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
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. Mathematics

(2022 Pattern)

(With the effect from Academic Year 2023-24)

Name of the Programme	**: M.Sc. (Mathematics)**
Program Code	**: PSMT**
Class	**: M.Sc. Part-II**
Semester	**: III**
Course Name	**: Combinatorics**
Course Code	**: PSMT231**
No. of lectures	**: 64**
No. of Credits	**: 4**

A) Course Objectives:

1. To introduce generating function models.
2. To solve recurrence relations.
3. To study inclusion/exclusion principle.
4. To understand Pigeonhole principle and counting techniques.
5. To provide students with a strong foundation in basic counting principles, permutations, combinations, and other fundamental concepts in Combinatorics.
6. To develop students' ability to solve a wide range of combinatorial problems using different methods and approaches.
7. Enable students to recognize and analyze different combinatorial structures, such as permutations and combinations.

B) Course Outcomes:

By the end of the course,

CO1. Student will be able to solve counting problems.

CO2. Student will be able to use generating function to simplify recurrence relation.

CO3. Students will apply combinatorial principles and techniques to solve counting problems.

CO4. Students will be able to solve linear recurrence relation.

CO5. Students will be able to compute a generating function and apply it to solve combinatorial problems.

CO6. Students will understand the fundamental counting principles like the rule of product, rule of sum, permutations, and combinations.

CO7. Student will learn how to calculate the number of ways to arrange or select elements from a set, with or without replacement.

TOPICS/CONTENT

Unit 1: General Counting Methods for Arrangements and Selections **[18 Lectures]**

1.1 Two basic counting principles
1.2 Simple Arrangement and Selections
1.3 Arrangements and Selections with Repetitions
1.4 Distributions
1.5 Binomial Identities

Unit 2: Generating Functions **[18 Lectures]**

2.1 Generating function models
2.2 Calculating coefficients of generating functions
2.3 Partitions
2.4 Exponential generating function
2.5 A Summation method

Unit 3: Recurrence Relations **[16 Lectures]**

3.1 Recurrence relation models
3.2 Divide and conquer relations
3.3 Solutions of linear Recurrence relations

Unit 4: Inclusion-Exclusion **[12 Lectures]**

4.1 Counting with Venn diagrams
4.2 Inclusion-Exclusion Formula
4.3 Restricted Positions and Rook polynomials

<u>Text Book:</u>

AlanTucker, "*Applied Combinations FourthEdition*". (JohnWileyandSons, Inc).

Unit 1 – Sections 5.1 to 5.5
Unit 2 – Sections 6.1 to 6.5
Unit 3 – Sections 7.1 to 7.5
Unit 4 – Sections 8.1 to 8.3

<u>Reference Books:</u>

1. V.K. Balkrishnan: Schaum's outline series, Theory and Problems of Combinations (MsGraw Hill).
2. K.D. Joshi: Foundations of Discrete Mathematics (Wiley Eastern Limited).
3. Marshal Hall Jr.: Combinatorial Theory, Second Edition (Wiley Inter science Publications).

	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					
CO 2		2			1				
CO 3		1		2					

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Mastering counting techniques in disciplinary knowledge enhances problem-solving abilities, pivotal in various quantitative analyses within the field.

CO4: Proficiency in solving linear recurrence relations within disciplinary knowledge enhances the understanding of iterative processes crucial in diverse mathematical and computational applications.

CO5: Understanding and applying generating functions in disciplinary knowledge facilitates advanced problem-solving techniques essential for tackling complex combinatorial problems in various mathematical and scientific domains.

CO7: Mastering permutations and combinations within disciplinary knowledge enables precise calculations essential in various mathematical analyses and modeling within the discipline.

PO2: Critical Thinking and Problem solving

CO2: Utilizing generating functions to simplify recurrence relations nurtures critical thinking by establishing a structured approach to analyze and solve complex iterative problems efficiently.

CO3: Applying combinatorial principles for counting problems enhances problem-solving skills by providing systematic approaches applicable across diverse problem domains.

CO6: Mastering fundamental counting principles cultivates critical thinking by enabling the strategic application of diverse mathematical techniques to analyze and solve varied problems systematically.

CO7: Understanding arrangements and selections within sets, with or without replacement, equips students with problem-solving skills essential for diverse mathematical analyses and practical problem-solving scenarios.

PO4: Research-related skills and Scientific temper

CO1: Solving counting problems develops research-related skills by fostering precision, logical reasoning, and systematic approaches to problem-solving in diverse fields of inquiry.

CO3: Applying combinatorial principles fosters scientific temper by instilling rigorous methods and logical approaches to problem-solving, essential across scientific disciplines for precise analysis and inference.

CO5: Computing generating functions to solve combinatorial problems enhances research-related skills by enabling sophisticated problem abstraction and innovative problem-solving approaches across diverse fields of study.

CO6: Understanding fundamental counting principles cultivates research skills by providing a foundational framework for systematic problem-solving and precise analysis in various research domains.

PO5: Trans-disciplinary knowledge

CO2: Utilizing generating functions to simplify recurrence relations enhances trans-disciplinary knowledge by providing a powerful, abstract tool applicable across diverse fields for problem-solving and pattern recognition.

CO5: Mastering generating functions for combinatorial problem-solving fosters trans-disciplinary knowledge by offering a versatile mathematical tool applicable across diverse fields for complex problem analysis and solution derivation.

