Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati (Autonomous)

Course and Credit Structure for (M.Sc. Mathematics) Part-II (2023 Pattern as per NEP-2020)

Year	**Sem.**	**Major**		**Research Methodology (RP)**	**OJT/ FP**	**RM**	**Cum. Cr.**
		Mandatory	**Electives**				
II	Sem-III	MAT-601-MJM: Linear Algebra(**Credit 04**) MAT-602-MJM: Field Theory (**Credit 04**)	MAT-611-MJE (A): Banach Spaces(**Credit02**) OR MAT-611-MJE (B): Algebraic Topology (**Credit 02**)	MAT-621-RP: Research Project (**Credit 04**)	--	--	**20**
		MAT-603-MJM: Practical based on Combinatorics (**Credit 02**) MAT-604-MJM: Practical: Python Programming (**Credit 02**)	MAT-612-MJE (A): Practical based on Graph Theory (**Credit 02**) OR MAT-612-MJE (B): Practical based on Coding (Credit 02)				
	Sem- IV	MAT-651-MJM: Differential Geometry (**Credit 04**) MAT-652-MJM: Lattice Theory (**Credit 04**)	MAT-661-MJE(A) Hilbert Spaces and Spectral Theory (**Credit02**) **OR** MAT-661-MJE(B) Cryptography(**Credit02**)	--	MAT-681-RP	--	**20**

		MAT-653-MJM: Practical based on Integral Equation (**Credit 02**)	MAT-662-MJE(A) Practical based on Boundary Value Problems **(Credit02)** **OR** MAT-662-MJE(B) Practical based on Mechanics (**Credit02**)		**Credit 06**		
22			**8**	**4**	**6**	**--**	**40**

*** 1 credit = 15 Hr.**

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati (Autonomous)

Course Structure for (M.Sc. Mathematics) Part-II (2023 Pattern as per NEP- 2020)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
III	Major (Mandatory)	MAT-601-MJM	Linear Algebra	Theory	04
	Major (Mandatory)	MAT-602-MJM	Field Theory	Theory	04
	Major (Mandatory)	MAT-603-MJM	Practical based on Combinatorics	Practical	02
	Major (Mandatory)	MAT-604-MJM	Practical: Python Programming	Practical	02
	Major (Elective)	MAT-611-MJE (A)	Banach Spaces	Theory	02
		MAT-611-MJE (B)	Algebraic Topology	Theory	
	Major (Elective)	MAT-612-MJE (A)	Practical based on Graph Theory	Practical	02
		MAT-612-MJE (B)	Practical based on Coding	Practical	
	Research Project (RP)	MAT-621-RP	Research Project	Practical	04
	Total Credits Semester III				**20**
IV	Major (Mandatory)	MAT-651-MJM	Differential Geometry	Theory	04
	Major (Mandatory)	MAT-652-MJM	Lattice Theory	Theory	04
	Major (Mandatory)	MAT-653-MJM	Practical based on Integral Equation	Practical	02
	Major (Elective)	MAT-661-MJE(A)	Hilbert Spaces and Spectral Theory	Theory	02
		MAT-661-MJE(B)	Cryptography	Theory	
	Major (Elective)	MAT-662-MJE(A)	Practical based on Boundary Value Problems	Practical	02
		MAT-662-MJE(B)	Practical based on Mechanics	Practical	
	Research Project (RP)	MAT-681-RP	Research Project (RP)	Practical	06
	Total Credits Semester-IV				**20**
Cumulative Credits Semester III and IV					**40**

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

Name of the Programme : M.Sc (Mathematics)
Program Code : PSMAT
Class : M.Sc
Semester : III
Course Type : Major (Mandatory)
Course Name : Linear Algebra
Course Code : MAT-601-MJM
No. of Lectures : 60
No. of Credits : 4

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 R^n 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.

Topics and Learning Points

	Teaching Hours
Unit 1: Vector Spaces	**20**
1.1 Definition and Examples	
1.2 Subspaces	
1.3 Basis and dimension	
1.4 Linear Transformations	
1.5 Quotient spaces	
1.6 Direct sum	
1.7 The matrix of a linear transformation.	
1.8 Duality	
Unit 2: Canonical Forms	**20**
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**
3.1 Inner Products	
3.2 Orthogonality	
3.3 The adjoint of a linear Transformation	
3.4 Unitary operators	
3.5 Self adjoint and normal operators.	
Unit 4: Applications of Linear Algebra	**4**
4.1 Any four applications from book 2.	

Text Book:

1. **Vivek Sahai, Vikas Bist, Linear Algebra, Narosa Publication.**
   Unit 1: Chapter 2: Section 1 to 8.
   Unit 2: Chapter 3: Section 1 to 4
   Unit 3: Chapter 4: Section 1 to 6
2. **Gilbert Strang, Linear Algebra and Its Applications, Fourth Edition.**

References:

1. Serge lang, Linear Algebra, springer.
2. M. Artin, Algebra, Prentice - Hall of India private Ltd.
3. K. Hoffman, Ray Kunje, Linear Algebra, Prentice - Hall of India private Ltd.
4. S. Kumaresan, Linear Algebra A Geometric approach, PHI Learning private Ltd.
5. Charles W. Curtis, Linear Algebra, Springer.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc-II (Sem III) **Subject:** Mathematics
Course: Linear Algebra **Course Code:**-MAT-601-MJM

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

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

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

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 sub fields, and its applications to other disciplines.
CO3: Students 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: Practical, Professional, and Procedural Knowledge:

CO1: Understanding of characteristic values of matrices, decomposition of matrices, operators, and forms on inner product spaces. To enhances Practical knowledge 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.
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.

