સૌરાષ્ટ્ર યુનિવર્સિટી
એકેડેમિક વિભાગ
યુનિવર્સિટી કેમ્પસ, યુનિવર્સિટી રોડ, રાજકોટ-૩૬૦૦૦૫

ફોન નં.(૦૨૮૧)૨૫૭૮૫૦૧ એક્સટે. નં.૨૦૨, ૩૦૪ ફેક્સ નં.(૦૨૮૧)૨૫૭૬૩૪૭ ઈ-મેઈલ : academic@sauuni.ac.in

નં.એકે/સાયન્સ/ 2604785 /૨૦૨૬

તા.૨૫/૦૬/૨૦૨૬

M.Sc. (Mathematics)

પરિપત્ર:-

સૌરાષ્ટ્ર યુનિવર્સિટીની સાયન્સ વિદ્યાશાખા હેઠળની અનુસ્નાતક કક્ષાના એમ.એસસી.(ગણિતશાસ્ત્ર) ના અભ્યાસક્રમ ચલાવતી સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓને આથી જાણ કરવામાં આવે છે કે, ચેરપર્સનશ્રી, ગણિતશાસ્ત્ર વિષયની અભ્યાસ સમિતિ તથા ડીનશ્રી, સાયન્સ વિદ્યાશાખા દ્વારા રજુ કરાયેલ એમ.એસસી.(ગણિતશાસ્ત્ર) સેમેસ્ટર-૧ અને ૦૨ નો SOP મુજબનો અભ્યાસક્રમ અધિકાર મંડળોની બહાલીની અપેક્ષાએ મંજુરી આપવા માન.કુલપતિ સાહેબને ભલામણ કરેલ છે. જે માન.કુલપતિશ્રીએ મંજુર કરેલ છે જેથી સંબંધિત તમામે તે મુજબ તેનો અમલ કરવા વિનંતી.

(મુસદ્દો કુલસચિવશ્રીએ મંજુર કરેલ છે.)

સહી/-
(ડૉ. એ. કે. જાડેજા)
કુલસચિવ

બિડાણ:- ઉપરોક્ત અભ્યસક્રમ

રવાના કર્યું

ઈ. ચા. એકેડેમિક ઓફિસર

પ્રતિ,

(૧) અધ્યક્ષશ્રી, ગણિતશાસ્ત્ર ભવન, સૌરાષ્ટ્ર યુનિવર્સિટી રાજકોટ.

(૨) સાયન્સ વિદ્યાશાખા હેઠળની ગણિતશાસ્ત્ર વિષય ચલાવતી સ્નાતક કક્ષાની સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓ તથા અનુસ્નાતક ભવનનાં અધ્યક્ષશ્રીઓ તરફ.

(3) ડીનશ્રી, સાયન્સ વિદ્યાશાખા

નકલ જાણ અર્થે રવાના:-

૧. માન.કુલપતિશ્રી/કુલસચિવશ્રીના અંગત સચિવ

નકલ રવાના (યોગ્ય કાર્યવાહી અર્થે):-

૧. પરીક્ષા વિભાગ

૨. પી.જી.ટી.આર. વિભાગ

૩. જોડાણ વિભાગ

SAURASHTRA UNIVERSITY

FACULTY OF SCIENCE

Course Structure and Syllabus for 1st and 2nd Semesters

M.Sc. in Mathematics

Based on

UGC's guidelines NEP-2020 "Curriculum and Credit Framework for Postgraduate Programmes"

Effective From June–2026 & onwards

(Submitted on 18-06-2026)

Programme Outcomes (PO):

By the end of the program, the following programme outcomes are aimed to be achieved.

PO 1	**Advanced Algebraic Structures** Demonstrate a deep structural understanding of finite groups, fields, modules, and commutative rings. Students will fluidly navigate the Galois correspondence and implement factorization techniques across complex algebraic domains.
PO 2	**Complex and Analytical Integration** Master complex variable mapping and evaluate real and complex integrals using residue theory and Laurent series. Students will systematically establish the analytical boundary behaviors of entire and meromorphic functions.
PO 3	**Differential Equations and Physical Modeling** Analyze the existence and uniqueness of linear and non-linear systems while solving higher-order boundary value problems. Students will accurately model physical phenomena using classical Heat, Wave, and Laplace partial differential equations.
PO 4	**Stochastic and Statistical Analysis** Apply advanced probability measures, joint bivariate distributions, and specialized stochastic models to real-world scenarios. Students will interpret asymptotic sample behavior using the Laws of Large Numbers and the Central Limit Theorem.
PO 5	**Relativistic Kinematics and Dynamics** Formulate mathematical structures of spacetime and evaluate high-velocity particle kinetics using Lorentz transformations. Students will resolve classical paradoxes by applying mass-energy equivalence to dynamic physical systems.
PO 6	**Tensor Calculus and Curvature Geometry** Master tensor algebra, covariant differentiation, and Christoffel symbols within affine and Riemannian manifolds. Students will solve higher-order geometric problems using the Riemann-Christoffel curvature tensor and Bianchi identities.
PO 7	**Canonical Transformations and Variational Principles** Formulate equations of motion for constrained systems utilizing Hamilton's variational framework and the principle of least action. Students will perform canonical transformations in phase space and evaluate rigid body rotations.
PO 8	**Spectral Theory and Linear Decompositions** Reduce abstract linear transformations to canonical, triangular, and Jordan forms by applying the Primary Decomposition Theorem. Students will analyze the geometry of unitary spaces using Hermitian and normal operator properties.
PO 9	**Lebesgue Measure and Integral Convergence** Construct Lebesgue measures on $\mathbb{R}$ to rigorously differentiate between Borel and non-measurable sets. Students will execute advanced limit evaluations using the Monotone Convergence Theorem and Fatou's Lemma.
PO 10	**Topological Invariants and Separation Hierarchy** Building abstract topologies and systematically classifying spaces within the T_i separation hierarchy.