CO6: Understanding fundamental counting principles cultivates trans-disciplinary knowledge by providing a universal framework for systematic problem-solving applicable across diverse fields and disciplines.

PO9: Self-directed and Life-long learning:

CO4: Mastering linear recurrence relations fosters lifelong learning by establishing a foundational understanding essential for continuous adaptation and problem-solving in various fields and evolving disciplines.

CO5: Learning to compute generating functions for combinatorial problem-solving nurtures lifelong learning by enabling adaptable problem-solving skills applicable across diverse fields and continual learning environments.

CO7: Understanding arrangements and selections within sets, with or without replacement, supports lifelong learning by providing foundational problem-solving skills adaptable to evolving contexts and continual learning endeavors.

Name of the Programme **: M.Sc. (Mathematics)**

Program Code **: PSMT**

Class **: M.Sc. Part-II**

Semester **: III**

Course Name **: Field Theory**

Course Code **: PSMT232**

No. of lectures **: 64**

No. of Credits **: 4**

Course Objectives:

1. To introduce algebraic extensions.
2. To study separable and inseparable extensions.
3. To construct Galois group for different Galois extensions.
4. To relate geometric constructions with algebraic extensions.
5. To make students familiar with basic properties and techniques of finite fields and their application to coding theory.
6. To understand solvability and insolvability of polynomials by radicals.
7. To understand structure of Galois group and its relation to lattice of subfields of fields.

Course Outcomes:

CO1. Student will be able to explain field extension.
CO2. Student will be able to recognize Galois extension.
CO3. Students will be manipulate expressions involving algebraic and transcendental elements.
CO4. Students will be understand fundamental concepts of field extensions and Galois theory and their role in modern mathematics and applied contexts.
CO5. Students will be able to produce examples and counterexamples using the concepts in the course.
CO6. Students will be able to handle Galois group abstractly by using fundamental theorem of Galois theory.
CO7. Students will be able to construct finite fields.

TOPICS/CONTENT

Unit 1: Field Extensions **[32 Lectures]**

1.1 Basic Theory of Field Extensions
1.2 Algebraic Extensions
1.3 Compass construction
1.4 Splitting Fields and Algebraic Closures
1.5 Separable and Inseparable Extensions
1.6 Cyclotomic Polynomials and Extensions

Unit 2: Galois Theory **[32 Lectures]**

2.1 Basic Definitions
2.2 The Fundamental Theorem of Galois Theory
2.3 Finite Fields
2.4 Composite Extensions and Simple Extensions
2.5 Galois Groups of Polynomials
2.6 Solvable and Radical Extensions: Insolvability of the Quintic.

Text Book:

Dummit and Foote,*"AbstractAlgebra"*,2ndEdition,Wiley EasternLtd.

Unit 1 – Sections 13.1 to 13.6
Unit 2 – Sections 14.1 to 14.4, 14.6, 14.7(statement)

Reference Book:

1. O.ZariskiandP.Sammuel,CommutativeAlgebra,Vol.1,VanNostrand.
2. P.BhattacharyaandS.Jain,Basic AbstractAlgebra,SecondEdition.
3. I. S. Luthar and I. B. S. Passi, Algebra Vol. 4: Field Theory, Narosa.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Students will elucidate field extensions by exploring the expansion of mathematical structures within their disciplinary knowledge.
CO2: Students will identify Galois extensions as specific field extensions possessing symmetrical properties within their disciplinary knowledge.
CO3: Students will proficiently handle expressions integrating algebraic and transcendental elements within their disciplinary knowledge.
CO5: Students will adeptly generate both illustrative instances and counterarguments employing the course concepts within their disciplinary domain.
CO6: Students will effectively manipulate Galois groups abstractly, employing the fundamental theorem of Galois theory within their disciplinary expertise.

PO2: Critical Thinking and Problem solving

CO1: Students will critically articulate field extensions by assessing their implications and applications in diverse contexts.
CO2: Students will adeptly identify Galois extensions in problem-solving scenarios, showcasing analytical skills within their discipline.
CO4: Students will critically comprehend the pivotal role of field extensions and Galois theory in modern mathematics and applied contexts, fostering analytical insights and perspectives.
CO7: Students will skillfully construct finite fields, applying critical thinking to discern their properties and applications within diverse contexts.

PO4: Research-related skills and Scientific temper
CO1: Students will demonstrate research skills by elucidating field extensions, showcasing comprehension and application in scholarly investigations.
CO2: Students will demonstrate research skills by identifying Galois extensions, showcasing their ability to navigate advanced mathematical concepts in scholarly pursuits.
Co4: Students will leverage scientific temper to grasp the fundamental concepts of field extensions and Galois theory, recognizing their significance in modern mathematics and applied contexts.
CO6: Students will adeptly manipulate Galois groups abstractly, employing the fundamental theorem of Galois theory with advanced research skills.

PO5: Trans-disciplinary knowledge
CO2: Students will adeptly identify Galois extensions across various disciplines, showcasing their interdisciplinary understanding and application.
CO5: Students will proficiently generate diverse examples and counterarguments utilizing course concepts, demonstrating interdisciplinary applicability.