PO 3: Entrepreneurial Mindset, Innovation, and Business Understanding:

CO 5: Linear algebra equips students with powerful problem-solving techniques that are vital in entrepreneurship. Whether it's optimizing resource allocation, analyzing market trends, or developing algorithms for data-driven decision-making, linear algebra provides the foundational tools to tackle complex problems efficiently.

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

CO1: Understanding of characteristic values of matrices, decomposition of matrices, operators, and forms on inner product spaces. To enhances student's 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.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

CO2: Studying the linear transformation and its matrix form improve research-related skills and a Analytical reasoning by cultivating a foundational understanding of mathematical transformation.

CO3: Students will develop research-related skills and Reasoning 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 transformations 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.

PO6: Communication, Collaboration, and Leadership:

CO1: Studying the decomposition of matrices, operators, and forms on inner product spaces. provides students with collaboration 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.

PO 10: Autonomy, Responsibility , and Accountability:

Autonomy, responsibility, and accountability serve as important course outcomes for linear algebra as they empower students to become independent learners, take ownership of their learning process, and demonstrate proficiency in the subject matter. These outcomes not only contribute to students' academic success but also equip them with valuable skills and attributes that are applicable in various personal and professional contexts.

CO 7: By holding students accountable for their understanding of key concepts, problem-solving abilities, and analytical skills, instructors ensure that learning objectives are met and that students are adequately prepared for further study or application of linear algebra in real-world contexts.

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

Name of the Programme	: M.Sc (Mathematics)
Program Code	: PSMAT
Class	: M.Sc.
Semester	: III
Course Type	: Major (Mandatory)
Course Name	: Field Theory
Course Code	: MAT-602-MJM
No. of Lectures	: 60
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:

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

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 and Learning Points

	Teaching Hours
Unit-I: Field Extensions	**30**

1.1 Basic Theory of Field Extensions
2.1 Algebraic Extensions
3.1 Classical Straightedge and Compass construction
4.1 Splitting Fields and Algebraic Closures
5.1 Separable and Inseparable Extensions
6.1 Cyclotomic Polynomials and Extensions

Unit-II: Galois Theory	**30**

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
2.7 Computation of Galois Groups over $\mathbb{Q}$

Text Book:

Dummit and Foote, *"* **Abstract Algebra** *",* 2nd Edition, Wiley Eastern Ltd.
Unit 1 – Sections 13.1 to 13.6
Unit 2 – Sections 14.1 to 14.4, 14.6, 14.7(statement) and 14.8

Reference Books:

1) **O. Zariski and P. Sammuel**, Commutative Algebra, Vol. 1, Van Nostrand.
2) **P. Bhattacharya and S. Jain,** Basic Abstract Algebra, Second Edition.
3) **I. S. Luthar and I. B. S. Passi,** Algebra Vol. 4: Field Theory, Narosa.

Mapping of Program Outcomes with Course Outcomes

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

Course: Field Theory **Course Code :** MAT-602-MJM

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

1.

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10
CO 1	1	1		1						
CO 2	1				2					
CO 3	2	1			1					
CO 4	1	1		2	2					
CO 5	2	1			1					
CO 6	1	2		2	1					
CO 7	1			1						

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: Students will be able to elucidate an extensive understanding and knowledge of their field extension.

CO2: Students will be able to acknowledge a comprehensive understanding of Galois extensions within their field.

CO3: Students will demonstrate comprehensive knowledge and understanding by constructing Galois groups for various Galois extensions.

CO4: Students will exhibit comprehensive knowledge and understanding by grasping fundamental concepts of field extensions and Galois theory, along with their roles in modern mathematics and applied contexts.

CO5: Students will demonstrate comprehensive knowledge and understanding by generating both examples and counterexamples using course concepts.

CO6: Students will demonstrate comprehensive knowledge and understanding by abstractly handling Galois groups through the application of the fundamental theorem of Galois theory.

CO7: Students will exhibit comprehensive knowledge and understanding by constructing finite fields.

PO2: Practical, Professional, and Procedural Knowledge:

CO1: Students will demonstrate practical, professional, and procedural knowledge in explaining field extensions.

CO3: Students will exhibit practical, professional, and procedural knowledge by manipulating expressions involving algebraic and transcendental elements.

