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

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

Semester	Course Code	Title of Course	No. of Credits	No. of Lectures
I	PSMT111	Measure Theory and Integration	4	64
	PSMT112	Advanced Calculus	4	64
	PSMT113	Group theory	4	64
	PSMT114	Numerical Analysis	4	64
	PSMT115	Ordinary Differential Equations	4	64
	PSMT116	Practical: Programming in C	4	64
II	PSMT121	Complex Analysis	4	64
	PSMT122	Topology	4	64
	PSMT123	Rings and Modules	4	64
	PSMT124	Linear Algebra	4	64
	PSMT125	Partial Differential Equations	4	64
	PSMT126	Practical: Programming in C++	4	64

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

SYLLABUS (CBCS) FOR M. Sc.I MATHEMATICS
Academic Year 2022-2023

Class: M. Sc I (Semester- II)
Paper Code: PSMT121

Paper	**: I**	**Title of Paper: Complex Analysis**
Credit	**: 4**	**No. of lectures: 64**

Topics/Contents:

1. The complex number system **(4 Lectures)**
1.1 The field of complex numbers
1.2 The complex plane
1.3 Polar representation and roots of complex numbers
1.4 Lines and Half planes in the complex plane.

2. Elementary Properties and Examples of Analytic Functions **(15 Lectures)**
2.1 Power Series
2.2 Analytic Functions
2.3 Analytic functions as mapping, Mobius transformation.

3. Complex Integration: **(15 Lectures)**
3.1 Riemann-Stieltjes integrals
3.2 Power series representation of analytic functions
3.3 Zeros of analytic function
3.4 The index of a closed curve
3.5 Cauchy's Theorem and Integral formula
3.6 The homotopic version of Cauchy's Theorem and simple connectivity
3.7 Counting zeroes; the Open Mapping Theorem
3.8 Goursat's Theorem.

4. Singularities **(15 Lectures)**
4.1 Classification of singularities
4.2 Residues
4.3 The Argument Principle

5. The Maximum Modulus Theorem **(15 Lectures)**

5.1 The Maximum Principle
5.2 Schwarz's Lemma.

Text Book: John B. Conway: Functions of one complex variable (Narosa Publishing house) (Chapter: 1,3,4,5 & 6.)

Reference Books:

1. S. Ponnusamy: Foundation of Complex Analysis, Narosa Publications. (Second Edition).
2. Complex Analysis, E. Stein and Shakarchi, Overseas Press (India) Ltd., Princeton Lectures in Analysis.
3. Lars V. Ahlfors: Complex Analysis (McGrawHill).
4. Ruel V. Churchill / James Ward Brown: Complex Variables and Applications (McGraw Hill).
5. Anant R. Shastri, Basic Complex Analysis of One Variable, Macmillan publishers India,2010

M.Sc I (Semester- II)
Paper Code: PSMT122
Paper: II **Title of Paper: Topology**
Credit: 4 **No. of lectures: 64**

Topics/Contents:

1. Countable and uncountable sets: (4 Lectures)
1.1 The axiom of choice
1.2 Well ordered sets

2. Topological spaces and continuous functions: (20 Lectures)
2.1Basis for topology
2.2Ordered topology
2.3 continuous functions
2.4 Product topology
2.5 Metric topology
2.6 Quotient topology.

3. Connectedness and compactness: (20 Lectures)
3.1 Connected spaces
3.2 Components and local connectedness
3.3 Compact spaces
3.4 Limit point compactness
3.5 Local compactness
3.6 One point Compactification.

4. Countability and separation axioms: (20 Lectures)
4.1 The countability axioms
4.2 Separation axioms
4.3 Normal spaces
4.4 The Urysohn lemma (Statement only)
4.5 The Urysohn metrization theorem (Statement only)
4.6 The Tietze extension theorem (Statement only).
4.7 Tychonoff theorem

Text Book: *Topology A first Course*, J. R. Munkres, Prentice Hall of India.
(Sections: 1.7, 1.9, 1.10, 1.11, 2.1 to 2.11, 3.1 to 3.8, 4.1 to 4.4, 5.1)

Reference Books:

1. *General Topology*, J. L. Kelley, Springer.
2. *Topology without Tears, Sidney A. Morris.*
2. *Topology*, J. Dugundji, Allyn and Bacon.
3. *General Topology*, S. Willard, Addison-Wesley Publishing Company
4. Counterexamples in Topology, L.A. Steen and J.A. Seebach Jr.

Class: M.Sc. I (Semester- (II)
Paper Code: PSMT123
Paper: III **Title of paper: Rings and Modules**
Credit: 04 **No. of Lectures: 64**

Topics/Contents:

1. Rings **[12 lectures]**
1.1 Rings of continuous functions,
1.2 Matrix Ring,
1.3 Polynomial Rings,
1.4 Power series Rings,
1.5 Laurent Rings,
16 Boolean Ring,
1.7 Direct Products
1.8 Several Variables,
1.9 Opposite Rings,
1.10 Characteristic of a Ring.