PO9: Self-directed and Life-long learning:
CO1: Students will continuously learn to articulate field extensions, fostering ongoing comprehension and knowledge expansion throughout their learning journey.
CO7: Students will consistently engage in constructing finite fields, fostering continual learning and exploration in their lifelong educational pursuit.

Name of the Programme	**: M.Sc. (Mathematics)**
Program Code	**: PSMT**
Class	**: M.Sc. Part-II**
Semester	**: III**
Course Name	**: Functional Analysis**
Course Code	**: PSMT233**
No. of lectures	**: 64**
No. of Credits	**: 4**

Course Objectives:

1. To introduce Banach space and operators on Banach space.
2. To study compact operators on normed space.
3. To introduce Hilbert space and operators on Hilbert space
4. Define and study Banach spaces, which are complete normed vector spaces.
5. Explore fundamental examples of Banach spaces.
6. Introduce Hilbert spaces and inner product spaces.
7. Study properties of Hilbert spaces, including completeness and orthogonality.

Course Objectives:

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

CO1. Students should demonstrate a thorough understanding of fundamental in functional analysis.

CO2. Students should demonstrate proficiency in working with Banach and Hilbert spaces, understanding their structures, properties, and significance in mathematical analysis.

CO3. Students should be familiar with spectral theory, including eigenvalues, eigenvectors, and the spectral theorem .

CO4. Students should be able to apply these concepts to various types of operators.

CO5. Students should comprehend the concept of dual spaces and weak topologies.

CO6. Student should able to work with dual spaces in the context of functional analysis.

CO7. Student will be able to discuss and explain compactness of an operator on normed space.

TOPICS/CONTENT

Unit 1: Banach space **[26 Lectures]**

1.1 The definitions and some Examples
1.2 Continuous Linear Transformations
1.3 The Hahn-Banach theorem.
1.4 The natural Embedding of N in N^{**}

1.5 Closed Graph and open Mapping theorems
1.6 The Conjugate of an operator

Unit 2: Hilbert space **[28 Lectures]**

2.1 The definition and some simple properties
2.2 Orthogonal complements
2.3 Orthonormal sets
2.4 The conjugate space H^*
2.5 The adjoint of an operator
2.6 Self adjoint operators
2.7 Normal and Unitary operators, Projections
2.8 Weak and Weak* convergence

Unit 3: Finite Dimensional Spectral Theory **[10 Lectures]**

3.1 Matrices
3.2 Determinants
3.3 The spectrum of an operator
3.4 The Spectral theory

Text Book:

G. F. Simmons, "Introduction to Topology and Modern Analysis".

Reference Book:

1. B. V. Limaye, Functional Analysis, Wiley Eastern Ltd.
2. Bachman and Narici, Functional Analysis, Narosa Publishing House, India.
3. John B. Conway, Introduction to Functional Analysis, Springer.
4. W. Rudin, Functional Analysis, Tata McGraw Hill Edition.
5. Anant R. Shastri, Basic Complex Analysis of One Variable, Macmillan publishers India, 2010.

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

Justification for the mapping

PO1: Disciplinary Knowledge:
CO2: Proficiency in working with Banach and Hilbert spaces is essential for students in mathematical analysis as these spaces provide fundamental frameworks for the rigorous study of functions, sequences, and operators. Mastery of their structures and properties equips students with the necessary tools to analyse and solve complex mathematical problems, facilitating a deeper understanding of functional analysis and its applications in various branches of mathematics and science.
CO4: The application of concepts to various types of operators in disciplinary knowledge fosters a versatile and comprehensive understanding, enabling students to adapt and excel in diverse problem-solving scenarios, thus promoting a well-rounded and adaptable skill set.
CO7: Understanding the compactness of an operator in a normed space is crucial for students as it provides a concise yet powerful tool for analysing the behaviour and properties of operators in functional analysis, facilitating the study of convergence and existence of solutions in various mathematical contexts.

PO2: Critical Thinking and Problem solving

CO1: Critical thinking and problem-solving skills in functional analysis enable students to analyse abstract mathematical structures, formulate rigorous proofs, and apply advanced concepts, fostering a deep comprehension of foundational principles in this branch of mathematics.
CO3: Familiarity with spectral theory, encompassing eigenvalues, eigenvectors, and the spectral theorem, enhances critical thinking and problem-solving skills by providing a fundamental framework for analysing linear operators and systems, enabling students to deduce structural properties and solve diverse mathematical problems across disciplines.
CO6: Working with dual spaces in functional analysis enhances critical thinking and problem-solving skills by enabling students to navigate the intricacies of dual pairings, duality theorems, and the interplay between linear functionals and their underlying spaces, fostering a deeper understanding of abstract mathematical structures and their applications.

PO3: Social competence
CO4: Applying functional analysis concepts to various types of operators cultivates social competence by fostering collaborative problem-solving skills, as students engage in group discussions, share diverse perspectives, and collectively explore the applications of abstract mathematical principles in real-world contexts.
CO7: Discussing and explaining the compactness of an operator in a normed space in the context of social competence fosters effective communication and collaboration by promoting the ability to convey complex mathematical concepts in a clear and accessible manner, facilitating interdisciplinary dialogue and cooperation.

PO4: Research-related skills and Scientific temper
CO2: Proficiency in working with Banach and Hilbert spaces demonstrates strong research-related skills and scientific temper by equipping students with the analytical tools needed for advanced mathematical investigations, fostering a rigorous and systematic approach to problem-solving and theoretical exploration in various scientific disciplines.

