Anekant Education Society's

Tuljaram Chaturchand Collge of Arts, Science and Commerce, Baramati.

(Autonomous)

Course & Credit Structure for M.Sc. Mathematics (2023 Pattern as per NEP 2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
III	Major (Mandatory)	MAT-601-MJM	Linear Algebra	Theory	04
	Major (Mandatory)	MAT-602-MJM	Field Theory	Theory	04
	Major (Mandatory)	MAT-603-MJM	Practical based on Combinatorics	Practical	02
	Major (Mandatory)	MAT-604-MJM	Practical based on Python Programming	Practical	02
	Major (Elective)	MAT-611-MJE (A)	Banach Spaces	Theory	02
		MAT-611-MJE (B)	Algebraic Topology		
	Major (Elective)	MAT-612-MJE (A)	Practical based on Graph Theory	Practical	02
		MAT-612-MJE (B)	Practical based on Coding Theory		
	Research Project	MAT-621-RP	Research Project	Practical	04
				Total Credits Semester-III	**20**
IV	Major (Mandatory)	MAT-651-MJM	Differential Geometry	Theory	04
	Major (Mandatory)	MAT-652-MJM	Lattice Theory	Theory	04
	Major (Mandatory)	MAT-653-MJM	Practical based on Integral Equations	Practical	02
	Major (Elective)	MAT-661-MJE (A)	Hilbert Spaces and Spectral Theory	Theory	02
		MAT-661-MJE (B)	Cryptography		
	Major (Elective)	MAT-662-MJE (A)	Practical based on Boundary Value Problems	Practical	02
		MAT-662-MJE (B)	Practical based on Mechanics		
	Research Project	MAT-681-RP	Research Project	Practical	06
				Total Credits Semester-IV	**20**
				Cumulative Credits Semester III + Semester IV	**40**

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme : M.Sc. Mathematics
Program Code : PSMAT
Class : M.Sc.
Semester : IV
Course Type : Major (Mandatory)
Course Name : Differential Geometry
Course Code : MAT-651-MJM
No. of Teaching Hours : 60
No. of Credits : 4

Course Objectives:

1. Discusses how to represent and analyze level sets graphically.
2. Introduces the concept of curves defined by a parameter, often time or arc length.
3. Describes surfaces generated by rotating a curve around an axis.
4. Discusses the image of a surface under the Gauss map, typically on a sphere.
5. Understand the Gauss map, geodesics, and related geometric properties.
6. Introduces how to differentiate tangent vector fields using the concept of covariant derivatives.
7. Study curvature, arc length, and line integrals in the context of plane curves.

Course Outcomes:

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

CO1: Apply level sets in solving problems related to contour plots and surfaces in multivariable calculus.

CO2: Understand the gradient as a vector field that points in the direction of the steepest ascent of the function.

CO3: Explore and understand the properties of tangent spaces, including their linear structure.

CO4: Understand the topological concept of connectedness and its importance in the study of surfaces.

CO5: Understand the geometric and topological implications of the spherical image.

CO6: Understand the importance of normal vectors in defining orientation, surface integrals, and flux.

CO7: Apply covariant derivatives in differential geometry and general relativity.

Topics and Learning Points

	Teaching Hours
Unit 1: Graphs and level sets	**06**
1.1 Level set	
1.2 Graphs of level sets	
Unit 2: Vector Field	**10**
2.1 Dot product	
2.2 Cross product	
2.3 Length of vector	
2.4 Vector field, smooth vector field	
2.5 Gradient	
2.6 Parameterized curve	
Unit 3: The Tangent Space	**06**
3.1 Tangent to level sets	
3.2 Properties	
Unit 4: Surface and Vector Field on Surface	**10**
4.1 Surface of Revolution	
4.2 Vector Field	
4.3 Tangent vector field, smooth vector field	
4.4 Normal vector field	
4.5 Connectedness	
Unit 5: The Gauss Map and Geodesics	**10**
5.1 Gauss map	
5.2 Spherical Image of oriented n-surfaces	
5.3 Speed of α	
5.4 Geodesics property	
Unit 6: The Parallel Transport, The Weingarten Map	**10**
6.1 Vector field	
6.2 Covariant derivatives	
6.3 Euclidean parallel	
6.4 Levi-Civita	
6.5 Use of Parallelism	
6.6 Properties of directional derivatives	
6.7 Covariant derivative of tangent vector field	
Unit 7: Curvature of Plane Curve & Arc Length & Line Integral	**08**
7.1 Significance of sign of K(P)	
7.2 Global parameterization	
7.3 Arc length	
7.4 Fundamental domain	
7.5 Differentiable 1-form	

Text Books:

J. A. Thorpe, *Elementary Topics in Differential Geometry*, Springer verleg.

Reference Books:

1. B. Oneill,ElementaryDifferentialGeometry, AcedamicNew-York.
2. Do Carmo M., Differential Geometry of Curves and Surfaces, Englewood Cliffs, N. J. Prentice Hall, 1977.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3		2	1		2			
CO 2	2			1						
CO 3										2
CO 4	3		2							1
CO 5	3	2	2		3		1			
CO 6				2						
CO 7	2	2	1		2					1

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Understanding level sets is crucial for interpreting and analyzing multivariable functions. This involves not only recognizing the geometric representation of functions but also applying these concepts in practical problems.
CO2: The gradient is a foundational concept in vector calculus, essential for understanding optimization, directional derivatives, and potential fields.
CO4: Understanding connectedness allows students to grasp more complex topological properties and is essential for the study of continuous functions, surface theory, and many areas of theoretical and applied mathematics.
CO5: Understanding this concept is critical for students to analyze and visualize surface properties, linking geometry with topology, and is applicable in various scientific and engineering fields.
CO7: Mastery of this concept reflects a deep understanding of how geometry and physics intersect, which is critical for advanced studies in these areas.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: This CO ensures students can translate theoretical knowledge into practical skills, such as interpreting and constructing contour plots, which are widely used in scientific and technical fields.
CO5: Students who understand the concept of spherical image can apply it to solve practical problems related to surface modeling and analysis, linking geometric intuition with professional practice.
CO7: By understanding and applying covariant derivatives, students gain the procedural knowledge necessary to engage in professional work involving complex geometrical and physical systems.
PO 3: Entrepreneurial Mindset, Innovation, and Business Understanding:
CO4: Connectedness is a concept that can be applied to network theory, which has implications for innovation in areas like telecommunications, social networks, and logistics.
CO5: The spherical image is important in industries like aerospace, architecture, and game design, where the understanding of surface properties leads to innovative solutions.
CO7: Covariant derivatives are integral to advanced physics and engineering, particularly in developing theories and models in general relativity and quantum mechanics. Entrepreneurs

with expertise in these areas can harness this knowledge to innovate in high-tech sectors such as space exploration, advanced simulations, and cutting-edge research and development.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: Applying level sets in solving problems requires a strong grasp of multivariable calculus and the ability to visualize complex functions. This CO develops specialized skills in mathematical modeling and critical thinking, enabling students to tackle problems involving contour plots and surfaces.

