Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
Autonomous

Course Structure for M.Sc. Mathematics (2022 Pattern)

M.Sc Mathematics-Semester IV

Principal
Tuljaram Chaturchand College
Baramati

Semester	Course Code	Title of Course	No. of Credits	No. of Lectures
III	PSMT231	Combinatorics	4	64
	PSMT232	Field Theory	4	64
	PSMT233	Functional Analysis	4	64
	PSMT234	Integral Equations	4	64
	PSMT235(A)	Astronomy	4	64
	PSMT235(B)	Graph Theory	4	64
	PSMT236	Practical: Python	4	64
IV	PSMT241	Number Theory	4	64
	PSMT242	Differential Geometry	4	64
	PSMT243	Fourier Analysis	4	64
	PSMT244	Lattice Theory	4	64
	PSMT245(A)	Coding theory	4	64
	PSMT245(B)	Cryptography	4	64
	PSMT246	Project	4	64

Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24 M.Sc.-II

Class : M.Sc.-II (Semester – IV)
Course Code : PSMT241
Course : I **Title of the Course : Number Theory**
Credit : 4 **No. of lectures : 64**

Course Objectives:

1. To solve problems numerically by various approximation methods.
2. To find the approximate area of some complex regions using Numerical Integration.
3. Demonstrate understanding of common Numerical Methods andhow they are used to obtain approximate solutions.
4. Perform an error analysis for various numerical methods.
5. Derive appropriate numerical methods to calculate a definite integral.
6. Analyze the error incumbent in any such numerical approximation.
7. Study different techniques of interpolation.

Course Objectives:

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

CO1. Student will be able to handle Machine Learning algorithms using Numerical Analysis.

CO2. Student will be able to construct a function which closely fits given n- points in the plane by using interpolation method.

CO3. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

CO4. Implement numerical methods in Scilab and other mathematical software.

CO5. Solve a linear system of equations using an appropriate numerical method.

CO6. Student will be able solve an algebraic or transcendental equation using an appropriate numerical method.

CO7. Student will be able to approximate a function using an appropriate numerical

TOPICS/CONTENT

Unit 1: Divisibility **[12 Lectures]**

1.1 Divisibility in integers
1.2 Division algorithm
1.3 G.C.D, L.C.M
1.4 Fundamental theorem of arithmetic
1.5 The number of primes

Principal
Tuljaram Chaturchand College
Baramati

1.6 Mersene numbers and Fermat numbers

Unit 2: Congruences **[15 Lectures]**

2.1 Properties of congruence relation
2.2 Residue classes their properties Fermat's and Euler's theorems
2.3 Wilson's Theorem
2.4 Linear congruence of degree one
2.5 Chinese remainder theorem

Unit 3: Arithmetic functions **[10 Lectures]**

3.1 Euler function
3.2 Greatest integer function
3.3 Divisor function $\delta(n)$
3.4 Mobius function $\mu(n)$
3.5 Properties and their inter relation

Unit 4: Quadratic Reciprocity **[15 Lectures]**

4.1 Quadratic residue.
4.2 Legendre's symbol its properties
4.3 Quadratic Reciprocity law
4.4 Jacobi symbol its properties
4.5 Sums of Two Squares

Unit 5: Some Diophantine Equations **[04 Lectures]**

5.1 The equation $ax + by = c$
5.2 simultaneous linear equations

Unit 6: Algebraic numbers **[08 Lectures]**

6.1 Algebraic Numbers.
6.2 Algebraic number fields.
6.3 Algebraic integers.
6.4 Quadratic fields.
6.5 Units in Quadratic fields.
6.6 Primes in Quadratic fields.

Text Book:

Ivan Niven & H. S. Zuckerman, An introduction to number theory, (Wiley EasternLimited).

Unit 1: Sections 1.1 to 1.3
Unit 2: Sections 2.1 to Section 2.4
Unit 3: Section 3.1, 3.3, 3.6.
Unit 4: Section 4.1 to Section 4.4
Unit 5: Section 5.1 and Section 5.2
Unit 6: Section 9.1 to Section 9.7

Reference Book:

1. T.M. Apostol, An Introduction to Analytical Number Theory, Springer International Student's Edition.
2. David M Burton, Elementary Number Theory, Universal Book Stall, New Delhi.
3. S. G. Telang, Number Theory, Tata Mc-graw Hill.
4. W. Rudin, Functional Analysis, Tata McGraw Hill.
5. G. H. Hardy, E.M.Wright, Introduction to Number Theory, Oxford university press.

Jagtap
Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24 M.Sc.-II

Class	**: M.Sc.-II (Semester – IV)**		
Course Code	**: PSMT242**		
Course	**: II**	**Title of the Course**	**: Differential Geometry**
Credit	**: 4**	**No. of lectures**	**: 64**

Course Objectives:

- To introduce equivalence of two curve, definition and parameterization of surface.
- To introduce tangent space of surfaces.
- To introduce integrate differential forms on surfaces.
- To get introduced to the notion of Serret-Frenet frame for space curves.
- To understand the idea of orientable and non-orientable surfaces.
- To get introduced to the concepts of a regular parameterized curve.
- To understand the isometry between two surfaces and characterization of local isometry between them.