PO7: Effective Citizenship and Ethics:

CO7: Understanding and explaining the compactness of an operator in a normed space in the context of effective citizenship and ethics promotes mathematical literacy, enabling individuals to engage responsibly in discussions and decision-making processes related to societal challenges that involve quantitative reasoning and analysis.

PO9: Self-directed and life –long learning:

CO3: Familiarity with spectral theory, encompassing eigen values, eigenvectors, and the spectral theorem, enhances self-directed and lifelong learning by providing students with foundational tools for continuous intellectual development, encouraging exploration of advanced mathematical concepts, and facilitating independent study in diverse academic and professional pursuits.

Name of the Programme	**: M.Sc. (Mathematics)**
Program Code	**: PSMT**
Class	**: M.Sc. Part-II**
Semester	**: III**
Course Name	**: Integral Equation**
Course Code	**: PSMT234**
No. of lectures	**: 64**
No. of Credits	**: 4**

A) Learning Objectives

1. To introduce various types of kernel in integrals transforms.
2. To solve linear and non-linear integral equations by different methods.
3. To study relationship between integral and differential equation.
4. To Categorise and solve different integral equations using various techniques.
5. Study various types of integral equations, including Fredholm and Volterra equations.
6. Analyze the properties and solutions of different integral equations.
7. Learn analytical and numerical methods for solving integral equations.

B) Learning Outcomes

CO1 Student will be able to learn and analyzed the concepts of Fredholm integral equation and Volterra integral equation.

CO2 Student will be able to identify different types of kernels and evaluate the problems based on various integral transforms.

CO3 Students should be able to demonstrate a comprehensive understanding of integral equations, particularly Volterra and Fredholm integral equations, including their definitions, classifications, and properties.

CO4 Familiarity with numerical methods for solving integral equations, including the use of computational tools and software for approximation and simulation.

CO5 To develop proficiency in applying integral equations to model and solve real-world problems from various disciplines, such as physics, and engineering.

CO6 To Understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.

CO7 To compare the differences between Volterra and Fredholm integral equation.

TOPICS/CONTENT

Unit 1: Introductory Concepts **[18 Lectures]**

1.1 Definitions
1.2 Classification of Linear Integral Equations
1.3 Solution of an Integral Equation
1.4 Converting Volterra Equation to ODE

1.5 Converting IVP to Volterra Equation
1.6 Converting BVP to Fredholm Equation

Unit 2:Fredholm Integral Equations **[18 Lectures]**

2.1 Introduction
2.2 The Decomposition Method
2.3 The Direct Computation Method
2.4 The Successive Approximation Method
2.5 The Method of Successive Substitutions
2.6 Comparison between Alternative Methods
2.7 Homogeneous Fredholm Equations

Unit 3: Volterra Integral Equations **[18 Lectures]**

3.1 Introduction
3.2 The Decomposition Method
3.3 The Series Solution Method
3.4 Converting Volterra Equation to IVP
3.5The Successive Approximation Method
3.6 Volterra Equation of the First Kind

Unit 4: Integro-Differential Equations **[10 Lectures]**

4.1 Introduction
4.2 Fredholm Integro-Differential Equations
4.3 Volterra Integro-Differential Equations

Text Book:

Abul-Majid Wazwaz, *"A First Course in Integral Equations-second edition*", World Scientific Publications.

Unit 1 – Chapter 1
Unit 2 – Chapter 2
Unit 3 – Chapter 3
Unit 4 – Chapter 4

Reference Books:

1. R.P. Kanwal, "Linear Integral Equation Theory and Techniques", Academic Press, New York, 1971.
2. Shanti Swarup, Integral Equations, Krishna Prakashan Media (p) Ltd. 1997.

	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							
CO 3	3								
CO 4			2						

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding the fundamentals is an important to achieving knowledge and the ability to apply it to problem-solving.

CO2: To achieve the learning objective of enabling students to analyze the type of kernela and apply for calculating iterated or degenerated kernel within disciplinary knowledge,

CO3: A solid understanding of integrals representations serves as a foundation for more advanced topics in related disciplines.

CO5: Knowledge of various formation of integral equations contribute meaningfully to to solution of real-world problems.

CO6: In disciplines related to reduce Initial value problems associated with linear differential equations to various integral contributing to improved operational performance.

CO7: Integral equation is versatile and applicable across diverse disciplines. Students applying various integral concepts to solve problems in various domains develop interdisciplinary problem-solving skills.

PO2: Critical Thinking and Problem solving

CO2: Studying different types of integral equations directly contributes to critical thinking skills in evaluating solution methods.

CO5: Disciplines often encounter problems that can be model and solve real-world problems from various disciplines, such as physics, and engineering.

CO7: Many real-world problems involve interconnected systems and relationships, making integral equationwith highly relevant. Students can see the direct application of their critical thinking skills to solve problems in areas such as integro differential equations, differential equation, and integral transforms.

PO3: Social competence:

CO4: Recognizing that problems including the use of computational tools and softwarecan be represented in multiple ways encourages students to think flexibly.

CO5: Applying distinct types of integral equations to real-world problems requires students to critically analyze scenarios and determine the most appropriate approach. They develop the capacity to evaluate the intricacies of different situations, considering multiple factors before applying different forms either in differential or in integral.