CO4: Students will demonstrate practical, professional, and procedural knowledge by understanding fundamental concepts of field extensions and Galois theory and their relevance in modern mathematics and applied contexts.
CO5: Students will demonstrate practical, professional, and procedural knowledge by generating examples and counterexamples using course concepts.
CO6: Students will apply practical, professional, and procedural knowledge by abstractly handling Galois groups using the fundamental theorem of Galois theory.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO1: Students will demonstrate specialized skills, critical thinking, and problem-solving abilities by explaining field extensions.
CO4: Students will demonstrate critical thinking and problem-solving skills by understanding the fundamental concepts of field extensions and Galois theory and their applications in modern mathematics and various contexts.
CO6: Students will employ critical thinking and problem-solving skills in abstractly handling Galois groups through the application of the fundamental theorem of Galois theory.
CO7: Students will demonstrate critical thinking and problem-solving skills by constructing finite fields.
PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO2: Students will demonstrate research, analytical reasoning by recognizing Galois extensions.
CO3: Students will engage in research and analytical reasoning by manipulating expressions involving algebraic and transcendental elements.
CO4: Students will engage in research and analytical reasoning to understand the fundamental concepts of field extensions and Galois theory, along with their roles in modern mathematics and applied contexts.
CO5: Students will employ research and analytical reasoning skills to generate examples and counterexamples using course concepts.
CO6: Students will employ research and analytical reasoning to handle Galois groups abstractly through the utilization of the fundamental theorem of Galois theory.

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

Name of the Programme : M.Sc (Mathematics)
Program Code : PSMAT
Class : M.Sc
Semester : III
Course Type : Major (Mandatory)
Course Name : Practical based on Combinatorics
Course Code : MAT-603-MJM
No. of Lectures : 60
No. of Credits : 2

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.

Course Outcomes:

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

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 and Learning Points

	Teaching Hours
Unit 1: General Counting Methods for Arrangements and Selections	**16**
1.1 Two basic counting principles	
1.2 Simple Arrangement and Selections	
1.3 Arrangements and Selections with Repetitions	
Unit 2: Generating Functions	**16**
2.1 Generating function models	
2.2 Calculating coefficients of generating functions	
2.3 Exponential generating functions	
Unit 3: Recurrence Relations	**16**
3.1 Recurrence relation models	
3.2 Divide and conquer relations	
3.3 Solutions of linear Recurrence relations	
Unit 4: Inclusion-Exclusion	**12**
4.1 Counting with Venn diagrams	
4.2 Inclusion-Exclusion Formula	
4.3 Restricted positions and Rook polynomials	

Text Book:

Alan Tucker, *"Applied Combinations Fourth Edition*". (John Wiley and Sons, Inc).

Unit 1 – Sections 5.1 to 5.3
Unit 2 – Sections 6.1 to 6.2 and 6.4
Unit 3 – Sections 7.1 to 7.3
Unit 4 – Sections 8.1 to 8.3

Reference Books:

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

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc.II (Sem III) **Subject:** Mathematics
Course: Practical based on Combinatorics **Course Code:** MAT-603-MJM)
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	PO10
CO 1	1	1		1	1					
CO 2	1	1		1	1					
CO 3	2			2	2					
CO 4		2			1					
CO 5	1			1	2					
CO 6	2	1			1					
CO 7	1	1		2						

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: Students will exhibit comprehensive knowledge and understanding by solving counting problems.
CO2: Students will demonstrate comprehensive knowledge and understanding by utilizing generating functions to simplify recurrence relations.
CO3: Students will demonstrate comprehensive knowledge and understanding by applying combinatorial principles and techniques to solve counting problems.
CO5: Students will exhibit comprehensive knowledge and understanding by computing generating functions and applying them to solve combinatorial problems.
CO6: Students will demonstrate comprehensive knowledge and understanding by grasping fundamental counting principles such as the rule of product, rule of sum, permutations, and combinations.
CO7: Students will acquire comprehensive knowledge and understanding by learning how to calculate the number of ways to arrange or select elements from a set, with or without replacement.

PO2: Practical, Professional, and Procedural Knowledge:
CO1: Students will demonstrate practical, professional, and procedural knowledge by solving counting problems.
CO2: Students will apply practical, professional, and procedural knowledge by using generating functions to simplify recurrence relations.
CO4: Students will demonstrate practical, professional, and procedural knowledge by solving linear recurrence relations.
CO6: Students will apply practical, professional, and procedural knowledge by understanding fundamental counting principles such as the rule of product, rule of sum, permutations, and combinations.
CO7: Students will acquire practical, professional, and procedural knowledge by learning to calculate the number of ways to arrange or select elements from a set, with or without replacement.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO1: Students will demonstrate critical thinking and problem-solving skills by solving counting problems.
CO2: Students will apply critical thinking and problem-solving skills by utilizing generating functions to simplify recurrence relations.
CO3: Students will demonstrate specialized skills, critical thinking, and problem-solving abilities by applying combinatorial principles and techniques to solve counting problems.
CO5: Students will demonstrate specialized skills, critical thinking, and problem-solving by computing generating functions and applying them to solve combinatorial problems.
CO7: Students will employ critical thinking and problem-solving skills to learn how to calculate the number of ways to arrange or select elements from a set, with or without replacement.

PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO1: Students will demonstrate research and analytical reasoning skills by solving counting problems.
CO2: Students will employ research and analytical reasoning to utilize generating functions for simplifying recurrence relations.
CO3: Students will utilize research and analytical reasoning to apply combinatorial principles and techniques in solving counting problems.
CO4: Students will employ research and analytical reasoning to solve linear recurrence relations.
CO5: Students will utilize research and analytical reasoning to compute generating functions and apply them to solve combinatorial problems.
CO6: Students will employ research and analytical reasoning to understand fundamental counting principles such as the rule of product, rule of sum, permutations, and combinations.