Programme Specific Outcomes (PSO):

By the end of the program, the following programme specific outcomes are aimed to be achieved.

PSO 1	**Core Mathematical Mastery** Demonstrate comprehensive knowledge and rigorous theoretical understanding of core mathematical domains, including advanced abstract algebra, complex variables, topology, and higher linear algebra.
PSO 2	**Analytical and Measure-Theoretic Competence** Develop structural capabilities in real analysis and Lebesgue measure theory, enabling the critical evaluation of function spaces, non-measurable sets, and powerful integral convergence theorems.
PSO 3	**Advanced Applied Modeling** Formulate, classify, and solve ordinary, partial differential, and integral equations to model and resolve complex boundary value problems in physical and mathematical structures.
PSO 4	**Theoretical Physics and Relativistic Mechanics** Apply advanced mathematical frameworks—including tensor calculus, Riemannian manifolds, and variational principles—to investigate the mechanics of particles, special relativity, and cosmological spacetime configurations.
PSO 5	**Stochastic and Computational Analytics** Analyze complex stochastic systems using probability measures, joint distributions, and sample statistics, while utilizing arithmetic functions and continued fractions to solve algebraic and number-theoretic equations.
PSO 6	**Mathematical Reasoning and Expression** Synthesize abstract properties—such as the separation hierarchy in topology, spectral theory in linear algebra, and ideal mappings in commutative rings—to construct logical proofs and successfully articulate them in oral and written evaluation.

M.Sc. in Mathematics

SCHEME OF INSTRUCTION AND EXAMINATIONS
For Students Admitted from A.Y. 2026 & Onwards

Semester - I							
Course Code	Course Title	Credits	Hours of Instruction / Week		Exam Weightage		
			TH	PR	INT	SEE	TOTAL
Part-I Discipline Specific Core Courses (CC)							
MSM-CC-101	DSC 1: Advanced Abstract Algebra	4	4	0	50	50	100
MSM-CC-102	DSC 2: Theory of Complex Variables	4	4	0	50	50	100
MSM-CC-103	DSC 3: Theory of Differential Equations	4	4	0	50	50	100
Part-II Discipline Specific Elective – Interdisciplinary (DSE- ID)							
MSM-EC-101 MSM-EC-102	DSE 1: Mathematical Statistics OR DSE 2: Sp. Theory of Relativity and Tensor Analysis	4	4	0	50	50	100
MSM-EC-103 MSM-EC-104	DSE 3: Classical Mechanics OR DSE 4: Theory of Banach Algebras	4	4	0	50	50	100
Part-III: Comprehensive Viva-Voce							
MSM-CVV-101	Comprehensive Viva-Voce-I	2	NA		Viva Exam		50
	Total	22	24		175	375	550

Master of Science in Mathematics
Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Advanced Abstract Algebra**
Course Code	**MSM-CC-101**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Classify complex group structures using Sylow Theorems and Abelian invariants. • Evaluate the hierarchy of integral domains and the behavior of ring homomorphisms. • Determine polynomial irreducibility and the degree of algebraic field extensions. • Construct splitting fields and characterize the properties of finite fields. • Unify group and field theories through the Fundamental Theorem of Galois Theory.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • deconstruct the structural properties of finite groups using Sylow Theorems. • identify and utilize the unique properties of Euclidean, Principal, and Factorization domains. • validate polynomial irreducibility and compute the degrees of various field extensions. • analyze the construction of splitting fields and the characteristics of finite fields. • execute the Galois correspondence to bridge group-theoretic and field-theoretic properties.

Unit No.	Topics	Hours
I	• Basic Concepts of Group Theory • Direct Products of Groups • Finitely Generated Abelian Groups • Invariants of Finite Abelian Groups • Sylow Theorems • Applications of Sylow Theorems	12
II	• Overview of Basic Ring Theory • Homomorphisms of Ideals • Sum and Direct Sum of Ideals • Nilpotent and Nil Ideals • Euclidean Domains • Principal Ideal Domains • Unique Factorization Domains	12
III	• Irreducible Polynomials • Eisenstein's Irreducibility Criterion • Division Rings and Fields • Extension Fields • Algebraic and Transcendental Extensions	12
IV	• Splitting Fields • Normal Extensions • Multiple Roots • Finite Fields	12
V	• Separable Extensions • Automorphisms and Fixed Fields • Galois Extensions • Fundamental Theorem of Galois Theory • Cyclic Extensions and Their Applications	12

REFERENCE BOOKS:

1. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Second Edition, Cambridge University Press, 1995.
2. M. Artin, Algebra, Prentice-Hall of India Private Ltd., New Delhi, 1994.
3. J. A. Gallian, Contemporary Abstract Algebra, Fourth Edition, Narosa Publishing House, New Delhi, 1999.
4. N. S. Gopalakrishnan, University Algebra, New Age International Private Ltd. Publishers, New Delhi, Sixth Reprint, 1998.
5. N. Herstein, Topics in Algebra, Second Edition, Wiley Publication, New York, 1975.

Master of Science in Mathematics
Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Theory of Complex Variables**
Course Code	**MSM-CC-102**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- Model the geometric properties of the extended complex plane and conformal transformations.
- Execute complex integration using Cauchy's integral formulas and winding numbers.
- Apply fundamental theorems to establish the boundary behavior of analytic functions.
- Determine the distribution of zeros and poles using mapping and meromorphic principles.
- Evaluate improper and complex integrals via Laurent series and the Residue Theorem.

Course Outcomes– COs

Upon successful completion of this course, students will be able to:

- map complex regions using bilinear and conformal transformations.
- compute line integrals using Cauchy's integral formulas and winding numbers.
- establish properties of analytic functions via Morera's and Liouville's theorems.
- analyze the distribution of zeros using the argument principle and Rouche's theorem.
- evaluate real and complex integrals by applying Laurent series and residue theory.