Course Outcomes:

- Student will be able to understand the treatment of Level sets, Geodesics, weingarten map, smooth curve, and line integral.
- Student will be able to find differential maps between surfaces.
- Students will develop understanding of basics of differential geometry.
- Student will be able to understand and solve problems which require the use of differential geometry.
- Students will know how to use formal mathematical reasoning and write mathematical proofs when necessary.
- Students will demonstrate ability to cover a topic independently and tp present their results in a written report.
- Student will be able to perform calculations of curvature and related quantities for curves and surfaces in 3-dimensional spaces.

TOPICS/CONTENT

Unit 1: Graphs and Level Sets **[03 Lectures]**

1.1 Level set
2.1 Graphs of Level Sets

Unit 2: Vector Field **[12 Lectures]**

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 **[04 Lectures]**

3.1 Tangent to Level Sets

3.2 Properties

Unit 4: Surface and Vector field on surface **[14 Lectures]**

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 **[8 Lectures]**

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 **[15 Lectures]**

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 derivative
6.7 Covariant Derivative ofTangent vector field

Unit 7: Curvature of Plane Curve and Arc Length And Line Integral **[8 Lectures]**

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 Book:

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

Reference Book:

1. B Oneill, Elementary Differential Geometry, Acedamic New-York.
2. Do Carmo M., Differential Geometry of Curves and Surfaces, Englewood Cliffs, N. J. PrenticeHall, 1977.

Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24 M.Sc.-II

Class	**: M.Sc.-II (Semester – IV)**		
Course Code	**: PSMT243**		
Course	**: III**	**Title of the Course**	**: Fourier Analysis**
Credit	**: 4**	**No. of lectures**	**: 64**

Course Objectives:

1. To understand theory in Fourier analysis.
2. To enable the students to study finite Fourier sine and cosine series.
3. To introduce theory of differentiation and integration of Fourier series.
4. Use Fourier series to solve boundary value problems.
5. Understand the convergence of Fourier series of continuous periodic functions.
6. To introduce Strum-Liouville problems.
7. To understand the convergence of Fourier series of piecewise continuous functions.

Course Outcomes:

1. Student will be able to calculate Fourier series of a function.
2. Student will Classify and solve partial differential equations.
3. Student will be able to evaluate the Fourier series expansion for different periodic functions.
4. Student will discuss the nature of the partial differential equations.
5. Student will be able to analyze the properties of a Fourier Transforms.
6. Student will be able to calculate the Fourier sine and cosine series and apply it in solving boundary value problems.
7. Student will be able to calculate the infinite Fourier series of elementary functions from the definition.

TOPICS/CONTENTS:

Unit 1: Fourier series **[10 lectures]**

1.1 Piecewise continuous functions
1.2 Fourier cosine series
1.3 Fourier sine series
1.4 Examples
1.5 Fourier series
1.6 Examples
1.7 Adaptations to other intervals

Unit 2: Convergence of Fourier Series **[12 lectures]**

2.1 One sided derivatives

2.2 A property of Fourier coefficients
2.3 A Fourier theorem
2.4 Discussion of the theorems and its corollary
2.5 Convergence on other intervals
2.6 Absolute and uniform convergence of Fourier series
2.7 Differentiation of Fourier series
2.8 Integration of Fourier series

Unit 3: The Fourier Method **[10 lectures]**
3.1 Linear operators
3.2 Principle of superposition
3.3 A temperature problem
3.4 A vibrating string problem

Unit 4: Boundary Value Problems **[10 lectures]**
4.1 A slab with faces at prescribed temperature
4.2 Related problems
4.3 A slab with internally generated heat
4.4 Steady temperatures in a rectangular plate
4.5 Cylindrical coordinates
4.6 A string with prescribed initial conditions

Unit 5: Orthonormal sets **[08 lectures]**
5.1 Inner products and orthonormal sets
5.2 Examples
5.3 Generalized Fourier series
5.4 Examples
5.5 Best approximation in the mean

Unit 6: Sturm-Liouville Problems and Applications **[08 lectures]**
6.1 Regular Strum Liouville problems
6.2 Orthogonality of eigen functions
6.3 Real valued eigen functions and nonnegative eigen values
6.4 Methods of solution
6.5 Examples of eigen-function Expansions
6.6 A temperature problem in rectangular coordinates

Unit 7: Bessel Functions and Applications **[06 lectures]**
7.1 Bessel functions $J_n(x)$
7.2 General solutions of Bessel's equation
7.3 Recurrence relations
7.4 Bessel's integral form
7.5 Some consequences of the integral forms
7.6 The zeros of $J_n(x)$

Text Book:

Churchill and Brown, Fourier Series and Boundary Value Problems, McGraw-Hill, 7th edition.