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

Name of the programme : M.Sc. (Mathematics)

Program Code : PSMAT

Class : M.Sc. -II

Semester : III

Course Type : Major (Mandatory)

Course Name : Practical: Python programming

Course Code : MAT-604-MJM

No. of Lectures : 60

No. of Credits : 2

Course Objectives:

1. To become acclimatized with the usage of Distinct Operators 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 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 and Learning Points

Teaching Hours

Unit 1: Introduction, and Operators in Python **[10 Lectures]**

1.1 Basic Syntax, Variable Declaration

1.2 Assignment and Logical operators

1.3 Comparison and Membership operators

Unit 2: Arrays Numbers and string manipulations **[12 Lectures]**

2.1 Arrays in Python

2.2 Accessing Strings

2.3 basic operations and String Slices

2.4 Functions and methods

2.5 Integer and Float

2.6 Complex

Unit 3: Lists, tuples Dictionaries and Set **[14 Lectures]**

3.1 Working with Lists and Function

3.2 Accessing tuples

3.3 Operations, Functions and method

3.4 Accessing values in dictionaries

3.5 Introduction of Sets

Unit 4: Looping and Control statements, Numpy Library **[12 Lectures]**

4.1 If, If-else, Nested if-else, For , While, Nested Loop

4.2 Break, Continue, Paas

4.3 Introduction of Numpy and operations

Unit 5: Python programming-Oops, Accessing values in dictionaries **[12 Lectures]**

5.1 Introduction to Oops, Classes and Objects

5.2 Read, and write function()

5.3 Exception handling

Text Book:

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

Reference Books:

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

Mapping of Program Outcomes with Course Outcomes

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

Course: Practical: Python programming **Course Code:** MAT-604-MJM

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

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

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

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.

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: Practical, Professional, and Procedural Knowledge:

CO1: Strongly mapped as the students need the Practical knowledge of python syntax and semantics related to List, Dictionaries, 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, and Strings.
CO3 Strongly mapped as the process of design makes student's more professional.
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.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO1: Strongly mapped as the students need the knowledge of python syntax and semantics related to List, Dictionaries, 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 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.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

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 research in scientific inquiries and investigations.

PO6: Communication, Collaboration, and Leadership:
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.

PO 10:Autonomy, Resposibility, and Accountability:

Overall, integrating autonomy, responsibility, and accountability into Python practicals ensures that students not only develop technical proficiency but also essential soft skills that are crucial for success in their future careers as programmers and software engineers.

CO3: Python practicals require students to take responsibility for their code and its outcomes. They must ensure that their programs are well-structured, efficient, and fulfill the given requirements. Moreover, they're responsible for debugging and fixing errors in their code, which instills a sense of accountability for their work.

CO5:Through Python practicals, students are encouraged to work independently, problem-solve, and develop their coding skills autonomously. They learn to navigate the Python environment, experiment with different algorithms, and find solutions to programming challenges. This autonomy fosters their self-reliance and prepares them for real-world scenarios where they'll need to work on tasks independently.

CO7:In Python practicals, students are held accountable for their code's functionality, performance, and adherence to best practices. They must be able to explain their coding choices, defend their design decisions, and justify their implementation strategies. This level of accountability encourages students to think critically about their code, understand its implications, and continuously strive for improvement.

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

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester : II

Course Type : Major (Elective)

Course Name : Banach Spaces

Course Code : MAT-611-MJE (A)

No. of Lectures : 30

No. of Credits : 2

Course Objectives:

1. Define normed linear spaces, understand the properties of norms, and explore examples of normed spaces.
2. Study the triangle inequality, convergence in normed spaces, and completeness of normed spaces.
3. Define Banach spaces as complete normed linear spaces, explore examples, and understand the importance of completeness.
4. Define and study bounded linear operators between normed linear spaces, including properties such as continuity, linearity, and the operator norm.
5. Introduce and prove the Hahn-Banach theorem and its consequences for the extension of bounded linear functionals.
6. Define the dual space of a normed linear space, discuss properties of dual spaces, and explore the relationship between a space and its dual.
7. Study normed linear spaces and their relation to Banach spaces.

Course Outcomes:

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

CO1- Understand the definitions of normed linear spaces and Banach spaces.

CO2- Recognize and apply properties of norms, including the triangle inequality and homogeneity.

CO3- Demonstrate knowledge of examples of normed linear spaces, such as Euclidean spaces and function spaces.

CO4- Understand the properties of Banach spaces, including the Banach fixed-point theorem.

CO5- Apply the concepts of normed linear spaces and Banach spaces to solve problems in analysis and functional analysis

CO6- Demonstrate the ability to construct and analyze proofs related to normed linear spaces and Banach spaces.

CO7- Define and understand the concept of boundedness in normed linear spaces.

Topics and Learning Points

Teaching Hours

UNIT1: Fundamental of Norm Spaces **07**

1.1 Linear space and linear map.
1.2 Metric spaces and linear maps.
1.3 Normed spaces.
1.4 Continuity of linear map.

UNIT2: Banach Space **07**

2.1 Hahn-Banach Theorem
2.2 Unique Hahn-Banach Extensions
2.3 Banach Spaces

UNIT3: Bounded Linear Maps on Banach Spaces **08**

3.1 Uniform Boundedness principle.
3.2 Closed Graph and Open Mapping Theorem.
3.3 Bounded Inverse Theorem.
3.4 Spectrum of a Bounded Operator.