2. Ideals **[12 lecture]**
2.1 Maximal Ideals,
2.2 Generators,
2.3 Basic Properties of Ideals,
2.4 Algebra of Ideals,
2.5 Quotient Rings,
2.6 Ideals in Quotient Rings,
2.7 Local Rings

3. Homomorphism of Rings **[12 lectures]**
3.1 Fundamental Theorems,
3.2 Endomorphism Rings,
3.3 Field of fractions,
3.4 Prime field

4. Factorization in Domains **[14 lectures]**
4.1Division in Domains,
4.2 Euclidean Domains,
4.3 Principal Ideal Domains,
4.4 Factorization Domains,
4.5 Unique Factorization Domains,
4.6 Eisenstein's Criterion.

5. Modules **[14 lectures]**
5.1 Direct Sum,
5.2 Free Modules,
5.3 Vector Spaces,
5.4 Quotient Module,
5.5 Homomorphism,
5.6 Simple Modules,
5.7 Modules over PID's.

Text Book: *Rings and Modules*, C. Musili, Narosa Publishing House.
(Section 1.1 to 1.12, 2.1 to 2.8, 3.1 to 3.5, 4.1 to 4.6, 5.1, 5.2, 5.4, 5.6, 5.7, 5.8).

Reference Books:

1. *Basic Abstract Algebra*, Bhattacharya, Nagpaul and Jain, Cambridge University Press.
2. *Rings and Modules*, C. Musili, Narosa Publishing House.
3. *Algebra II*, Luther and Passi, Narosa Publishing House.
4. *Abstract Algebra,* David S. Dummit and Richard M. Foote.

Class: M. Sc. I (Semester-I)
Course Code: PSMT124
Course: IV **Title of Course : Linear Algebra**

Credit:4 **No. of lectures: 64**

Topics/Contents:

Unit 1. Vector Spaces **[16 Lectures]**
1.1 Subspaces
1.2 Basis and dimension
1.3 Linear Transformations
1.4 Quotient spaces
1.5 Direct sum
1.6 The matrix of a linear transformation.

Unit 2. Canonical Forms **[16 Lectures]**
2.1 Eigenvalues and eigenvectors
2.2 The minimal polynomial
2.3 Diagonalizable and triangulable operators
2.4 The Jordan Form
2.5 The Rational Form.

Unit 3. Inner Product Spaces **[16 Lectures]**
4.1 Inner Products
4.2 Orthogonality
4.3 The adjoint of a linear Transformation
4.4 Unitary operators
4.5 Self adjoint and normal operators.

Unit 4. Bilinear Forms **[16 Lectures]**
4.1 Definition and examples
4.2 The matrix of a bilinear form
4.3 Orthogonality
4.4 Classification of bilinear forms.

Text Book:-Vivek Sahai, Vikas Bist: Linear Algebra (Narosa Publishing House).
Chapters 2, 3, 4, and 5.

Reference Books:
i) Serge lang springer: Linear Algebra
ii) M. Artin: Algebra (Prentice - Hall of India private Ltd.)
iii) K. Hoffman and Ray Kunje: Linear Algebra (Prentice - Hall of India private Ltd.)
iv) S. Kumaresan: Linear Algebra (PHI Learning private Ltd.)
v) Charles W. Curtis: Linear Algebra, Springer.
vi) Gilbert Strang: Introduction to Linear Algebra, Wellesley Publishers.

Class: M. Sc. I (Semester- II)
Paper Code: PSMT125
Paper: V **Title of Paper: Partial Differential Equations**
Credit: 4 **No. of lectures: 64**

Topics/Contents:

1. First Order P.D.E. - I **(15 Lectures)**
1.1 Introduction,
1.2 Genesis of first order P.D.E.
1.3 Classification of integrals
1.4 Linear equations of the first order
1.5 Pfaffian differential equations

2. First Order P.D.E. - II **(15 Lectures)**
2.1 Compatible systems
2.2 Charpit's Method
2.3 Jacobi's Method
2.4 Quasi-Linear Equations
2.5 Non-Linear First Order P.D.E.

3. Second Order P.D.E. - I **(17 Lectures)**
3.1 Genesis of second order P.D.E.
3.2 Classification of second order P.D.E.
3.3 One Dimensional Wave Equation
3.4 Laplace Equation
3.5 Boundary Value Problems
3.6 The Cauchy Problem

4. Second Order P.D.E. - II **(17 Lectures)**
4.1 Dirichlet and Neumann Problem for different regions
4.2 Harnack's Theorem
4.3 Heat Conduction Problem
4.4 Duhamel's Principle
4.5 Classification of P.D.E. in the case of n-variables
4.6 Families of Equipotential Surfaces.
4.7 Kelvin's Inversion Theorem

Text Book
T. Amarnath: An Elementary Course in Partial Differential Equations (2nd edition) (Narosa Publishing House) [Section 1.1 to 2.9].

Reference Books:
1. K. Sankara Rao: Introduction to partial differential equation, third edition.
2. I.N. Sneddon: Elements of partial differential equations (Mc-Graw Hill Book Company)
3. An Introduction to Partial Differential equations, Yehud Pinchor & Jaco Rubinstein, (Cambridge university press)
4. W. E. Williams: Partial Differential equations (Clarendon press-oxford)
5. E. T. Copson : Partial differential equations (Cambridge university press).