Reference Books:

E. Stein and R. Shakharchi, Fourier Series and Boundary Value Problems, New age International.

Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24

Class : M.Sc.-II (Semester – IV)
Course Code : PSMT244
Course : IV **Title of the Course : Lattice Theory**
Credit : 4 **No. of lectures : 64**

A) Course Objectives:

1) To study the concept of Lattice as an algebra and Lattice as a poset.
2) To familiarize the concepts of Distributivity and Modularity.
3) Generalization of lattice concept by dropping one or more of the lattice identities.
4) To know the concept and applications of Lattice Theory.
5) To study relation between Graph Theory and Lattice Theory
6) To know Lattice-ordered Groups and related concepts.
7) To study complements, relative complements, and semi-complements of elements of a bounded lattice.

B) Course Outcomes:

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

CO1: Student will be able to understand how lattices as an algebra and as a poset are used as tools and mathematical models in the study of networks.
CO2: Students will be able to classify Distributive and Modular Lattices.
CO3: Student will be able to learn the equivalent conditions for a lattice to become modular and distributive.
CO4: Understand the concepts of maximal chain condition, Duality, and atoms in lattices.
CO5: Student will be able to learn the property of homomorphism of lattices.
CO6: To recognize the significance of ideal lattices.
CO7: Students will be able to explain the relation between Graph Theory and Lattice Theory.

TOPICS/CONTENT

Unit 1: Lattice First Concepts **[36 Lectures]**

1.1 Two definitions of lattices
1.2 Hasse diagrams
1.3 Homomorphism
1.4 Isotone maps
1.5 Ideals and congruence relations
1.6 Congruence lattices
1.7 Product of lattices
1.8 Complete lattice
1.9 Ideal lattice
1.10 Distributive –Modular inequalities and identifies
1.11 Complements and pseudo complements

Principal
Tuljaram Chaturchand College
Baramati

1.12 Boolean lattice of pseudo complements
1.13 Join and meet-irreducible elements.

Unit 2: Characterization theorems and representation theorems **[20 Lectures]**

2.1 Characterization theorem
2.2 Birkhoff`s distributivity criterion
2.3 Hereditary subsets, rings of sets
2.4 Stone theorems
2.5 Nachbin theorem
2.6 Statements of Hashimoto's theorem.

Unit 3: Modular and Semimodular lattices **[8 Lectures]**

3.1 Isomorphism theorem
3.2 Upper and lower covering conditions
3.3 Kuros-Ore theorem
3.4 Jordan-Holder chain condition.

<u>Text Book:</u>

G. Gratzer, General Lattice Theory, Birkhauser, IInd Edition 1998.

Unit 1 – Sections 1.1, 1.2, 1.3, 1.4,1.6
Unit 2 – Section 2.1
Unit 3 – Section 3.1
Unit 4 – Section 3.2

<u>Reference Books:</u>

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

Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24 M.Sc.-II

Class : M.Sc. II (Semester – IV)
Course Code : PSMT 245(A)
Course : V(A) **Title of the Course : Coding Theory**
Credit : 4 **No. of lectures : 64**

Course Objectives:

1. To learn how codes in mathematics are used for error correction and data transmission.
2. To understand information theoretic behaviour of a communication system.
3. To understand various source coding techniques for data compression.
4. To understand various channels coding techniques and their capability.
5. To build and understanding of fundamental concepts of data communication and networking.
6. Development and implementation of advanced algorithms.
7. To define and apply the basic concepts of information theory(entropy, channel capacity etc.

Course Outcomes:

1. Student will be able to derive equations for entropy, mutual information and channel capacity for all kinds of channels.
2. Student will be able to implements the various types of source coding algorithms and analyse their performance.
3. Student will be able to explain various methods of generating and detecting different types of error correcting codes.
4. Student will be able to perform information theoretic analysis of communication system.
5. Student will be able to design a data compression scheme using suitable source coding techniques.
6. Student will be able to design a channel coding scheme for a communication system.
7. Student will be able to comprehend various error control code properties.

TOPICS/CONTENT

Unit 1: Source Coding **[16 Lectures]**

1.1 Definition and examples
1.2 Uniquely decodable codes
1.3 Instantaneous codes
1.4 Constructing instantaneous codes
1.5 Kraft's inequality
1.6 McMillan's inequality

Unit 2: Optimal Codes **[16 Lectures]**

2.1 Optimality

Principal
Tuljaram Chaturchand College
Baramati

2.2 Binary Huffman codes
2.3 Average word length of Huffman codes
2.4 Optimality of binary Huffman codes
2.5 R-ary Huffman codes
2.6 Extensions of sources

Unit 3: Entropy **[16 Lectures]**

3.1 Information and entropy
3.2 Properties of a entropy function
3.3 Entropy and average word length
3.4 Shannon- Fano Coding
3.5 Entropy of extensions and products
3.6 Shannon's first theorem
3.7 An example of Shannon's first theorem

Unit 4: Information channels **[16 Lectures]**

4.1 Notation and definitions
4.2 The binary symmetric channel
4.3 System entropies
4.4 Extension of Shannon's first theorem to information channels
4.5 Mutual information
4.6 Channel capacity

<u>Text Book:</u>

Gareth A. Jones and J. Mary Jones, Information and Coding Theory, Springer

Unit 1 – Sections 1.1 to 1.6
Unit 2 – Sections 2.1 to 2.6
Unit 3 – Sections 3.1 to 3.7
Unit 4 – Sections 4.1 to 4.8

<u>Reference Books:</u>

1. Andre Neubauer, Jurgen Freudenberger, Volker Kuhn, Coding Theory, Wiley.
2. S. Veluswamy, Information Theory and Coding, New Age International (P) Ltd.
3. J. H. van Lint, Introduction to Coding Theory, Springer, 3rd Edition.
4. P. S. Satyanarayana, Concept of Information Theory & Coding, Medtech.