UNIT4: Spaces of Bounded Linear Functionals **08**

4.1 Duals and Transposes.
4.2 Duals of $L^p([a,b])$ and $C([a,b])$.
4.3 Weak and weak* Convergence.
4.4 Reflexivity.

Text Book:

Balmohan V Limaye Functional Analysis ,New age International publishers.
Unit 1 – Sections1.2 to 1.4 and 2.1 to 2.2,
Unit 2 - Sections 2.3 to 2.4
Unit 3 - Sections 3.1 to 3.4,
Unit 4 - Sections 4.1 to 4.4

References:

1. Balmohan V Limaye Functional Analysis ,New age International publishers.
2. G. F. Simmons, “Introduction to Topology and Modern Analysis”
3. Bachman and Narici, Functional Analysis, Narosa Publishing House, India.
4. John B Conway, Introduction to Functional Analysis, Springer.
5. W. Rudin, Functional Analysis, Tata McGraw Hill Edition.
6. Anant R. Shastri, Basic Complex Analysis of One Variable, Macmillan publishers India, 2010.

Choice Based Credit System Syllabus (2023 Pattern)

Mapping of Program Outcomes with Course Outcomes

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

Course: Banach spaces **Course Code:** MAT-611-MJE (A)

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	PO10
CO 1	3	2		2	2	2				
CO 2	3	3		3	3	2				
CO 3		3								
CO 4	2	3		2	2	2				
CO 5	1									
CO 6	3	3		3	1	2				
CO 7	3	2		2	1	2				

Justification for the mapping

PO1. Comprehensive knowledge and understanding:
All course outcomes contribute significantly to this program outcome as they require a deep understanding of normed linear spaces and Banach spaces**.**

PO2. Practical, professional, and procedural knowledge:
CO2, CO4, CO5, and CO6 directly involve the application of concepts, properties, and problem-solving in various scenarios.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:
CO2, CO4, CO5, and CO6 are directly related to critical thinking, problem-solving, and specialized skills in the realm of normed linear spaces and Banach spaces.

PO5. Research, Analytical Reasoning, and Ethical Conduct: CO1, CO4, and CO6 require analytical reasoning and potentially ethical considerations in dealing with proofs and theorems.

PO6. Communication, Collaboration, and Leadership: While not directly addressed, CO6 might indirectly contribute to communication skills through the construction and presentation of proofs.

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

Name of the Programme	: M.Sc (Mathematics)
Program Code	: PSMAT
Class	: M.Sc
Semester	: III
Course Type	: Major (Elective)
Course Name	: Algebraic Topology
Course Code	: MAT-611(B)-MJE
No. of Lectures	: 30
No. of Credits	: 2

Course Objectives:

1. Understand the concept of homotopy of paths and its significance in algebraic topology.
2. Define the fundamental group of a topological space and its properties.
3. Explore the concept of covering spaces and their relationship with the fundamental group.
4. Study the fundamental group of the circle and its application in algebraic topology.
5. Study the Seifert-van Kampen Theorem and its importance in computing fundamental groups.
6. Compute the fundamental group of a wedge of circles using the Seifert-van Kampen Theorem.
7. Study covering transformations and their role in classifying covering spaces.

Course Outcomes:

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

CO1 Student will be able to Analyse retractions and fixed points in topological spaces and their implications.

CO2: Student will be able to understand the Fundamental Theorem of Algebra and its connection to algebraic topology.

CO3: Student will be able to explore the Borsuk-Ulam Theorem and its applications.

CO4: Student will be able to explore the concept of covering spaces and their relationship with the fundamental group

CO5: Student will be able to analyse the fundamental groups of the torus and the Dunce Cap using algebraic topology techniques.

CO6: Student will be able to analyze the existence of covering spaces and their relationship with topological spaces

CO7: Student will be able to understand the equivalence of covering spaces and their implications in algebraic topology.

Topics and Learning Points

	Teaching Hours
Unit-I: The Fundamental Group-I	**08**
1.1 Homotopy of Paths.	
2.1 The Fundamental Group.	
3.1 Covering Spaces.	
4.1 The Fundamental Group of the Circle.	
Unit-II: The Fundamental Group-II	**06**
2.1 Retractions and Fixed Points.	
2.2 The Fundamental Theorem of Algebra.	
2.3 The Borsuk-Ulam Theorem.	
Unit-III: The Seifert-van Kampen Theorem	**08**
3.1 Direct Sums of Abelian Groups (only revision).	
3.2 Free Products of Groups (only revision)	
3.3 Free Groups	
3.4 The Seifert-van Kampen Theorem.	
Unit-III: Classification of Covering Spaces	**06**
4.1 Equivalence of Covering Spaces.	
4.2 The Universal Covering Spaces.	
4.3 Covering Transformations.	
4.4 Existence of Covering Spaces	

Text Book:

James R. Munkres, Topology, Second Edition, Pearson Prentice Hall.
Chapter 9: Sections: 51, 52, 53, 54, 55, 56, 57.
Chapter 11: Sections: 67, 68 (Only revision), 69, 70, 71, 73.
Chapter 13: Sections: 79, 80, 81, 82.

