Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce, Baramati

(Empowered Autonomous)

M.Sc. Degree Program in Statistics

(Faculty of Science & Technology)

CBCS Syllabus

M.Sc. Part – I (Statistics) Semester – I

For Department of Statistics

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2026 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2026-2027

Title of the Programme: M.Sc. Part – I (Statistics)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Statistics and related subjects, the Board of Studies in Statistics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the first semester of M.Sc. Statistics, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

The word Statistics is used in different ways in different contexts. To a cricket fan, Statistics is the information about runs scored or wickets taken by a player. To the manager of a manufacturing unit, Statistics may be the information about the process control. To a medical researcher investigating the effects of a new drug, Statistics are evidence of research efforts. To a college student, Statistics are the grades or marks scored in a course. Thus, in all

these illustrations Statistics word refers to quantitative data in the area under study. Statistics as a subject is an important branch of knowledge and is devoted to various techniques of collection, presentation, analysis and interpretation of data. It is a science of learning from data.

The program emphasizes both theory and applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. Accordingly, the program has important features such as individual/ group projects, elective courses and courses on standard software packages such as MATLAB, MINITAB, SYSTAT, SPSS, R. Syllabus of the first two semesters covers core courses. The second year syllabus contains core, elective and open courses. It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science, and mathematics in place of electives.

This Statistics syllabus serves as a guide to the course content, objectives, and expectations for students pursuing a degree in Statistics. This program is designed to provide you with a solid foundation in statistical theory, methods, and applications, equipping you with the necessary skills to analyse and interpret data effectively. Statistics is a discipline that revolves around the collection, analysis, interpretation, presentation, and organization of data. In today's data-driven world, the need for statisticians has never been greater. This program aims to foster your understanding of statistical concepts, develop your analytical thinking, and enhance your ability to make informed decisions based on data-driven evidence.

Throughout this program, you will be exposed to a wide range of statistical topics, including probability theory, mathematical statistics, regression analysis, experimental design, multivariate analysis, time series analysis, and more. You will also gain proficiency in statistical software and programming languages commonly used in the field, such as SPSS, Minitab, R, Python, etc.

In summary, the M.Sc. in Statistics program offers a comprehensive education in statistical theory and practice. It equips you with the skills needed to analyze data, draw meaningful conclusions, and make evidence-based decisions. We are excited to embark on this educational journey with you and look forward to your growth as a skilled statistician.

Overall, revising the Statistics syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Programme Specific Outcomes (PSOs)

PSO1. Proficiency in Statistical Concepts and Techniques: Understand and apply fundamental concepts of probability distribution and statistical inference.

PSO2. Data Analysis and Interpretation: Collect, organize, and analyse data using appropriate statistical methods. Interpret and communicate the results of statistical analyses effectively to both technical and non-technical audiences.

PSO3. Statistical Computing and Programming: Utilize statistical software packages, such as R or Python, to implement statistical analyses and simulations.

PSO4. Research and Problem-Solving: Identify research problems, formulate appropriate hypotheses, and design research studies.

PSO5. Statistical Consulting and Collaboration: Collaborate with researchers, scientists, and professionals from various domains to provide statistical support and consultancy.

PSO6. Ethical and Professional Practice: Understand and adhere to the ethical guidelines and standards for handling confidential data and ensuring data privacy.

PSO7. Application of statistical software for data analysis: Students should gain hands-on experience with statistical software packages, such as R or Excel, to perform basic data analysis tasks.

Program Outcomes for M.Sc.(Statistics)

PO1	**Advanced Disciplinary Knowledge & Originality:** Demonstrating comprehensive and advanced knowledge in the chosen field of science, extending beyond the undergraduate level, providing a specialized foundation for developing and applying original ideas, particularly within a research context.
PO2	**Research, Analysis, and Complexity:** Ability to formulate hypotheses and design experiments while demonstrating the capacity to integrate knowledge and handle complex information, even when it is incomplete or limited.
PO3	**Problem Solving in New Contexts:** Apply theoretical knowledge and problem-solving abilities to unfamiliar, real-world, or multidisciplinary environments, moving beyond standard classroom scenarios to innovative applications.
PO4	**Technical Mastery and Scientific Reasoning:** Utilize modern tools, specialized techniques, and instruments with high proficiency, underpinned by a deep rationale and scientific reasoning for the choice of methodology.
PO5	**Integrated Communication:** Clearly and unambiguously communicate complex scientific conclusions, and the knowledge/rationale supporting them, to both specialist peers and non-specialist stakeholders.
PO6	**Ethical, Social, and Professional Judgment:** Adhere to strict ethical standards in research while reflecting on the social and environmental responsibilities linked to the application of scientific knowledge and professional judgments.
PO7	**Autonomous and Lifelong Learning:** Exhibit the learning skills necessary to pursue further study or professional development in a largely self-directed and autonomous manner.
PO8	**Employability, Innovation, and Entrepreneurship:** Translate advanced technical skills and independent thinking into professional excellence within industry, academia, or entrepreneurial ventures.

Title of the Programme: M.Sc. – I (Statistics)

Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce Baramati, Dist.-Pune, MS, India.

(Empowered Autonomous)

Board of Studies in Statistics
(Academic Year 2025-26 to 2027-28)

Sr. No.	Name of Members	Designation
1.	**Prof. Dr. Kakade Vikas Chintaman** Head & Professor, Department of Statistics, T. C. College, Baramati.	**Chairperson**
2.	**Prof. Dr. Jagtap Avinash Srirangrao** Principal, Department of Statistics, T. C. College, Baramati	Member
3.	**Dr. Dhane Neeta Kishor** Associate Professor, Department of Statistics, T. C. College, Baramati	Member
4.	**Dr. Patil Vaishali Vilas** Associate Professor, Department of Statistics, T. C. College, Baramati	Member
5.	**Dr. Swami Chandrashekhar Panchayya** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
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11.	**Dr. Arekar Trupti Shantanu** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
12.	**Miss. Rakate Priya Nanasaheb** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member

13.	**Ms. Choudhar Shital Balu** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
14.	**Miss. Dhokchaule Rutuja Babasaheb** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
15.	**Miss. Ghadge Kiran Tanaji** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
16.	**Miss. Ranmode Snehal Sanjay** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
17.	**Miss. Prabhune Utkarsha Shrinivas** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
18.	**Dr. Akanksha Kashikar**	Vice-Chancellor Nominee Subject Expert from SPPU, Pune
19.	**Dr. Koshti Rohan**	Subject Expert from Outside the Parent University
20.	**Prof. Gardi Chandrakant Gopal**	Subject Expert from Outside the Parent University
21.	**Mr. Kadam Saurabh**	Representative from industry/corporate sector/allied areas
22.	**Dr. Limbore Jaya Laxman**	Member of the College Alumni
23.	**Miss. Shirke Shatakshi Shrikant**	UG Student
24.	**Miss. Pathak Siddhi Rajendra**	PG Student

Course Structure for M.Sc. Part-I (Statistics) (2026 Pattern)

Level	Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
6.0	I	Major (Mandatory)	STA-501-MRM	Linear Algebra	Theory	04
			STA-502-MRM	Probability Distributions	Theory	04
			STA-503-MRM	Parametric Inference-I	Theory	02
			STA-504-MRM	Statistics Practical – I	Practical	02
			STA-505-MRM	Introduction to Python	Practical	02
		Major (Elective)	STA-506-MJE(A)	Mathematical Analysis	Theory (Any One)	02
			STA-506-MJE(B)	Calculus		
			STA-507-MJE(A)	Practical Based on Sampling Techniques and Numerical Analysis	Practical (Any One)	02
			STA-507-MJE(B)	Practical Based on Optimization Techniques		
		Research Methodology (RM)	STA-508-RM	Research Methodology	Theory	04
Total Credits Semester – I						**22**
6.0	II	Major (Mandatory)	STA-551-MRM	Multivariate Analysis	Theory	04
			STA-552-MRM	Probability Theory	Theory	04
			STA-553-MRM	Parametric Inference – II	Theory	02
			STA-554-MRM	Statistics Practical – II	Practical	02
			STA-555-MRM	Statistics Practical – III	Practical	02
		Major (Elective)	STA-556-MJE(A)	Stochastic Processes	Theory (Any One)	02
			STA-556-MJE(B)	Reliability Theory		
			STA-557-MJE(A)	Data Visualization Using Tableau and Power BI	Practical (Any One)	02
			STA-557-MJE(B)	Practical Based on Reliability Theory		
		On Job Training (OJT)	STA-558-OJT	On Job Training	Theory	04
Total Credits Semester – II						**22**
Cumulative Credits for PG Diploma – I and II						**44**

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Mandatory Theory
Course Name	: Linear Algebra
Course Code	: STA-501-MRM
No. of Credits	: 4 credits
No. of Teaching Hours	: 60

Course Objectives:

1. Use the basic concepts of vector and matrix algebra
2. Understand real vector spaces and subspaces and apply their properties.
3. Solve systems of linear equations using various methods
4. Understand concepts required in advanced statistical and machine learning techniques.
5. Evaluate mathematical expressions to compute quantities that deal with linear systems and eigen value problems.
6. Construct a spectral decomposition of a matrix.
7. Characterize and classify quadratic forms using eigen values and eigenvectors

Course Outcomes:

By the end of the course, students will be able to:

CO1. understand the concepts of vectors, matrices, linear transformations, and systems of linear equations.

