Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce, Baramati

(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 Collegeof Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2023-2024

(Eligibility : B.Sc. Statistics)

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 moralcapacities 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 wicketstaken by a player. To the manager of a manufacturing unit, Statistics may be theinformation about the process control. To a medical researcher investigating the effectsof 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 illustrationsStatistics word refers to quantitative data in the area under study. Statistics as a subjectis 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 ofstatistics and is structured to provide knowledge and skills in depth necessary for theemployability 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 corecourses. The second year syllabus contains core, elective and open courses. It ispossible 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.

Anekant Education Society's

Tuljaram Chaturchand College,Baramati

(Autonomous)

Board of Studies (BOS) in Statistics

From 2022-23 to 2024-25

Sr.No.	Name	Designation
1.	Prof. Dr. Vikas C. Kakade	Chairman
2.	Prin. Dr. Avinash S. Jagtap	Member
3.	Dr. Neeta K. Dhane	Member
4.	Dr.Vaishali V. Patil	Member
5.	Mrs.Sarita D. Wadkar	Member(Ad hoc)
6.	Mr.Chandrashekhar P. Swami	Member
7.	Ms.Priti M. Mohite	Member(Ad hoc)
8.	Ms.Nilambari A. Jagtap	Member (Ad hoc)
9.	Miss.Kalyani C. Kale	Member (Ad hoc)
10.	Ms.Pooja S. Zanjurne	Member (Ad hoc)
11.	Dr.Akanksha S. Kashikar	Vice-Chancellor Nominee
12.	Prin. Dr.Rajendra G. Gurao	Expert from other University
13.	Mr.RohanKoshti	Expert from other University
14.	Mr.SaurabhKadam	Industry Expert
15.	Dr. Jaya L. Limbore	Meritorious Alumni
16.	Miss. Priya N. Rakate	Invitee Member
17.	Ms.Ankita G. Deshmukh	Invitee Member
18.	Ms.Shital B. Choudhar	Invitee Member

19.	Miss. Kiran Banda (M.Sc. II)	Student Representative
20.	Mr.RushikeshPandhare (M.Sc. II)	Student Representative
21.	Mr. Bharat Jambhulkar (TYBSc)	Student Representative
22.	Miss. Prapti Mane (TYBSc)	Student Representative

Credit Distribution Structure for M.Sc. Part-I (Statistics)

<table>
<tr><th rowspan="2">Level</th><th rowspan="2">Semester</th><th colspan="2">Major</th><th rowspan="2">Research Methodology (RM)</th><th rowspan="2">OJT/FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th>Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="5">6.0</td><td rowspan="4">Sem-I</td><td>STA-501-MJM: Linear Algebra (Credit 04)</td><td rowspan="4">STA -511-MJE(A): Mathematical Analysis

STA-511-MJE(B): Calculus and Statistical Computing (Credit 04)</td><td rowspan="4">STA -521-RM: Research Methodology (Credit 04)</td><td rowspan="4">--</td><td rowspan="4">--</td><td rowspan="4">20</td><td rowspan="5">PG Diploma (after 3 Year Degree)</td></tr>
<tr><td>STA -502-MJM: Probability Distributions (Credit 04)</td></tr>
<tr><td>STA -503-MJM: Statistics Practical – I (Credit 02)</td></tr>
<tr><td>STA -504-MJM: Statistics Practical –II (Credit 02)</td></tr>
<tr><td rowspan="4">Sem-II</td><td>STA -551-MJM: Multivariate Analysis (Credit 04)</td><td>STA -561-MJE (A): Probability Theory

STA-561-MJE(B): Stochastic Processes (Credit 04)</td><td>--</td><td>STA-581-OJT/FP: On Job Training/ Field Project</td><td>--</td><td>20</td></tr>
<tr><td>STA -552-MJM: Regression Analysis (Credit 04)</td></tr>
<tr><td>STA -553-MJM: Statistics Practical – III (Credit 02)</td></tr>
<tr><td>STA -554-MJM: Statistics Practical – IV (Credit 02)</td></tr>
</table>

*** 1 credit = 15 Hr.**

Course Structure for M.Sc. Part-I (Statistics)(2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	STA-501-MJM	Linear Algebra	Theory	04
	Major (Mandatory)	STA -502-MJM	Probability Distributions	Theory	04
	Major (Mandatory)	STA -503-MJM	Statistics Practical – I	Practical	02
	Major (Mandatory)	STA -504-MJM	Statistics Practical – II	Practical	02
	Major (Elective)	STA-511-MJE (A)	Mathematical Analysis	Theory	04
		STA-511-MJE(B)	Calculus and Statistical Computing	Theory	
	Research Methodology (RM)	STA -521-RM	Research Methodology	Theory	04
	Total Credits Semester I				**20**
II	Major (Mandatory)	STA -551-MJM	Multivariate Analysis	Theory	04
	Major (Mandatory)	STA -552-MJM	Regression Analysis	Theory	04
	Major (Mandatory)	STA -553-MJM	Statistics Practical – III	Practical	02
	Major (Mandatory)	STA -554-MJM	Statistics Practical – IV	Practical	02
	Major (Elective)	STA -561-MJE (A)	Probability Theory	Theory	04
		STA-561-MJE (B)	Stochastic Processes	Theory	
	On Job Training (OJT)/Field Project (FP)	STA -581-OJT/FP	On Job Training Field Project	Training/Project	04
	Total Credits Semester-II				**20**
Cumulative Credits Semester I and II					**40**