Reference Books:

1) **Allen Hatcher**, Algebraic Topology, Cambridge University Press, 2002.
2) **M.A. Armstrong**, Basic Topology, Springer International Edition, 2004.
3) **J. J. Rotman**, An Introduction to Algebraic Topology, Springer, 1988.
4) **E. H. Spanier,** Algebraic Topology, Springer, 1994.

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc.-II (Sem III) **Subject:** Mathematics
Course: Algebraic Topology **Course Code:** MAT-611-MJE (B)
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	PO10
CO 1	3	2			3					
CO 2	3	2		3	2					1
CO 3	2						1			
CO 4	2	2			2	2				
CO 5				2						
CO 6	2					2				
CO 7	2	3		2	1					1

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:
CO1: The analysis of retractions and fixed points in topological spaces requires a deep understanding of mathematical concepts, indicating a strong relation to comprehensive knowledge and understanding.
CO2: Understanding the Fundamental Theorem of Algebra and its connection to algebraic topology involves grasping complex mathematical theories, indicating a strong relation to comprehensive knowledge and understanding.
CO3: Exploring the Borsuk-Ulam Theorem involves understanding its implications across various areas, indicating a moderate relation to comprehensive knowledge and understanding.
CO4: Exploring covering spaces and their relationship with the fundamental group requires a solid understanding of algebraic topology concepts, indicating a strong relation to comprehensive knowledge and understanding.
CO6: Analysing the existence of covering spaces and their relationship with topological spaces involves a thorough understanding of mathematical concepts, indicating a strong relation to comprehensive knowledge and understanding.
CO7: Understanding the equivalence of covering spaces in algebraic topology requires a deep understanding of mathematical concepts, indicating a strong relation to comprehensive knowledge and understanding.

PO2: Practical, Professional, and Procedural Knowledge:
CO1: Analysing retractions and fixed points involves applying mathematical techniques in practical contexts, indicating a moderate relation to practical knowledge.
CO2: Understanding the connection between the Fundamental Theorem of Algebra and algebraic topology requires practical application of mathematical theories, indicating a moderate relation to practical knowledge.
CO4: Exploring covering spaces involves applying procedural knowledge in mathematical analysis, indicating a moderate relation to procedural knowledge.
CO7: Understanding the equivalence of covering spaces involves applying procedural knowledge

in mathematical analysis, indicating a moderate relation to procedural knowledge.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO2: Understanding the connection between the Fundamental Theorem of Algebra and algebraic topology involves critical analysis, indicating a strong relation.
CO5: Analyzing fundamental groups using algebraic topology techniques requires specialized skills in mathematical reasoning, indicating a strong relation.
CO7: Understanding the equivalence of covering spaces involves critical analysis and problem-solving, indicating a strong relation.

PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO1: Analysing retractions and fixed points may involve research into mathematical concepts, indicating a moderate relation to research and analytical reasoning.
CO2: Understanding the connection between the Fundamental Theorem of Algebra and algebraic topology may require analytical reasoning, indicating a moderate relation.
CO4: Exploring covering spaces involves analytical reasoning and research into mathematical concepts, indicating a moderate relation.
CO7: Understanding the equivalence of covering spaces may involve research into mathematical concepts, indicating a moderate relation.

PO6: Communication, Collaboration, and Leadership:
CO4: Exploring covering spaces may involve collaboration with peers in problem-solving, indicating a low relation to collaboration skills.
CO6: Analyzing the existence of covering spaces may involve collaboration in mathematical analysis, indicating a low relation to collaboration skills.

PO7: Digital Proficiency and Technological Skills:
CO3: Exploring the Borsuk-Ulam Theorem may involve digital research into its various applications, indicating a low relation to digital proficiency.

PO10: Autonomy, Responsibility, and Accountability:

CO2: Understanding the connection between the Fundamental Theorem of Algebra and algebraic topology may encourage autonomy and responsibility in learning, indicating a low relation.
CO7: Understanding the equivalence of covering spaces may encourage autonomy in learning and responsibility in understanding mathematical concepts, indicating a low relation.

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

Name of the Programme : M.Sc (Mathematics)

Program Code : PSMT

Class : M. Sc. II

Semester : III

Course Type : Major (Elective)

Course Name : Practical based on Graph Theory

Course Code : MAT-612-MJE(A)

No. of Lectures : 60

No. of Credits : 2

Course Objectives:

1. Understand the fundamental concepts of graph theory, including graphs, vertices, edges, and paths.
2. Learn different types of graphs, such as directed graphs, undirected graphs, weighted graphs, and bipartite graphs.
3. Study graph representation methods, including adjacency matrices, adjacency lists, and incidence matrices.
4. Understand and apply graph connectivity concepts, including connected components and graph bridges.
5. Learn about graph coloring techniques, including vertex coloring and edge coloring
6. Study graph algorithms for finding shortest paths, such as Dijkstra's algorithm and Bellman-Ford algorithm.
7. Explore applications of graph theory in computer science, including network analysis, routing algorithms, and data structures.