Principal
Tuljaram Chaturchand College
Baramati

Academic Year 2023-24 M.Sc.-II

Class : M.Sc.-II (Semester – IV)
Course Code : PSMT245 (B)
Course : V(B) **Title of the Course : Cryptography**
Credit : 4 **No. of lectures : 64**

Course Objective:

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

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 viewpoint.
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.

Principal
Tuljaram Chaturchand College
Baramati

TOPICS/CONTENT

Unit 1: Introduction to cryptography **[17 Lectures]**

1.1 Cryptography in Modern world
1.2 Substitution cipher
1.3 Monoalphabetic ciphers
1.4 Transposition Cipher
1.5 Vigenere Cipher
1.6 Introduction to polygraphic substitution ciphers
1.7 cryptanalysis of substitution cipher

Unit 2: Symmetric key cryptography **[17 Lectures]**

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
2.5 Algorithms: Data Encryption Standard, Advanced Encryption Standard, IDEA (International Data Encryption Algorithm)
2.6 Attacks against DES, AES, IDEA

Unit 3: Public key Cryptography **[15 Lectures]**

3.1 Introduction and Overview
3.2 The RSA algorithm
3.3 Diffie Hellman Key protocol, exchange message
3.4 Algorithms: Discrete Logarithm, MD5
3.5 Attacks against RSA

Unit 4: Applications of Cryptography **[15 Lectures]**

4.1 Digital Signature
4.2 Kerberos
4.3 Pretty Good privacy
4.4 Internet protocol security
4.5 C, C++, and Python programming implementation of topics on Ciphers

<u>Reference Books:</u>

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

Credit System Syllabus (2022 Pattern)

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc-II (Sem IV) **Subject:** Mathematics
Course: Number Theory **Course Code:** -PSMT241

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Finding quotients and remainders from integer division is a fundamental operation in arithmetic and computer science, essential for tasks like modular arithmetic, algorithm design, and data structure implementation.

CO2: Understanding the definitions of congruence, residue classes, and least residues is essential for foundational comprehension in number theory and modular arithmetic.

CO3: Identifying arithmetic functions and Dirichlet multiplications is crucial in number theory to analyze the behavior of prime numbers and investigate their properties within the framework of multiplicative number theory.

CO4: The Mobius inversion formula is a powerful tool in number theory and combinatorics that allows us to recover existing identities and relationships by reversing the summation or convolution process, providing a systematic and efficient method for studying number-theoretic functions and relationships.

CO5: Determine multiplicative inverses modulo n to solve linear congruences, as these inverses allow for division in modular arithmetic, enabling the solution of equations of the form ax ≡ b (mod n).

CO6: Applying Wilson's theorem helps identify the existence of primitive roots in modular arithmetic by revealing that if (p-1) is prime, then primitive roots exist modulo p.

CO7: Understanding legendary symbols is essential for identifying quadratic or non-quadratic residues modulo p in number theory and modular arithmetic, a key component of disciplinary knowledge.

PO2: Critical Thinking and Problem solving

Principal
Tuljaram Chaturchand College
Baramati

CO2: Understanding the definitions of congruence, residue classes, and least residues is essential for critical thinking and problem-solving in number theory, modular arithmetic, and cryptography, enabling the manipulation and analysis of modular equations and their applications in diverse mathematical and real-world scenarios.
CO3 Identifying arithmetic functions and Dirichlet multiplications is essential for critical thinking and problem-solving in number theory, enabling the analysis and manipulation of number sequences and their properties to tackle complex mathematical problems..
CO4 The Mobius inversion formula is a powerful tool for unraveling existing identities by providing a systematic method to transform and solve problems involving arithmetic functions, fostering critical thinking and problem-solving skills in number theory and combinatorics.
CO5: Determine multiplicative inverses modulo n to solve linear congruences is critical for problem-solving in number theory and cryptography, as it enables efficient solutions to equations in modular arithmetic, a fundamental concept with various real-world applications.
CO6: Applying Wilson's theorem is a fundamental step in determining the existence of primitive roots, demonstrating a key aspect of critical thinking and problem-solving in number theory.
CO7: Understanding legendary symbols is essential for distinguishing between quadratic and non-quadratic residues modulo p, a key component of critical thinking and problem-solving in number theory and cryptography.

PO4: Research-related skills and Scientific temper
CO4: The Mobius inversion formula is a powerful tool for revealing underlying patterns in existing identities, demonstrating critical research-related skills and a strong scientific temper in unravelling complex mathematical relationships.