Class : M.Sc I (Semester- II)
Paper code: PSMT126
Paper : VI **Title of Paper : Practical: Programming in C++**
Credit : 4 **No. of lectures: 64**

Topics/Contents:

Unit1. Introduction: [06L]

1.1 What is object oriented programming?
1.2 Why do we need object oriented.
1.3 Programming characteristics of object-oriented languages C and C++.
1.4 C++ Programming basics: Output using cout. Directives.
1.5 Input with cin. Type bool.
1.6 The setw manipulator.
1.7 Type conversions.

Unit 2. Functions in C++: [10L]

2.1. Returning values from functions.
2.2 Reference arguments.
2.3 Overloaded function.
2.4 Inline function.
2.5 Default arguments.
2.6 Returning by reference.

Unit 3.Object and Classes: [16L]

3.1Making sense of core object concepts (Encapsulation, Abstraction, Polymorphism, Classes,Messages Association, Interfaces)
3.2 Implementation of class in C++,
3.3 C++ Objects as physical object,
3.4 C++ object as data types constructor. Object as function arguments.
3.5 The default copy constructor, returning object from function. Structures and classes. Classes objects and memory static class data. Const and classes.
3.5 Arrays and string arrays fundamentals.
3.6 Arrays as class Member Data : Arrays of object, string, The standard C++ String class Operator overloading : Overloading unary operations
3.7 Overloading binary operators, data conversion, pitfalls of operators overloading and conversion keywords.
3.8 Explicit and Mutable.

Unit4 Inheritance: [16L]

4.1 Concept of inheritance.
4.2 Derived class and based class.
4.3 Derived class constructors.
4.4 Member function, inheritance in the English distance class.
4.5 class hierarchies, inheritance and graphics shapes, public and private inheritance,
4.6 Aggregation: Classes within classes, inheritance and program development.
4.7 Pointer: Addresses and pointers. The address of operator and pointer and arrays.
4.8 Pointer and Faction pointer and C- types string.

Unit5. Memory management: **[16L]**
5.1 New and Delete, pointers to objects, debugging pointers.
5.2 Virtual Function: Virtual Function, friend function, Static function, Assignment and copy
5.3 Initialization, this pointer, dynamic type information.
5.4 Streams and Files : Streams classes, Stream Errors, Disk File I/O with streams, file pointers, error 5.5 handling in file I/O with member function, overloading the extraction and insertion operators,
5.6 Memory as a stream object, command line arguments, and printer output.
5.7 Templates and Exceptions: Function templates, Class templates Exceptions

Text Book **:** Let us C++, Yashwant Kanetkar

Reference Book :

1. Object Oriented Programming in C++ , E. Balgurusamy.
2. Schaum's series programming with C++ by Byron Gottfried.

Credit System Syllabus (2022 Pattern)

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc-I (Sem II) **Subject:** Mathematics
Course: Complex Analysis **Code:** PSMT121

Course Objectives:

1. To understand and learn to use Argument principle.
2. To study the techniques of complex variables and functions together with their derivative, Contour integration and transformation.
3. To study complex power series and classification of singularities.
4. To study calculus of residue and its applications in the evaluation of integrals.
5. To understand range of analytic functions.
6. To understand range of analytic functions.
7. To understand Gamma and Zeta functions, their properties and relationships.

Course Outcomes:

1. Student will be able to represent complex numbers algebraically and geometrically.
2. Students will analyze limit, continuity and differentiation of functions of complex variables.
3. Student will be able to understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.
4. Student will be able to understand Cauchy theorem and Cauchy integral formula and apply these to evaluate complex contour integrals.
5. Student will be able to classify singularities and poles and evaluate complex integration using the residue theorem.
6. Student will be able to understand conformal mapping.
7. Student will be able to find the Taylor's series of a function and determine its circle of convergence.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: The Argument Principle provides a systematic framework for analyzing and evaluating the logical and persuasive aspects of disciplinary knowledge, enhancing critical thinking and communication skills.

CO2: Studying complex variables, derivatives, contour integration, and transformations enhances critical thinking and problem-solving by providing powerful mathematical tools to analyze and solve complex real-world problems.

CO3: Studying complex power series and the classification of singularities is essential in disciplinary knowledge as it provides a deeper understanding of the behaviour of complex functions, enabling the accurate analysis and modelling of phenomena in various scientific and engineering fields..

CO4: Studying the calculus of residues and its applications is crucial in disciplinary knowledge because it equips individuals with a powerful technique for efficiently evaluating complex integrals, which is invaluable in solving intricate problems in mathematics, physics, engineering, and various scientific disciplines..

CO5: Understanding the range of analytic functions is fundamental in disciplinary knowledge as it provides insights into the behaviour and limitations of functions used in various scientific and mathematical applications, enabling more accurate and informed analyses and problem-solving.

CO6: Understanding the modulus of complex-valued functions and related results is crucial in disciplinary knowledge for assessing magnitudes, oscillations, and critical properties of functions, facilitating precise analysis and predictions in scientific and engineering domains.

CO7: Understanding Gamma and Zeta functions, their properties, and relationships is essential in disciplinary knowledge as they play a pivotal role in advanced mathematical and scientific computations, offering valuable tools for solving complex problems and modelling real-world phenomena.