CO2: Understanding gradients as vector fields involves critical thinking and problem-solving, particularly in optimization and physics.

CO6: Normal vectors are crucial in many areas of calculus and physics, particularly in defining
the orientation of surfaces, calculating surface integrals, and determining flux.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

CO2: Understanding gradients involves analytical reasoning to interpret and apply this concept in various scenarios. This CO develops research skills by enabling students to solve optimization problems and analyze physical systems.

CO5: Understanding the spherical image requires analytical reasoning to comprehend its geometric and topological implications. This CO fosters research skills by enabling students to model and analyze surfaces with curvature and orientation.

CO7: Applying covariant derivatives requires advanced analytical reasoning to understand their role in differential geometry and physics. This CO develops research skills by enabling students to tackle complex problems in general relativity and space-time models.

PO7: Digital Proficiency and Technological skills:

CO1: Applying level sets involves using mathematical software and digital tools to create and analyze contour plots and surfaces. This enhances digital proficiency by requiring students to use technology for visualization and computation, which is essential for tasks in data analysis, engineering, and scientific research.

CO5: Analyzing the spherical image involves using digital tools to visualize and manipulate geometric and topological concepts.

PO 10: Autonomy, Responsibility, and Accountability:

CO3: Exploring tangent spaces requires students to independently study and understand complex geometric concepts. This encourages autonomy in developing a deep understanding of tangent spaces and their properties.

CO4: Responsibility and accountability are emphasized as students must ensure their interpretations of connectedness are accurate and contribute to sound analyses of surfaces.

CO7: Students must take responsibility for their work, ensuring that their application of covariant derivatives is accurate and contributes to valid theoretical models or practical solutions.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Mandatory)
Course Name	**:** Lattice Theory
Course Code	**:** MAT-652-MJM
No. of Teaching Hours	**:** 60
No. of Credits	**:** 4

Course Objectives:

1. To understand Fundamental Concepts of Lattices.
2. To analyze Lattice Operations and Structures.
3. To explore and analyze operations within lattices such as join and meet, and understand irreducible elements.
4. To learn and apply key characterization and representation theorems, including Birkhoff's distributivity criterion and Stone's theorem.
5. To study Modular and Semimodular Lattices.
6. To apply Theoretical Knowledge to Practical Problems.
7. Enhance problem-solving skills by applying lattice theory concepts to complex problems and proofs.

Course Outcomes:

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

CO1: Describe and differentiate between various definitions of lattices.
CO2: Construct and interpret Hasse diagrams for partially ordered sets.
CO3: Analyze and apply lattice homomorphisms and isotone maps.
CO4: Understand and work with ideals, congruence relations, and their lattices.
CO5: Apply characterization and representation theorems to lattice structures.
CO6: Explain and apply the properties of modular and semimodular lattices.
CO7: Investigate and use advanced lattice theorems, including Stone's and Nachbin's theorems.

Topics and Learning Points

	Teaching Hours
Unit 1: Basic of Lattices	**10**
1.1 Two definitions of lattices	
1.2 Hasse diagrams	
1.3 Homomorphism	
1.4 Isotone maps	
1.5 Ideals and congruence relations	
Unit 2: Types of Lattices	**22**
2.1 Congruence lattices	
2.2 Product of lattices	
2.3 Complete Lattice	
2.4 Ideal Lattice	
2.5 Distributive- Modular inequalities and identities	
2.6 Complements and Pseudo complements	
2.7 Boolean lattice of pseudo complement	
2.8 Join and meet irreducible elements	
Unit 3: Characterization theorems and representation theorems	**20**
3.1 Characterization theorem	
3.2 Birkhoff`s distributivity criterion	
3.3 Hereditary subsets, rings of sets	
3.4 Stone theorems	
3.5 Nachbin theorem	
Unit 4: Modular and Semimodular lattices	**08**
4.1 Isomorphism theorem	
4.2 Upper and lower covering conditions	
4.3 Kuros-Ore theorem	
4.4 Jordan-Holder chain condition	

Text Books:

G. Gratzer, *General Lattice Theory*, Birkhauser, 2nd Edition 1998.

Reference Books:

1. Lattice Theory: First Concepts and Distributive Lattices, George Gratzer.
2. Lattice Theory: Special Topics and applications, G. A. Gratzer, Springer.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	-	2	-	-	-	-	-	-
CO 2	3	2	-	2	-	-	1	-	-	-
CO 3	3	3	-	3	2	-	-	-	-	-
CO 4	3	2	-	3	2	-	-	-	-	-
CO 5	3	2	-	3	3	-	-	-	-	-
CO 6	3	-	-	3	3	-	-	-	-	-
CO 7	3	-	-	3	3	-	-	-	-	-

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Strongly aligned, as understanding and differentiating definitions require foundational knowledge.
CO2: Strongly aligned because understanding Hasse diagrams requires foundational knowledge.
CO3: A strong understanding of lattice structures is necessary to analyze homomorphisms and isotone maps.
CO4: Strongly aligned because working with these concepts requires a deep understanding of lattice theory.
CO5: Understanding and applying theorems require solid foundational knowledge.
CO6: A strong understanding of lattice properties is essential.
CO7: Strongly aligned as this CO involves understanding advanced lattice theorems.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: Understanding lattice concepts can be applied in various professional contexts.
CO2: Constructing Hasse diagrams is a practical skill used in mathematical and professional settings.
CO3: Practical knowledge is needed to apply these concepts in different contexts.
CO4: Applying these concepts in practice requires procedural knowledge.
PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO1: Differentiating definitions involves critical thinking to identify the nuances between them.
CO2: Interpreting diagrams requires analytical reasoning and problem-solving.
CO3: Analyzing and applying these concepts require problem-solving skills.
CO4: Working with these structures involves significant problem-solving skills.
CO5: Applying these theorems requires analytical thinking and problem-solving skills.
CO6: Applying properties to solve problems requires critical thinking.
CO7: Investigating and using these theorems involves critical thinking and problem-solving.
PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO3: Application of these concepts could involve research and analytical reasoning.
CO4: Understanding congruence relations and ideals involves research and critical analysis.
CO5: Strongly aligned as these theorems are essential in advanced research and analytical reasoning.