Course Outcomes:

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

CO1- Apply graph theory concepts to model and solve real-world problems in various domains, demonstrating the versatility and applicability of graph theory.

CO2- Demonstrate a deep understanding of fundamental graph theory concepts, including graphs, vertices, edges, and paths.

CO3- Apply different graph representation methods, such as adjacency matrices and adjacency lists, to solve graph-related problems.

CO4- Analyze and classify different types of graphs, including directed, undirected, weighted, and bipartite graphs.

CO5- . Investigate graph connectivity concepts, including connected components and graph bridges, and apply them to solve connectivity problems.

CO6 Apply graph coloring techniques, such as vertex coloring and edge coloring, to solve graph coloring problems.

CO7- . Evaluate and analyze the applications of graph theory in computer science, including network analysis, routing algorithms, and data structures.

Topics and Learning Points

	Teaching Hours
UNIT1: Graphs Paths and Cycles	**16**
1.5 Definition of Graph,Path Cycle and examples	
1.6 Three puzzles and connectivity.	
1.7 Eulerian Graphs.	
1.8 Hamiltonian Graphs and some algorithm	
UNIT2: Trees and planarity	**16**
2.1 Properties of trees	
2.2 Counting tree	
2.3 Planar Graphs	
2.4 Euler's Formula	
2.5 Graphs on other surfaces	
2.6 Dual and Infinites Graphs.	
UNIT3: Coloring Graphs	**14**
3.1 Coloring Vertices.	
3.2 Brooks theorem and coloring maps.	
3.3 Coloring edges and chromatic polynomials.	
UNIT4: Digraphs	**14**
4.1 Eulerian Digraphs	
4.2 Ford Fulkerson Algorithm	
4.3 Tournaments.	
4.4 Markov chain.	

Text Book:

Robin J. Wilson, "Introduction to Graph Theory", Fourth edition .

Unit 1 – Chapter 1, and 2nd,

Unit 2 - Chapter 3 and 4th

Unit 3 - Chapter 5,

Unit 4 - Chapter 6 and Chapter 7

References:

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

Choice Based Credit System Syllabus (2023 Pattern)

Mapping of Program Outcomes with Course Outcomes

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

Course: Practical based on Graph Theory **Course Code:** MAT-612-MJE(A)

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	PO10
CO 1	2	3	3	3	3	3	3		3	1
CO 2	3	3	1	3	2	2	2		2	1
CO 3	2	3	2	3	2	2	1		2	1
CO 4	3	3	1	3		3			3	1
CO 5	3	3	1	3	3	3				1
CO 6	2	3	1	3	2	2	1		3	1
CO 7	3	3	2	3	3	3	1		1	1

Justification for the mapping

PO1. Comprehensive knowledge and understanding:
All course outcomes (COs) align with PO1 as graph theory requires a comprehensive understanding of its concepts and applications.

PO2. Practical, professional, and procedural knowledge:
CO1, CO2, CO4, CO5, CO6, and CO7 directly involve applying theoretical knowledge to practical problems, making them strongly related to PO2.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:
CO1 and CO7, especially when applied to computer science applications, demonstrate innovation and business understanding in technologies like network analysis and routing algorithms.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:
CO1, CO2, CO4, CO5, CO6, and CO7 involve critical thinking, problem-solving, and developing specialized skills in graph theory.

PO5.Research, Analytical Reasoning, and Ethical Conduct:
CO1, CO2, CO4, CO5, CO6, and CO7 require research, analysis of different graph types, and the ethical considerations in data structures and network analysis.

PO6. Communication, Collaboration, and Leadership:
While not as direct, CO7 involves understanding and communicating the applications of graph theory in computer science fields, aligning with PO6.

PO7.Digital Proficiency and Technological Skills:
CO1, CO3, and CO7 involve using digital tools and technologies to model, represent, and analyze graphs, linking them to PO7.

PO9. Value Inculcation, Environmental Awareness, and Ethical Practices:
CO1, CO2, CO4, CO5, CO6, and CO7 involve ethical considerations, especially when applied to areas like data structures and network analysis.

PO10. Autonomy, Responsibility, and Accountability: CO1, CO2, CO4, CO5,CO6,and CO7 develop autonomy and responsibility in problem-solving and analysis within the realm of graph theory.

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

Name of the Programme	: M.Sc (Mathematics)
Program Code	: PSMAT
Class	: M.Sc.
Semester	: III
Course Type	: Major (Elective)
Course Name	: Practical based on Coding
Course Code	: MAT-612-MJE (B)
No. of Lectures	: 60
No. of Credits	: 2

Course Objectives:

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

Course Outcomes:

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

CO1: Student will be able to derive equations for entropy, mutual information and channel capacity for all kinds of channels.

CO2: Student will be able to implements the various types of source coding algorithms and analyse their performance.

CO3: Student will be able to explain various methods of generating and detecting different types of error correcting codes.

CO4: Student will be able to perform information theoretic analysis of communication system.

CO5: Student will be able to design a data compression scheme using suitable source coding techniques.

CO6: Student will be able to design a channel coding scheme for a communication system.