CBCS Syllabus as per NEP 2020 for M.Sc. Part-IStatistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Theory
Course Name	: Linear Algebra
Course Code	: STA-501-MJM
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 machinelearning techniques.
5. Evaluate mathematical expressions to compute quantities that deal with linear systems and eigenvalue problems.
6. Construct a spectral decomposition of a matrix.
7. Characterize and classify quadratic forms using eigenvalues 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 eigenvalues 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,Secondedition,Hindustan Book Agency.
7. Rao C.R. (2001) Linear Statistical Inference and Its Application,SecondEdition,Wiley.
8. Schott J. (2016) Matrix Analysis for Statistics,Third edition Wiley.
9. Searl S.B.(2006) Matrix Algebra Useful for Statistics,Wiley.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Theory
Course Name	: Probability Distributions
Course Code	: STA-502-MJM
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 modeling 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 Points

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. AnirbanDasGupta, 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)

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Practical
Course Name	: Statistics Practical – I
Course Code	: STA-503-MJM
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. usestatistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyzereal 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-Schmidthorthogonalization 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.

Topics and Learning Points

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.	Computation of probability of events related to bivariate probability distribution, non-central χ^2, t, F-distributions
12.	Model sampling from Gamma, Chi-square, Weibull, Lognormal probability distribution
13.	Model sampling from discrete and continuous distribution
14.	Model sampling from mixture distribution
15.	Model sampling from bivariate probability distribution

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

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

Course Objectives:

1. Students should be able to estimate parameters under various sampling techniques.
2. Students should be able to find solutions of equations using various numerical computing methods.
3. Students will be able to gain proficiency in utilizing numerical software packages commonly used in statistical analysis, such as R, Python, MATLAB, or other relevant software.
4. Students will be able 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. usestatistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyzereal 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.

thinkcritically to evaluate existing research literature in the field of statistics.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Estimation of parameters in simple random sampling using SRSWR and SRSWOR
2.	Estimation of parameters in Systematic sampling
3.	PPS sampling
4.	Stratified sampling (using ratio and regression)
5.	Cluster sampling with equal and unequal cluster size
6.	Introduction to LaTex – I
7.	Introduction to LaTex – II
8.	Two stage sampling
9.	Simultaneous Transcendental equations
10.	Bivariate Interpolation
11.	Unconstraint Optimization Techniques
12.	Computation of integral by Riemann and Riemann-Stieltjes integral
13.	Jackknife technique and Bootstrap technique
14.	Review of Research Paper (2 Practicals)

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Mathematical Analysis
Course Code	: STA-511-MJE(A)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. Rigorous understanding of mathematical conceptssuch 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. acquirethe knowledgeto 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)

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 (15L)

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 (15L)

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 (15L)

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 (without proof), implicit function theorem (without proof).Introduction and examples of sequence of real valued function, point wise convergence of sequence of functions, definition of uniform convergence of sequence of function.

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.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Calculus and Statistical Computing
Course Code	: STA-511-MJE(B)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. Rigorous understanding of mathematical conceptssuch as integration, interpolation and extrapolation etc.
2. Students will gain a thorough understanding of various numerical algorithms used in statistical analysis.
3. Students will learn how to implement numerical algorithms using programming languages or statistical software packages.

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. acquirethe knowledgeto 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 (20L)

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 (10L)

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 (15L)

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

Unit – 4 (15L)

i) Newton–Raphson method for two or more simultaneous transcendental equations.

ii) Interpolation, forward difference, backward difference, Newton's bivariate interpolation formula.

iii) Unconstrained optimization: Grid search method, Gradient search, Seepest descent method, Newton's, method, Simpson's, Trapezoidal rule for bivariate integrals.

iv) Simulation: Linear congruential generator; Monte Carlo method to evaluate single and multiple integrals, simulation of random sample

v) Jackknife estimators, Boot-Strap method.

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. S.S. Sastry (2009)Introductory methods of Numerical Analysis, Prentice Hall.
7. D. Somasundaram, B. Choudhary (2016) A first Course in Mathematical Analysis, Narosa.
8. W. John Braun, Duncan J. Murdoch, (2016) A First Course in Statistical Programming with R, Cambridge University Press.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Statistics (2023 Pattern)

Name of the Programme	: M.Sc. Statistics
Program Code	: PSSTA
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Research Methodology
Course Name	: Research Methodology
Course Code	: STA-521-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 **(15L)**

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 **(10L)**

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 **(20L)**

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:

1. Des Raj &Chandhok P.(1998), Sample survey theory. (Narosa)
2. Murthy M.N.(1977) Sampling theory and methods. (Statistical Publishing Society)
3. ParimalMukhopadhyay, Theory and methods of survey sampling, Prentice Hall of India private limited, 2nd Edition, 2008.
4. W.G.Cochran, (1977) Sampling techniques.(John Wiley and sons)
5. Sukhatme P.V. Sukhatme B.V. and C. Ashok Sampling theory of surveyand applications.(Indian society for Agricultural statistics)
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.
8. Research Methodology; Sinha S.C. and Dhiman, A.K., 2002. Ess Publications. 2 volumes.
9. Research Methods: the concise knowledge base; Trochim W.M.K., 2005. Atomic Dog Publishing. 270p.
10. Research Methodology ;Panneerselvam R., PHI, Learning Pvt. Ltd., New Delhi – 2009.

Examination Pattern / Evaluation Pattern

Teaching and Evaluation (for Major, Minor, AEC, VEC, IKS courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	4 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Teaching and Evaluation (for VSC, SEC & CC courses)

- Evaluation to be done by Internal & External Experts
- No descriptive end semester written examination
- Evaluation to be done at Department level preferably prior to commencement of Theory /Practical Examinations
- Evaluation to be done on the Skills gained by student