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

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

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

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

Equivalence of the old syllabus and new syllabus

Old Course		**New Course**	
MAT4101	Real Analysis	PSMT111	Measure Theory and Integration
MAT4102	Advanced Calculus	PSMT112	Advanced Calculus
MAT4103	Group theory	PSMT113	Group theory
MAT4104	Numerical Analysis	PSMT114	Numerical Analysis
MAT4105	Ordinary Differential Equations	PSMT115	Ordinary Differential Equations
MAT4106	Practical: Programming in C	PSMT116	Practical: Programming in C

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

Class: M. Sc. I (Semester- I)
Course Code: PSMT111
Course: I **Title of Course: Measure Theory and Integration**
Credit:4 **No. of lectures: 64**

TOPICS/CONTENTS:

1. Measures on real line [12 *Lectures*]
1.1 Lebesgue Outer Measure
1.2 Measurable Sets
1.3 Measurable Functions
1.4 Borel and of Lebesgue Measurability

2. Integration of function on real variables [16 *Lectures*]
2.1 Integration of nonnegative function
2.2 General Integral
2.3 Integration of Series
2.4 Riemann and Lebesgue Integral

3. Differentiation [16 *Lectures*]
3.1 Functions of Bounded variation
3.2 Lebesgue Differentiation Theorem
3.3 Differentiation Theorem
3.4 Differentiation and Integration

4. Abstract Measure Space [10 *Lectures*]
4.1 Measure and outer measure
4.2 Uniqueness of extension
4.3 Completion of Measure
4.4 Measure Space
4.5 Integration with respect to measure

5. Inequalities and L^p Spaces [10 *Lectures*]
5.1 The L^p Spaces
5.1 Convex function
5.2 Jensen's Inequality
5.3 The Inequalities of Holder and Minkowski
5.4 Completeness of $L^p(\mu)$

<u>Text Book:</u>

G. de Barra, *Measure Theory and Integration*, New Age International Limited Publishers, 2000.

Unit 1 - sections 2.1, 2.2, 2.4, 2.5,

Unit 2 - sections 3.1 to 3.4,

Unit 3 – sections 4.3 to 4.6,

Unit 4 - section 5.1 to 5.6,

Unit 5 - section 6.1 to 6.5.

Reference Books:

1. Elias M. Stein and Rami Shakarchi, *Real Analysis,* Princeton University press.
2. Karen Saxe, *Beginning Functional Analysis*, Springer International Edition.
3. W. Rudin, *Principles of Mathematical Analysis*, Mc. Graw Hill.
4. H. L. Royden, P. M. Fitzpatrick, *Real Analysis (Fourth Edition),* Pearson publication Asia Ltd.

Class : M.Sc. I (Semester- I)
Course Code : PSMT112
Course: II **Title of Course: Advanced Calculus**
Credit: 4 **No. of lectures: 64**

TOPICS/CONTENTS:

1. Differential Calculus of Scalar and Vector Field: [16 *Lectures*]
1.1 Derivative of a scalar field with respect to a vector
1.2 Directional derivative, Gradient of a scalar field
1.3 Derivative of a vector field
1.4 Matrix form of the chain rule
1.5 Inverse function theorem and Implicit function theorem.

2. Line Integrals: [12 *Lectures*]
2.1 Path and line integrals
2.2 The concept of work as a line integral
2.3 Independence of path
2.4 The first and the second fundamental theorems of calculus for line integral
2.5 Necessary condition for a vector field to be gradient.

3. Multiple Integrals: [14 *Lectures*]
3.1 Double integrals
3.2 Applications to area and volume
3.3 Green's Theorem in the plane
3.4 Change of variables in a double integral
3.5 Transformation formula
3.6 Change of variables in an n-fold integral.

4. Surface Integrals: [14 *Lectures*]
4.1 The fundamental vector product
4.2 Area of a parametric surface
4.3 Surface integrals
4.4 The theorem of Stokes
4.5 The curl and divergence of a vector field
4.6 Gauss divergence theorem and its applications

5. Application of Differential Calculus: [8 *Lectures*]
5.1 Partial differential equation
5.2 a first order partial differential equation with constant coefficients
5.3 The one Dimensional wave equation.