CO2. familiar with the properties and characteristics of vector spaces, concepts like subspaces, basis, linear independence and dimension.

CO3. learn about eigen values and eigenvectors and their applications in various fields.

CO4. explore inner product spaces, orthogonality and orthogonal projections.

CO5. apply the concept of decomposition of a matrix.

CO6. understand the concepts of quadratic forms and solve problems.

CO7. explore applications of linear algebra in multivariate analysis, linear models etc.

Topics and Learning Points

Unit – 1 **(15L)**

Vector space, subspace, linear dependence and independence, basis and dimension of a vector space, orthogonal and orthonormal vectors, null space, Gram-Schmidt Orthogonalization process, orthonormal basis, orthogonal projection of vector, algebra of matrices, row and column spaces of a matrix, elementary operations.

Unit – 2 **(18L)**

Partitioned matrix, Elementary matrix, Determinant of a matrix, elementary properties, Determinant and inverse of partitioned matrix, Kronecker product. Rank of a matrix, rank and nullity, inverse of a matrix null space, idempotent matrix, Generalised inverse, Moore Penrose generalized inverse, solution of a system of homogenous and non-homogeneous linear equation, theorem related to existence of solution and examples

Unit – 3 **(18L)**

Eigen values and eigen vectors, eigen spaces, Geometric and algebraic multiplicity of an eigen value, Properties of eigen values. Right and left characteristic vector, orthogonal property of characteristic vector Cayley – Hamilton theorem and minimal polynomial, application of Caley Hamilton theorem and its applications. Spectral decomposition of real symmetric matrix singular value decomposition, nth power of a matrix, Jordan decomposition.

Unit – 4 **(9L)**

Real Quadratic form (QF), Classification, Rank and signature, reduction of any QF to diagonal form. Definiteness of a matrix, equivalence of nonnegative definite matrix and variance covariance matrix, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic form.

References:

1. Graybill, F.A(1961) An Introduction to Linear Statistical Models Vol-1, McGraw-Hill Book Company Inc.
2. Hadely G. (1962) Linear Algebra, Narosa Publishing House.
3. Harville D. (1997) Matrix Algebra From Statistics Perspective, Springer.
4. Kumaresan S. (2000), Linear Algebra: A geometric approach, Prenttice Hall.

5. R. B. Bapat Linear Algebra and Linear Models.
6. Rao A. R. and Bhimasankaram P. (2000), Linear Algebra, Second edition, Hindustan Book Agency.
7. Rao C. R. (2001) Linear Statistical Inference and Its Application, Second Edition, Wiley.
8. Schott J. (2016) Matrix Analysis for Statistics, Third edition Wiley.
9. Searl S. B. (2006) Matrix Algebra Useful for Statistics, Wiley.

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	1	1	2	1
CO2	3	2	1	1	1	1	2	1
CO3	3	2	2	2	1	1	2	2
CO4	3	2	2	2	1	1	2	1
CO5	3	2	3	2	1	1	2	2
CO6	3	2	2	2	1	1	2	1
CO7	3	3	3	2	2	1	2	3

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1 : Builds strong foundational understanding of vectors, matrices, linear transformations, and systems of linear equations.

CO2 : Develops in-depth knowledge of vector spaces, subspaces, basis, linear independence, and dimension.

CO3 : Provides advanced understanding of eigenvalues and eigenvectors and their theoretical importance.

CO4 : Strengthens conceptual clarity in inner product spaces, orthogonality, and projections.

CO5 : Enhances advanced knowledge of matrix decomposition techniques.

CO6 : Develops solid theoretical understanding of quadratic forms.

CO7 : Extends disciplinary knowledge through applications in multivariate analysis and linear models.

PO2: Research, Analysis, and Complexity

CO1 : Encourages analytical thinking through structured problem-solving in linear systems.

CO2 : Supports abstraction and logical reasoning required for higher-level mathematical analysis.

CO3 : Enables analysis of complex systems using eigen techniques.

CO4 : Involves analytical reasoning in orthogonality and projections.

CO5 : Assists in handling complex matrix problems and decompositions.

CO6 : Develops analytical skills through solving quadratic form problems.

CO7 : Strongly supports research-oriented thinking in statistical and modeling applications.

PO3: Problem Solving in New Contexts

CO1: Applies basic linear algebra tools to unfamiliar problem settings.

CO3 : Uses eigen concepts in real-world and interdisciplinary applications.

CO4 : Applies orthogonality concepts in optimization problems.

CO5 : Strongly supports solving real-world problems using matrix decomposition.

CO6 : Applies quadratic forms in optimization and classification problems.

CO7 : Strong application in multivariate analysis and linear models.

PO4: Technical Mastery and Scientific Reasoning

CO1 : Supports logical reasoning in solving linear algebraic problems.

CO3 : Enables use of computational techniques involving eigenvalues.

CO4 : Supports technical reasoning in projection methods.

CO5 : Encourages structured approaches in matrix factorization techniques.

CO6: Enhances reasoning in algebraic problem-solving.

PO5: Integrated Communication

CO7 : Enables interpretation and communication of mathematical results in applied contexts.

CO1–CO6: Support clear mathematical expression and logical presentation of solutions.

PO6: Ethical, Social, and Professional Judgment

CO1–CO7 : Indirectly contribute by promoting disciplined problem-solving and responsible application of mathematical tools.

PO7: Autonomous and Lifelong Learning

CO1–CO7 : Encourage self-directed learning and continuous skill development in advanced mathematical concepts.

PO8: Employability, Innovation, and Entrepreneurship

CO3 : Enhances employability through computational and analytical techniques.

CO5 : Useful in industry applications involving data and optimization.

CO7 : Strongly supports employability and innovation in data science, analytics, and research domains.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Mandatory Theory
Course Name	: Probability Distributions
Course Code	: STA-502-MRM
No. of Credits	: 4 credits
No. of Teaching Hours	: 60

Course Objectives:

1. Explore various types of probability distributions.
2. Learn how to calculate and interpret probabilities.
3. Study properties and characteristics of probability distributions.
4. Apply probability distributions to real-world scenarios.
5. Develop skills in data analysis and statistical inference: Probability distribution concepts are often essential in statistical inference and data analysis.
6. Students may learn how to use software like R, Python, or Excel to analyze and visualize data based on probability distributions.
7. How to apply mathematical concepts to real-world situations, analyze problems, and make informed decisions based on probability.

Course Outcomes:

By the end of the course, students will be able to:

CO1. understand characteristics about discrete and continuous random variable and their probability distributions.

CO2. prepare students for modelling real data using distributions

CO3. develop understanding of distribution theory related for further advanced topics in statistical inference.

CO4. develop problem-solving techniques to solving real-world events.

CO5. apply selected probability distributions to solve problems.

CO6. present the analysis of derived statistics to all audiences.

CO7. develop problem-solving techniques needed to accurately calculate probabilities.

Topics and Learning Point:

Unit – 1 (15L)

Random experiments and it's sample space, probability axioms, random variables, probability distribution of random variables, discrete and continuous random variable, functions of random variables and its distribution, mixture of probability distribution, m.g.f, p.g.f of distribution function. Moment inequalities: Markov, Chebychev, Holder, Minkowski and Jensen's inequalities with their applications. Basic inequality

Unit – 2 (15L)

Multiple random variables, joint, marginal and conditional distribution, variance covariance matrix, independence of random variables, marginal and conditional densities using joint densities, conditional expectations and variance, convolution of random variable, compound distribution, exponential family of distribution, location and scale families, non-regular family.