PO4: Research-related skills and Scientific temper:

CO7: Comparison of the differences between Volterra and Fredholm integral equationvaluable in research, where identifying types can lead to the formulation and the generation of new knowledge.

PO5: Trans-disciplinary knowledge

Integrating transdisciplinary knowledge into an Integral Equations course enriches the learning experience, equipping students with the skills and perspectives needed to excel in a rapidly changing and interconnected world.

CO5: Analyzing integral equation with distinct kernels equips students with a foundational skill set applicable across disciplines, fostering a trans-disciplinary perspective. Integral equations find applications in various disciplines, including physics, engineering, biology, economics, and more. Transdisciplinary knowledge allows students to explore how integral equations are used in different fields, providing a more comprehensive understanding of their relevance.

CO6: Real-world problems often require an interdisciplinary approach. Transdisciplinary knowledge equips students with the ability to apply integral equations to solve complex problems that span multiple disciplines.

CO7: Exposure to transdisciplinary knowledge stimulates creativity and innovation. Students can draw inspiration from different fields to develop novel approaches to solving problems related to integral equations.

PO 7 : Effective Citizenship and Ethics:

CO5: Understanding the broader implications of using integral equations in different contexts helps students make informed decisions and promotes a sense of social responsibility.

PO9:Self-directed and Life-long learning

CO6: Application of integral equation into interdisciplinary subjects promotes a mindset of continuous learning. Students equipped with a diverse skill set and knowledge base are better prepared to adapt to evolving challenges and advancements in integral equations and related fields throughout their careers.

Name of the Programme **: M.Sc. (Mathematics)**

Program Code **: PSMT**

Class **: M.Sc. Part-II**

Semester **: III**

Course Name **: Astronomy**

Course Code **: PSMT235 (A)**

No. of lectures **: 64**

No. of Credits **: 4**

Learning Objectives:

1. To measure spherical angles to the nearest degree.
2. To discover facts about spherical triangles.
3. To learn about great circle, geodesic, spherical triangle.
4. To identify corresponding intersecting planes to a given spherical triangle.
5. To understand the different coordinated systems to locate the celestial object in space.
6. To understand phases of moon.
7. To explore motion of sun and moon.

Course outcomes:

CO1: Students will understand the importance of the mother planet and its atmosphere.

CO2: Student will be understand Earth moon system.

CO3: Students will be able to discover facts about spherical triangles.

CO4: Students well be able to understand Kepler's law of planetary motion.

CO5: Student will be able to know effect of the aberration in celestial objects.

CO6: Student will understand the phenomenon of parallax in the celestial objects.

CO7: Students will be able to calculate the arc length between two points on a sphere using the cosine rule for sides.

TOPICS/CONTENT

Unit 1: Spherical Trigonometry **[6 Lectures]**

1.1 Definitions

1.2 Fundamental Formulae

Unit 2: Right Angle Triangles **[18 Lectures]**

Unit 3: Spherical Astronomy **[22 Lectures]**

3.1 Cellestial Sphere
3.2 Coordinate Systems
3.3 Rising and Setting of Stars
3.4 Rate of Change of Zenith and Azimuth
3.5 Motion of Sun
3.6 Twilight
3.7 Dip of Horizon

Unit 4: Refraction **[18 Lectures]**

<u>Text Book:</u>

Spherical Astronomy by M. L. Khanna-Published by Jai Prakash Nath and Company Meerut(U.P).

Unit 1 – Chpater 1
Unit 2 – Chapter 2
Unit 3 – Chpater 3
Unit 4 – Chapter 4

<u>Reference Book:</u>

1. Spherical Astronomy by Karr.

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

Justification for the mapping

PO1: Disciplinary Knowledge:

CO1: Disciplinary Knowledge: Understanding the importance of the mother planet and its atmosphere is essential for fostering environmental literacy and promoting sustainable practices, aligning with the interdisciplinary nature of ecological sciences and Earth systems studies..

CO2: Understanding the Earth-moon system is crucial in disciplinary knowledge as it provides insights into celestial mechanics, gravitational interactions, and planetary formation, fostering a comprehensive grasp of fundamental principles in astronomy and astrophysics.

CO4: Understanding Kepler's laws of planetary motion is crucial in disciplinary knowledge as it provides fundamental insights into the mathematical relationships governing the orbital motion of celestial bodies, contributing to the foundation of classical celestial mechanics and advancing our comprehension of planetary dynamics.
CO5: Disciplinary Knowledge: Understanding the effect of aberration in celestial objects enables students to comprehend the impact of optical distortions on observational data, enhancing their proficiency in astrophysics and observational astronomy.
CO7: Disciplinary Knowledge Justification: The application of the cosine rule for sides in spherical geometry facilitates accurate determination of arc length between two points on a sphere, essential for precise measurements and calculations in fields such as geodesy, astronomy, and navigation.

PO2: Critical Thinking and Problem solving
CO1: Critical Thinking and Problem Solving Justification: Recognizing the significance of Earth and its atmosphere fosters critical thinking by encouraging students to analyze environmental challenges, propose sustainable solutions, and engage in problem-solving to address complex issues such as climate change and ecosystem preservation.
CO3: Critical Thinking and Problem Solving Justification: Exploring facts about spherical triangles enhances students' analytical skills by requiring them to navigate the complexities of three-dimensional geometry, fostering a deeper understanding of spatial relationships and encouraging strategic problem-solving in various real-world contexts.
CO6: Critical Thinking and Problem Solving Justification: Exploring the phenomenon of parallax in celestial objects cultivates students' analytical skills by prompting them to assess the changing perspectives from different vantage points, fostering a deeper understanding of spatial relationships in astronomy and enhancing problem-solving abilities in celestial observations.