CO7: Student will be able to comprehend various error control code properties

Topics and Learning Points

	Teaching Hours
Unit 1: Source Coding	**12**
1.1 Definition and examples	
1.2 Uniquely decodable codes	
1.3 Instantaneous codes	
1.4 Constructing instantaneous codes	
Unit 2: Optimal Codes	**16**
2.1 Optimality	
2.2 Binary Huffman codes	
2.3 Average word length of Huffman codes	
2.4 Optimality of binary Huffman codes	
2.5 R-ary Huffman codes	
Unit 3: Entropy	**16**
3.1 Information and entropy	
3.2 Properties of a entropy function	
3.3 Entropy and average word length	
3.4 Shannon's first theorem	
Unit 4: Information channels	**16**
4.1 Notation and definitions	
4.2 The binary symmetric channel	
4.3 System entropies	
4.4 Extension of Shannon's first theorem to information channels	

Text Book:

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

Unit 1 – Sections 1.1 to 1.4
Unit 2 – Sections 2.1 to 2.5
Unit 3 – Sections 3.1 to 3.5
Unit 4 – Sections 4.1 to 4.4

References:

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

Mapping of Program Outcomes with Course Outcomes

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

Course: Practical based on Coding **Course Code:** MAT-612-MJE (B)

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	PO10
CO 1	3	3			3					
CO 2	2	3		3			2			1
CO 3	3				2					
CO 4	2	2			3					
CO 5				2			1			
CO 6	3	3					1			
CO 7	2	3		2	1					2

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: This outcome requires students to derive equations for entropy, mutual information, and channel capacity, demonstrating a deep understanding of fundamental concepts in information theory.

CO2: Implementing source coding algorithms and analyzing their performance enhances students' understanding of compression techniques and their theoretical underpinnings.

CO3: Understanding various methods of generating and detecting error correcting codes contributes to a comprehensive knowledge of error control techniques.

CO4: Performing information theoretic analysis of communication systems involves understanding complex theoretical frameworks, contributing to comprehensive knowledge.

CO6: Designing channel coding schemes necessitates a thorough understanding of channel characteristics and coding principles, contributing to comprehensive knowledge.

CO7: Comprehending various error control code properties deepens students' understanding of error detection and correction mechanisms.

PO2: Practical, Professional, and Procedural Knowledge:

CO1: While primarily theoretical, understanding the derivation of equations for entropy, mutual information, and channel capacity lays the groundwork for practical applications in communication systems.

CO2: Implementing source coding algorithms and analyzing their performance directly enhances practical knowledge by engaging students in hands-on coding and performance evaluation.

CO4: Performing information theoretic analysis requires applying theoretical knowledge to practical communication system scenarios, enhancing professional knowledge.

CO6: Designing channel coding schemes requires procedural knowledge of encoding and decoding processes, enhancing practical understanding.

CO7: Comprehending error control code properties provides procedural knowledge necessary for implementing and analyzing error control mechanisms.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:
CO2: Implementing source coding algorithms and analyzing their performance involves critical thinking and problem-solving to optimize coding schemes for efficiency.
CO5: Designing data compression schemes necessitates critical thinking to select appropriate source coding techniques based on specific requirements.
CO7: Comprehending error control code properties requires critical thinking to analyze the effectiveness of different error control mechanisms.
PO5: Research, Analytical Reasoning, and Ethical Conduct:
CO1: Deriving equations for entropy, mutual information, and channel capacity requires research into existing theories and analytical reasoning to understand and apply them effectively.
CO3: Explaining methods of generating and detecting error correcting codes requires research into coding techniques and analytical reasoning to understand their effectiveness.
CO4: Performing information theoretic analysis demands analytical reasoning to interpret results and draw conclusions about communication system performance.
CO7: Comprehending error control code properties requires analytical reasoning to evaluate the impact of different error control mechanisms on communication system performance and reliability.

PO7: Digital Proficiency and Technological Skills:
CO2: Implementing source coding algorithms and analyzing their performance requires digital proficiency in coding and technological skills in using software tools for performance evaluation.
CO5: Designing data compression schemes involves digital proficiency in implementing source coding techniques using appropriate software tools.
CO6: Designing channel coding schemes requires digital proficiency in implementing coding schemes using simulation tools and analyzing their performance.
PO10: Autonomy, Responsibility, and Accountability:
CO2: Implementing source coding algorithms and analyzing their performance fosters autonomy by requiring students to independently apply theoretical knowledge to practical scenarios.
CO7: Comprehending error control code properties cultivates responsibility by emphasizing the importance of error detection and correction in communication systems.

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

Name of the Programme	**:** M.Sc. (Mathematics)
Program Code	**:** PSMAT
Class	**:** M.Sc.II
Semester	**:** III
Course Type	**:** RP
Course Name	**:** Research Project
Course Code	**:** MAT-621-RP
No. of Lectures	**:** 60
No. of Credits	**:** 4

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Examination Pattern / Evaluation Pattern

Teaching and Evaluation (for Major, Minor, AEC, VEC, IKS courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	4 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Teaching and Evaluation (for VSC, SEC & CC courses)

- Evaluation to be done by Internal & External Experts
- No descriptive end semester written examination
- Evaluation to be done at Department level preferably prior to commencement of Theory /Practical Examinations
- Evaluation to be done on the Skills gained by student