Unit – 3 (15L)

Bivariate normal, bivariate Poisson, bivariate exponential, (Olkins method 3 types), multinomial, Dirichlet, sampling distribution of statistics from univariate normal random samples.

Unit – 4 (15L)

Non-central $\chi 2$, t, F distribution and their properties, distribution of linear and quadratic forms in iid standard normal variable (technique based on m.g.f.), Independence of two linear forms, Independence of two quadratic forms and independence of linear and quadratic forms, order statistics, joint distribution of order statistics, distribution of rth order statistics, joint distribution of (rth and sth order statistics and their function), distribution of range.

References:

1. Anirban DasGupta, Fundamentals of Probability: A First Course
2. Casella and Burger(2002) Statistical Inference (Duxbury advanced series II edition)
3. Feller, Fundamentals of Probability: A First Course
4. Hogg R. V. and Craig R. G. (1978): Introduction to Mathematical Statistics Ed.4.
5. Johnson N.L. & Kotz S.(1996) Distributions in statistics Vol.I .VolI and Vol III John Wiley and sons Inc.)

6. Johnson N.L., Kotz S., Balkrishnan, N. Multivariate Distributions (John Wiley and sons)
7. Rohatagi V.K. & Saleh A.K.(2001) Introduction to probability theory and mathematical statistics. (John Wiley and sons)
8. Rohatgi V. K. and Saleh A. K. Md. E. (2002): An Introduction to probability and statistics, John wiley & Sons (Asia).

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	1	1	–	2	–
CO2	2	3	2	2	1	–	2	1
CO3	3	3	1	2	–	–	2	–
CO4	2	2	3	2	1	1	2	2
CO5	2	2	3	3	1	–	1	2
CO6	1	1	1	1	3	1	1	1
CO7	3	2	2	2	–	–	2	1

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Builds strong foundational knowledge of discrete and continuous random variables and probability distributions.

CO3: Develops in-depth theoretical understanding of distribution theory required for advanced statistical inference.

CO7: Strengthens conceptual accuracy in probability calculations, reinforcing disciplinary competence.

PO2: Research, Analysis, and Complexity

CO2: Enables students to analyze real data and select appropriate probability distributions for modeling.

CO3: Supports analytical thinking needed to handle complex statistical concepts and incomplete information.

CO4: Encourages structured analysis while solving real-world probability problems.

PO3: Problem Solving in New Contexts

CO4: Strongly develops problem-solving abilities for unfamiliar and real-world probability scenarios.

CO5: Applies probability distributions to practical and multidisciplinary problems beyond

textbook examples.

CO7: Enhances adaptability in calculating probabilities across varied problem contexts.

PO4: Technical Mastery and Scientific Reasoning

CO5: Requires appropriate selection and application of probability distributions using sound scientific reasoning.

CO2: Moderately develops technical skills in modeling data with statistical distributions.

CO3: Supports reasoning behind theoretical methods used in statistical inference.

PO5: Integrated Communication

CO6: Strongly emphasizes clear presentation and interpretation of statistical results for both technical and non-technical audiences.

CO1: Encourages basic explanation of probability concepts, supporting communication skills.

PO6: Ethical, Social, and Professional Judgment

CO4: Introduces ethical awareness while applying probability concepts to real-world events and decision-making.

CO6: Encourages responsible and accurate reporting of statistical findings.

PO7: Autonomous and Lifelong Learning

CO1: Builds a strong base that supports independent learning in advanced probability and statistics.

CO3: Motivates learners to pursue advanced topics such as inference and research independently.

CO7: Develops self-reliance in applying probability techniques accurately.

PO8: Employability, Innovation, and Entrepreneurship

CO4: Enhances practical problem-solving skills valued in industry and applied research.

CO5: Supports employability by applying probability models to real-life and professional problems.

CO2: Provides basic exposure to data modeling useful in professional environments.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Mandatory Theory
Course Name	: Parametric Inference- I
Course Code	: STA-503-MRM
No. of Credits	: 2
No. of Teaching Hours	: 30

Course Objectives:

1. Understand the concept of sufficiency and apply Ronald A. Fisher's idea of sufficient statistics in statistical inference.
2. Apply the Factorization Theorem to identify sufficient and minimal sufficient statistics.
3. Examine properties such as completeness, joint sufficiency, likelihood equivalence, and exponential family distributions.
4. Understand and compute Fisher Information and the information matrix in estimation problems.
5. Study linear estimation theory including estimable functions, Gauss-Markov Theorem, and Best Linear Unbiased Estimators (BLUE).
6. Apply important results such as Cramer-Rao Inequality, Rao-Blackwell Theorem, and Lehmann-Scheffe Theorem for obtaining efficient estimators.
7. Construct and interpret confidence intervals, including shortest expected length and uniformly most accurate confidence intervals.

Course Outcomes:

By the end of the course, students will be able to:

CO1. identify and construct sufficient and minimal sufficient statistics using the Factorization Theorem.
CO2. determine completeness and apply Lehmann-Scheffe theorem to obtain MVUEs.
CO3. compute Fisher information and apply Cramer-Rao lower bound to assess efficiency of estimators.
CO4. derive and interpret Best Linear Unbiased Estimators using the Gauss-Markov theorem.

CO5. improve estimators using Rao-Blackwell theorem and verify necessary and sufficient conditions for MVUE and MVBUE.
CO6. identify ancillary statistics and analyze exponential family distributions admitting minimal sufficient statistics.
CO7. construct and evaluate confidence intervals including shortest expected length and uniformly most accurate confidence intervals for parameters.

Topics and Learning Points:

Unit 1: **(12L)**

Sufficiency, Fisher's concept of sufficiency, Sufficient statistic, Factorization theorem, Joint Sufficiency, Likelihood Equivalence, Minimal Sufficiency, construction of Minimal Sufficient Statistic, Completeness, Exponential family and Pitman family admitting Minimal Sufficient Statistic.

Unit 2: **(11L)**

Fisher information and information matrix, Estimable function, Best Linear Unbiased Estimator, Gauss-Markov theorem, Cramer Rao inequality and its application, Rao-Blackwell theorem, Completeness, Lehman-Scheffee theorem and its application, necessary sufficient condition of MVUE, necessary and sufficient condition for MVBUE and their applications, Ancillary statistic.

Unit 3: **(7L)**

Confidence Interval (C.I.); Shortest Expected Length C.I. Uniformly Most Accurate C.I., Unbiased C.I.

References:

1. Casella G. and Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
2. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
3. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
4. Lehman E.L (1988) Theory of point estimation (John Wiley)
5. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
6. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics(John Wiley & sons)
7. Dasgupta A. (2008), Asymptotic Theory of Statistics and Probability, Spinger-Verlag,New York.

8. Ulhas Jayram Dixit (2016) ISBN 978-981-10-0888-7 Examples in Parametric Inference with R.

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	1	1	2	1
CO2	3	3	2	3	1	1	2	1
CO3	3	3	2	3	1	1	2	2
CO4	3	2	3	3	1	1	2	2
CO5	3	3	2	3	1	1	2	1
CO6	3	3	2	2	1	1	2	1
CO7	3	3	3	2	2	2	2	2

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Identify and construct sufficient and minimal sufficient statistics using the Factorization Theorem.
CO2: Determine completeness and apply Lehmann–Scheffé theorem to obtain MVUEs.
CO3: Compute Fisher information and apply Cramér–Rao lower bound to assess estimator efficiency.
CO4: Derive and interpret Best Linear Unbiased Estimators using the Gauss–Markov theorem.
CO5: Improve estimators using Rao–Blackwell theorem and verify MVUE/MVBUE conditions.
CO6: Identify ancillary statistics and analyze exponential family distributions.
CO7: Construct and evaluate advanced confidence intervals.

PO2: Research, Analysis, and Complexity

CO1: Apply factorization theorem in statistical modeling.
CO2: Analyze completeness to derive optimal estimators.
CO3: Evaluate estimator efficiency using Fisher information.
CO4: Integrate model assumptions in Gauss–Markov framework.
CO5: Apply Rao–Blackwell improvement techniques.
CO6: Examine structural properties of exponential family.
CO7: Analyze properties of confidence intervals under complex settings.

PO3: Problem Solving in New Contexts

CO1: Apply sufficiency concepts to diverse distributions.
CO2: Solve estimation problems in unfamiliar statistical models.