PO2: Critical Thinking and Problem solving

CO1: Learning the Argument Principle enhances critical thinking and problem-solving skills by providing a systematic approach to analyze and evaluate the logical and persuasive aspects of complex issues and arguments.

CO2: Studying complex variables, derivatives, contour integration, and transformations fosters critical thinking and problem-solving by equipping individuals with powerful mathematical tools that enable the analysis and resolution of complex, real-world problems across various disciplines.

CO3: Studying complex power series and the classification of singularities enhances critical thinking and problem-solving by providing a deep understanding of the behaviour of complex functions, enabling more accurate and sophisticated analysis of intricate mathematical and scientific problems.

CO4: Studying the calculus of residue and its applications is essential for critical thinking and problem-solving as it equips individuals with a powerful technique for efficiently evaluating complex integrals, making it a valuable tool in solving intricate problems in mathematics, physics, and engineering.

CO5: Understanding the range of analytic functions is essential for critical thinking and problem-solving because it provides insights into the behaviour and limitations of functions used in various scientific and mathematical applications, enabling more accurate analysis and informed problem-solving across disciplines.

CO6: Understanding the modulus of complex-valued functions and related results is crucial for critical thinking and problem-solving as it aids in assessing magnitudes, oscillations, and critical properties of functions, facilitating precise analysis and predictions in scientific and engineering contexts.
CO7: Understanding Gamma and Zeta functions, their properties, and relationships is vital for critical thinking and problem-solving, as they provide powerful mathematical tools for advanced computations and modelling in diverse scientific and engineering applications.

PO4: Research-related skills and Scientific temper
CO2: Studying complex variables, derivatives, contour integration, and transformations cultivates research-related skills and a scientific temper by equipping individuals with advanced mathematical tools crucial for conducting rigorous analyses and investigations in diverse scientific disciplines.
CO7: Understanding Gamma and Zeta functions, their properties, and relationships fosters research-related skills and a scientific temper, as these functions play a fundamental role in advanced mathematical research, facilitating precise modeling and analysis in scientific inquiries and
investigations.

PO5: Trans-disciplinary knowledge
CO5: Understanding the range of analytic functions is crucial for trans-disciplinary knowledge as it equips individuals with a foundational mathematical concept essential for diverse applications across various fields, fostering a holistic approach to problem-solving.

CO6: Understanding the modulus of complex-valued functions and related results is essential for trans-disciplinary knowledge, as it provides a common mathematical language for analyzing and comparing data and phenomena across different disciplines, promoting interdisciplinary collaboration and problem-solving.

PO9: Self-directed and Life-long learning:
CO2: Studying techniques of complex variables, derivatives, contour integration, and transformation supports self-directed and life-long learning by equipping individuals with powerful mathematical tools that can be applied across a wide range of contexts and disciplines, promoting ongoing personal and professional development.
CO7: Understanding Gamma and Zeta functions, their properties, and relationships contributes to self-directed and life-long learning by providing individuals with advanced mathematical knowledge that can be continually applied and expanded upon, fostering a commitment to ongoing intellectual growth and problem-solving capabilities.

Class: M.Sc-I (Sem II) **Subject:** Mathematics
Course: Topology **Course Code:** PSMT122

Course Objectives:

1. Understanding of terms, definitions, and theorems in topology.
2. Use of continuous functions, homeomorphism to understand topological spaces.
3. Demonstrate an understanding of the concepts of topological spaces and their role in mathematics.
4. To introduce the student to elementary properties of topological spaces and structures defined on them.
5. To introduce the student to maps between topological spaces.
6. To develop the student's ability to handle abstract ideas of Mathematics and Mathematical proofs.
7. To present an introduction to the field of topology, with emphasis on those aspects of the subject that are basic to higher mathematics.

Course Outcomes:
By the end of the course, students will be able to:
CO1: Understand countable and uncountable sets and distinct type of topologies with respect to bases.
CO2: Understand difference between Metric Spaces and Topological Spaces.
CO3: Classify certain topological spaces based on topological properties like Connectedness and compactness.
CO4: Understand the separation axioms, metrizable spaces, first and second countability axioms among various spaces.
CO5: Demonstrate an understanding of the concepts of metric spaces and topological spaces, and their role in mathematics.
CO6: Prove basic results about completeness, compactness, connectedness and convergence within these structures.
CO7: Prepare for studying advanced research level courses on Topology.

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

Justification for the mapping

PO 1: Disciplinary Knowledge:

CO1: Student will master in countability of sets.

CO2: Student will develop a deep understanding of difference between Metric and Topological spaces.

CO3: Students will demonstrate the classification of topological spaces based on knowledge of topological properties.

CO4: Student will develop understanding of separation axioms, metrizable spaces and countability axioms.

CO5: Student will demonstrate concepts of Metric spaces and their role in other subjects.

PO 2: Critical Thinking and Problem Solving:

CO1: Student will apply their knowledge of topological spaces and solve the problem countability.

CO2: Student will apply their knowledge and find the difference between Metric spaces and Topological spaces.