Unit No.	Topics	Hours
I	• The Extended Complex Plane and Its Spherical Representation • Analytic and Entire Functions • Bilinear Transformations: Properties and Classifications • Branches of Many-Valued Functions • Definitions and Properties of Conformal Mapping	12
II	• Riemann-Stieltjes Integrals and Their Properties • Line Integrals and Their Properties • Fundamental Theorem of Calculus for Line Integrals • Cauchy's Integral Formula • Cauchy's Theorem for Analytic Functions on an Open Disc • Winding Numbers and Properties of Closed Rectifiable Curves	12
III	• Cauchy-Goursat Theorem • Morera's Theorem • Cauchy's Inequality • Liouville's Theorem and the Identity Theorem • Maximum and Minimum Modulus Theorems	12
IV	• Schwarz Lemma • Meromorphic Functions • The Argument Principle • Rouché's Theorem • The Open Mapping Theorem • The Inverse Function Theorem	12
V	• Isolated Singularities • Classification of Singularities • Laurent Series • The Residue Theorem • Evaluation of Integrals	12

REFERENCE BOOKS:

1. Functions of one complex variable, second edition, Springer Verlag publication by J B Conway.
2. Complex Analysis by L. V. Ahlfors, International Student Edition, Third Edition, Mc Graw – Hill Book Company, 1979.
3. Complex Analysis by Karunakaran, Second Edition, Narosa Publishing House, 2006.
4. A First Course in Complex Analysis with Applications by Dennis G. Zill and Patrik D. Shanahan, Second Edition, Jones & Bartlett Student Edition, 2010.
5. Complex Analysis by S. Lang, Addison-Wesley, 1977.

Master of Science in Mathematics
Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Theory of Differential Equations**
Course Code	**MSM-CC-103**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Analyze the existence, uniqueness, and qualitative behavior of linear and non-linear first-order systems. • Solve constant coefficient systems by utilizing matrix exponentials, eigenvalues, and fundamental matrices. • Formulate partial differential equations by identifying their order, degree, and underlying mathematical structure. • Implement direct integration and separation of variables to derive analytical solutions for partial differential equations. • Classify and resolve classical second-order equations, including the Heat, Wave, and Laplace models.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • evaluate the existence and uniqueness of solutions for linear and non-linear systems. • compute fundamental matrices and matrix exponentials using eigenvalue techniques. • derive partial differential equations to model physical and mathematical structures. • resolve boundary value problems using the method of separation of variables. • model physical phenomena using the Heat, Wave, and Laplace equations.

Unit No.	Topics	Hours
I	**Linear Systems of Differential Equations** • The Existence and Uniqueness Theorem • Linear Homogeneous Systems • Linear Non-Homogeneous Systems • Non-Linear Systems of First-Order Equations	12
II	**Linear Systems with Constant Coefficients** • The Exponential of a Matrix • Eigenvalues and Eigenvectors of Matrices • Calculation of the Fundamental Matrix • Two-Dimensional Linear Systems • Applications to Population Problems	12
III	**Basic Concepts of Partial Differential Equations** • Introduction to Partial Differential Equations • Fundamental Concepts and Definitions • Order and Degree of Partial Differential Equations • Formation of Partial Differential Equations	12
IV	**Solutions of Partial Differential Equations** • General Theory and Classification of PDE Solutions • The Method of Direct Integration • The Method of Separation of Variables	12
V	**Second-Order Partial Differential Equations** • Classification of Second-Order Partial Differential Equations • Three Fundamental Types of Linear Second-Order PDEs • The One-Dimensional Heat Equation and Homogeneous Boundary Conditions • The One-Dimensional Wave Equation and Its Solution • Laplace's Equation and Potential Theory	12

REFERENCE BOOKS:

1. Ordinary Differential Equations by G. Birkoff and G. C. Rota, Second edition, Ginn and Co (1995)
2. Introduction to Ordinary Differential Equations by E. A. Coddington, Prentice Hall of India, 1996.
3. Elements of Ordinary Differential Equations by M Golom and M. E. Shinks, Second Edition, McGraw-Hill Books Co., 1965.
4. Theory and Problems of Differential Equations by F. Ayers, McGraw Hill, 1972.
5. Advanced Engineering Mathematics by E. Kreyzig, John Willey and Sons, 2002.
6. Partial Differential Equations by F. John, Narosa Publishing Company, New Delhi, 1979.
7. Elementary Course in Partial Differential Equations by Amarnath, Narosa Publishing House, New Delhi, 1997.

Master of Science in Mathematics
Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Mathematical Statistics**
Course Code	**MSM-EC-101**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Establish the foundations of probability measures, random variables, and Bayesian inference. • Quantify variable behavior through moments, expectation, and moment generating functions. • Identify and model stochastic phenomena using specialized discrete and continuous distributions. • Analyze bivariate relationships through joint distributions, covariance, and correlation. • Validate statistical convergence using the Laws of Large Numbers and the Central Limit Theorem.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • apply fundamental probability measures and Bayes' Theorem to solve complex stochastic problems. • characterize random variables using moments, expected values, and moment generating functions. • identify and utilize appropriate discrete and continuous probability models for diverse real-world scenarios. • evaluate joint behavior, dependence, and correlations between multiple random variables in bivariate systems. • interpret the asymptotic behavior of sample statistics using the Laws of Large Numbers and the Central Limit Theorem.