CO3: Assess estimator efficiency in applied contexts.
CO4: Use BLUE in regression-type real-world problems.
CO5: Improve practical estimators using Rao–Blackwellization.
CO6: Analyze exponential family applications in modeling.
CO7: Design accurate confidence intervals in applied research.

PO4: Technical Mastery and Scientific Reasoning

CO1: Logical derivation of sufficient statistics.
CO2: Application of completeness and optimality principles.
CO3: Strong analytical reasoning in Cramér–Rao bounds.
CO4: Strong methodological reasoning in Gauss–Markov theorem.
CO5: Strong technical refinement of estimators.
CO6: Theoretical structure of exponential families.
CO7: Technical construction of optimal confidence intervals.

PO5: Integrated Communication

CO1–CO6: Require articulation of mathematical proofs and statistical reasoning.
CO7: Presentation and interpretation of interval estimates.

PO7: Autonomous and Lifelong Learning

CO1–CO4: Promote independent analytical skill development.
CO5 & CO6: Encourage deeper theoretical exploration.
CO7: Develop independent capability in interval construction.

PO8: Employability, Innovation, and Entrepreneurship

CO1–CO6: Provide foundational statistical tools for analytics and research roles.
CO7: Interval estimation skills relevant in industry decision-making.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Mandatory Practical
Course Name	: Statistics Practical – I
Course Code	: STA-504-MRM
No. of Credits	: 2 credits
No. of Teaching Hours	: 60

Course Objectives:

1. Students should be able to review the core topics in probability and statistics through the study and practice of data analysis and graphical interpretation using statistical software.
2. Students will learn to use numerical computing tools and programming languages, such as MATLAB, Python, or R, to implement and solve linear algebra problems
3. Students should be able to solve systems of linear equations using various methods.
4. Students will explore applications of linear algebra in data analysis and machine learning.
5. Students should be able to plots different probability distributions and draw a model sample from it.
6. Students will develop a deep understanding of common probability distributions.
   Students will gain experience in applying probability distributions to real-world data analysis problems.

Course Outcomes:

By the end of the course, students will be able to:

CO1. use statistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyze real life situations.

CO2. acquire skills in solving systems of linear equations using various techniques.

CO3. construct the orthogonal matrix associated with a non-singular matrix through a Gram-Schmidth orthogonalization process, diagonalization of a symmetric matrix, the role of eigenvalues, eigenvectors, Cayley Hamilton theorem in theory of

matrices etc.

CO4. develop critical thinking skills to analyze and solve problems by using linear algebra concepts.

CO5. understand various discrete and continuous probability distributions along with their real-life applications.

CO6. proficient in using simulation techniques to generate random samples from specific probability distributions.

CO7. apply appropriate probability distributions to model and analyze real-world data sets from various fields.

Title of Experiments:

Sr. No.	Title of Experiments
1.	Introduction to Statistical Software (Minitab, R, Matlab, SPSS)
2.	Matrices
3.	G-Inverse and MPG-Inverse
4.	Eigen value, Eigen vectors, Spectral decomposition, Power of matrix- I
5.	Eigen value, Eigen vectors, Spectral decomposition, Power of matrix- II
6.	Solution of system of linear equations using Gauss elimination and Gauss Jordon methods
7.	Solution of system of linear equations using Gauss Seidal and Gauss Jacobi methods
8.	Application of Calley- Hamilton Theorem
9.	Classification and reduction of quadratic forms
10.	Plotting of density function, distribution functions, univariate and bivariate probability distributions
11.	Model sampling from discrete and continuous distribution
12.	Model sampling from mixture distribution

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	3	2	1	2	3
CO2	3	2	2	2	1	1	2	2
CO3	3	3	2	3	2	1	2	2
CO4	2	3	3	2	2	1	2	2
CO5	3	3	2	2	1	1	2	2
CO6	2	3	3	3	1	1	2	3
CO7	3	3	3	3	2	1	2	3

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Use statistical software in real-life analysis.

CO2: Acquire skills in solving systems of linear equations using various techniques.

CO3: Construct orthogonal matrices, apply Gram-Schmidt process, diagonalization, eigenvalues, eigenvectors, Cayley-Hamilton theorem.

CO4: Develop critical thinking using linear algebra concepts.

CO5: Understand various discrete and continuous probability distributions and their applications.

CO6: Use simulation techniques for probability distributions.

CO7: Apply probability distributions to model real-world datasets.

PO2: Research, Analysis, and Complexity

CO3: Advanced matrix theory concepts involving eigenvalues and diagonalization.

CO4: Critical thinking and analytical problem solving.

CO6: Simulation techniques and stochastic modeling.

CO7: Statistical modeling and real-world data analysis.

CO1, CO2, CO5: Moderate contribution through applied and analytical skills.

PO3: Problem Solving in New Contexts

CO4: Critical thinking using linear algebra concepts.

CO6: Simulation-based problem solving.

CO7: Application of probability models in diverse domains.

CO1, CO2, CO3, CO5: Moderate support in applying theoretical knowledge.

PO4: Technical Mastery and Scientific Reasoning

CO1: Use of R, Python, MATLAB, SPSS, Minitab.

CO3: Advanced matrix computation and theoretical justification.

CO6: Simulation techniques and computational implementation.

CO2, CO5: Moderate technical application.

PO5: Integrated Communication

CO4: Logical reasoning improves structured communication of solutions.

CO7: Interpretation and presentation of modeled results.

Other COs contribute partially through analytical explanation skills.

PO6: Ethical, Social, and Professional Judgment

CO7: Application of probability models in real-world decision making.

Other COs show partial linkage through responsible data handling and professional computational practice.

PO7: Autonomous and Lifelong Learning

All COs contribute moderately

PO8: Employability, Innovation, and Entrepreneurship

CO1: Software proficiency enhances employability.

CO6: Simulation and computational modeling skills.

CO7: Data modeling and analytics for industry applications.

CO2, CO3, CO4, CO5: Moderate contribution through strong analytical foundation.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Mandatory Practical
Course Name	: Introduction to Python
Course Code	: STA-505-MRM
No. of Credits	: 2
No. of Teaching Hours	: 60

Course Objectives:

1. To introduce students to the Python programming environment and basic syntax.
2. To develop understanding of variables, data types, and operators in Python.
3. To enable students to apply conditional and looping constructs for problem solving.
4. To familiarize students with Python data structures such as lists, tuples, sets, and dictionaries.
5. To enhance skills in string manipulation.
6. To develop the ability to write modular programs using user-defined functions.
7. To provide hands-on experience in file handling for data storage and retrieval.
8. To strengthen logical thinking and programming skills through practical implementation of Python programs.

Course Outcomes:

By the end of the course, students will be able to:

CO.1. Set up and work efficiently in the Python programming environment using basic commands.

CO.2. Use variables and built-in data types to store and manipulate data in Python programs.

CO.3. Apply arithmetic and logical operators to solve computational problems.

CO.4. Implement decision-making and looping constructs to control program flow.

CO.5. Perform operations on Python data structures such as lists, tuples, sets, and dictionaries.

CO.6. Manipulate and process strings using built-in string functions.

CO.7. Design and implement reusable code using user-defined functions.

CO.8. Develop programs for reading from and writing to files for persistent data storage.

Title of Experiments:

Sr. No.	Title of Experiments	No. of Practical
1.	Basics of Python • Variables and data types • Basic input and output • Operators and expressions • Comments and style conventions	01
2.	Data Structures • List, tuple, and dictionary, set • Basic operations on data structures • Indexing and slicing • List comprehensions	02
3.	Control Structures • Conditional statements (if, elif, else) • Loops (for and while) • Break and continue statements • Indentation and code blocks	03
4.	Functions • Defining and calling functions • Parameters and arguments • Return statement and function output	03
5.	Introduction to numpy	02
6.	Introduction to pandas	02
7.	Data visualization on using matplotlib and seaborn libraries • Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot	02

References:

1. Charles Severance, Python for Everybody, 1st Edition, CreateSpace Independent Publishing, 2016.
2. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd Edition, O'Reilly Media, 2015.
3. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press, 2017.

4. E. Balagurusamy, Introduction to Programming Using Python, McGraw Hill Education, 2016.
5. R. Nageswara Rao, Core Python Programming, Dreamtech Press, 2018.

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	1	3	1	1	2	2
CO2	3	2	2	3	1	1	2	2
CO3	2	2	3	3	1	1	2	2
CO4	2	3	3	3	1	1	2	2
CO5	3	2	3	3	1	1	2	3
CO6	2	2	2	3	2	1	2	2
CO7	3	3	3	3	2	1	3	3
CO8	3	3	3	3	2	2	3	3

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Set up and work efficiently in Python programming environment.