PO5: Trans-disciplinary knowledge
CO1: "Find the quotients and remainder from integer division transcends disciplinary boundaries, applying to various fields of study."

CO3: Arithmetic functions are elementary number theory functions used in various mathematical disciplines, while Dirichlet multiplications are a tool in analytic number theory that combines functions to study number-theoretic properties in a trans-disciplinary approach.

CO6: Applying Wilson's theorem to calculate primitive roots enables us to bridge number theory with computational algebra, showcasing the power of trans-disciplinary knowledge.

PO7: Effective Citizenship and Ethics

CO7: Understanding polynomial rings and their properties can enhance mathematical reasoning skills, fostering a foundation for informed decision-making in various ethical and societal contexts.

PO9: Self-directed and Life-long learning:

CO4: The Mobius inversion formula enables the identification of underlying patterns and relationships, fostering self-directed and lifelong learning by revealing the interconnected nature of mathematical structures.

CO7 : Self-directed and lifelong learning is essential for individuals to continually expand their knowledge and adapt to evolving challenges in an increasingly complex and dynamic world.

Class: M.Sc-II (Sem IV) **Subject:** Mathematics
Course: Differential Geometry **Course Code:** -PSMT242

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
CO 1		2							
CO 2	2				2				3
CO 3	2								
CO 4		3			3				
CO 5	1								
CO 6									
CO 7	2	3			1				

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Studying Level sets, Geodesics, Weingarten map, smooth curves, and line integrals enhances a student's comprehension of fundamental concepts in differential geometry and contributes to their disciplinary knowledge.
CO3: Justification: Understanding differential maps between surfaces is essential for grasping the mathematical foundation of geometry and topology within the discipline of mathematics.
CO5: Justification: Developing proficiency in formal mathematical reasoning and proof writing equips students with essential skills for solving complex problems and advancing in their disciplinary knowledge.
CO7: Justification: Developing proficiency in formal mathematical reasoning and proof writing equips students with essential skills for solving complex problems and advancing in their disciplinary knowledge.

PO2: Critical Thinking and Problem solving

CO1: Studying the treatment of level sets, geodesics, Weingarten maps, smooth curves, and line integrals enhances critical thinking and problem-solving skills by enabling students to navigate complex geometric and analytical challenges in various mathematical and scientific contexts.
CO4: Studying differential geometry equips students with the critical thinking and problem-solving skills needed to tackle complex mathematical challenges and real-world problems.
CO7: Studying differential geometry equips students with the critical thinking and problem-solving skills necessary to tackle complex mathematical problems in a geometric context.

Principal
Tuljaram Chaturchand College
Baramati

PO5: Trans-disciplinary knowledge

CO2: Justification: The ability to find differential maps between surfaces fosters trans-disciplinary knowledge by bridging mathematical concepts with real-world applications, enabling students to navigate complex problems across various fields.

CO4: Studying differential geometry fosters trans-disciplinary knowledge by equipping students with the skills to comprehend and tackle complex problems across diverse fields through geometric insights and techniques.

CO7: Studying curvature and related calculations in 3-dimensional spaces fosters trans-disciplinary knowledge by enabling students to analyze and apply geometric concepts across various fields, from physics and engineering to computer graphics and biology.

PO9: Self-directed and Life-long learning

CO2: Justification: Teaching students to find differential maps between surfaces promotes self-directed and lifelong learning by fostering problem-solving skills and encouraging exploration beyond the classroom.

Class: M.Sc-II (Sem IV) **Subject:** Mathematics

Course: Fourier Analysis **Course Code:** -PSMT243

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Studying the theory of Fourier analysis in disciplinary knowledge is essential as it forms the foundation for advanced mathematical techniques used in diverse fields, enabling precise analysis and modelling of complex phenomena, and facilitating in-depth understanding and problem-solving within those disciplines.

Principal
Tuljaram Chaturchand College
Baramati

CO2: Studying finite Fourier sine and cosine series in disciplinary knowledge is crucial as it equips students with the mathematical tools necessary to represent and analyze a wide range of real-world phenomena, promoting a deeper understanding of complex systems and facilitating problem-solving within their specific disciplines.
CO3: Introducing the theory of differentiation and integration of Fourier series in disciplinary knowledge is vital as it enables a deeper understanding of the mathematical properties and applications of Fourier analysis, which is widely used in various scientific and engineering disciplines, enhancing the ability to solve complex problems and make precise predictions.
CO4: Using Fourier series to solve boundary value problems in disciplinary knowledge is essential as it provides a powerful mathematical technique for analyzing and solving complex problems related to heat transfer, wave propagation, and other phenomena, enhancing the ability to model and address real-world challenges within specific fields.
CO5: Understanding the convergence of Fourier series of continuous periodic functions in disciplinary knowledge is crucial as it ensures the accuracy and reliability of Fourier analysis techniques, enabling precise modelling and analysis of various phenomena within specific disciplines, thus enhancing problem-solving and research capabilities.
CO6: Introducing Sturm-Liouville problems in disciplinary knowledge is important as it provides a powerful mathematical framework for solving a wide range of differential equations, making it an essential tool for understanding and addressing complex phenomena and problems within specific disciplines, thereby enhancing problem-solving and research capabilities.
CO7: Understanding the convergence of Fourier series of piecewise continuous functions in disciplinary knowledge is crucial as it allows for accurate representation and analysis of a broader range of real-world phenomena, providing a foundational mathematical tool for addressing complex problems within specific fields, enhancing problem-solving and research capabilities.