CO6: Explaining and applying these properties often involves research and analysis.
CO7: Strongly aligned as using advanced theorems involves deep analytical reasoning.
PO7: Digital Proficiency and Technological skills:
CO2: Constructing diagrams can involve using digital tools or software.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics
(2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Mandatory)
Course Name	**:** Practical based on Integral Equations
Course Code	**:** MAT-653-MJM
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To introduce students to the basic concepts of integral equations, including the types of kernels and their applications.
2. To study the relationship between differential equations and integral equations, particularly through the application of the Leibnitz rule and conversion techniques.
3. To provide students with the ability to formulate and solve boundary value problems using integral equations.
4. To teach students the methods for solving homogeneous Fredholm integral equations, with a focus on separable kernels and their properties.
5. To explore the concept of eigen functions, particularly their orthogonality, and its significance in the context of integral equations.
6. To introduce Hilbert-Schmidt theory and apply it to solve integral equations involving symmetric kernels.
7. To enhance students' computational skills through practical exercises that involve solving integral equations, working with eigenvalues and eigen functions, and applying numerical methods.

Course Outcomes:

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

CO1: Identify and distinguish between different types of kernels and understand their roles in integral equations.

CO2: Using the Leibnitz rule to differentiate under the integral sign and understand the conversion of differential equations to integral equations.

CO3: Formulate boundary value problems and solve them using appropriate integral equation methods.

CO4: Proficient in solving homogeneous Fredholm integral equations, particularly those with separable kernels.

CO5: Understand the concept of eigen function orthogonality and will be able to construct orthonormal systems of functions.

CO6: Apply Hilbert-Schmidt theory to expand symmetric kernels in eigenfunctions and solve related integral equations.

CO7: Develop practical skills in solving integral equations, including the use of numerical methods and computational tools.

Topics and Learning Points

Teaching Hours

Theory **12**

- Introduction and Types of Kernel
- Leibnitz Rule and Connection with Differential equation
- Boundary Value Problem
- Solution of Homogeneous Fredholm Integral equation of the second kind with Separable kernel.
- Fredholm Integral equation with Separable kernel
- Introduction of Hilbert-Schmidt Theory
- Symmetric Kernel

List of Practical **48**

1. Eigen value and Eigen function
2. Differentiation Under the sign of Integration
3. Solution of an Integral Equation
4. Conversion of Differential Equations to Integral Equations: Initial value problem
5. Boundary Value Problem
6. Solutions of Fredholm Integral Equations with Separable kernel
7. Orthogonality of Eigen function
8. Fredholm Integral equation with Separable kernel
9. Hilbert-Schmidt Theory: Symmetric Kernels
10. Orthonormal Systems of Functions
11. Expansion of Symmetric Kernel in Eigen function
12. Solution of the Fredholm Integral equation of First kind

Reference Books:

1. Abul-Majid Wazwaz, “A First Course in Integral Equations-second edition”, World Scientific Publications.
2. R.P. Kanwal, “Linear Integral Equation Theory and Techniques”, Academic Press, New York, 1971.
3. Shanti Swarup, Integral Equations, Krishna Prakashan Media (p) Ltd. 1997.
4. S.K.Pundir, R.Pundir, “Integral Equations and Boundary value problems”, Pragati Prakashan, India.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	2	-	2	-	-	1	-	-	-
CO 2	3	2	-	2	2	-	1	-	-	-
CO 3	3	2	-	3	2	-	-	-	-	-
CO 4	3	3	-	3	2	-	-	-	-	-
CO 5	3	2	-	3	3	-	-	-	-	-
CO 6	3	3	-	3	3	-	2	-	-	-
CO 7	3	3	-	3	3	-	3	-	-	-

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Strongly aligned, as identifying and distinguishing between kernel types requires a solid understanding of the theoretical aspects of integral equations.
CO2: Strongly aligned, as using the Leibnitz rule is a fundamental mathematical technique.
CO3: Strongly aligned, as understanding boundary value problems is a crucial aspect of integral equations.
CO4: Strongly aligned, as solving these integral equations requires a deep understanding of the theory.
CO5: Strongly aligned, as understanding eigen function orthogonality is key to many areas of mathematics and physics.
CO6: Strongly aligned, as applying Hilbert-Schmidt theory is an advanced topic requiring comprehensive knowledge.
CO7: Strongly aligned, as a comprehensive understanding is required to apply numerical methods effectively

PO2: Practical, Professional, and Procedural Knowledge:
CO1: Moderately aligned, as understanding kernel roles can be applied in solving practical problems.
CO2: Moderately aligned, as applying the Leibnitz rule and converting equations has practical relevance.
CO3: Strongly aligned, as solving boundary value problems has direct practical applications.
CO4: Strongly aligned, as this skill is essential for solving practical problems in various fields.
CO5: Strongly aligned, as constructing orthonormal systems is a practical skill in functional analysis.
C06: Strongly aligned, as this CO involves applying advanced theoretical knowledge in practical situations.
CO7: Strongly aligned, as this CO is focused on practical skills, including the use of computational tools.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO1: Understanding different kernel types involves analytical thinking and problem-solving skills.
CO2: Moderately aligned, as this CO requires critical thinking to apply the Leibnitz rule in various contexts.
CO3: Strongly aligned, as formulating and solving these problems require critical problem-solving skills.
CO4: Strongly aligned, as solving Fredholm integral equations involves specialized problem-solving skills.
CO5: Strongly aligned, as this CO involves critical thinking to construct and apply these systems.
CO 6: Strongly aligned, as expanding kernels and solving integral equations require specialized problem-solving skills.
CO7: Strongly aligned, as solving integral equations numerically involves significant problem-solving skills.

PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO2: Students will demonstrate research and analytical reasoning skills by solving counting problems.
CO3: Slightly aligned, as understanding the conversion involves analytical reasoning.
CO4: Moderately aligned, as solving boundary value problems involves research and analysis.
CO5: Moderately aligned, as solving these equations often involves analytical reasoning and research. Students will apply practical, professional, and procedural knowledge by understanding fundamental counting principles such as the rule of product, rule of sum, permutations, and combinations.
CO6: Moderately aligned, as constructing orthonormal systems requires analytical reasoning.
CO7: Strongly aligned, as applying this theory involves research and analytical reasoning.

PO7 Digital Proficiency and Technological Skills:
CO1: Slightly aligned, as identifying and visualizing kernels may require the use of computational toolsStudents will demonstrate practical, professional, and procedural knowledge by solving counting problems.
CO2: Slightly aligned, as computational tools may be used for solving these equationsStudents will apply practical, professional, and procedural knowledge by using generating functions to simplify recurrence relations.
CO6: Slightly aligned, as digital tools may be used in applying the theory.
CO7: Strongly aligned, as this CO directly involves the use of computational tools.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics
(2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Elective)
Course Name	**:** Hilbert Spaces and Spectral Theory
Course Code	**:** MAT-661-MJE (A)
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To gain a thorough understanding of the structure and properties of inner productspaces.
2. Learn to apply the concepts of orthonormal sets and projections in solvingproblems related to Hilbert spaces.
3. To understand and utilize the Riesz Representation Theorem in various contexts.
4. To understand the concepts and properties of adjoint operators, and theirsignificance in the study of Hilbert spaces.
5. To learn the fundamentals of matrix theory, including determinants and spectra of operators.
6. To understand and apply the Spectrum Theorem to both finite and infinite dimensional spaces.
7. To study the spectrum of compact operators and their implications in functional analysis and operator theory.