CO2: Use variables and built-in data types effectively.

CO5: Perform operations on Python data structures.

CO7: Design reusable programs using user-defined functions.

CO8: Develop file handling programs for persistent storage.

CO3, CO4, CO6: Contribute moderately through logical operations, control structures, and string processing.

PO2: Research, Analysis, and Complexity

CO4: Implement decision-making and looping constructs for solving complex problems.

CO7: Develop modular solutions demonstrating analytical ability.

CO8: Handle file processing and structured data management.

CO2, CO3, CO5, CO6: Support data manipulation and logical problem analysis.

CO1: Basic environment setup supports analysis foundation.

PO3: Problem Solving in New Contexts

CO3: Apply operators to solve computational problems.

CO4: Control program flow for real-world logic building.

CO5: Solve data-driven problems using Python data structures.

CO7: Develop reusable and scalable program solutions.

CO8: Implement file-based applications for real-world use.

CO2, CO6: Moderate contribution through data and string handling.

CO1: Limited contribution through basic setup.

PO4: Technical Mastery and Scientific Reasoning

CO1–CO8: All course outcomes strongly contribute to technical mastery in Python programming and scientific coding methodology.

PO5: Integrated Communication

CO6: String manipulation supports formatted output and communication.

CO7: Writing modular and readable code improves communication of logic.

CO8: File handling and structured outputs support documentation and reporting.

CO1–CO5: Limited but supportive role through program clarity.

PO6: Ethical, Social, and Professional Judgment

CO8: File handling and data management relate to responsible data usage.

CO1–CO7: Provide foundational professional coding practices.

PO7: Autonomous and Lifelong Learning

CO7: Encourages modular programming and independent development.

CO8: Promotes self-directed project development.

CO1–CO6: Build progressive independent programming capability.

PO8: Employability, Innovation, and Entrepreneurship

CO5: Data structure mastery enhances industry readiness.

CO7: Reusable code development supports innovation.

CO8: Real-world application development using file systems.

CO1–CO4, CO6: Provide employable technical programming skills.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Mathematical Analysis
Course Code	: STA-506-MJE(A)
No. of Credits	: 2
No. of Teaching Hours	: 30

Course Objectives:

1. Rigorous understanding of mathematical concepts such as metric space, sequences, series, limits, and continuity.
2. Throughout the course, students will be exposed to various applications of mathematical analysis in statistics.
3. They will learn about approximation methods and techniques, such as Taylor series expansions, which are crucial for statistical estimation and inference.
4. Students will learn to apply these concepts to analyze statistical functions, models, and data.
5. Development of students' ability to construct and understand mathematical proofs.
6. Students will study different types of convergence.

Course Outcomes:

By the end of the course, students will be able to:

CO1. students will develop strong analytical and logical reasoning skills through the study of mathematical analysis.

CO2. comprehend and construct rigorous mathematical proofs, and use deductive reasoning to solve complex mathematical problems.

CO3. Understand the fundamental mathematical concepts which will useful in learning probability theory course.

CO4. acquire the knowledge to analyze mathematical problems in the context of statistics.

CO5. understand the different types of convergence, such as pointwise convergence, uniform convergence.

CO6. construct and understand mathematical proofs on various results.

CO7. Understand the concepts which required for further studies in Probability Theory and Asymptotic Inference.

Topics and Learning Points:

Unit – 1 **(10L)**

Set of real numbers, supremum and infimum of sets of real numbers, real field, Euclidean spaces, Finite, Countable and uncountable sets, metric spaces, interior points and limit points of a set, open set, closed set and Compact set. Bolzano-Weierstrass theorem and Heine-Borel theorem (statement only). Application of these theorems.

Unit – 2 **(8L)**

Sequence of real numbers, convergence and divergence of sequence, subsequences of a sequence, Cauchy sequences, completeness of R, limit inferior, limit superior of the sequences, some special sequences.

Unit – 3 **(6L)**

Series of real numbers, convergence of series, tests for convergence of series (ratio test, root test), alternative series, conditional and absolute convergence, power series and radius of convergence, examples and problems on these concepts.

Unit – 4 **(6L)**

Limits of functions, continuous function, discontinuity, uniform continuity, monotone function and discontinuity. Concept and examples on Derivative of real function, mean value theorem, L' Hospital rule, Taylor's theorem, Inverse function theorem, implicit function theorem. Introduction and examples of sequence of real valued function, point wise convergence of sequence of functions, definition of uniform convergence of sequence of function.

Note:

1. Detailed proofs of theorems and results are not required to be covered in classroom teaching.
2. Clear explanation and interpretation of theorems/results, and use adequate illustrations clarify each concept**.**

References:

1. Apostol T.M. (1975). Mathematical Analysis: A modern approach to advanced calculus. Addison- Wesley
2. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw-Hill

3. Goldberg R.R.(1964): Methods of Real Analysis-Blaisell Publishing company, New York, U.S.A.
4. Bartle R.G. & Sherbert D.R. (2000): Introduction to Real Analysis-John Wiley & Sons Inc.
5. Bartle R. G. (1976). Elements of Real Analysis, John Wiley
6. Mapa S. K. (2018) Inroduction to Real Analysis, Sarat Book Distributors, Kolkata
7. Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer
8. Ajit Kumar (2019), A Basic Course in Real Analysis, A Chapman & Hall Book.
9. Kumar A. and Kumaresan S. (2014), A basic course in real analysis, CRC Press.

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	1	1	2	1
CO2	3	3	2	2	2	1	2	1
CO3	2	2	1	2	1	1	2	1
CO4	2	3	2	3	2	1	2	2
CO5	3	3	2	2	1	1	2	1
CO6	3	3	2	2	2	1	2	1
CO7	3	2	2	2	1	1	3	2

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1 : Strong analytical and logical reasoning forms the foundation of advanced mathematical knowledge.

CO2 : Rigorous proof construction reflects higher-level disciplinary mastery.

CO3 : Fundamental concepts support advanced probability learning.

CO4 : Application of analysis in statistics strengthens disciplinary integration.

CO5 : Understanding convergence is central to higher mathematical theory.

CO6 : Proof-based understanding enhances originality and theoretical depth.

CO7 : Concepts supporting Probability Theory and Asymptotic Inference directly align with advanced disciplinary specialization.

PO2: Research, Analysis, and Complexity

CO1: Analytical reasoning supports handling complex mathematical structures.

CO2: Deductive reasoning and proof construction are core research skills.

CO3 : Conceptual understanding assists in analyzing probabilistic frameworks.
CO4 : Statistical problem analysis strongly supports hypothesis testing and research design.
CO5 : Convergence concepts are crucial in advanced research and asymptotic studies.
CO6 : Proof construction strengthens research methodology.
CO7 : Supports research preparation in probability and inference.

PO3: Problem Solving in New Contexts

CO1 : Logical reasoning enables solving abstract and applied problems.
CO2 : Deductive reasoning aids in tackling unfamiliar problems.
CO3 : Provides partial support in applied probability contexts.
CO4 : Statistical applications extend problem-solving to real-world contexts.
CO5 : Convergence concepts help solve analytical modeling problems.
CO6 : Proof skills support structured problem-solving.
CO7 : Advanced probability concepts aid in new analytical contexts.

PO4: Technical Mastery and Scientific Reasoning

CO1 : Develops structured scientific reasoning.
CO2 : Enhances logical rigor and methodological thinking.
CO3 : Strengthens theoretical tools needed for probability.
CO4 : Strongly aligned due to statistical and analytical application.
CO5 : Convergence theory strengthens mathematical modeling rigor.
CO6 : Proof development supports systematic reasoning.
CO7 : Prepares students for technically advanced probability methods.

PO5: Integrated Communication

CO1 : Logical clarity partially supports structured explanation.
CO2 : Proof writing improves mathematical communication skills.
CO3 : Basic conceptual explanation ability.
CO4 : Statistical interpretation requires clear communication.
CO5 : Conceptual explanation of convergence.
CO6 : Mathematical proof writing enhances precise communication.
CO7 : Conceptual understanding supports academic discussion.

PO6: Ethical, Social, and Professional Judgment

(All COs show partial relation (1) as the course is theoretical and indirectly contributes through responsible analytical thinking and professional mathematical rigor.)