PO3: Social competence
CO4: "Understanding Kepler's laws of planetary motion fosters social competence by promoting scientific literacy and critical thinking, enabling students to engage in informed discussions about the natural world and its impact on society."
CO7: "Collaborating with peers to calculate arc length on a sphere using the cosine rule fosters a supportive learning environment, promoting teamwork and effective communication in mastering mathematical concepts."

PO4: Research-related skills and Scientific temper
CO2: Research-related skills and scientific temper enable students to comprehend the intricacies of the Earth-Moon system by fostering critical thinking, evidence-based inquiry, and a rigorous approach to analysing celestial phenomena.
CO7: "Mastering the calculation of arc length on a sphere using the cosine rule for sides enhances students' research-related skills and scientific temper by fostering a deeper understanding of geometric principles and promoting analytical thinking in spatial applications."

PO7:Effective Citizenship and Ethics:
CO7: Mastering the calculation of arc length on a sphere through the cosine rule for sides cultivates effective citizenship and ethics by promoting mathematical literacy, analytical

problem-solving, and an understanding of precision essential for informed decision-making in various civic and ethical contexts.

PO8: Environment and Sustainability:

CO3: Understanding spherical triangles equips students with the geometric knowledge necessary for comprehending Earth's curved surface, facilitating a holistic understanding of environmental and sustainability issues through spatial reasoning, enabling informed decision-making for responsible and ecologically conscious actions.

CO7: Proficiency in calculating the arc length on a sphere using the cosine rule for sides contributes to environmental and sustainability awareness by empowering students with the mathematical tools needed for precise measurements in geospatial analysis, aiding in the understanding and monitoring of Earth's features crucial for sustainable environmental practices and resource management.

PO9: Self-directed and life –long learning:

CO3: Acquiring the ability to discover facts about spherical triangles fosters self-directed and life-long learning by instilling curiosity, research skills, and the capacity for independent exploration, essential for continuous personal and intellectual development beyond formal educational settings.

Name of the Programme	**: M.Sc. (Mathematics)**
Program Code	**: PSMT**
Class	**: M.Sc. Part-II**
Semester	**: III**
Course Name	**: Graph Theory**
Course Code	**: PSMT235 (B)**
No. of lectures	**: 64**
No. of Credits	**: 4**

Course Objectives:

1. Define basic graph terminology, including vertices, edges, loops, and simple graphs..
2. Explore various ways to represent graphs, including adjacency matrices and adjacency lists.
3. Study concepts of connected graphs, components, and isolated vertices.
4. Introduce the concept of planar graphs and their properties.
5. Study graph coloring, including vertex coloring and edge coloring.
6. Discuss applications of graph coloring, such as map coloring.

Course Outcomes:

CO1. Students will demonstrate a solid understanding of fundamental graph theory concepts, including vertices, edges, and adjacency, connectivity, and graph representations.

CO2. Students will be able to analyze the properties of graphs, including connectedness, cycles, and paths, and apply graph algorithms for traversal and analysis.

CO3. Students will be able to choose appropriate graph representations for different scenarios.

CO4. Students will demonstrate an understanding of planar graphs, Euler's formula, and graph coloring, and be able to apply these concepts to solve related problems.

CO5. Students will develop the ability to design and implement graph algorithms, such as depth-first search, breadth-first search, Dijkstra's algorithm, and Kruskal's algorithm.

CO6. Students will apply graph coloring concepts to solve real-world problems, such as scheduling, map coloring, and resource allocation.

CO7. Students will develop critical thinking skills by applying graph theory concepts to analyze and solve complex problems in various domains.

TOPICS/CONTENT

Unit 1: Introduction **[4 Lectures]**

1.1 Definitions

1.2 Examples

1.3 Three puzzles

Unit 2: Paths and cycles **[10 Lectures]**

2.1 Connectivity

2.2 Eulerian graphs

2.3 Hamiltonian graphs

2.4 Some algorithms

Unit 3: Trees **[10 Lectures]**

3.1 Properties of trees

3.2 Counting trees

3.3 More applications

Unit 4: Planarity **[12 Lectures]**

4.1Planar graphs

4.2 Euler's formula

4.3 Graphs on other surfaces

4.4 Dual graphs

4.5 Infinite graphs

Unit 5: Coloring graphs **[12 Lectures]**

5.1 **C**oloring vertices

5.2 Brooks' theorem

5.3 Coloring maps

5.4 Coloring edges

5.5 Chromatic polynomials

Unit 6: Digraphs **[8 Lectures]**

6.1 Definitions

6.2 Eulerian digraphs and tournaments

6.3 Markov chains

Unit 7: Matching, marriage and Menger's theorem **[8 Lectures]**

7.1 Menger's theorem

7.2 Network flows

Text Book:

Robin J. Wilson, *“Introduction to Graph Theory”,* Fourth edition.