Course Outcomes:

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

CO1: Demonstrate a solid understanding of the concepts of inner product spaces, including norms, distances, and orthonormal sets.

CO2: Apply the geometric properties of Hilbert spaces to solve problems involving projections and orthonormality.

CO3: Utilize the Riesz Representation Theorem to represent and solve various problems involving continuous linear functionals.

CO4: Identify and work with bounded operators on Hilbert spaces, including understanding their properties and implications.

CO5: Compute and analyze the adjoint of an operator, and understand its role and significance.

CO6: Proficiently handle matrix representations, compute determinants, and analyze the spectrum of operators in finite-dimensional settings.

CO7: Apply the Spectrum Theorem to understand and describe the spectral properties of linear operators.

Topics and Learning Points

	Teaching Hours
Unit 1: Geometry of Hilbert Spaces	**05**
1.1 Inner Product Spaces	
1.2 Orthonormal sets	
Unit 2: Projections	**05**
2.1 Projections	
2.2 Riesz Representation Theorems	
Unit 3: Bounded Operators on Hilbert Spaces	**10**
3.1 Bounded Operators	
3.2 Adjoint Operators	
3.3 Normal, self-adjoint and unitary operators	
Unit 4: Finite dimensional Spectral Theory	**10**
4.1 Matrices	
4.2 Determinants and spectrum of an operator	
4.3 The spectrum theorem	
4.4 Spectrum of compact operator	

Text Books:

B. V. Limaye, *Functional Analysis*, Wiley Eastern Ltd.

Reference Books:

1. Bachmanand Narici, Functional Analysis, Narosa Publishing House, India.
2. Introduction to Topology and Modern Analysis By G. F. Simmons.
3. John B. Conway, Introduction to Functional Analysis, Springer.
4. W. Rudin, Functional Analysis,Tata Mc Graw Hill Edition.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	1								
CO 2	2	2								
CO 3		1								
CO 4	2	2								
CO 5		2								
CO 6	3									
CO 7	2									

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Understanding norms, distances, and orthonormal sets provides a strong foundation for more complex topics and ensures a comprehensive grasp of essential mathematical concepts.
CO2: This emphasizes applying theoretical knowledge to solve practical problems, demonstrating the ability to utilize geometric properties effectively.
CO4: Working with bounded operators involves understanding their role in Hilbert spaces, which is essential for a comprehensive understanding of functional analysis.
CO6: This CO involves applying knowledge of matrix theory and spectral analysis in finite-dimensional contexts. It ensures students have a comprehensive understanding of these concepts and their applications, crucial for a thorough grasp of linear algebra.
CO7: The Spectrum Theorem is a key result in operator theory. Applying it to understand and describe spectral properties shows a deep and comprehensive understanding of linear operators, which is integral to advanced mathematics.

PO2: Practical, Professional, and Procedural Knowledge:
CO1: Understanding norms, distances, and orthonormal sets is crucial for effectively applying these concepts in practical scenarios, such as in signal processing, machine learning, and data analysis.
CO2: By solving practical problems related to projections and orthonormality, students develop professional skills in utilizing geometric properties, which are essential in fields such as optimization, quantum mechanics, and statistical analysis.
CO3: Mastery of the Riesz Representation Theorem allows students to tackle complex problems involving continuous linear functionals.
CO4: Identifying and working with bounded operators equips students with practical skills for professional applications in areas like control theory, signal processing, and functional analysis.
CO5: Proficiency in computing and analyzing adjoint operators is important for professional applications such as in engineering, physics, and applied mathematics.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Elective)
Course Name	**:** Cryptography
Course Code	**:** MAT-661-MJE (B)
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To understand basics of Cryptography and various electronic codes.
2. To learn different encryption techniques along with digital signatures and their use in various protocols.
3. To learn about how to maintain the Confidentiality, Integrity and availability of a data.
4. To develop attitude and interest along with necessary knowledge among the students.
5. Explain the importance and application of each of confidentiality, integrity, Authentication and availability.
6. To learn different encryption techniques using RSA algorithms.
7. To impart the knowledge of encryption and decryption techniques and their applications in managing the security of data.

Course Outcomes:

CO1: Student will be able to, apply some early substitution and translation ciphers.
CO2: Student will be able to, distinguish symmetric key encryption systems from public key encryption systems.
CO3: Student will be able to, assess simple cryptographic methods from a practical view point.
CO4: Student will be able to use cryptography methods to do further academic studies and research.
CO5: Student will be able to perform Security Related real-world problems.
CO6: Student will demonstrate the use of symmetric key encryption systems and public key encryption systems.
CO7: Students will be able to describe advantages and disadvantages of various encryption and decryption systems.

Topics and Learning Points

Topic	Teaching Hours
Unit 1: Introduction to cryptography	**10**
1.1 Cryptography in Modern world	
1.2 Substitution cipher	
1.3 Monoalphabetic ciphers	
1.4 Transposition cipher	
1.5 Vigenere cipher	
Unit 2: Symmetric key cryptography	**08**
2.1 Introduction and overview	
2.2 Stream cipher, Block cipher	
2.3 Modes of operation, Electronic code book	
2.4 Cipher block chaining, Cipher feedback	
Unit 3: Public key Cryptography	**08**
3.1 Introduction and Overview	
3.2 The RSA algorithm	
3.3 Diffie Hellman Key protocol, exchange message	
3.4 Attacks against RSA	
Unit 4: Applications of Cryptography	**04**
4.1 Digital Signature	
4.2 Internet protocol security	

Text Books:

Atul Kahate, *Cryptography and Network security*, Tata Mcgraw Hill.