PO7: Autonomous and Lifelong Learning

CO1 : Analytical reasoning promotes independent learning.
CO2 : Proof skills encourage self-directed study.
CO3 : Foundational concepts prepare for advanced courses.
CO4 : Application in statistics fosters interdisciplinary growth.
CO5 : Advanced topics motivate higher study.
CO6 : Independent proof construction enhances self-learning.
CO7 : Strongly supports progression to Probability Theory and Asymptotic Inference.

PO8: Employability, Innovation, and Entrepreneurship

CO1 : Analytical thinking supports professional skills.

CO2 : Logical rigor contributes to technical roles.
CO3 : Foundation for probability-related careers.
CO4 : Statistical analysis strongly enhances employability.
CO5 : Theoretical support for advanced data roles.
CO6 : Proof skills useful in academia and research roles.
CO7 : Strong preparation for careers in statistics, research, and analytics.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Calculus
Course Code	: STA-506-MJE(B)
No. of Credits	: 2
No. of Teaching Hours	: 30

Course Objectives:

1. To review and strengthen foundational concepts of calculus of one variable.
2. To develop a comprehensive understanding of functions of several variables.
3. To enable students to analyze multivariable functions using gradient vectors, directional derivatives, and Jacobians.
4. To familiarize students with Taylor's theorem and the Mean Value Theorem in several variables.
5. To introduce the theory of Riemann integration.
6. To provide conceptual and practical knowledge of Riemann–Stieltjes integration.
7. To develop competence in evaluating improper integrals and special functions.

Course Outcomes:

By the end of the course, students will be able to:

CO1. students will develop strong analytical and logical reasoning skills through the study of mathematical analysis.
CO2. comprehend and construct rigorous mathematical proofs, and use deductive reasoning to solve complex mathematical problems.
CO3. Understand the fundamental mathematical concepts which will useful in learning probability theory course.
CO4. acquire the knowledge to analyze mathematical problems in the context of statistics.
CO5. understand the different types of convergence, such as pointwise convergence, uniform convergence.
CO6. construct and understand mathematical proofs on various results.
CO7. Understand the concepts which required for further studies in Probability Theory and Asymptotic Inference.

Topics and Learning Points

Unit – 1 (15L)

Review of calculus of one variable: differentiability, mean value theorem and Taylor series expansion. Functions of several variables: Continuity, uniform continuity, absolute continuity, functions of several variables, directional derivatives, differentials of functions of several variables, the gradient vector, properties, convex and concave functions differentials of composite functions (of several variables) and the chain rule, the mean value theorem, a sufficient condition for the existence of the differential, partial derivatives of higher order and Taylor's formula. Applications of partial differentiation, Jacobians

Unit – 2 (8L)

Riemann integral, refinement of partitions, norm of partition, condition of integrability, Riemann sums, properties of Riemann integral functions, inequalities, fundamental theorem of calculus, definition and existence of Riemann – Stieltjes integral.

Unit – 3 (7L)

Improper integrals of first and second kind for one variable, tests for convergence of beta, and Gamma functions, relation between beta and gamma functions, properties of beta and gamma functions, duplication formula, evaluation of some improper integrals

References:

1. Bartle R.G. & Sherbert D.R. (2000): Introduction to Real Analysis-John Wiley & Sons Inc.
2. Mapa S. K. (2018) Inroduction to Real Analysis, Sarat Book Distributors, Kolkata
3. Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer
4. Ajit Kumar (2019), A Basic Course in Real Analysis, A Chapman & Hall Book.
5. Kumar A. and Kumaresan S. (2014), A basic course in real analysis, CRC Press.
6. D. Somasundaram, B. Choudhary (2016) A first Course in Mathematical Analysis, Narosa.
7. W. John Braun, Duncan J. Murdoch, (2016) A First Course in Statistical Programming with R, Cambridge University Press.

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	1	1	1	2	1
CO2	3	3	2	2	1	1	2	1
CO3	2	2	1	1	1	1	2	1
CO4	2	3	2	2	1	1	2	1
CO5	3	2	2	2	1	1	2	1
CO6	3	3	2	2	2	1	2	1
CO7	3	2	2	1	1	1	3	2

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1 : Strong analytical and logical reasoning reflects advanced disciplinary foundation.
CO2 : Construction of rigorous proofs demonstrates deep disciplinary mastery.
CO3 : Understanding foundational concepts supports advanced study.
CO4 : Application in statistics strengthens subject knowledge.
CO5 : Study of convergence is a core advanced topic in analysis.
CO6 : Proof construction strengthens originality and theoretical depth.
CO7 : Preparation for probability and asymptotic inference reflects advanced specialization.

PO2: Research, Analysis, and Complexity

CO1 : Logical reasoning supports analytical research thinking.
CO2 : Rigorous proofs directly support research formulation and complexity handling.
CO3 : Conceptual clarity aids integration of knowledge.
CO4 : Statistical analysis requires research-oriented analytical skills.
CO5 : Convergence concepts are crucial in theoretical research.
CO6 : Proof-based reasoning is central to research methodology.
CO7 : Foundation for advanced inference supports research growth.

PO3: Problem Solving in New Contexts

CO1 : Analytical skills help solve unfamiliar mathematical problems.
CO2 : Deductive reasoning aids complex problem-solving.
CO3 : Provides basic theoretical support.
CO4 : Statistical applications enable real-world problem solving.
CO5 : Convergence analysis applies to applied mathematical contexts.

CO6 : Proof techniques enhance structured problem-solving.
CO7 : Supports application in advanced probability contexts.

PO4: Technical Mastery and Scientific Reasoning

CO1 : Builds foundational reasoning skills.
CO2 : Emphasizes logical and structured reasoning.
CO3 : Basic theoretical understanding.
CO4 : Analytical application in statistics strengthens scientific reasoning.
CO5 : Understanding convergence enhances theoretical rigor.
CO6 : Proof techniques reflect technical mastery.
CO7 : Supports higher-level reasoning development.

PO5: Integrated Communication

CO1 : Logical thinking supports structured communication.
CO2 : Proof writing improves clarity in presentation.
CO3 : Conceptual explanation skills developed.
CO4 : Interpretation of statistical results requires clarity.
CO5 : Mathematical explanation of convergence concepts.
CO6 : Proof construction improves formal mathematical communication.
CO7 : Supports academic communication in advanced topics.

PO6: Ethical, Social, and Professional Judgment

All COs (1): Mathematical rigor promotes honesty, logical integrity, and disciplined reasoning, though ethics is not a direct course focus.

PO7: Autonomous and Lifelong Learning

CO1 : Analytical ability supports independent learning.
CO2 : Proof skills enable self-directed exploration.
CO3 : Conceptual foundation aids future study.
CO4 : Statistical knowledge supports academic progression.
CO5 : Convergence concepts prepare for advanced coursework.
CO6 : Proof-writing fosters independent academic growth.
CO7 : Direct preparation for advanced probability and inference courses.

PO8: Employability, Innovation, and Entrepreneurship

All COs (1–2 range): Analytical reasoning, problem-solving, and statistical understanding support employability and academic careers, though the course is primarily theoretical.
CO7 : Strong linkage to advanced applications enhances professional readiness.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Elective Practical
Course Name	: Practical Based on Sampling Techniques and Numerical Analysis
Course Code	: STA-507-MJE(A)
No. of Credits	: 2 credits
No. of Teaching Hours	: 60

Course Objectives:

1. To apply appropriate estimation under various sampling techniques.
2. To enable students to.
3. To train students in handling complex sampling designs.
4. To enhance computational proficiency in numerical methods.
5. To strengthen problem-solving, interpretation, and reporting skills.
6. To familiarize students with resampling techniques.
7. To gain an understanding of ethical considerations and responsible conduct in statistical research.

Course Outcomes:

By the end of the course, students will be able to:

CO1. use statistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyze real life situations.

CO2. understand different sampling survey methods and give examples of situations where these methods are useful.

CO3. learn R-reporting and developing own R code and use of different R packages.

CO4. learn how to implement numerical algorithms using programming languages or statistical software packages.

CO5. acquire hands-on experience in coding and applying numerical methods to solve statistical problems

CO6. gain proficiency in selecting appropriate optimization algorithms, setting up optimization problems, and interpreting optimization results in a statistical context.

CO7. understand the strengths and limitations of different numerical integration and

differentiation techniques and apply them to statistical problems. Think critically to evaluate existing research literature in the field of statistics.