Text Book:
T. M. Apostol, *Calculus*, Vol. II (2nd edition) , John Wiley and Sons, Inc.
Unit 1: Sections 8.1 to8.22
Unit 2: Sections 10.1 to 10.11 and 10.14 to 10.16

Unit 3: Sections 11.1 to 11.5 and 11.19 to 11.22 and 11.26 to11.34
Unit 4: Sections 12.1 to 12.15, 12.18 to 12.21
Unit 5: Sections 9.1 to 9.5
(For Inverse function theorem and Implicit function theorem refer the book "Mathematical Analysis" by T. M. Apostol)

Reference Books:

1. T. M. Apostol, *Mathematical Analysis*, Narosa publishing house.
2. W. Rudin, *Principles of Mathematical Analysis*, McGraw-Hill.
3. A. Devinatz, *Advanced Calculus*, Holt, Rinehart and Winston.

Class : M.Sc. I (Semester- I)
Course Code : PSMT113
Course: III **Title of Course: GroupTheory**
Credit: 4 **No. of lectures: 64**

TOPICS/CONTENTS:

1. Groups [11 *Lectures*]
1.1 Semigroups and groups
1.2 Homomorphism
1.3 Subgroups and Cosets
1.4 Cyclic groups
1.5 Permutation groups
1.6 Generators and relations

2. Normal Subgroups [16 *Lectures*]
2.1 Normal subgroups and quotient groups
2.2 Isomorphism theorems
2.3 Automorphisms
2.4 Conjugacy and G-sets

3. Normal Series [11 *Lectures*]
3.1 Normal series
3.2 Solvable groups
3.3 Nilpotent groups

4. Permutation Groups [12 *Lectures*]
4.1 Cyclic decomposition
4.2 Alternating group A_n
4.3 simplicity of A_n

5. Structure theorems of groups [14 *Lectures*]
5.1 Direct products
5.2 Finally generated abelian groups
5.3 Invariants of a finite abelian group
5.4 Sylow theorems
5.5 Groups of orders p^2 and pq.

Text Book: P.B .Bhattacharya, S. K .Jain and S .R. Nagapaul – *Basic Abstract Algebra*, Cambridge University Press.

Unit 1: Section 4.1 to 4.6

Unit 2: Section 5.1 to 5.4

Unit 3: Section 6.1 to 6.3

Unit 4: Section 7.1 to 7.3

Unit 5: Section 8.1 to 8.5

<u>Reference Books:</u>

1. I.S. Luthar and I.B.S. Passi : Algebra (Volume 1) Groups (Narosa Publishing House)
2. I.N. Herstein : Topics in Algebra (Wiley-Eastern Ltd)
3. N.S. GopalaKrishnan : University Algebra (Wiley-Eastern Ltd)
4. Fraleigh : A First Course in Abstract Algebra
5. Dummit and Foote: Abstract Algebra (Wiley-Eastern Ltd).

Class: M. Sc. I (Semester- I)
Course Code: PSMT114
Course: IV **Title of Course : Numerical Analysis**

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

TOPICS/CONTENTS:

1. Root of Nonlinear Equations [12 *Lectures*]

1.1 Introduction
1.2 Methods of Solution
1.3 Iterative methods
1.4 Evaluation of Polynomials
1.5 Bisection method
1.6 False Position method
1.7 Newton Raphson Method and Secant Method
1.8 Fixed Point Method, System of Nonlinear Equations and Roots of Polynomials.

2. Direct and Iterative Solution of Linear Equations [16 *Lectures*]

2.1 Existence of Solution
2.2 Solution by elimination
2.3 Basic Gauss Elimination method
2.4 Gauss elimination with pivoting and Gauss-Jordan Method
2.5 Triangular Factorization Methods and Round- off Errors and Refinement
2.6 Matrix Inversion Method and Jacobi Iterative method
2.7 Gauss-Seidel Method and Convergence of Iteration Methods.

