards.
- Gain insight into how to use C for object-oriented programming features for statistical computation.

UNIT-I
History and importance of C/C++. Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants. (12 hours)

UNIT-II
Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Library

functions. Managing input and output operations: reading and printing formatted and unformatted data. (12 hours)

UNIT-III

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional (?) operator. Looping in C/C++: for, nested for, while, do…while, jumps in and out of loops. (12 hours)

UNIT-IV

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only). (12 hours)

UNIT V

User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values , arguments with return values, no arguments but returns a value, functions that return multiple values. Recursion function. Passing arrays to functions. (12 hours)

SKILL ENHANCEMENT COURSES: STASEC-201 LAB
(Statistical Computing Using C)

Full Marks = 30 [End Semester Exam (30)]
Pass Marks = 12[End Semester Exam (12)]

List of Practicals

1. Plot of a graph y = f(x)
2. Roots of a quadratic equation
3. Sorting of an array and hence finding median
4. Mean, Median and Mode of a Grouped Frequency Data
5. Variance and coefficient of variation of a Grouped Frequency Data
6. Value of n! using recursion
7. Random number generation from uniform distribution
8. Matrix addition, subtraction, multiplication
9. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit
10. t-test for difference of means
11. Paired t-test
12. F-test
13. Karl-Pearson correlation coefficient
14. Fitting of lines of regression

SUGGESTED READING:

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2nd Edition,Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
3. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill.
4. Kanetkar Y. P. (2008) Let us C, 8th Edition, Infinity Science Press

INTER DISCIPLINARY COURSES: STAIDC-201

(Sampling and Elements of Hypothesis Testing)

Semester III
(Credits: 3)
Contact Hours: 45
Full Marks = 100 [End Semester Exam (70) +Internal (30)]
Pass Marks = 40[End Semester Exam (28) +Internal (12)]

Learning Objectives:

- Understand the fundamental concepts of population and sample, distinguishing between complete enumeration and sampling, and identify sources of sampling and non-sampling errors.
- Explain various types of sampling methods, including non-probability and probability sampling, and comprehend the procedures for simple random sampling with and without replacement, along with estimating population parameters and variances.
- Define random sample, parameter, and statistic, articulate null and alternative hypotheses, and discern between simple and composite hypotheses, as well as understand the significance levels, probabilities of Type I and Type II errors, and critical regions, along with interpreting p-values and sampling distributions of statistics.
- Apply unbiased estimation techniques for sample mean and sample variance, compute the standard error of sample mean, and conduct large sample tests for single mean, difference of means, standard deviation, and difference of standard deviations.
- Implement tests of significance based on Chi-square for goodness of fit and independence of attributes, t-distribution, and F-distribution to analyse statistical relationships and make informed inferences.

Learning Outcomes:

- Students will be able to differentiate between population and sample and recognize the implications of complete enumeration versus sampling, thereby minimizing sampling and non-sampling errors in research studies.
- Learners will proficiently select appropriate sampling methods and execute procedures for simple random sampling, enabling accurate estimation of population parameters and variances.
- Participants will demonstrate a sound understanding of hypothesis testing, including formulating null and alternative hypotheses, interpreting significance levels, and making informed decisions based on p-values and sampling distributions.

- By applying unbiased estimation techniques and conducting large sample tests, students will effectively analyze data sets, compute sample statistics, and draw valid conclusions about population parameters.
- Through practical application of tests of significance, including Chi-square, t-distribution, and F-distribution, learners will evaluate statistical relationships and draw meaningful insights from data analysis tasks.

UNIT-I

Definition of random variable, expectation, variance and covariance, statement of addition and multiplication theorem of expectation.

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Pilot Survey, basic principle of sample survey. (9 hours)

UNIT-II

Types of sampling: non-probability and probability sampling, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean and total. (9 hours)

UNIT-III

Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors and critical region (definition only). Concept of *p*- value. Sampling distribution of a statistic. (9 hours)

UNIT-IV

Standard error of sample mean. Large sample tests for single mean, difference of means and related problems. (9 hours)

UNIT-V

Tests of Significance based on Chi-square (goodness of fit and independence of attributes), student's and Fisher's t test (single mean and difference of means) and F test for variances. (9 hours)

SUGGESTED READING:

1. A.M. Goon, M.K. Gupta, and B. Dasgupta (2005): *Fundamentals of Statistics* (Vol. II), 8th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
3. N. G. Das (2008) "Statistical Methods," Tata McGraw-Hill Publishing Company Ltd., New Delhi.
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