Title of Experiments:

Sr. No.	Title of Experiments
1.	Estimation of parameters in Systematic sampling
2.	PPS sampling
3.	Stratified sampling (using ratio and regression)
4.	Cluster sampling with equal and unequal cluster size
5.	Two stage sampling
6.	Simultaneous Transcendental equations
7.	Bivariate Interpolation
8.	Unconstraint Optimization Techniques-I
9.	Unconstraint Optimization Techniques-II
10.	Computation of integral by Riemann and Riemann-Stieltjes integral
11.	Jackknife and Bootstrap techniques
12.	Review of Four Research Papers (equivalent to 2 practicals)

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	3	3	1	1	2	3
CO2	3	3	2	2	2	2	1	2
CO3	2	2	3	3	3	1	3	3
CO4	2	2	3	3	1	1	2	3
CO5	2	3	3	3	1	1	2	3
CO6	3	3	3	3	2	2	2	3
CO7	3	3	2	2	3	3	3	2

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO2 : Strong understanding of sampling survey methods builds advanced statistical foundation.

CO6 : Optimization algorithms require deep disciplinary knowledge.

CO7 : Numerical techniques and critical evaluation of research literature reflect advanced domain knowledge.

CO1, CO3, CO4, CO5 : Application of statistical software and numerical methods strengthens subject expertise.

PO2: Research, Analysis, and Complexity

CO2 : Designing sampling methods directly relates to research methodology.

CO5 : Applying numerical methods to statistical problems enhances analytical research capability.

CO6 : Optimization involves complex problem formulation and analysis.

CO7 : Critical evaluation of literature strengthens research and analytical thinking.

CO1, CO3, CO4 : Use of software and algorithm implementation supports research analysis.

PO3: Problem Solving in New Contexts

CO1 : Using statistical software to analyze real-life situations promotes problem-solving.

CO3 : Developing R code and packages enables application in new contexts.

CO4 : Implementing numerical algorithms fosters applied problem-solving.

CO5 : Hands-on coding develops ability to solve real statistical problems.

CO6 : Optimization problem setup in practical contexts strongly supports this PO.

CO2, CO7 : Sampling and numerical techniques moderately support applied problem solving.

PO4: Technical Mastery and Scientific Reasoning

CO1 : Strong proficiency in statistical software tools.

CO3 : Advanced R coding and package utilization.

CO4 : Implementation of numerical algorithms demonstrates technical mastery.

CO5 : Practical coding enhances scientific reasoning.

CO6 : Optimization techniques require methodological reasoning.

CO2, CO7 : Survey methods and numerical analysis moderately contribute.

PO5: Integrated Communication

CO3: R-reporting directly develops communication of statistical findings.

CO7 : Critical evaluation of research literature enhances scientific communication.

CO2, CO6 : Survey interpretation and optimization results need structured reporting.

CO1, CO4, CO5 : Software usage contributes partially to communication skills.

PO6: Ethical, Social, and Professional Judgment

CO7 : Critical evaluation of research promotes ethical awareness.

CO2 : Ethical considerations in survey sampling.

CO6 : Responsible interpretation of optimization results.

CO1, CO3, CO4, CO5 : Professional software use partially relates to ethics.

PO7: Autonomous and Lifelong Learning

CO3 : Independent R coding and package learning.

CO7 : Research evaluation fosters lifelong learning.

CO1, CO4, CO5, CO6 : Continuous technical skill development.

CO2 : Sampling knowledge partially contributes.

PO8: Employability, Innovation, and Entrepreneurship

CO1: Software proficiency enhances employability.

CO3: R development skills support industry readiness.

CO4 : Programming and numerical algorithms build innovation.

CO5 : Practical coding skills improve job prospects.

CO6 : Optimization skills are highly industry-relevant.

CO2, CO7 : Survey design and research evaluation moderately enhance employability.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. Part – I
Semester	: I
Course Type	: Major Elective Practical
Course Name	: Practical Based on Optimization Techniques
Course Code	: STA-507-MJE(B)
No. of Credits	: 2 credits
No. of Teaching Hours	: 60

Course Objectives:

1. To Understand and apply the Simplex algorithm, solve linear programming problems using artificial variable techniques, including the Two-Phase and Big-M methods.
2. To Gain a deep understanding of duality in Linear Programming Problems (LPP), and apply duality theory to test optimality in various optimization problems such as the transhipment problem.
3. To Learn and implement advanced techniques such as the cutting plane method (Gomory's method) for both all-integer and mixed-integer linear programming problems, as well as the Branch and Bound method.
4. Develop proficiency in nonlinear programming and quadratic programming problems using methods like Wolfe's and Beale's techniques.
5. To Explore the principles of dynamic programming and apply them to deterministic processes, sequential and non-sequential discrete optimization problems
6. To develop inventory models for single-item inventory control, including EOQ models with and without shortages.
7. To Perform sensitivity analysis to assess the impact of changes on feasibility and optimality in optimization problems,

Course Outcomes:

By the end of the course, students will be able to:

CO1. solve linear programming problems using artificial variable techniques .

CO2. apply duality theory to test optimality in various optimization problems such as the transshipment problem.

CO3. learn and implement advanced techniques such as all-integer and mixed-integer linear programming problems.

CO4. develop proficiency in nonlinear programming and quadratic programming problems.

CO5. explore the principles of dynamic programming and apply them to deterministic processes

CO6. develop inventory models for single-item inventory control, including EOQ models with and without shortages.

CO7. perform sensitivity analysis to assess the impact of changes on feasibility and optimality in optimization problems.

Title of Experiments:

Sr. No.	Title of Experiments
1.	Solving the primal LP (or dual LP) by using Simplex method.
2.	Solving the primal LP (or dual LP) by using following methods. i) Charne's Big-M method. ii) Dual simplex method.
3.	Getting optimal solution for dual LP (without solving DLP) using optimal solution for primal LP.
4.	Sensitivity Analysis in Linear Programming.
5.	Practical's based on inventory models.
6.	Simulation of various queuing models and verification of their steady state distributions.
7.	Solving Additional Constraints / Fractional Cutting Plane by Gomory's method
8.	Solving Mixed Integer Linear Programming by Gomory's method
9.	Solving dynamic programming: Bellman's Optimality Principle model I,II

10.	Dynamic programming Approach for solving linear programming problem
11.	Solving graphical method for non linear programming
12.	Solving Quadratic programming problem using Kuhn-Tucker conditions
13.	Solving Quadratic programming problem using Wolfes Method

Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	1	1	1	2
CO2	3	3	3	3	1	1	1	2
CO3	3	2	3	3	1	1	2	3
CO4	3	3	3	3	1	1	2	2
CO5	3	3	3	2	1	1	2	2
CO6	3	2	3	2	1	2	2	3
CO7	3	3	3	3	2	2	2	3

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Strong foundation in linear programming and artificial variable techniques enhances advanced disciplinary knowledge.

CO2: Duality theory strengthens deep theoretical understanding of optimization.

CO3: Integer and mixed-integer programming reflects advanced optimization techniques.

CO4: Nonlinear and quadratic programming require advanced mathematical rigor.

CO5: Dynamic programming builds higher-level analytical understanding.

CO6: Inventory modeling demonstrates applied advanced operations research knowledge.

CO7: Sensitivity analysis deepens conceptual and analytical mastery.

PO2: Research, Analysis, and Complexity

CO1: Artificial variable techniques involve structured analytical reasoning.

CO2: Duality theory directly supports hypothesis testing and analytical validation.

CO3: Integer programming introduces complex constraint handling.

CO4: Nonlinear programming addresses highly complex mathematical models.

CO5 : Dynamic programming involves recursive reasoning and complex decision-making.

CO6 : Inventory models require analytical evaluation of demand and cost variables.

CO7 : Sensitivity analysis critically evaluates model robustness under uncertainty.

PO3: Problem Solving in New Contexts

CO1 : Linear programming can be applied to real-world allocation problems.

CO2 : Duality theory supports optimization in logistics and transshipment problems.

CO3 : Integer programming is widely used in scheduling and planning problems.

CO4 : Nonlinear programming applies to engineering and economic optimization.

CO5 : Dynamic programming solves multistage decision problems.

CO6 : Inventory models apply directly to supply chain and industrial systems.

CO7 : Sensitivity analysis ensures adaptability to changing environments.

PO4: Technical Mastery and Scientific Reasoning

CO1 : Artificial variable techniques require structured algorithmic reasoning.

CO2 : Duality applications demand methodological precision.