Unit No.	Topics	Hours
I	**Introduction Probability** • Probability Experiments • Probability Measures and Their Properties • Conditional Probability • Independent Events • Bayes' Theorem • Random Variables • Probability Density Functions • Distribution Functions for Discrete and Continuous Variables • Percentiles for Continuous Random Variables	12
II	**Moments of Random Variables and Chebyshev's Inequality** • Expected Values of Random Variables • Variance of Random Variables • Chebyshev's Inequality • Moment Generating Functions	12
III	**Special Probability Distributions** • Discrete Distributions: Bernoulli and Binomial Distributions • Geometric, Negative Binomial, Hypergeometric, Poisson, and Riemann Zeta Distributions • Continuous Distributions: Uniform distribution • Gamma and Beta Distributions • Normal, Lognormal, Inverse Gaussian, and Logistic Distributions	12
IV	**Bivariate Random Variables** • Bivariate Discrete and Continuous Random Variables • Conditional Distributions • Independence of Random Variables • Covariance of Bivariate Random Variables • Variance of Linear Combinations of Random Variables • Correlation and Independence • Joint Moment Generating Functions	12
V	**Sequences of Random Variables and Order Statistics** • Distributions of Sample Mean and Variance • Laws of Large Numbers and the Central Limit Theorem • Order Statistics and Sample Percentiles • Sampling Distributions for Normal Populations • Chi-Square Distribution • Student's t-Distribution • Snedecor's F-Distribution	12

REFERENCE BOOKS:

1. Prasanna Sahoo, Probability and Mathematical Statistics, University of Louisville 2008.
2. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics (11th Edition), Sultan Chand & Sons.

Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Sp. Theory of Relativity and Tensor Analysis**
Course Code	**MSM-EC-102**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Evaluate the limitations of classical mechanics by analyzing Galilean transformations and the historical implications of the Michelson–Morley null result. • Construct the mathematical framework of Special Relativity using Einstein's postulates to derive the Lorentz transformation equations. • Apply relativistic kinematics and dynamics to solve complex problems involving time dilation, length contraction, and mass-energy equivalence $E = mc^2$. • Master the algebraic structure of tensors, focusing on the distinction between covariant and contravariant properties within affine and Riemannian manifolds. • Implement advanced differential geometry techniques, including Christoffel symbols and covariant differentiation, to analyze curvature and tensor-based physical operators.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • analyze the transition from Newtonian physics to Einsteinian relativity through the lens of coordinate invariance and the constancy of the speed of light. • derive and utilize Lorentz transformations to resolve paradoxes in relativistic velocity and spacetime intervals. • quantify relativistic effects on mass, momentum, and energy for particles traveling at high velocities. • formulate mathematical models in curved space using metric tensors and the geometry of vector fields. • solve higher-order geometric problems using the Riemann–Christoffel curvature tensor and Bianchi identities.

Unit No.	Topics	Hours
I	**Classical Relativity and the Michelson–Morley Experiment** • The Principle of Relativity in Classical Mechanics and Inertial Frames • Galilean Coordinate and Velocity Transformations • Invariance of Newtonian Laws under Classical Transformations • The Michelson–Morley Experiment: Design and Interferometry Techniques • Significance of the Null Result and Implications for the Speed of Light c.	12
II	**Einsteinian Relativity and Lorentz Transformations** • Fundamental Postulates of the Special Theory of Relativity • Derivation of Lorentz Transformation Equations for Space and Time • Relativistic Law of Velocity Addition • The Spacetime Interval and its Invariant Nature • Physical Consequences of the Lorentz Transformation Framework	12
III	**Kinematic and Dynamic Consequences of Special Relativity** • Length Contraction and Proper Length • Time Dilation and Proper Time • Relativistic Law of Addition of Velocities • Variation of Mass with Velocity • Relativistic Momentum and Kinetic Energy • Mass-Energy Equivalence ($E = mc^2$) • Applications and Numerical Problems	12
IV	**Tensor Algebra and Vector Analysis in Manifolds** • Foundations of Tensor Algebra and Algebraic Operations • Vector Fields and Coordinate Transformations in Affine Space • The Geometry of Vector Fields in Riemannian Space • Covariant and Contravariant Tensors in Multilinear Algebra • Metric Tensors and Curvature Properties of Riemann Spaces	12
V	**Advanced Tensor Calculus and Differential Geometry** • Christoffel Symbols of the First and Second Kind • Covariant Differentiation and the Connection Coefficients • Transformation Laws and Non-Tensor Properties of Christoffel Symbols • The Riemann–Christoffel Curvature Tensor and Bianchi Identities • Differential Operators in Tensor Notation	12

REFERENCE BOOKS:

1. The Special theory of Relativity – Benerji and Benarjee. Pub.: Prentice Hall India Ltd.
2. Essential Relativity – W. Rindler. Pub. Springer Verlag.

Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Classical Mechanics**
Course Code	**MSM-EC-103**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Develop a deep understanding of symmetry principal and conservation laws and their applications in modern physical system. • Develop the skills necessary to formulate equations of motion for constrained systems through D'Alembert's Principle and the calculus of variations. • Explore the advanced analytical methods of canonical transformations and Poisson brackets for describing the evolution of mechanical systems. • Integrate the kinematics of rigid body rotations with the relativistic foundations of space, time, and mass-energy equivalence. • Provide a rigorous introduction to tensor algebra and differential geometry for the analysis of curvature in Riemannian manifolds.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • demonstrate the ability to use variational principles to analyze dynamical systems. • derive and solve the Euler–Lagrange equations for particles and systems under diverse holonomic and non-holonomic constraints. • utilize generating functions and the principle of least action to perform canonical transformations in phase space. • parametrize rotations using Euler angles and resolve relativistic kinematic effects using Lorentz transformation equations. • compute Christoffel symbols and curvature tensors to evaluate geometric properties in non-Euclidean spaces.