PO2: Critical Thinking and Problem solving
CO1: Understanding the theory in Fourier analysis is vital for critical thinking and problem-solving as it equips individuals with a powerful mathematical framework for analyzing complex phenomena, enabling precise modelling and insightful problem-solving in various disciplines, fostering a deeper understanding of critical issues and their solutions.
CO2: Classifying and solving partial differential equations is a critical thinking and problem-solving skill that empowers students to tackle a wide array of complex real-world problems across various disciplines, fostering analytical thinking, and enhancing their ability to address intricate and multifaceted challenges.
CO3: Evaluating Fourier series expansions for various periodic functions enhances critical thinking and problem-solving skills by providing a systematic approach to analyze and model complex phenomena, enabling effective problem-solving in diverse disciplines.
CO4: Discussing the nature of partial differential equations fosters critical thinking and problem-solving skills by promoting a deep understanding of the fundamental properties and behaviours of these equations, enabling effective problem analysis and solutions in various disciplines.
CO5: Analyzing the properties of Fourier Transforms enhances critical thinking and problem-solving skills by providing a versatile mathematical tool for understanding and solving complex problems in diverse fields, facilitating precise analysis and modelling of phenomena.
CO6: Calculating Fourier sine and cosine series and applying them to solve boundary value problems is essential for critical thinking and problem-solving, as it equips students with a

Principal
Tuljaram Chaturchand College
Baramati

powerful mathematical technique to address real-world challenges, fostering analytical skills and effective solutions in various disciplines.

CO7: Calculating the infinite Fourier series from the definition in critical thinking and problem-solving enhances mathematical reasoning and analytical skills, enabling students to accurately represent and analyze complex functions and phenomena, facilitating effective problem-solving in diverse disciplines.

PO4: Research-related skills and Scientific temper

CO1: Calculating Fourier series of a function in research-related skills and scientific temper enhances one's ability to analyze and model complex phenomena, fostering precise data interpretation and mathematical skills that are vital for conducting rigorous research and making informed scientific conclusions.

CO5 Analyzing the properties of Fourier Transforms in research-related skills and scientific temper enhances the capacity for in-depth data analysis and modeling, contributing to more rigorous research practices and fostering a commitment to evidence-based scientific inquiry.

CO7: Calculating infinite Fourier series from the definition in research-related skills and scientific temper enhances mathematical proficiency and analytical capabilities, vital for conducting thorough research and promoting a rigorous, evidence-based scientific approach.

PO5: Trans-disciplinary knowledge

CO4: Discussing the nature of partial differential equations in trans-disciplinary knowledge fosters a foundational understanding of these equations, promoting a holistic approach to problem-solving and enabling their application in diverse fields of study and collaboration.

CO5: Analyzing the properties of Fourier Transforms in trans-disciplinary knowledge provides a versatile mathematical tool for understanding and addressing complex phenomena, facilitating interdisciplinary problem-solving and enhancing collaboration across diverse fields of study.

PO9: Self-directed and Life-long learning:

CO2: Classifying and solving partial differential equations in self-directed and life-long learning fosters independent problem-solving skills and equips individuals to continually adapt and apply mathematical techniques across various disciplines, promoting lifelong intellectual growth.

Principal
Tuljaram Chaturchand College
Baramati

Class: M.Sc.II (Sem IV) **Subject:** Mathematics
Course: Lattice Theory **Course Code:** PSMT244

A) Course Objectives:

8) To study the concept of Lattice as an algebra and Lattice as a poset.
9) To familiarize the concepts of Distributivity and Modularity.
10) Generalization of lattice concept by dropping one or more of the lattice identities.
11) To know the concept and applications of Lattice Theory.
12) To study relation between Graph Theory and Lattice Theory
13) To know Lattice-ordered Groups and related concepts.
14) To study complements, relative complements, and semi-complements of elements of a bounded lattice.

15) Course Outcomes:

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

CO1: Student will be able to understand how lattices as an algebra and as a poset are used as tools and mathematical models in the study of networks.
CO2: Students will be able to classify Distributive and Modular Lattices.
CO3: Student will be able to learn the equivalent conditions for a lattice to become modular and distributive.
CO4: Understand the concepts of maximal chain condition, Duality, and atoms in lattices.
CO5: Student will be able to learn the property of homomorphism of lattices.
CO6: To recognize the significance of ideal lattices.
CO7: Students will be able to explain the relation between Graph Theory and Lattice Theory.