3. Curve Fitting Interpolation: [8 *Lectures*]

3.1 Polynomial forms and linear interpolation
3.2 Lagrange Interpolation Polynomial
3.3 Newton Interpolation Polynomial and Interpolation with equidistant points.

4. Numerical Differentiation and Integration: [16 *Lectures*]

4.1 Differentiating Continuous functions
4.2 Forward difference quotient
4.3 Central difference quotient
4.4 Error analysis and Newton-Cotes Methods
4.5 Trapezoidal Rule, Simpsons 1/3 rule, Simpsons 3/8 rule.

5. Numerical Solution of Ordinary Differential Equations and Boundary-value Problems [12 *Lectures*]

5.1 Taylor Series Method
5.2 Euler's Method and Heun's Method
5.3 Polygon Method and Runge -Kutta Methods
5.4 Shooting Method
5.5 Finite Difference Method

5.6 Solving Eigenvalue Problems
5.7 Power method.

Text Book: E Balagurusamy, *Numerical Methods*, , McGraw Hill.

Unit 1: Section 6.1 to 6.3 and 6.5 to 6.10.

Unit 2: Section 7.1 to 7.8, and 7.10.

Unit 3: Section 8.1 to 8.5

Unit 4: Section 9.1 to 9.7

Unit 5: Section 11.1, 11.2, 13.2 to 13.6, 14.1 to 14.4.

Reference Books:

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis,* Pearson Prentice Hall 2007.
2. S. S. Sastry, *Introduction Methods of Numerical Analysis (4th Edition),* Prentice.
3. John H. Mathews, Kurtis D. Fink , *Numerical Methods using Matlab ,4th Edition* , Pearson Education (Singapore) Ltd. Indian Branch , Delhi 2005.
4. K .E. Atkinson, *An Introduction to Numerical Analysis*, John Wiley and sons.
5. J. I. Buchman and P. R. Turner, *Numerical Methods and Analysis*, McGraw-Hill.
6. M.K. Jain, S.R.K. Iyengar, R.K. Jain, *Numerical Methods for scientific & engineering Computation, 5th Edition*, New Age International Publication.

Class: M. Sc. I (Semester- I)
Course Code: PSMT115
Course: V **Title of Course: Ordinary Differential Equations**
Credit: 4 **No. of lectures: 64**

TOPICS/CONTENTS:

1. Linear equations with constant coefficients [14 *Lectures*]

1.1 Second order homogeneous equations

1.2 Initial value problems for second order equations

1.3 Linear dependence and independence

1.4 Formula for the Wronskian

1.5 Non homogeneous equations of order two and order n.

1.6 Homogeneous equations of order n.

1.7 Algebra of constant coefficients equations

2. Linear equations with variable coefficients [14 *Lectures*]

2.1 Initial value problems for the homogeneous equation

2.2 Solutions of the homogeneous equation

2.3 Wronskian and linear independence

2.4 Reduction of order of the homogeneous equation

2.5 Non homogeneous equations with analytic coefficients

2.6 Homogeneous equations

2.7Legendre equation,

3. Linear Equations with regular singular points [12 *Lectures*]

3.1 Euler equation

3.2 Second order equation with regular singular points

3.3 Exceptional cases

3.4 Bessel's equation

3.5 Regular singular point at infinity

4. Existence and uniqueness of solutions to first order equations [12 *Lectures*]

4.1 Equations with variables separated

4.2 Exact equations

4.3 Method of successive approximations

4.4 Lipschitz condition

4.5 Approximation and uniqueness to solution

5. Existence and uniqueness of solutions to systems and n^{th}order equations[12 *Lectures*]
5.1 Complex n-dimensional space
5.2 Systems as vector equations
5.3 Existence and uniqueness of solutions to systems
5.4 Existence and uniqueness for linear systems
5.5 Equations of order n

Text Book:

E. A. Coddington, *An Introduction to Ordinary Differential Equations,* Prentice- Hall, 1987.

Unit 1 - sections 2.2 to 2.12,

Unit 2 - sections 3.1 to 3.8,

Unit 3 – sections 4.1, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9,

Unit 4 - section 5.1 to 5.5 and 5.8,

Unit 5 - section 6.4 to 6.8.