Unit No.	Topics	Hours
I	• Mechanics of a Particle and Systems of Particles • Classification and Theory of Constraints • D'Alembert's Principle and Lagrange's Equations • Techniques of the Calculus of Variations • Hamilton's Variational Principle and Derivation of Lagrange's Equations • Cyclic Coordinates and Conservation Theorems	12
II	• Hamilton's Equations of Motion • Routh's Procedure and Cyclic Coordinates • Derivation of Hamilton's Equations from Hamilton's Variational Principle • The Principle of Least Action	12
III	• Equations of Canonical Transformations and Generating Functions • Illustrative Examples of Canonical Transformations • Canonical Analysis of the One-Dimensional Harmonic Oscillator • Poisson Brackets and Their Fundamental Properties	12
IV	• Independent Coordinates and Degrees of Freedom of a Rigid Body • Orthogonal Transformation Matrices and Rotational Symmetry • The Euler Angles and Parametrization of Rotations • The Cayley-Klein Parameters • Euler's Theorem for Rigid Body Displacement	12
V	• Fundamental Postulates of Special Relativity • The Lorentz Transformation Equations • Relativistic Law of Velocity Addition • Force and Energy Equations in Relativistic Mechanics	12

REFERENCE BOOKS:

1. Classical Mechanics, H Goldstein, C Poole, J Safko, 3rd Edition, Addison-Wesley / Pearson (2002).
2. Classical Mechanics, C. R. Mondal, Prentice Hall of India Pvt. Ltd.
3. Mechanics (Course of Theoretical Physics, Vol. 1), L.D. Landau, E.M. Lifshitz, Butterworth-Heinemann, 3rd Edition, (1982).

Semester I

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Theory of Banach Algebras**
Course Code	**MSM-EC-104**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• To introduce the basic concepts, examples, and fundamental properties of Banach algebras. • To develop understanding of spectral theory and algebraic structures in Banach algebras. • To study Gelfand theory and its role in representing Banach algebras. • To explore the structure and properties of Banach -algebras and C-algebras. • To apply Banach algebra concepts in harmonic analysis and operator theory.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • Understand fundamental definitions, examples, and properties of Banach algebras. • Analyze spectral concepts including spectrum, resolvent, and spectral radius in Banach algebras. • Apply Gelfand theory to study structure and representation of Banach algebras. • Understand properties and applications of Banach -algebras and C-algebras. • Apply Banach algebra techniques in harmonic analysis and operator theory.

Unit No.	Topics	Hours
I	• Algebraic structures and normed algebras • Definition and examples of Banach algebras • Invertible and singular elements • Topological divisors of zero (TDZ) and related results	12
II	• Spectrum and spectral radius • Resolvent set and resolvent function • Spectral mapping theorem • Spectral radius formula • Gelfand–Mazur theorem • Ideals, radical, and semisimplicity	12
III	• Complex homomorphisms • Gelfand topology and Gelfand space • Compactness of Gelfand space • Gelfand transform and representation • Examples of Gelfand spaces	12
IV	• Banach *-algebras and examples • C*-algebras and properties • Self-adjoint elements • Stone–Weierstrass theorem • Gelfand–Neumark theorem • Closed ideals in $\boldsymbol{C}(\boldsymbol{X})$	12
V	• Applications in harmonic analysis • Applications in operator theory • Functional analytic methods in Banach algebras • Review of important theorems and problem-solving techniques	12

REFERENCE BOOKS:

[1] Kaniuth E., A Course in Commutative Banach Algebras, Springer, New York, 2009.
[2] Larsen R., Banach Algebras, Marcell-Dekker, 1973.
[3] Simmons G.F., Introduction to Topology and Modern Analysis, McGraw-Hill Co., Tokyo, 1963.

M.Sc. in Mathematics

SCHEME OF INSTRUCTION AND EXAMINATIONS
For Students Admitted from A.Y. 2026 & Onwards

Semester - II							
Course Code	Course Title	Credits	Hours of Instruction / Week		Exam Weightage		
			TH	PR	INT	SEE	TOTAL
Part-I Discipline Specific Core Courses (CC)							
MSM-CC-201	DSC 1: Higher Linear Algebra	4	4	0	50	50	100
MSM-CC-202	DSC 2: Lebesgue Measure Theory	4	4	0	50	50	100
MSM-CC-203	DSC 3: Topology	4	4	0	50	50	100
Part-II Discipline Specific Elective – Interdisciplinary (DSE- ID)							
MSM-EC-201 MSM-EC-202	DSE 1: Number Theory OR DSE 2: General Theory of Relativity & Cosmology	4	4	0	50	50	100
MSM-EC-203 MSM-EC-204	DSE 3: Integral Equations OR DSE 4: Commutative Ring Theory	4	4	0	50	50	100
Part-III: Comprehensive Viva-Voce							
MSM-CVV-201	Comprehensive Viva-Voce II	2	NA		Viva Exam		50
	Total	22	24		175	375	550

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Higher Linear Algebra**
Course Code	**MSM-CC-201**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- Establish a rigorous understanding of the algebra of linear transformations and their matrix representations through characteristic roots and vectors.
- Explore the structural decomposition of linear operators by analyzing triangular forms and the invariant properties of nilpotent transformations.
- Master the Primary Decomposition Theorem and the construction of Jordan and Rational canonical forms for comprehensive operator analysis.
- Analyze the geometry of inner product spaces and the spectral properties of Hermitian, Unitary, and Normal transformations.
- Investigate the classification of real quadratic forms and the algebraic structures of groups that preserve symmetric and skew-symmetric bilinear forms.

Course Outcomes– COs

Upon successful completion of this course, students will be able to:

- transition fluidly between abstract linear transformations and their matrix counterparts to solve eigenvalue problems.
- reduce linear operators to their simplest triangular representations and identify the unique invariants of nilpotent systems.
- apply the Primary Decomposition Theorem to decompose vector spaces and determine the Jordan and Rational forms of a given matrix.
- utilize the Cayley–Hamilton Theorem and Cramer's Rule to evaluate the properties of special transformations in unitary spaces.
- categorize quadratic forms using Sylvester's Law of Inertia and analyze the symmetry properties of bilinear mappings.