Reference Books:

1. Adam J. Elbirt, Understanding and Applying cryptography and Data security, CRC press.
2. Bruice Schneier, Applied Cryptography, Wiley India Edition.
3. Neil Koblitz, A course in Number theory and Cryptography, Springer, Second Edition.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	-	-	-	-	-	-	-	-	3
CO 2	3	-	-	2	-	-	-	-	-	3
CO 3	-	3	-	2	-	-	-	-	-	-
CO 4	-	-	-	-	2	-	-	-	-	-
CO 5	-	3	-	3	-	-	-	-	-	-
CO 6	-	-	-	-		2	2	-	-	-
CO 7	3	-	-	2	-	-	-	-	-	3

Justification for the mapping

PO 1: Disciplinary Knowledge:
CO1: This CO requires foundational knowledge of cryptographic techniques, which aligns with the comprehensive understanding of principles and theories covered in PO1.
CO2: It requires understanding the core concepts of encryption systems.
CO7: Describing the pros and cons of encryption systems involves a deep understanding of the subject Knowledge.
PO 2: Critical Thinking and Problem Solving:
Critical thinking and problem-solving skills are essential for making ethical decisions in cryptographic practices.
CO3: Assessing cryptographic methods involves practical application and understanding their efficacy in real-world scenarios, aligning with PO2.
CO5: It involves the application of specialized skills to solve practical security problems, which aligns with PO2's emphasis on practical knowledge.
PO 4: Research-related skills and Scientific temper:
CO2: It requires understanding the core concepts of encryption systems and the ability to critically evaluate the differences between these systems, which involves problem-solving skills aligned with PO4.
CO3: it requires problem-solving and critical evaluation skills, which align with PO4.
CO5: It involves the application of specialized skills to solve practical security problems, which aligns with PO4's focus on problem-solving.
PO5: Trans-disciplinary knowledge:
CO4: It emphasizes the application of cryptography in research and advanced studies, directly correlating with the research and analytical reasoning aspects of PO5.
PO6: Personal and professional competence:
CO6: Demonstrating encryption systems requires technological proficiency (PO7) and the ability to effectively communicate and possibly collaborate in a team setting, aligning with PO6.
PO7: Digital Proficiency and Technological Skills:
CO6: Demonstrating encryption systems requires technological proficiency (PO7).

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics
(2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Elective)
Course Name	**:** Practical based on Boundary Value Problems
Course Code	**:** MAT-662-MJE (A)
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To understand and apply the principles of heat conduction for analyzing temperature distributions in materials with specific boundary conditions.
2. To explore the impact of internally generated heat on the thermal behavior of different materials and analyze resulting temperature distributions.
3. To develop skills in solving steady-state temperature problems in rectangular plates using analytical methods.
4. To gain proficiency in applying cylindrical coordinate systems to solve heat conduction and related physical problems.
5. To understand and analyze the dynamics of a vibrating string under prescribed initial conditions using wave equations.
6. To investigate and understand resonance phenomena in physical systems, particularly in the context of electric bars, through mathematical modelling.
7. To apply Sturm-Liouville theory for solving differential equations that arise in physics and engineering contexts.

Course Outcomes:

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

CO1: Apply the principles of heat conduction to analyze temperature distribution in a slab with prescribed boundary conditions.

CO2: Analyze the effects of internal heat generation on temperature profiles in various materials.

CO3: Solve steady-state heat conduction problems in rectangular coordinates, specifically in rectangular plates.

CO4: Apply cylindrical coordinate systems to solve heat conduction and related problems.

CO5: Analyze the dynamic behavior of a string under prescribed initial conditions using wave equations.

CO6: Investigate resonance phenomena in physical systems, particularly in electric bars, using mathematical models.

CO7: Apply Sturm-Liouville theory to solve differential equations arising in physics and engineering.

Topics and Learning Points

Teaching Hours

Theory **12**

- Heat equation
- Rectangular coordinates
- Orthogonality
- Eigen value and eigen function
- Strum liouville theory

List of Practical **48**

1. Practical based on slab with faces at prescribed temperature
2. Practical based on slab with internally generated heat
3. Practical based on steady temperature in rectangular plate
4. Practical based on cylindrical coordinates
5. Practical based on string with prescribed initial condition
6. Practical based on resonance and electric bar
7. Practical based on regular strum Liouville problem
8. Practical based on orthogonality of eigen function
9. Practical based on real valued eigen function and non-negative eigen values
10. Practical based on eigen function expansion
11. Practical based on temperature problem in rectangular coordinate
12. Practical based on modification of method

Reference Books:

1. J.W. Brown, R. V. Churchill, "Fourier Series and Boundary Value Problems", Seventh edition, Mc-Graw Hill Publication, India.
2. Murray Spiegel, "Fourier analysis with Applications to Boundary value problems", Schaum's outline Series, Mc-Graw Hill Publication, India.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	3	3	-	-	-	-	-	-	-	-
CO 2	-	-	-	3	-	-	-	-	-	-
CO 3	3	3	-	3	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	3	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	2	-	-	-
CO 7	-	-	-	-	3	-	-	-	-	-

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: It requires a strong theoretical foundation in heat conduction and the ability to apply this knowledge to practical scenarios.
CO3: It requires knowledge of heat conduction theories and the application of this knowledge in practical and procedural problem-solving in rectangular coordinates.
CO4: It requires specialized knowledge of cylindrical coordinate systems and the ability to apply this to solve complex problems.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: It requires a strong theoretical foundation in heat conduction and the ability to apply this knowledge to practical scenarios.
CO3: It requires knowledge of heat conduction theories and the application of this knowledge in practical and procedural problem-solving in rectangular coordinates.
PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO2: It involves understanding the physics of internal heat generation and requires critical thinking to analyze and solve related problems.
CO4: It requires specialized knowledge of cylindrical coordinate systems and the ability to apply this to solve complex problems.
CO5: It involves understanding wave dynamics and critically analyzing these conditions to solve wave-related problems.
PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO7: It requires specialized mathematical skills and often involves research and analytical reasoning to apply Sturm-Liouville theory effectively.
PO7: Digiralproficiancy and technological skills:
CO6: It requires theoretical knowledge of resonance and the ability to use digital tools and technology to model and investigate these phenomena.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics
(2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Major (Elective)
Course Name	**:** Practical based on Mechanics
Course Code	**:** MAT-662-MJE (B)
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. Develop a deep understanding of the equations of motion for both single particles and systems of particles, and apply these equations to analyze various mechanical scenarios.
2. Understand the concepts of degrees of freedom and generalized coordinates, and apply these to simplify and solve mechanical problems.
3. Utilize D`Alembert`s principle to solve dynamic problems and understand the conservation of energy in various contexts.
4. Explore variational principles including the minimum surface of revolution and the Brachistochrone problem, and apply this principle to solve optimization problem in mechanics.
5. Understand Hamilton`s principle for both conservative and non-conservative systems.
6. Apply Kepler`s laws of planetary motion, derive them from Newtonian mechanics, and understand concepts such as escape velocity and the Virial theorem.
7. Study the differential equation governing the orbit of a particle and relate these to Newton`s law of gravitation.

Course Outcomes:

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

CO1: Derive and apply the equations of motion for individual particles and systems of particles.

CO2: Analyze motion under constraints, distinguishing between holonomic and non-holonomic constraints, as well as scleronomic and rheonomic constraints.

CO3: Determine degrees of freedom and use generalized coordinates to simplify complex mechanical systems.

CO4: Use D`Alembert`s principle to solve dynamic problems and apply the conservation of energy theorem.