Unit 1 – Chpater 1
Unit 2 – Chapter 2
Unit 3 – Chpater 3
Unit 4 – Chapter 4
Unit 5 – Chpater 5
Unit 6 – Chapter 6 and Chapter 7
Unit 7 – Chpater 8

Reference Book:

1. Narsingh Deo, “Graph Theory: With Application to Engineering and Computer Science”, Prentice Hall of India, 2003.
2. Douglas Brent west, “Introduction to Graph Theory”**,** Prentice Hall 2001.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Demonstrate the application of graph theory concepts in solving problems and scenarios. Apply knowledge to model real-world situations using graphs.

CO2: To achieve the learning objective of enabling students to analyze the properties of graphs and apply graph algorithms for traversal and analysis within disciplinary knowledge,

CO3: A solid understanding of graph representations serves as a foundation for more advanced topics in graph theory and related disciplines.

CO5: Knowledge of planar graphs, Euler's formula, and graph coloring facilitates effective communication and collaboration across disciplines. Students with a solid understanding of these concepts can contribute meaningfully to interdisciplinary teams working on complex problems.

CO6: In disciplines related to operations management and logistics, scheduling is a critical aspect. Graph coloring can be applied to schedule tasks, allocate resources, and optimize the efficiency of various processes, contributing to improved operational performance.

CO7: Graph theory is versatile and applicable across diverse disciplines. Students applying graph theory concepts to solve problems in various domains develop interdisciplinary problem-solving skills.

PO2: Critical Thinking and Problem solving

CO2: Graph theory problems often involve breaking down complex problems into smaller, more manageable components. Students must decompose problems into sub-problems related to connectivity, cycles, and paths. This enhances their problem-solving skills by enabling them to tackle individual components before addressing the larger problem.
CO5: Disciplines often encounter problems that can be modeled as graphs, such as network design, resource allocation, and optimization. Students equipped with the ability to design and implement graph algorithms can address discipline-specific challenges systematically.
CO7: Many real-world problems involve interconnected systems and relationships, making graph theory highly relevant. Students can see the direct application of their critical thinking skills to solve problems in areas such as network design, social network analysis, and resource allocation.

PO3: Social competence:
CO3: Recognizing that problems can be represented in multiple ways encourages students to think flexibly.
CO6: Applying graph coloring to real-world problems requires students to critically analyze scenarios and determine the most appropriate approach. They develop the capacity to evaluate the intricacies of different situations, considering multiple factors before applying graph coloring concepts.

PO4: Research-related skills and Scientific temper:
CO7: Graph theory enhances students' ability to recognize patterns within complex systems. This skill is invaluable in research, where identifying patterns in data can lead to the formulation of hypotheses and the generation of new knowledge.

PO5: Trans-disciplinary knowledge
CO2: Analyzing graph properties equips students with a foundational skill set applicable across disciplines, fostering a trans-disciplinary perspective. Mastery of graph algorithms for traversal and analysis enhances problem-solving abilities, preparing students to address diverse challenges in various fields

CO7: An applying graph theory concept enhances students' critical thinking skills as they navigate through diverse domains, fostering trans-disciplinary knowledge. This approach encourages analytical reasoning and problem-solving, enabling students to tackle complex challenges

PO 7: Effective Citizenship and Ethics:

CO7: Integrating graph theory into education cultivates critical thinking skills, fostering effective citizenship and ethical decision-making. The application of graph theory concepts to analyze complex problems equips students with the ability to make informed, ethically sound choices in diverse domains, promoting responsible and thoughtful engagement in societal issues

PO 8: Environment and Sustainability:

CO5: Equipping students with graph algorithm proficiency supports sustainable problem-solving, enabling the design and implementation of tailored solutions for environmental challenges. Mastery of algorithms like depth-first search and Dijkstra's algorithm empowers students to address complex issues, fostering innovation in sustainable practices**.**

CO7:Utilizing graph theory in education cultivates critical thinking, empowering students to analyze environmental complexities. By applying graph theory to sustainability issues, students develop the skills needed for informed decision-making, contributing to effective solutions and fostering a sustainable future

PO9:Self-directed and Life-long learning

CO6: Applying graph coloring in education promotes self-directed and life-long learning by empowering students to solve practical challenges like scheduling and resource allocation. This skill set encourages continuous learning as students adapt graph coloring concepts to address evolving real-world problems throughout their personal and professional lives.

Name of the Programme	**: M.Sc. (Mathematics)**
Program Code	**: PSMT**
Class	**: M.Sc. Part-II**
Semester	**: III**
Course Name	**: Practical: Python**
Course Code	**: PSMT236**
No. of lectures	**: 64**
No. of Credits	**: 4**

Course Objectives:

1. To become acclimatized with the usage of functions and strings in Python
2. To study relation between computer programming and mathematics and prepare students for advanced programming.
3. To become familiar with the basics of Python Programming, how to use variables and expressions, conditional statements, loops, and control statements.
4. Develop job-relevant skills with hands-on projects.
5. To get accustomed to the various operators used in Lists, functions of tuples and dictionaries, attributes of files and the concept of exception.
6. To get familiar with the topics of regular expressions, classes and objects.
7. To learn how to create for loop and while loop programmes.