Unit No.	Topics	Hours
I	• The Algebra of Linear Transformations • Characteristic Roots and Vectors • Matrix Representations of Linear Transformations	12
II	• Canonical Forms: The Triangular Form • Nilpotent Linear Transformations • Invariants of Nilpotent Linear Transformations	12
III	• The Primary Decomposition Theorem • Jordan Canonical Form • Rational Canonical Form	12
IV	• Trace, Transpose, and Determinants • Cramer's Rule and the Cayley–Hamilton Theorem • Review of Inner Product Spaces • Hermitian, Unitary, and Normal Transformations	12
V	• Real Quadratic Forms and Sylvester's Law of Inertia • Bilinear Forms: Symmetric and Skew-Symmetric • Groups Preserving Bilinear Forms	12

REFERENCE BOOKS:

1. N. Herstein, Topics in Algebra, 2/e, Wiley Publication, 1975
2. Linear Algebra, K. Hoffman and R. Kunze, 2nd ed. Englewood Cliffs, NJ, USA: Prentice-Hall, 1971.

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Lebesgue Measure Theory**
Course Code	**MSM-CC-202**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Develop a rigorous foundation in the construction of Lebesgue measure on $\mathbb{R}$ by extending the concept of length to a broader σ -algebra of sets. • Characterize the structural properties of measurable functions and their approximation by simpler classes, such as step and simple functions. • Master the theory of Lebesgue integration and the powerful convergence theorems that overcome the limitations of the Riemann integral. • Investigate the deep connection between differentiation and integration through the study of absolute continuity and functions of bounded variation.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • distinguish between Borel and Lebesgue measurable sets and apply the properties of outer measure to analyze non-measurable sets. • implement Littlewood's Three Principles to describe the behavior of measurable functions and their convergence properties. • evaluate complex integrals using the Monotone Convergence Theorem, Fatou's Lemma, and the Lebesgue Dominated Convergence Theorem. • prove the Fundamental Theorem of Calculus for absolutely continuous functions and decompose functions into components of bounded variation.

<table>
<tr><th>Unit No.</th><th>Topics</th><th>Hours</th></tr>
<tr><td>I</td><td>Lebesgue Measure on $\mathbb{R}$
• Foundations of Set Theory: Algebras and σ-algebras
• Borel Sets: G_δ and F_σ Sets
• The Length of Open and Closed Sets in $\mathbb{R}$
• Outer Measure and its Fundamental Properties
• Measurable Sets and the σ-algebra of Measurable Sets
• Inner and Outer Approximation of Measurable Sets by Open, Closed, and Borel Sets
• Construction of Non-Measurable Sets</td><td>15</td></tr>
<tr><td>II</td><td>Lebesgue Measurable Functions
• Measurable Functions and their Equivalent Formulations
• Algebraic and Analytic Properties of Measurable Functions
• Simple Functions and Step Functions
• Approximation of Measurable Functions by Simple Functions
• Littlewood’s Three Principles (Thematic Statements)</td><td>15</td></tr>
<tr><td>III</td><td>Lebesgue Measurable Functions
• Measurable Functions and their Equivalent Formulations
• Algebraic and Analytic Properties of Measurable Functions
• Simple Functions and Step Functions
• Approximation of Measurable Functions by Simple Functions
• Littlewood’s Three Principles (Thematic Statements)</td><td>15</td></tr>
<tr><td>IV</td><td>Differentiation and Integration on $\mathbb{R}$
• Convergence in Measure and its Properties
• Differentiation of Monotone Functions
• Functions of Bounded Variation (BV)
• Differentiation of an Integral and the Lebesgue Set
• Absolute Continuity and the Fundamental Theorem of Calculus</td><td>15</td></tr>
</table>

REFERENCE BOOKS:

1. H.L. Royden and P.M. Fitzpatrick, *Real Analysis*, 4th Edition, Pearson.
2. An introduction to Measure and Integration by I. K. Rana, Narosa Publishing House, New Delhi.
3. G. de Barra, Measure Theory and Integration, New Age International.
4. Elias M. Stein and Rami Shakarchi, Real Analysis: Measure Theory, Integration, and Hilbert Spaces, Princeton University Press.
5. Walter Rudin, Real and Complex Analysis, McGraw-Hill.

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Topology**
Course Code	**MSM-CC-203**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- Establish the fundamental concepts of topological spaces, providing a rigorous grounding in the construction of topologies via bases, subspaces, and product spaces.
- Analyze the interplay between metric structures and continuous mappings, while exploring the topological invariants of connectedness and path-connectedness.
- Investigate the hierarchy of separation axioms and the foundational lemmas of Urysohn and Tietze that characterize the existence of continuous functions.
- Explore the concept of compactness as a generalization of closed and bounded sets, focusing on the implications of Tychonoff's Theorem and the Heine–Borel property.
- Refine the study of compactness through sequential and local forms while examining the theory of compactification and the completeness of metric spaces.

Course Outcomes– COs

Upon successful completion of this course, students will be able to:

- construct topologies using various bases and determine the interior, closure, and limit points of sets in abstract topological environments.
- identify homeomorphisms between spaces and categorize topological spaces based on their local and path-connected components.
- classify spaces within the T_i hierarchy and utilize Urysohn's Lemma to solve problems involving the extension of continuous functions.
- apply the Finite Intersection Property and the Lebesgue Covering Lemma to evaluate the compactness of complex topological systems.
- perform one-point compactifications and distinguish between sequentially compact and limit point compact spaces in the context of complete metric spaces.