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
CO 1	3	3		1	3				
CO 2	3	3		3		2			2
CO 3	3	3		1					1
CO 4	3	2		1					
CO 5	3	3		1					
CO 6	3	3		2	2				2
CO 7	3	2		3	3	2			2

Justification for the mapping

Principal
Tuljaram Chaturchand College
Baramati

PO 1: Disciplinary Knowledge:
CO1, CO3, CO4 and CO5 are building blocks of Lattice theory that helps students to acquire the knowledge and skills required for the advanced lattice theory concepts. CO 2, CO 6 and CO 7 require students to develop deep understanding of types of Lattices and apply the concepts in the Graph Theory.

PO 2: Critical Thinking and Problem Solving:
All the Course outcomes also contribute to the development of students' critical thinking and problem-solving skills. For example, CO1, CO3, CO4, and CO5 require students to think critically about how to apply Lattice, Boolean Lattice, Modular Lattice to solve different Lattice Identities. CO2, CO6 and CO7 require students to think critically and apply the knowledge to classified types of Lattices.

PO 4: Research-related skills and Scientific temper:
CO1, CO3, CO4 and CO5 require students to apply their knowledge of atoms, Modular Lattice, Boolean algebra and ideal Lattice to solve problems in networks in computer science and Graph theory. CO2, CO6 and CO7 enhance the educational experience and prepare students for the advanced studies and research in the related lattice theory fields.

PO5: Trans-disciplinary knowledge:
CO1, CO6, and CO7 contribute to the development of student's trans-disciplinary knowledge. For example, CO1 requires students to learn how to apply Boolean algebra as a tool in network models. CO6 and CO7 requires students to develop an understanding of the connections between Lattice diagram and graphical diagram in graph theory and other subjects.

PO6: Personal and professional competence:
CO2, and CO7 contribute to the development of students personal and professional competence. For example, CO2 reflect the practical application of various types of Lattices. CO2 and CO7 require students to develop their ability to work independently and as part of a team**.** This integrated approach prepares students for the challenges and demands of their chosen careers and equips them with the skills and mindset required for continuous growth and adaptability.

PO9: Self-directed and Life-long learning:
CO2, CO3, CO6 and C07 empower students to view challenges as opportunities for growth and learning. For example, all of the mentioned COs requires students to develop their ability to learn graph theoretical concepts in terms lattices.

TULJARAM CHATURCHAND COLLEGE BARAMATI

Principal
Tuljaram Chaturchand College
Baramati

Class: M.Sc.II (Sem IV) **Subject:** Mathematics

Course: Coding Theory **Course Code:** PSMT245 (A)

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Deriving equations for entropy, mutual information, and channel capacity for all types of channels in disciplinary knowledge enhances understanding of information theory and communication systems, enabling precise analysis and problem-solving in various scientific and engineering disciplines.

CO2: Implementing various sources coding algorithms and analyzing their performance in disciplinary knowledge equips students with practical skills in data compression and information theory, fostering a deeper understanding of communication systems and enhancing problem-solving capabilities in related fields.

CO3: Explaining methods for generating and detecting error correcting codes in disciplinary knowledge enhances knowledge of coding theory, crucial for reliable data transmission and storage, promoting problem-solving and robust communication system design in various fields.

CO4: Performing information theoretic analysis of communication systems in disciplinary knowledge enables students to assess system efficiency and capacity, enhancing their ability to optimize and design effective communication systems in various scientific and engineering contexts.

CO5: Designing a data compression scheme with source coding techniques in disciplinary knowledge fosters practical skills in information compression, improving data transmission efficiency and promoting effective problem-solving in data-intensive applications across various fields.

CO6: Designing a channel coding scheme for a communication system in disciplinary knowledge is crucial for ensuring reliable data transmission, enhancing students' problem-solving abilities, and enabling the design of robust communication systems across diverse scientific and engineering applications.

PO2: Critical Thinking and Problem solving

CO1: Deriving equations for entropy, mutual information, and channel capacity for diverse channels in critical thinking and problem-solving enhances analytical skills and the ability to

Principal
Tuljaram Chaturchand College
Baramati

make informed decisions in communication systems and information theory, fostering precise problem analysis and innovative solutions.

CO2: Implementing source coding algorithms and analyzing their performance in critical thinking and problem-solving enhances analytical and decision-making skills, promoting a deeper understanding of data compression techniques and their practical application in communication systems.

CO3: Explaining methods for generating and detecting error correcting codes in critical thinking and problem-solving cultivates a deeper understanding of coding theory, fostering logical reasoning and the ability to devise effective error correction strategies for reliable data communication across diverse applications.

CO4: Performing information theoretic analysis of communication systems in critical thinking and problem-solving enhances analytical skills and the capacity to make informed decisions for optimizing communication system performance and solving complex challenges in scientific and engineering domains.

CO5: Designing a data compression scheme with source coding techniques in critical thinking and problem-solving fosters creative and logical problem-solving skills, enabling students to develop efficient data compression solutions for various applications in scientific and engineering contexts.