CO3: Students will use the knowledge of topological properties and classified topological spaces.

CO4: Student will use their understanding of separation axioms, metrizable spaces and countability axioms and solve problems on it.

CO6: Students will prove basic results of compactness and completeness within the structure.

PO 4: Research-related skills and Scientific temper:

CO 7: Students will apply mathematical concepts to further research and study of advanced subjects.

PO6: Personal and professional competence:

CO5: Students will demonstrate the ability to apply concepts of Metric space, Topological space and their role in mathematics.

CO7: Students will demonstrate the ability to work independently and solve various practical problems. This integrated approach prepares students for the challenges.

PO9: Self-directed and Life-long learning:

CO3: Students will demonstrate the ability to classified Topological spaces and solve practical problems.

CO7: Students will demonstrate the ability to apply topological concepts for advanced study which is helpful for self-improvement.

Class: M.Sc-I (Sem II) **Subject:** Mathematics
Course: Rings and Modules **Course Code:** PSMT123

Course Objectives:

1. To understand the structure of a ring and its basic properties.
2. To understand the properties such as associativity, distributivity, and the existence of an additive identity and additive inverse.
3. To study importance of rings as a fundamental object in algebra.
4. To understand the concepts of modules as a generalization of vector spaces.
5. To know the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains.
6. To explain integral domains and fields as special types of rings.
7. To investigate polynomial rings and their properties.

Course Outcomes:

1. Define a ring and recognize its fundamental properties, distinguishing it from other algebraic structure.
2. Understand the concept of ring homomorphisms, which are function preserves the ring structure.
3. Students will demonstrate a solid understanding of algebraic structures, particularly rings and modules.
4. To factor elements in a ring, including how to perform operations and factor polynomials within such rings.
5. Use the concept of ideals and how they relate to subrings, along with a deep knowledge of the quotient ring
6. Students will develop problem-solving skills by solving exercises and proving theorems related to rings and modules.
7. Know how to add and multiply polynomials over arbitrary fields, and be able to use this to define polynomial rings.

Mapping of Program Outcomes with Course Outcomes

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding the structure and basic properties of rings is fundamental in algebraic mathematics, providing a foundation for abstract algebra and its applications in various mathematical and scientific disciplines.

CO2: Understanding properties like associativity, distributivity, and the existence of additive identity and inverse is essential in mathematics as they form the basis for algebraic structures, underpinning various mathematical and scientific disciplines.

CO3: Studying the importance of rings as a fundamental algebraic object is crucial for a wide range of mathematical disciplines, as they serve as a cornerstone for abstract algebra and provide a versatile framework for solving mathematical problems and modeling various real-world phenomena..

CO4: Understanding modules as a generalization of vector spaces is essential in various mathematical and scientific disciplines, offering a more flexible framework for studying algebraic structures and linear transformations beyond vector spaces..

CO5: Knowing the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains is vital in algebra and number theory, providing insights into the structure and factorization properties of integers and polynomials, which have applications in various mathematical disciplines..

CO6: Explaining integral domains and fields as special types of rings is essential in algebra and mathematical disciplines, as they represent algebraic structures with crucial properties, including divisibility, enabling the study of numbers and algebraic systems..

CO7: Investigating polynomial rings and their properties is essential in algebra and mathematics, serving as a foundational tool for studying functions, algebraic geometry, and various mathematical and scientific disciplines.

PO2: Critical Thinking and Problem solving

CO1: Understanding the structure of a ring and its basic properties is critical for developing problem-solving skills in algebra, fostering the ability to analyze abstract mathematical structures and apply them to real-world problems.

CO2: Analyzing the algebraic structure of a problem can help identify the underlying relationships and operations, aiding in critical thinking and problem solving.
CO3: Studying rings is crucial in critical thinking and problem solving, as they provide a versatile and abstract framework for understanding various algebraic structures, enhancing one's problem-solving abilities across diverse mathematical contexts.
CO4: Understanding modules as a generalization of vector spaces enhances critical thinking and problem-solving skills by providing a broader framework for solving diverse mathematical and real-world problems.
CO5: Understanding the interrelationship between Euclidean domains, principal ideal domains, and unique factorization domains enhances critical thinking and problem-solving abilities by providing a foundational grasp of the structures underlying number theory and abstract algebra, facilitating more effective problem-solving in related domains.
CO6: Understanding integral domains and fields as specialized rings is essential for critical thinking and problem solving in abstract algebra, as it allows for more precise and efficient mathematical modeling and problem-solving in a variety of contexts.
CO7: Exploring polynomial rings enhances critical thinking and problem-solving skills by offering insight into algebraic structures, equipping individuals with tools to solve a wide range of mathematical problems and real-world applications.

PO5: Trans-disciplinary knowledge

CO1: Understanding the structure of a ring and its basic properties is essential in transdisciplinary knowledge because it provides a universal framework for studying diverse mathematical and real-world systems that exhibit similar algebraic behaviors.

CO3: The study of rings in algebra is essential for building a strong foundation that transcends various disciplines, enabling a deeper understanding of abstract structures, which can be applied to fields ranging from number theory to computer science and beyond.