Unit No.	Topics	Hours
I	• Definition of a Topology and Topological Spaces • Open Sets and Closed Sets • Comparison of Topologies: Finer and Coarser Topologies • Basis for a Topology • Order Topology (Simply Ordered Topology) • Limit Points and Closure of a Set • Interior Points and the Interior of a Set • Subspace Topology • Product Topology	12
II	• Metric Topology and Properties of Metric Spaces • Continuous Functions and Homeomorphisms • Convergent and Cauchy Sequences in Topology • Uniform Convergence • Connectedness and Connected Components • Path Connectedness and Local Connectedness	12
III	• T_1 Spaces and Hausdorff (T_2) Spaces • Regular Spaces and T_3 Spaces • Completely Regular Spaces • Normal Spaces and T_4 Spaces • Urysohn's Lemma and Tietze's Extension Theorem (Statements)	12
IV	• Compact Spaces and their Topological Properties • The Finite Intersection Property • The Tube Lemma and Tychonoff's Theorem • The Heine–Borel Theorem • The Lebesgue Covering Lemma	12
V	• Limit Point Compactness and Sequentially Compact Spaces • Local Compactness and Theory of Compactification • One-Point Compactification • Complete Metric Spaces and their Properties	12

REFERENCE BOOKS:

1. Topology – A First Course, J. R. Munkres, Prentice Hall of India (2000).
2. Introduction to Topology and Modern Analysis - G. F. Simmons, Tata McGraw- Hill edition-2004.
3. General Topology by S. Willard, Addison – Wesley Publishing Company (1970).

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Number Theory**
Course Code	**MSM-EC-201**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- Establish a rigorous mathematical foundation in divisibility, prime number theory, and the unique factorization properties of the integers.
- Master the theory of congruences, including the solution of linear systems and the characterization of primitive roots.
- Explore the representation of real numbers through Farey sequences and continued fractions to evaluate optimal rational approximations.
- Analytical techniques for solving non-linear integer equations, specifically focusing on Pell's equation and periodic expansions.
- Investigate the properties of multiplicative arithmetic functions and the geometric structures of Pythagorean triples.

Course Outcomes– COs

Upon successful completion of this course, students will be able to:

- implement the Euclidean algorithm for greatest common divisors and apply the Fundamental Theorem of Arithmetic to complex divisibility proofs.
- solve simultaneous modular equations using the Chinese Remainder Theorem and determine the existence of primitive roots for various moduli.
- find fundamental and general solutions to Pell's equation and solve linear Diophantine equations in multiple variables.
- expand irrational numbers into infinite continued fractions and use Hurwitz's Inequality to assess approximation precision.
- evaluate the properties of arithmetic functions, such as the Möbius and Euler totient functions, and generate Pythagorean triples.

Unit No.	Topics	Hours
I	• The Theory of Divisibility • The Greatest Common Divisor (GCD) and Least Common Multiple (LCM) • The Euclidean Algorithm • Prime Numbers and their Distribution • The Fundamental Theorem of Arithmetic	12
II	• Foundations of Congruences • Complete and Reduced Residue Systems • Linear Congruences and their Solutions • The Chinese Remainder Theorem • The Degree of a Congruence Equation • Primitive Roots and Indices	12
III	• Farey Fractions and Sequences • Properties of Irrational Numbers • Simple Continued Fractions: Finite and Infinite Representations • Approximation of Irrational Numbers by Rationals • Hurwitz's Inequality	12
IV	• Periodic Continued Fractions • Pell's Equation and its Fundamental Solutions • Linear Diophantine Equations and General Methods of Solution	12
V	• Pythagorean Triples • The Greatest Integer Function • Arithmetic Functions: Multiplicative and Additive Properties	12

REFERENCE BOOKS:

1. An Introduction to the Theory of Numbers, I. Niven, H. S. Zuckerman, and H. L. Montgomery, 5th Edition, John Wiley & Sons, (1991).
2. Elementary Number Theory, D. M. Burton, 7th Edition, McGraw-Hill, (2011).
3. Number Theory, Z. I. Borevich, I. R. Shafarevich, Academic Press, (1966).
4. An Introduction to the Theory of Numbers, G. H. Hardy and E. M. Wright, 6th Edition, Oxford University Press, (2008).
5. An introduction to the geometry of numbers, J. W. S. Cassels, Springer-Verlag, (1959).
6. Number Theory, G. E. Andrews, Dover publications, (1994).

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**General Theory of Relativity & Cosmology**
Course Code	**MSM-EC-202**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- To develop understanding of spacetime and gravitation using differential geometry
- To introduce tensor calculus and curvature concepts.
- To study Einstein's field equations and their physical meaning.
- To analyse exact solutions like Schwarzschild spacetime.
- To understand cosmological models and relativistic phenomena.

Course Outcomes– Cos

Upon successful completion of this course, students will be able to:

- Understand geometric structure of spacetime and basic differential geometry
- Apply tensor calculus and curvature concepts in relativity
- Derive and interpret Einstein field equations
- Analyze black hole solutions and relativistic effects
- Explain cosmological models and large-scale structure of the universe

Unit No.	Topics	Hours
I	• Review of special relativity and limitations • Principle of equivalence (weak and strong forms) • Introduction to curved spacetime • Coordinate systems and transformations • Manifolds, charts, and coordinate patches • Tangent spaces and vectors • Metric tensor and line element	12
II	• Contravariant and covariant tensors • Tensor algebra and tensor fields • Covariant differentiation • Affine connection and Christoffel symbols • Parallel transport • Geodesics and geodesic equation • Riemann curvature tensor • Ricci tensor and scalar curvature	12
III	• Physical motivation of Einstein's equations • Energy-momentum tensor • Einstein field equations (EFE) • Cosmological constant • Conservation laws and Bianchi identities • Weak-field approximation • Linearized gravity	12
IV	• Schwarzschild solution • Properties of Schwarzschild spacetime • Event horizon and singularities • Geodesics in Schwarzschild geometry • Black holes and basic properties • Kerr solution (introductory) • Gravitational time dilation and redshift	12
V	• Cosmological principle • Friedmann–Lemaître–Robertson–Walker (FLRW) metric • Friedmann equations • Expanding universe models • Big Bang theory (introductory) • Gravitational waves (basic idea) • Applications of general relativity in astrophysics	12

REFERENCE BOOKS:

1. S. Weinberg, Gravitation and Cosmology. New York, USA: Wiley, 1972.
2. B. F. Schutz, A First Course in General Relativity, 2nd ed. Cambridge, UK: Cambridge University Press, 2009.
3. R. M. Wald, General Relativity. Chicago, USA: University of Chicago Press, 1984.
4. S. W. Hawking and G. F. R. Ellis, The Large Scale Structure of Space-Time. Cambridge, UK: Cambridge University Press, 1973.

Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Integral Equations**
Course Code	**MSM-EC-203**
Course Credit	**04**
Total Marks	**100**

Course Objectives
• Introduce the basic theory and applications of integral equations. • Develop problem-solving skills through systematic methods of solution. • Train students in transforming differential equations and boundary value problems into integral equations. • Familiarize students with analytical methods, approximation procedures, and numerical ideas. • Emphasize worked examples, computation techniques, and applications rather than abstract proofs.

Course Outcomes– COs
Upon successful completion of this course, students will be able to: • Identify and classify integral equations. • Transform differential equations into integral equations. • Solve Fredholm and Volterra equations using standard methods. • Apply iterative and approximation techniques. • Understand eigenvalue problems associated with kernels. • Apply numerical methods to approximate solutions.

Unit No.	Topics	Hours
I	**Introduction to Integral Equations and Classification** • Preliminary concepts and review of functions. • Origin and formation of integral equations. • Classification: Fredholm, Volterra, first kind, second kind, homogeneous and non-homogeneous equations. • Kernels: symmetric, separable and degenerate kernels, etc.. • Leibnitz's rule of differentiation under integral sign.(statement only) • Methods of reduction of differential equations into Volterra integral equations.	15
II	**Solution of Fredholm Integral Equations** • Characteristic values and characteristic functions. • Solution of Homogeneous Fredholm Integral Equations of second kind with separable or degenerate kernels. • Fredholm alternative (statement only) and problems based on it. • Solution of Fredholm Integral Equation of second kind by Successive approximations or Iterative Method or Neumann's Series. • Applications and worked examples.	15
III	**Volterra Integral Equations and Integro-Differential Equations** • Solution of Volterra Integral Equation of second kind by Successive approximations or Iterative Method or Neumann's Series. • Solution of Volterra Integral Equation of second kind by reducing to Differential Equation. • Solution of Volterra equations of the first kind.	15
IV	**Integral Equations with Symmetric Kernels and Numerical Methods** • Fundamental properties of Eigenvalues and Eigenfunctions for symmetric kernals. • Hilbert Theorem for symmetric kernel. (statement only) • Symmetric kernels and orthogonality property. • Hilbert–Schmidt theory (statement only) and examples based on it. • Solution of Fredholm integral equation of the first kind with symmetric kernel. • Singular integral equation. • Solution of the Abel Integral equation.	15

REFERENCE BOOKS:

1. M. D. Raisinghania, Integral Equations and Boundary Value Problems
2. Ram P. Kanwal – Linear Integral Equations
3. F. G. Tricomi – Integral Equations
4. Abdul J. Jerri – A First Course in Integral Equations
5. C. Corduneanu – Integral Equations and Boundary Value Problems
6. Rainer Kress – Linear Integral Equations: Theory and Technique

Master of Science in Mathematics
Semester II

Course Category	**M.Sc. (Mathematics)**
Title of the Course	**Commutative Ring Theory**
Course Code	**MSM-EC-204**
Course Credit	**04**
Total Marks	**100**

Course Objectives

- To develop a strong foundation in commutative rings and ideal theory.
- To understand factorization properties in integral domains.
- To study Noetherian conditions and module theory.
- To analyze localization and extension of rings.
- To introduce advanced concepts such as primary decomposition and spectrum of rings.

Course Outcomes– COs

- Understand structure of commutative rings and properties of ideals.
- Apply factorization techniques in UFDs, PIDs, and Euclidean domains.
- Analyze Noetherian rings and modules using chain conditions.
- Use localization and integral extensions in ring theory problems.
- Interpret advanced algebraic structures like Spec(R) and primary decomposition.

Unit No.	Topics	Hours
I	• Definitions of rings and subrings • Integral domains and fields • Ring homomorphisms and isomorphisms • Ideals: prime and maximal ideals • Quotient rings and their properties	12
II	• Divisibility in integral domains • Unique Factorization Domains (UFDs) • Principal Ideal Domains (PIDs) • Euclidean domains • Relationships among ED, PID, and UFD	12
III	• Ascending Chain Condition (ACC) • Noetherian rings and examples • Hilbert Basis Theorem • Modules over a ring • Submodules and factor modules	12
IV	• Localization of rings and modules • Properties of localization • Extension and contraction of ideals • Integral extensions • Integral closure	12
V	• Radical of an ideal • Primary decomposition • Artinian rings and DCC • Spectrum of a ring Spec(R) • Zariski topology (basic introduction)	12

REFERENCE BOOKS:

1. Introduction to Commutative Algebra, M. F. Atiyah and I. G. Macdonald, Reading, MA, USA: Addison-Wesley, 1969.
2. Commutative Ring Theory, H. Matsumura, Cambridge, UK: Cambridge University Press, 1989.
3. Commutative Algebra with a View Toward Algebraic Geometry, D. Eisenbud, New York, NY, USA: Springer, 1995.
4. Algebra, S. Lang, 3rd ed. New York, NY, USA: Springer, 2002.
5. Basic Commutative Algebra, B. Singh and R. Jain, New Delhi, India: World Scientific, 2011.