CO6: Designing a channel coding scheme for a communication system in critical thinking and problem-solving cultivates logical reasoning and creative problem-solving skills, enabling students to enhance communication system reliability and address complex challenges across various scientific and engineering fields.

CO7: Comprehending various error control code properties in critical thinking and problem-solving enhances analytical skills and the ability to make informed decisions when designing robust error control mechanisms for reliable data transmission in diverse applications.

PO4: Research-related skills and Scientific temper

CO2: Implementing source coding algorithms and analyzing their performance in research-related skills and scientific temper fosters a practical understanding of data compression techniques, enhancing the ability to conduct rigorous research and promote evidence-based, efficient data transmission in diverse fields.

CO6: Analyzing the properties of Fourier Transforms in research-related skills and scientific temper enhances the capacity for in-depth data analysis and modeling, contributing to more rigorous research practices and fostering a commitment to evidence-based scientific inquiry.

PO5: Trans-disciplinary knowledge

CO4: Performing information theoretic analysis of communication systems in trans-disciplinary knowledge enhances analytical skills, fostering a holistic understanding of communication principles applicable across diverse fields, facilitating interdisciplinary problem-solving.

CO5 Designing a data compression scheme with source coding techniques in trans-disciplinary knowledge promotes practical problem-solving skills applicable in a variety of fields, enhancing data efficiency and facilitating interdisciplinary collaboration and innovation.

Principal
Tuljaram Chaturchand College
Baramati

PO9: Self-directed and Life-long learning:

CO1: Deriving equations for entropy, mutual information, and channel capacity for various channels in self-directed and life-long learning fosters continuous intellectual growth, enabling individuals to independently explore and apply information theory concepts in diverse fields throughout their lifetime.

CO2: Implementing source coding algorithms and analyzing their performance in self-directed and life-long learning cultivates independent problem-solving skills, enabling ongoing personal and professional development by staying up-to-date with evolving data compression techniques.

Class: M.Sc-II (Sem III) **Subject:** Mathematics

Course: Cryptography **Course Code:** -PSMT245 (B)

Course Objective:

8. To understand basics of Cryptography and various electronic codes.
9. To learn different encryption techniques along with digital signatures and their use in various protocols.
10. To learn about how to maintain the Confidentiality, Integrity and availability of a data.
11. To develop attitude and interest along with necessary knowledge and skills among the students
12. Explain the importance and application of each of confidentiality, integrity, Authentication and availability.
13. To learn different encryption techniques using RSA algorithms.
14. To impart the knowledge of encryption and decryption techniques and their applications in managing the security of data.

Course Outcomes:

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

CO8	Student will be able to, apply some early substitution and translation ciphers.
CO9	Student will be able to, distinguish symmetric key encryption systems from public key encryption systems.
CO10	Student will be able to, assess simple cryptographic methods from a practical viewpoint.
CO11	Student will be able to use cryptography methods to do further academic studies and research.
CO12	Student will be able to perform Security Related real-world problems.
CO13	Student will demonstrate the use of symmetric key encryption systems and public key encryption systems.
CO14	Students will be able to describe advantages and disadvantages of various encryption and decryption systems.

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

Principal
Tuljaram Chaturchand College
Baramati

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

Justification for the mapping

PO1: Disciplinary Knowledge

The entire Course outcomes are contributes to the achievement of the proficiency in implementing cryptographic algorithms. All CO's require students to mastery of cryptographic techniques and algorithms.

PO 2: Critical Thinking and Problem Solving:

Critical thinking and problem-solving skills are essential for making ethical decisions in cryptographic practices. All of the Course outcomes contribute to the development of students' critical thinking and problem-solving skills. For example, CO1, CO3, CO4, and CO5 require students to think critically about how to solve new challenges as they arise in an ever-changing cyber security landscape. CO2, CO6 and CO7 require students to think critically and solve intricate problems related to encryption, decryption, and security.

PO 4: Research-related skills and Scientific temper:

CO3, CO4, CO5 and CO7 require students to apply their knowledge of Cryptosystem to find new encryption and decryption methods. CO2, CO6 and CO7 are helpful for advanced studies and research in the security problem and various real world coding decoding problems.

PO5: Trans-disciplinary knowledge:

CO4, CO5, and CO7 contribute to the development of students trans-disciplinary knowledge. For example, CO4 requires students to learn how to use cryptographic techniques for further academic studies and research. CO5 and CO7 require students to apply cryptography techniques in different I.T and Cyber security fields.

PO6: Personal and professional competence:

Principal
Tuljaram Chaturchand College
Baramati

All CO's contribute to the development of student's personal and professional competence. All of the CO's require students to develop their communication skills and the ability to solve real world problems.

PO9: Self-directed and Life-long learning:

All CO'S contribute to the development of self-directed and lifelong learning skills aligns with fostering a growth mindset among students. These skills empower students to view challenges as opportunities for growth and learning. For example, the entire COs requires students to develop their ability to learn new security algorithms and established algorithm for encryption and decryption.

TULJARAM CHATURCHAND COLLEGE BARAMATI

Jagtap

Principal
Tuljaram Chaturchand College
Baramati