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:

CO3: Understanding rings as a fundamental algebraic structure is essential for self-directed lifelong learning in algebra, providing a solid foundation for advanced mathematical concepts and problem-solving skills.

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

Course: Linear Algebra **Course Code:** PSMT124

Course Objectives:

1. To find Eigen values, eigenvectors, Jordan form and their applications.
2. Characterize linear transformations and express linear transforms in matrix equations.
3. Understand Diagonalization, Orthogonally, Adjoint operator and linear forms.
4. To introduce the concept of vectors in $\mathbb{R}$ and concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.
5. To introduced various applications of vectors in computer graphics and proof of basic results in linear algebra using appropriate proof-writing techniques.
6. This course unit aims to introduce the basic ideas and techniques of linear algebra for use in many other lecture courses.
7. Solve systems of linear equations using various methods including Gaussian and Gauss Jordan elimination and inverse matrices.

Course Outcomes:

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

CO1 Understand characteristic values of matrices, decomposition of matrices, operators, and forms on inner product spaces.

CO2 Explain the concept of linear transformation and study its applications.

CO3 Find eigenvalues, eigenvectors, minimal polynomial, diagonalizable matrix and Jordan canonical form.

CO4 Apply linear algebra concepts to model, solve, and analyze real-world situations.

CO5 To find an ordered basis for a finite dimensional vector space to represent the matrix of the linear operator in simple form and decompose the given vector space into a sum of its subspaces.

CO6 Find the null space of a matrix and represent it as the span of independent vectors.

CO7 Demonstrate understanding of inner products and associated norms solve some problems in economics, computer graphics and statistics using linear algebra.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Studying the characteristic values of matrices, decomposition of matrices, operators, and forms on inner product spaces is essential to gain a basic knowledge.
CO2: Capability of demonstrating comprehensive knowledge of basic concepts and ideas in mathematics and its subfields, and its applications to other disciplines.
CO3: Studenrts calculated eigen values and eigen vectors using the knowledge of operation on matrices and its properties.
CO4: Students will acquire the essential skill of utilizing concepts of linear algebra to solve problems related to the model and real-life problems, enhancing their disciplinary knowledge in mathematical and physical sciences.
CO5: This learning outcome ensures that students acquire the ability to solve the problems in terms of standard basis within their specific disciplinary knowledge area, facilitating their comprehension of fundamental mathematical concepts in their field of study.
CO6: This knowledge allows students to analyse and solve complex physical and mathematical problems by identifying the underlying governing equation, which is essential in various scientific and engineering disciplines.

PO2: Critical Thinking and Problem solving.

CO1: Understanding of characteristic values of matrices, decomposition of matrices, operators, and forms on inner product spaces. enhances students critical thinking and problem-solving skills by providing a basic knowledge of matrices.
CO2: Studying application of linear transformation and its properties developing a deeper understanding of fundamental properties towards transformation and its matrix form.
CO4: Applying linear algebra concepts to model, solve, and Analysing and evaluating proofs, arguments, and effectively develop judgment and decision making skills.
CO5: Teaching standard partial differential equations cultivates critical thinking and problem-solving skills in students by providing them with the knowledge and tools to tackle complex mathematical problems.
CO7: Students representing the problems of inner products and associated norms, including invoking appropriate context knowledge, and identifying objectives and initial conditions relevant to the problem improve problem solving skills.

PO3: Social competence

C04: Using concepts of linear algebra students should be solve various real-world challenges and use their knowledge towards the society or country.

PO4: Research-related skills and Scientific temper

CO2: Studying the linear transformation and its matrix form improve research-related skills and a scientific temper by cultivating a foundational understanding of mathematical transformation.
CO3: Students will develop research-related skills and a scientific temper by mastering the eigen value, Diagonalization of matrix and Jordan form enhancing their ability to tackle complex eigen value and rational form problems and fostering a deep understanding of the subject matter.
CO4: Using linear model and other properties students uses various transformation to solving recent research problems in various ways.

CO7 : Studying advanced concepts of linear algebra cultivates research-related skills and fosters a scientific temper by enabling students to classify and analyze Rational and Jordan canonical form.

PO5: Trans-disciplinary knowledge

CO1: Studying the decomposition of matrices, operators, and forms on inner product spaces. provides students with trans-disciplinary knowledge by fostering a deep understanding and it should be useful other subjects like functional analysis, Metric Spaces, etc.

CO2: Studying linear transformation fosters trans-disciplinary knowledge by providing students with a fundamental tool to model and analyze complex phenomena across various fields, from physics and engineering subjects.

CO5: Studying an ordered basis for a finite dimensional vector space to represent the matrix of the linear operator in simple form and decompose the given vector space into a sum of its subspaces by fostering an understanding of mathematical principles applicable across various fields.

PO9: Self-directed and life –long learning:

CO7: Students should be able to demonstrate understanding of inner products and associated norms solve some problems in economics, computer graphics and statistics using linear algebra and develop a foundational that underpin a wide range of real-world phenomena, enabling them to adapt and apply their knowledge effectively in diverse problem-solving contexts.