CO5: Solve variational problems such as the minimum surface of revolution and the Brachistochrone problem.

CO6: Apply Hamiltonian`s principle to both conservative and non- conservative systems and derive Lagrange`s Equations of motion from this principle.

CO7: Apply Kepler`s laws of planetary motion, deriving and explaining Kepler`s first, second and third laws.

Topics and Learning Points

Teaching Hours

Theory **12**

- Conservation Theorem
- Hamilton`s Principle
- Kepler`s law of planetary motion
- Newton`s law of gravitation

List of Practical **48**

1. Equation of motion and conservation theorem.
2. Conservation theorem of linear momentum of the system of particles, Angular momentum of system of particles.
3. Transformation relations, principle of virtual work, D`Alembert`s Principle.
4. Generalization of theorem, Minimum surface of revolution, Brachistochrone problem.
5. Isoperimetric problems, variational problems with moving boundaries.
6. Functional dependent on functions of two dependent variables.
7. Hamilton`s principle for non-conservative and conservative system.
8. Derivation of Hamilton`s equation of motion from Hamilton`s principle.
9. Conservative and Scleronomic system, non-conservative and Rheonomic system.
10. Reduction of Two body problems to an equivalent one body problem.
11. Kepler`s laws of planetary motion, Kepler`s first, second and third law.
12. Newton`s law of gravitation from Kepler`s law of planetary Motion.

Reference Books:

1. Classical Mechanics (3rd Ed.) by Herbert Goldstein, Charles Poole, John Safko (Pearson Education).
2. Classical Mechanics by Gupta, Kumar and Sharma (A Pragati Edition]).
3. Classical Mechanics by RanaJoag (McGraw Hill India).
4. Classical Mechanics by R. N. Tiwari and B. S. Thakur (PHI).

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1		2			1					
CO 2	3				2					
CO 3	3									
CO 4	3				1					
CO 5	2	1			2					
CO 6		2		2						
CO 7	2	1		2	3					

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO2: Students will exhibit the ability to analyse and differentiate between various types of constraints (holonomic, non-holonomic, scleronomic, and rheonomic).
CO3: Students will effectively determine degrees of freedom and apply generalized coordinates to simplify and solve complex mechanical systems.
CO4: Students will be proficient in applying dynamic principles such as D'Alembert's principle and the conservation of energy theorem. They will be able to express kinetic energy as a homogeneous quadratic function of generalized velocities and use these principles to solve dynamic problems.
CO5: Students will demonstrate expertise in solving variational problems, including the minimum surface of revolution and the Brachistochrone problem.
CO7: Students will apply Kepler's laws of planetary motion to derive and explain Kepler's First, Second, and Third Laws.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: Students will apply the equations of motion to practical problems involving individual particles and systems of particles. They will be able to use these principles to analyze and solve real-world mechanical systems in various engineering contexts.
CO5: Students will solve variational problems such as the minimum surface of revolution and the Brachistochrone problem, applying variational principles to optimize engineering designs.
CO6: Students will derive and use Lagrange's equations of motion and Hamiltonian formulations to solve real-world mechanical problems.
CO7: Students will apply Kepler's laws of planetary motion to solve problems related to orbital dynamics and gravitational systems. They will use these laws to analyze and design space missions and other aerospace engineering application.
PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO6: Students will apply Hamilton's principle to both conservative and non-conservative systems, demonstrating specialized skills in deriving and utilizing Lagrange's equations and Hamiltonian formulations.
CO7: Students will apply Kepler's laws of planetary motion and solve problems related to orbital dynamics and gravitational systems.
PO5: Research, Analytical Reasoning, and Ethical Conduct:

CO1: Emphasize the importance of accuracy and honesty in reporting results when deriving equations, acknowledging sources, and properly citing references in their research.
CO2: Students will conduct a thorough study of constrained systems, comparing various types of constraints across different mechanical systems. They will review case studies and research papers that highlight the distinction between these constraints.
CO4: Students will develop the capability to apply D'Alembert's principle and the conservation of energy theorem to various dynamic problems, reasoning through complex situations to reach solutions.
CO5: Encourage students to explore the history and development of variational principles, including classical problems like the Brachistochrone, and modern applications in various fields of physics and engineering.
CO7: Students will study the historical context of Kepler’s laws, examining the original work as well as subsequent developments and applications in modern astronomy and space science.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Research Project
Course Name	**:** Research Project
Course Code	**:** MAT-681-RP
No. of Teaching Hours	**:** 90
No. of Credits	**:** 6

Course Objectives:

1. To enhance the ability to conduct independent research by formulating a research question, and conducting a literature review.
2. To utilize advanced mathematical theories and methods to solve complex problems, demonstrating a deep understanding of mathematical concepts and their practical applications.
3. To gain proficiency in analyzing and interpreting data relevant to the research topic, including the use of statistical or computational tools where applicable.
4. To develop critical thinking skills by evaluating existing research, identifying gaps in the literature, and proposing novel solutions or theories based on rigorous mathematical reasoning.
5. To improve scientific writing and communication skills by preparing a comprehensive research report or thesis that clearly presents the research objectives, methodologies, results, and conclusions.
6. To understand and adhere to ethical standards in research, including proper citation of sources, avoiding plagiarism, and ensuring the integrity of data and results.
7. To prepare and deliver a professional oral presentation of the research findings to peers and faculty, demonstrating the ability to effectively communicate complex mathematical ideas and defend the research outcomes.

Course Outcomes:

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

CO1: Conduct independent research by developing a research question, reviewing relevant literature, and applying advanced mathematical techniques to explore and solve a specific problem.

CO2: Apply advanced mathematical theories and methods to their research, showing a deep understanding of the concepts and their relevance to solving complex problems.

CO3: Exhibit proficiency in analyzing and interpreting data using appropriate statistical or computational tools, and will be able to draw meaningful conclusions from their analyses.

CO4: Critically evaluate existing research in their field, identify gaps, and propose innovative solutions or theories, demonstrating original thinking and problem-solving abilities.

CO5: Produce a well-structured and comprehensive research report or thesis that effectively communicates their research objectives, methodologies, results, and conclusions, adhering to academic standards.