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

CO1	Understand Python syntax and semantics and be fluent in the use of Python flow control and Functions.
CO2	Develop, run, and manipulate Python programs using Core data structures like Lists, Dictionaries
CO3	Develop, run and manipulate Python programs using File Operations and searching pattern using conditionals and loops.
CO4	Decompose a Python program into functions and interpret the concepts of object-oriented programming using Python.
CO5	Determine the need for scraping websites and working with CSV and represent compound data using Python lists, tuples, dictionaries etc.
CO6	Student will be able to capable of using functions like “if”, different types of loops and read, write data from files in Python programs.

CO7 Student will be able to convert data type, to build lists, to know difference between running python programs on Mac and Windows. Also Utilize Python packages in developing software applications.

TOPICS/CONTENT

Unit 1: Introduction, Variables and Data types in Python **[6 Lectures]**

1.1 History
1.2 First Python Program
1.3 Basic Syntax
1.4 Variable declaration
1.5 Declaration Rules

Unit 2: Operators in Python **[4 Lectures]**

2.1 Assignment operator
2.2 Logical Operator
2.3 Comparison Operator
2.4 Membership Operator

Unit 3: Arrays and string manipulations and Numbers **[12 Lectures]**

3.1 Arrays in Python
3.2 Accessing Strings
3.3 basic operations and String Slices
3.4 Functions and methods
3.5 Integer and Float
3.6 Complex

Unit 4: Lists and tuples **[10 Lectures]**

4.1 Accessing List
4.2 Working with lists and function
4.3 Accessing tuples
4.4 Operations
4.5 Functions and method

Unit 5: Dictionaries and Set **[4 Lectures]**

5.1 Accessing values in dictionaries
5.2 Properties and function
5.3 Introduction of sets

Unit 6: Conditional Statements, Looping and Control statements **[4 Lectures]**

6.1 If, If-else, Nested if-else
6.2 For , While, Nested Loop

6.3 Break, Continue, Paas

Unit 7: Functions, Numpy Library and operations **[8 Lectures]**

7.1 User functions
7.2 Filter and map function
7.3 Defining a function
7.4 Installation and introduction of Numpy
7.5 Array Creation

Unit 8: Python Object oriented programming-Oops **[8 Lectures]**

8.1 Introduction to Oops
8.2 Classes and Objects
8.3 Inheritance

Unit 9:Files, Exceptions and regular expression in Python **[8 Lectures]**

9.1 Read, and write function()
9.2 Exception handling
9.3 Expressions

Text Book:

Dr. R. Nageswara Rao, *"Core Python Programming- Second Edition",* dreamtech press, 2016.

Reference Book:

1. Wesley J. Chun, "Core Python Programming- Second Edition", Prentice Hall, 2006.
2. Beginning of Python: From Novice to Professional, Magnus Lie Hetland, A press.
3. E-Books: python_tutorial.pdf, python-book_01.pdf.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Strongly mapped as students gain the knowledge on Python syntax and semantics and be fluent in the use of Python flow control in writing the programs.

CO2: Moderately mapped as only few students identify their own problem by conducting literature review for writing programs.

CO3: Strongly mapped as designing and implementation is required to write the program for the given problem statement.

CO4: Moderately mapped as students learn modern IDE tools to execute python programs / applications (Python IDLE / Anaconda with spyder IDE).

CO5: Moderately mapped as students apply the concepts learnt in continuing professional development and new developments.

CO6: Strongly mapped as students understand fundamentals of Python syntax and semantics and fluent in the use of concepts in writing the programs to build application.

CO7: Students could apply their knowledge in practice including in multi-disciplinary or multi-professional contexts and utilize the package for new software.

PO2: Critical Thinking and Problem solving.

CO1: Strongly mapped as the students need the knowledge of python syntax and semantics related to List, Dictionaries, and Strings to apply them in building applications which needs python programming constructs.
CO2: Strongly mapped as problem analysis is necessary for solving /developing any application using appropriate python programming construct such as List, Dictionaries, Strings.
CO3 Strongly mapped as the process of design and implementation must be followed while applying the concepts.
C04: Moderately mapped as students learn modern IDE tools to execute python programs / applications (Python IDLE / Anaconda with Spyder IDE).
CO6: Moderately mapped as students apply the concepts learnt in continuing professional development and new developments.
CO7: Moderately mapped as students utilize Python packages and use this concept in developing new software's.

PO3: Social competence
C07: Using knowledge student convert data type, to build lists, to know difference between running python programs on Mac and Windows. Also Utilize Python packages in developing software applications which is helpful to solve various security challenges of society or country.

PO4: Research-related skills and Scientific temper

CO1: Studying Python syntax, and different programs develops research-related skills and investigations in diverse scientific disciplines.

CO2: Applying Lists, Dictionaries and run various Python programs plays key role to develop new problem-solving approach by with powerful mathematical tools.

CO3: Classifying for loop and while loop programs for various unsolved research problems.

CO7 Developing new software is now plays a vital role in advanced mathematical researchin scientific inquiries and investigations.

PO5: Trans-disciplinary knowledge

CO3: Network analysis in computer science, Graph Theory and various fields will be useful in different programs and using this trans-disciplinary knowledge students develop new programs.

PO9: Self-directed and Life-long learning:

CO3: All students design and develop the applications and Working with CSV, and PDF File Formats.

CO5: As students learn modern IDE tools to build and execute python applications(Anaconda with Spyder IDE).

CO7: Students apply the concepts learnt in continuing professional development and new product developments.