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

Course: Partial Differential Equation **Course Code:** PSMT125

Course Objectives:

1. To develop an understanding of numerical methods for partial differential equations.
2. To familiarize the students with first and higher order partial differential equations and their classification.
3. Students will learn the separation of variables method to solve linear parabolic, elliptic and hyperbolic partial differential equations.
4. Applications of partial differential equations in other subject and real world problems.
5. To apply problem solving using concepts & techniques from partial differential equations & Fourier analysis applied to diverse situations in physics, engineering, financial mathematics & in other mathematical context.
6. To introduce various applications of PDEs in many fields of science.

Course Outcomes:

1. Student will be able to understand the formation and solution pf PDE of first and second order.
2. Student will solve first order linear and non Linear PDE by using Charpit and Jacobi method.
3. Student will be able to understand the basic properties of standard PDE's
4. Student will be able to use PDE's to find solutions of wave equation and laplace equation.
5. Student will be able to understand how to solve the given standard partial differential equations.
6. Solve second-order linear PDEs using methods such as separation of variables, Fourier series, and eigen function expansions.
7. Understand and apply Green's functions in the context of solving linear PDEs.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Studying the formation and solution of first and second-order Partial Differential Equations (PDEs) is essential for students to gain a foundational understanding of mathematical tools that are widely applied across various disciplines, enabling them to analyze complex physical phenomena and make informed decisions in their respective fields.
CO2: Students will learn to solve first-order linear and nonlinear partial differential equations (PDEs) using Charpit's method for linear PDEs and Jacobi's method for nonlinear PDEs, enhancing their disciplinary knowledge in mathematical methods for PDE analysis..
CO3: Studying standard partial differential equations (PDEs) equips students with a fundamental understanding of the core properties and principles governing a wide range of natural phenomena, facilitating their grasp of disciplinary knowledge.
CO4: Students will acquire the essential skill of utilizing partial differential equations (PDEs) to solve problems related to the wave equation and Laplace's equation, enhancing their disciplinary knowledge in mathematical and physical sciences.
CO5: This learning outcome ensures that students acquire the ability to solve standard partial differential equations within their specific disciplinary knowledge area, facilitating their comprehension of fundamental mathematical concepts in their field of study.
CO6: This knowledge allows students to analyse and solve complex physical and mathematical problems by identifying the underlying governing equation, which is essential in various scientific and engineering disciplines.
CO7: Distinguishing between linear and nonlinear partial differential equations (PDEs) is crucial for understanding the fundamental behaviour of physical systems and mathematical modelling, facilitating more accurate problem-solving in various disciplines.

PO2: Critical Thinking and Problem solving

CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) enhances students' critical thinking and problem-solving skills by providing a foundational understanding of mathematical modeling and analytical methods applicable in various scientific and engineering disciplines.
CO2: Students will develop critical thinking and problem-solving skills by solving first-order linear and nonlinear partial differential equations using the Charpit and Jacobi methods.
CO3: Studying standard PDEs enhances critical thinking and problem-solving skills by providing a foundation to analyze and solve complex mathematical and physical problems in various fields, fostering a deeper understanding of fundamental properties and behaviors.
CO4: Studying partial differential equations (PDEs) equips students with the critical thinking and problem-solving skills necessary to analyze and solve complex physical problems, particularly in scenarios involving wave and Laplace equations, fostering a deeper understanding of mathematical and physical principles.
CO6: Students can identify the type of a second-order partial differential equation through critical thinking and problem-solving by analyzing its coefficients and characteristics to classify it as elliptic, parabolic, or hyperbolic.
CO7: Students should be able to distinguish between linear and nonlinear partial differential equations (PDEs) to develop critical thinking and problem-solving skills, as it enables them to apply appropriate mathematical techniques and strategies when addressing real-world problems with varying degrees of complexity.

PO3: Social competence
C04: Teaching students how to solve wave and Laplace equations through partial differential equations (PDEs) enhances their social competence by fostering problem-solving skills and critical thinking, which are transferable to various real-world challenges.

PO4: Research-related skills and Scientific temper
CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) fosters research-related skills and a scientific temper by cultivating a foundational understanding of mathematical modeling and problem-solving in various scientific disciplines.
CO2: Students will develop research-related skills and a scientific temper by mastering the Charpit and Jacobi methods to solve first-order linear and nonlinear partial differential equations, enhancing their ability to tackle complex mathematical problems and fostering a deep understanding of the subject matter.
CO6 : Studying second order partial differential equations (PDEs) cultivates research-related skills and fosters a scientific temper by enabling students to classify and analyze PDEs, a fundamental tool in various scientific disciplines..

PO5: Trans-disciplinary knowledge

CO1: Studying the formation and solution of first and second-order partial differential equations (PDEs) provides students with trans-disciplinary knowledge by fostering a deep understanding of mathematical modeling and its applications across various fields, from physics and engineering to economics and biology.

CO5: Studying standard partial differential equations fosters trans-disciplinary knowledge by providing students with a fundamental tool to model and analyze complex phenomena across various fields, from physics and engineering to economics and biology.
CO6: Studying second-order partial differential equations (PDEs) equips students with the ability to discern the PDE's type and promotes trans-disciplinary knowledge by fostering an understanding of mathematical principles applicable across various fields.