CO6: Adhere to ethical research practices, including proper citation, avoiding plagiarism, and ensuring the accuracy and integrity of their research findings.
CO7: Effectively prepare and deliver a clear and professional oral presentation of their research findings.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	2	-	-	-	-	-	-	-	2
CO 2	2	2	2	2	-	-	-	-	-	-
CO 3	2	2	-	-	3	-	2	-	-	-
CO 4	2	-	2	2	-	-	-	-	-	-
CO 5	2	2	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	2	-	-	-	-	-
CO 7	-	-	-	-	-	-	-	-	-	2

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: This CO requires a deep understanding of the research area to effectively formulate a research question and conduct a thorough literature review. Knowledge of existing theories and methodologies is essential.
CO2: Utilizing advanced mathematical theories requires a strong foundational understanding of these concepts. Students must apply their knowledge to solve complex problems effectively.
CO3: Proficiency in data analysis requires a comprehensive understanding of statistical and computational methods.
CO4: Critical evaluation of research and identification of gaps require a thorough understanding of the subject matter.
CO5: Effective scientific writing and communication require a deep understanding of the research topic and its context.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: Conducting a literature review and formulating a research question involves applying research methodologies and adhering to academic procedures, reflecting practical and procedural knowledge.
CO2: Applying mathematical methods in practical scenarios involves procedural knowledge and professional skills in mathematics.
CO3: Analyzing and interpreting data involves the practical use of statistical and computational tools, reflecting procedural knowledge.
CO5: Preparing a research report or thesis involves applying professional writing skills and adhering to academic and procedural standards.
PO 3: Entrepreneurial Mindset, Innovation, and Business Understanding:
CO2: Though not primarily focused on business understanding, using advanced theories can foster an innovative mindset as students apply mathematical concepts in novel ways.
CO4: Identifying gaps in research and proposing new solutions encourages an entrepreneurial and innovative mindset.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO2: This CO directly involves specialized skills in mathematics and the application of critical thinking to solve complex problems.
CO4: This CO focuses on developing critical thinking skills, specialized problem-solving abilities, and innovative solutions.
PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO3: Effective data analysis is a core aspect of research and involves strong analytical reasoning. Ethical conduct is important in ensuring accurate and unbiased data interpretation.
CO6: This CO is directly related to ethical research practices, including proper citation and avoiding plagiarism which is essential components of ethical conduct in research.
PO7: Digital Proficiency and Technological skills:
CO3: Data analysis often relies on digital tools and technology, highlighting the need for proficiency in these areas.
PO 10: Autonomy, Responsibility, and Accountability:
CO1: This CO emphasizes the importance of independently managing the research process, which requires autonomy and accountability for one's research efforts and decisions.
CO7: Delivering a professional presentation involves taking responsibility for effectively communicating and defending research findings, demonstrating autonomy in presenting one's work.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Skill Development Course
Course Name	**:** Scilab Programming
Course Code	**:** MAT-631-SDC
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

8. To develop proficiency in using fundamental Scilab commands for matrix operations, basic arithmetic, and array manipulations.
9. To develop a comprehensive understanding of basic and advanced matrix operations, including addition, multiplication, and inversion, and apply these operations to solve practical problems in Scilab.
10. Utilize Scilab to find solutions for systems of linear equations using various numerical methods and techniques, and interpret the results effectively.
11. Learn to calculate and interpret eigenvalues and eigenvectors of matrices using Scilab, and understand their significance in various applications, such as stability analysis and matrix diagonalization.
12. Acquire skills in matrix diagonalization, including the process and its implementation in Scilab, and understand its applications in simplifying complex matrix operations.
13. To Create and analyze 2-D and 3-D graphs in Scilab to visualize data, understand graphical representations, and interpret results to draw meaningful conclusions.
14. To develop and refine programming skills in Scilab for implementing numerical methods, including polynomial operations and custom functions, to solve a variety of mathematical and engineering problems.

Course Outcomes:

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

CO1: Perform a variety of matrix operations, including addition, multiplication, inversion, and transposition, and apply these techniques to solve problems involving matrices.

CO2: Demonstrate the ability to solve systems of linear equations using Scilab, including understanding and implementing methods for solving such systems.

CO3: Apply the Newton-Raphson methods to find approximates solutions to nonlinear equations and assess the accuracy and efficiency of the method in Scilab.

CO4: Compute eigenvalues and eigenvectors for given matrices, interpret their significance, and apply these concepts in various mathematical and engineering contexts.

CO5: Understand and apply matrix diagonalization techniques to simplify matrix operations and solve related problems using Scilab.

CO6: Create and analyze 2-D and 3-D graphs to visualize data and interpret graphical results effectively, enhancing their ability to present and analyze data graphically.

CO7: Develop programming skills in Scilab for implementing numerical methods and polynomial operations, including solving practical problems through custom scripts.

Topics and Learning Points

	Teaching Hours
Unit 1: Introduction to Scilab	**10**
1.1 Installation	
1.2 Introduction and overview	
1.3 Some basic Commands	
1.4 Matrix operations	
1.5 System of Linear Equation	
1.6 Elementary row and Column operation	
1.7 Calculation of Eigen value and Eigen vector	
1.8 Diagonalization	
Unit 2: Revision of Scilab with some basic commands	**08**
2.1 Size, Length, eye, ones, rand, zeros, etc.	
2.2 Operations on functions	
2.3 ‘Deff’ command for one and two variable functions	
Unit 3: Graph Presentations	**08**
3.1 Graphs of some standard function	
3.2 The 2-D and 3-D Graphs	
3.3 Color Graphs	
Unit 4: Scilab Programming for Numerical Methods	**04**
4.1 Newton Raphson Method	
4.2 Operations on Polynomial	

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	2	-	2	-	-	1	-	-	2
CO 2	2	2	-	2	-	-	1	-	-	1
CO 3	2	3	-	1	2	-	1	-	-	1
CO 4	2	2	-	1	2	-	1	-	-	-
CO 5	2	2	-	1	-	-	1	-	-	-
CO 6	2	1	-	1	-	2	1	-	-	-
CO 7	2	1	-	1	-	-	1	-	-	1

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Understanding of various matrix operations, their theoretical aspects.
CO2: Knowledge of methods for solving linear equations.
CO3: Theoretical understanding of the Newton-Raphson method.
CO4: Knowledge of eigenvalues and eigenvectors.
CO5: Understanding of matrix diagonalization.
CO6: Understanding of graphical representation of data.
CO7: Knowledge of programming concepts in Scilab.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: Practical application of matrix operations.
CO2: Practical skills in solving systems of linear equations.
CO3: Practical application of the Newton-Raphson method.
CO4: Practical skills in computing eigenvalues and eigenvectors.
CO5: Practical application of matrix diagonalization techniques.
CO6: Practical skills in creating and analyzing graphs.
CO7: Practical programming skills and application of numerical methods.
PO3: Entrepreneurial Mindset, Innovation, and Business Understanding
No specific COs directly map to this PO in the provided content.
PO4: Specialized Skills, Critical Thinking, and Problem-Solving
CO1: Application of specialized matrix operations for problem-solving.
CO2: Specialized problem-solving in linear systems.
CO3: Critical thinking in evaluating numerical method efficiency.
CO4: Problem-solving using eigenvalues and eigenvectors.
CO5: Critical problem-solving through diagonalization.
CO6: Specialized problem-solving through graphical data analysis.
CO7: Specialized problem-solving through programming.
PO5 Research, Analytical Reasoning, and Ethical Conduct:
CO3: Research and analysis of the efficiency of the Newton-Raphson method.
CO4: Analytical reasoning in interpreting eigenvalues.
PO6 Communication, Collaboration, and Leadership:
CO6: Effective communication of graphical results.
PO7: Digital Proficiency and Technological Skills:

CO1: Use of Scilab for performing matrix operations.
CO2: Use of Scilab for solving linear equations.
CO3: Use of Scilab for implementing the Newton-Raphson method.
CO4: Use of Scilab for calculating eigenvalues and eigenvectors.
CO5: Use of Scilab for matrix diagonalization.
CO6: Use of Scilab for creating and analyzing graphs.
CO7: Use of Scilab for programming and solving numerical problems.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy

No specific COs directly map to this PO in the provided content.