CO3 : Integer programming involves advanced computational techniques.

CO4 : Nonlinear and quadratic programming require deep methodological reasoning.

CO5 : Dynamic programming uses systematic recursive approaches.

CO6 : Inventory modeling involves quantitative modeling tools.

CO7 : Sensitivity analysis demonstrates methodological and analytical expertise.

PO5: Integrated Communication

CO1–CO6 : Partial contribution through presentation of optimization results.

CO7 : Sensitivity analysis requires interpretation and clear communication of model impact.

PO6: Ethical, Social, and Professional Judgment

CO1–CO5 : Indirect relevance through responsible model application.

CO6 : Inventory models impact economic and social resource management.

CO7 : Sensitivity analysis supports responsible decision-making under uncertainty.

PO7: Autonomous and Lifelong Learning

CO1 : Basic independent problem-solving skills.

CO2 : Analytical reasoning supports independent learning.

CO3 : Advanced programming techniques encourage self-learning.

CO4 : Nonlinear optimization promotes deeper independent exploration.

CO5 : Dynamic programming fosters structured self-directed thinking.

CO6 : Inventory modeling encourages real-world analytical skills.

CO7 : Sensitivity analysis develops reflective learning abilities.

PO8: Employability, Innovation, and Entrepreneurship

CO1 : Linear programming has industrial applications.

CO2: Optimization theory enhances operational efficiency skills.

CO3: Integer programming is highly relevant in industry.

CO4: Nonlinear programming supports advanced technical roles.

CO5: Dynamic programming applies to decision sciences.

CO6 : Inventory control models are core industry tools.

CO7 : Sensitivity analysis is crucial for managerial decision-making.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2026 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSST
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Research Methodology
Course Name	: Research Methodology
Course Code	: STA-508-RM
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To introduce the statistical aspects associated with the design and analysis of sample surveys, and to develop your understanding of the principles and methods used to design survey sampling schemes.
2. Understand the steps in developing a sampling plan.
3. Distinguish between probability and non-probability sampling.
4. Develop critical thinking on sampling methods and results.
5. Understand potential sources of error and limitations of different sampling techniques.
6. To introduce the fundamental concepts and principles of research, including the scientific method, research questions and research designs.
7. To develop skills in designing research studies, including formulating research questions, selecting appropriate research designs.
8. To develop critical thinking to evaluate research studies, methodologies, and findings.

Course Outcomes:

By the end of the course, students will be able to:

CO1. define principal concepts about sampling.

CO2. lists the stages of sampling process..

CO3. understand the distinctive features of different sampling techniques and their related estimation problems.

CO4. learn the practical applications of the various sampling techniques in real life situations.

CO5. develop an appreciation for research ethics and demonstrate an understanding of ethical principles and guidelines in conducting research..

CO6. apply appropriate research design principles to formulate research questions.

CO7. develop research proposals that demonstrate clear research objectives,

appropriate methodologies, and justifications for the significance of the research

Topics and Learning Points

Unit - 1: **(15L)**

Introduction to Sampling , review of basic finite population sampling techniques SRSWR, SRSWOR, Stratified, Systematic, Probability Proportional to Size With Replacement (PPSWR) methods, cumulative total method and Lahiri's method for estimation problem, estimation of finite population mean and total, PPSWOR methods and related estimation of a finite population mean (Horvitz-Thompson and Des Raj estimators for a general sample size and Murthy's estimator for a sample of size 2), midzuno scheme of sampling.

Unit - 2: Data pre-processing and cleaning: **(8L)**

Use of supplementary information for estimation, ratio and regression estimators using separate strata and combined strata, unbiased and almost unbiased ratio type estimators of population mean, post stratification, variance of estimator of population mean under it. Cluster sampling with clusters of equal sizes and unequal size, estimation of population mean and its standard error, two stage sampling with equal first stage units, expected value and the variance of sample mean, multistage-sampling, Multiphase sampling.

Unit - 3: Interpretation and Report Writing: **(12L)**

Meaning of research, objective of research, motivation in research, types of research, research approaches, significance of research, defining the research problem, selecting the problem, necessity of defining the problem, techniques involved in defining a problem, designing a questionnaire.

Unit - 4: Publication Ethics and Open Access Publishing **(15L)**

Layout of the research report, types of reports, construction of title and preparation of abstract for research paper / proposed project, writing of materials and methods, results discussions, conclusion etc., writing of research proposals, significance of report writing, different steps in writing report, oral presentation, mechanics of writing research report, precautions for writing research reports, research ethics. Use of tools or techniques for research: methods to search required information effectively, reference management software like Zotero/ Mendeley, software for paper formatting like LaTex/ MS office, software for detection of plagiarism.

References:

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6. Research Methodology: Methods and Techniques, Kothari C.R., 1990. New Age International.

7. An introduction to Research Methodology; Garg B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002., RBSA Publishers.

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Programme Outcomes and Course Outcomes Mapping:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	1	1	–	1	–
CO2	2	2	1	1	1	–	1	–
CO3	3	3	2	2	1	1	1	1
CO4	2	2	3	2	2	1	1	2
CO5	1	1	1	–	2	3	2	1
CO6	2	3	2	2	2	1	2	1
CO7	3	3	2	2	3	2	2	2

Justification for Mapping PO and CO

PO1: Advanced Disciplinary Knowledge & Originality

CO1: Strongly related as understanding principal concepts of sampling builds advanced foundational knowledge.
CO2: Moderately related since knowledge of sampling stages strengthens disciplinary understanding.
CO3: Strong link as distinguishing sampling techniques and estimation reflects specialized knowledge.
CO4: Application enhances disciplinary competence.
CO5: Ethical awareness supports originality but indirectly.
CO6: Research design principles extend advanced academic knowledge.
CO7: Developing research proposals demonstrates mastery and originality in the discipline.

PO2: Research, Analysis, and Complexity

CO1 : Conceptual clarity supports research analysis.
CO2 : Understanding stages aids structured research processes.
CO3 : Strongly related as sampling techniques and estimation are core analytical tools.
CO4 : Practical application requires handling complex real-world data.
CO5 : Ethical awareness is necessary but indirectly analytical.
CO6 : Strong alignment—formulating research questions directly reflects hypothesis development.
CO7 : Research proposal writing demonstrates advanced analytical integration.

PO3: Problem Solving in New Contexts

CO1 : Basic concepts indirectly support problem-solving.
CO2: Knowledge of stages contributes partially.
CO3: Selection of appropriate sampling technique involves contextual problem solving.
CO4: Strongly aligned—real-life application reflects new-context problem solving.
CO5: Ethical consideration influences responsible solutions.

CO6: Research design helps solve contextual research problems.

CO7: Proposal development applies solutions to novel research settings.

PO4: Technical Mastery and Scientific Reasoning

CO1: Conceptual knowledge partially supports methodology.

CO2: Procedural knowledge moderately supports technical reasoning.

CO3: Choosing appropriate sampling techniques requires technical proficiency.

CO4: Practical application strengthens technical mastery.

CO6: Research design selection reflects scientific reasoning.

CO7: Proposal methodology development demonstrates technical competency.

PO5: Integrated Communication

CO1: Concept explanation involves basic communication.

CO2: Describing sampling stages involves structured communication.

CO3: Explaining sampling distinctions requires clarity.

CO4: Communicating real-life applications requires better articulation.

CO5: Ethical discussions require structured communication.

CO6: Research questions must be clearly framed.

CO7: Strong link—research proposals demand advanced written and structured communication.

PO6: Ethical, Social, and Professional Judgment

CO3: Ethical considerations arise in sampling methods.

CO4: Real-life applications require responsible judgment.

CO5: Strongly aligned—direct focus on research ethics and guidelines.

CO6: Ethical considerations in research design.

CO7: Proposal development must justify ethical compliance.

PO7: Autonomous and Lifelong Learning

CO1 & **CO2** : Foundational knowledge supports independent growth.

CO3: Analytical ability encourages continuous learning.

CO4: Practical exposure fosters experiential learning.

CO5: Ethical reflection supports professional development.

CO6: Independent formulation of research questions reflects autonomy.

CO7: Proposal development encourages self-directed scholarship.

PO8: Employability, Innovation, and Entrepreneurship

CO3: Sampling knowledge is industry-relevant.

CO4: Strong practical relevance enhances employability.

CO5: Ethical research increases professional credibility.

CO6: Research design skills support innovation.

CO7: Proposal writing supports academic, consultancy, and entrepreneurial ventures.