PO7: Effective Citizenship and Ethics

CO7: Students should be able to distinguish between linear and nonlinear PDEs in self-directed and life-long learning to understand the fundamental classification that dictates the behavior and solutions of partial differential equations, enabling them to apply appropriate methods and techniques in various fields throughout their educational and professional journeys.

PO8 :Envionment and Sustainability :
CO4: Students will use PDEs to address environmental and sustainability challenges by modeling wave propagation and spatial distribution in the context of the wave equation and Laplace equation, enabling informed decision-making for sustainable practices.

PO9: Self-directed and life –long learning:

CO4: Mastering PDEs for wave and Laplace equations fosters self-directed and life-long learning by equipping students with essential problem-solving skills for diverse real-world applications in physics, engineering, and beyond.

CO7: Students should be able to distinguish between linear and nonlinear PDEs in self-directed and life-long learning to develop a foundational understanding of mathematical models that underpin a wide range of real-world phenomena, enabling them to adapt and apply their knowledge effectively in diverse problem-solving contexts.

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

Course: Practical programming in C++ **Course Code:** PSMT126

Course Objectives:

1. To understand basic programming in C++.
2. To study mathematics using programming and the basic syntax of c++.
3. Understand the OOP principles, objects, inheritance and polymorphism.
4. Understand the proficiency in using pointers and references to work.
5. To develop and understand the representation of numbers in c++.
6. Solve a specific problem or perform a task efficiently using C++.
7. Break the program into smaller, functions for easier maintenance and understanding.

Course Objectives:

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

CO1: Describe and use constructors and destructors
CO2: Use fundamentals of Cprogramming to implement algorithms In mathematics.
CO3: Develop a C ++ program.
CO4: Exploring C++ programming.
CO5: Managing input and output operations.
CO6: Understand the basics of file handling mechanisms.
CO7: Solve repetitive work using C++ programming.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Using C++ programming fundamentals to implement mathematical algorithms enables efficient and precise numerical computations, facilitating solutions to complex mathematical problems in various disciplines.
CO3: Develop a C++ program to enhance disciplinary knowledge and practical skills in software development and problem-solving.
CO4: Exploring C++ programming enhances disciplinary knowledge by providing a strong foundation in a versatile and widely used programming language, enabling problem-solving and software development skills across various domains.
CO5: Managing input and output operations is essential for efficient data communication and storage, ensuring proper handling of information in various computing and data-driven systems.
CO6: Understanding file handling mechanisms is crucial for effective data management and ensures compliance with data integrity and security protocols in various disciplinary domains.
CO7: C++ programming enables automation and efficiency by eliminating manual, repetitive tasks through its powerful and versatile features.

PO2: Critical Thinking and Problem solving

CO2: Using C programming fundamentals to implement mathematical algorithms enhances critical thinking and problem-solving skills by applying logic and abstraction to solve complex mathematical problems efficiently.
CO3: Developing a C++ program fosters critical thinking and problem-solving skills by requiring logical analysis, algorithmic design, and troubleshooting to create efficient and functional software solutions.
CO4: Exploring C++ programming enhances critical thinking and problem-solving skills by fostering logical and structured thinking in solving complex programming challenges.
CO5: Managing input and output operations is essential for critical thinking and problem solving as it ensures data accessibility and enables the analysis and manipulation of information, a fundamental aspect of effective decision-making and creative problem-solving.
CO6: Understanding file handling mechanisms is critical for critical thinking and problem-solving as it enables efficient data management, troubleshooting, and the development of creative solutions for various technical challenges.
CO7: C++ programming automates repetitive tasks, enhancing critical thinking by allowing developers to focus on solving unique challenges rather than manual, redundant operations.

PO3: Social competence

C07: Using C++ programming to automate repetitive tasks enhances social competence by freeing up time for meaningful interactions and collaboration with others.

PO4: Research-related skills and Scientific temper

CO3: Developing a C++ program enhances research-related skills and promotes a scientific temper by fostering critical thinking, problem-solving, and structured experimentation in software development.

CO4: Exploring C++ programming fosters research-related skills and a scientific temper by promoting problem-solving, critical thinking, and a systematic approach to software development.
CO7 : C++ programming automates repetitive tasks, enhancing research-related skills and fostering a scientific temper by streamlining data analysis and experimentation.

PO5: Trans-disciplinary knowledge
CO3: Developing a C++ program promotes trans-disciplinary knowledge by enhancing problem-solving skills and facilitating collaboration across diverse fields through the application of programming in various domains.

PO7: Effective Citizenship and Ethics

CO6: Understanding the basics of file handling mechanisms promotes responsible and ethical digital citizenship by enabling users to manage and share information securely and ethically.

PO8 : Envionment and Sustainability :

CO7: C++ programming can automate repetitive tasks, reducing manual effort and promoting environmental sustainability by optimizing resource utilization and minimizing errors.

PO9: Self-directed and life –long learning :

CO3: Developing a C++ program fosters self-directed and lifelong learning by enhancing problem-solving skills, programming proficiency, and adaptability in a rapidly evolving technological landscape.
CO4: Exploring C++ programming promotes self-directed and lifelong learning by fostering continuous skill development and adaptability in the ever-evolving field of computer science.

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