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices

No specific COs directly map to this PO in the provided content.

PO10: Autonomy, Responsibility, and Accountability:

CO1: Responsibility in performing accurate matrix operations.
CO2: Responsibility in solving and interpreting linear systems.
CO3: Responsibility in applying and assessing the Newton-Raphson method.
CO7: Responsibility in developing and using programming solutions.

CBCS Syllabus as per NEP 2020 for M.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** M.Sc. Mathematics
Program Code	**:** PSMAT
Class	**:** M.Sc.
Semester	**:** IV
Course Type	**:** Skill Development Course
Course Name	**:** LaTeX for Scientific Writing
Course Code	**:** MAT-691-SDC
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To define LaTeX and explain its purpose, history, and basic installation process.
2. To structure a LaTeX document; including creating simple LaTeX input file and compiling it.
3. To gain proficiency in LaTeX syntax and commands essential for creating formatted documents.
4. To format text, including applying different font styles and colors, both in text mode and math mode.
5. To organize and structure complex documents using sectioning, labeling, and referring to numbered items.
6. To equipped to manage advanced features such as text alignment, quoting, and listing/tabbing texts.
7. To create and format tables using the tabular environment, including the use of lines, the array package, and vertical positioning.

Course Outcomes:

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

CO1: To demonstrate the ability to use LaTeX to create well-structured and formatted documents, showcasing an understanding of its syntax and structure.

CO2: To format text and mathematical content appropriately, including the application of different fonts and colors.

CO3: Students will effectively organize documents with sections, labels, and references, ensuring clarity and consistency in their work.

CO4: To manage text alignment and quoted text accurately, enhancing the readability and presentation of their documents.

CO5: Students will use LaTeX to create and format lists and tabs, improving document organization and readability.

CO6: Students will be proficient in creating and formatting tables, including drawing lines and using advanced features from packages like array.

CO7: Students will effectively handle the vertical positioning of tables in documents, ensuring proper layout and alignment.

Topics and Learning Points

	Teaching Hours
Unit 1: Introduction	**08**
1.1 What is LaTeX	
1.2 History	
1.3 Getting started with LaTeX: Installation	
1.4 Document structure	
1.5 Compile a LaTeX Input file	
1.6 LaTeX Syntax	
Unit 2: Formatting Words, Lines and Paragraphs	**08**
2.1 Text and Math mode fonts	
2.2 Emphasized Fonts	
2.3 Colored Fonts	
Unit 3: To Deal with Complicating Features in a Documents	**10**
3.1 Sectioning	
3.2 Labeling and Referring Numbered Items	
3.3 Text Alignment	
3.4 Quoted Texts	
3.5 Listing and Tabbing Texts	
Unit 4: Table Preparation	**04**
4.1 Table through the tabular Environment	
4.2 Drawing lines in tables	
4.3 Use of Array Package	
4.4 Vertical Positioning of Tables	

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	2	1	-	-	-	1	-	-	-
CO 2	2	2	-	-	-	-	1	-	-	-
CO 3	-	3	-	2	-	2	-	-	-	-
CO 4	-	2	-	2	-	-	1	-	-	-
CO 5	-	2	2	1	-	-	1	-	-	-
CO 6	2	1	2	-	-	2	1	-	-	-
CO 7	2	1	2	-	-	-	1	-	-	-

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1, CO2, CO6, CO7: These COs require a deep understanding of LaTeX's syntax, structure, and advanced features, demonstrating comprehensive knowledge.
PO2: Practical, Professional, and Procedural Knowledge:
CO1: Practical skills in LaTeX are crucial for creating well-structured documents. Understanding LaTeX syntax and structure involves practical application, making it a core aspect of procedural knowledge.
CO2: Formatting text and mathematical content with LaTeX involves hands-on skills and understanding of LaTeX's formatting options, which directly relates to professional and procedural knowledge.
CO3: Organizing documents with sections, labels, and references requires practical skills in using LaTeX to ensure clarity and consistency, demonstrating procedural knowledge in document management.
CO4: Managing text alignment and quoted text accurately involves practical application of LaTeX commands to enhance readability, showcasing professional and procedural skills.
CO5: Creating and formatting lists and tabs in LaTeX involves practical application of LaTeX tools to improve document organization, reflecting procedural and professional knowledge.
CO6: Proficiency in creating and formatting tables, including advanced features like drawing lines and using packages, demonstrates both practical and professional skills in LaTeX.
CO7: Effective handling of vertical positioning of tables involves practical skills in layout management, showcasing procedural knowledge in document formatting.
PO3: Entrepreneurial Mindset, Innovation, and Business Understanding
CO1: Mastery of LaTeX demonstrates an innovative approach to document preparation. By using advanced tools, students showcase their readiness to adopt and leverage technology in a business context, reflecting an entrepreneurial mindset.
CO5: The ability to create and format lists and tabs in LaTeX demonstrates practical skills in document organization. In business, well-organized documents are essential for clarity and efficiency, reflecting an innovative approach to information presentation.
CO6: Proficiency in advanced table formatting, including the use of LaTeX packages, shows the ability to handle complex data presentations innovatively. This skill is valuable in business contexts where detailed and well-organized data is required for analysis and decision-making.

CO7: Handling the vertical positioning of tables demonstrates a detailed understanding of document layout and alignment. This skill is crucial for producing professional-quality documents in business, where precise formatting is essential for clarity and effectiveness.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving

CO3, CO4, CO5: These COs involve critical thinking and problem-solving in organizing and formatting documents effectively.

PO6: Communication, Collaboration, and Leadership:

CO3: Effective document organization improves communication and can be critical in collaborative and leadership scenarios.

PO7: Digital Proficiency and Technological Skills:

CO1, CO2, CO4, CO5, CO6, CO7: These COs require advanced LaTeX skills, showcasing proficiency in digital tools and technological capabilities.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy

No specific COs directly map to this PO in the provided content.

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices

No specific COs directly map to this PO in the provided content.