Reference Books:

1. G. F. Simmons, *Differential Equations with applications and Historical notes,* Tata-McGraw Hill.
2. G. Birkhoff and G.C. Rota, *Ordinary differential equations*, John Wiley and Sons.
3. S. G. Deo, V. Lakshmikantham, V. Raghvendra, *Text book of Ordinary Differential Equations*,
Second edition, TataMc-Graw Hill.
4. G. F. Simmons and S. G. Krantz, *Differential Equations,* Tata- McGraw-Hill.

Class: M. Sc. I (Semester- I)
Course Code : PSMT116
Course:VI **Title of Course: Practical- Programming in C**
Credit: 4 **No. of lectures: 64**

TOPICS/CONTENTS:

1. Introductory concepts in C [8 Hours]
2. C Fundamentals [10 Hours]
3. Operators and Expressions [8 Hours]
4. Data input and outputs [8 Hours]
5. Preparing and running a program [10 Hours]
6. Control statements [6 Hours]
7. Functions [4 Hours]
8. Program Structures [4 Hours]
9. Arrays [3 Hours]
10. Pointers [3 Hours]

Text Book:

Yeshwant Kanetkar, *Let us C*, BPB Publications.

Reference Books:

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Prentice Hall.
2. Byrons S. Gottfried, Programming with C, Schaum's Outline Series.
3. S.A.Teukolsky, *Numerical recipes in C,* W. H. Press.

Credit System Syllabus (2022 Pattern)

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc-I (Sem I) **Subject:** Mathematics
Course: Measure Theory and Integration **Course Code:** -PSMT111

Course Objectives:

1. To acquire knowledge of basic and advanced concepts in Measure Theory which are useful in Fourier analysis and Functional Analysis.
2. To get familiar with concepts of measurable functions, Differentiation, and, Integration.
3. To develop the ability to solve simple and complex problems.
4. To learn how to use knowledge as a foundation for many branches of mathematics such as probability theory, stochastic process and functional analysis.
5. To learn the basic elements of Measure Theory providing the students an additional opportunity to develop skills in modern analysis as well as providing a rigorous foundation for other branches of mathematics.
6. To develop familiarity with measures, Lebesgue integration, differentiation and convergence.
7. Get accustomed to the level and difficulty of math graduate courses.

Course Outcomes:

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

CO1 Understand the concept of Lebesgue integral, Convergence Theorem, and Riemann integral for Riemann integrable functions.

CO2 To solve problems involving measure theory.

CO3 Students should display their mathematical maturity by being able to approach unfamiliar problems and critically evaluate purported proofs/examples.

CO4 Know the basic theory of measure and integral and students will be able to apply the theory in the course to solve a variety of problems than appropriate level of difficulty.

CO5 Learn how a smallest sigma algebra containing all open sets which ensures the measurability of all continuous function and how a measure called Borel measure is defined on this sigma algebra which ensures the integrability of a huge class of continuous functions.

CO6 Realize a measure may take real values even complex values and learn to characterize bounded linear functionals on L_p.

CO7 Students will be able to develop an appreciation of the basic concepts of measure theory. Apply measure theory to real world problems.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: This includes an intuitive understanding, from which the definitions could essentially be recalled many years after the course.
CO2: Students can apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
CO3: As this a completely rigorous course, it allows for the presentation of mathematical arguments in the assignments. It is generally expected that students will make substantive progress in presentation using disciplinary Knowledge.
CO4: Studying the distinct concepts in measure theory is crucial in disciplinary knowledge because it is helpful in solving intricate problems in mathematics, and various scientific disciplines.
CO5: Understanding sigma algebra and Borel measure an integral fundamental in disciplinary knowledge as they play a pivotal role in advanced mathematical and scientific computations.

PO2: Critical Thinking and Problem solving.
All CO'S enhances critical thinking and problem-solving by providing a deep understanding of the behaviour of complex problems, enabling more accurate and sophisticated analysis of intricate mathematical and scientific problems. Understanding the convergence theorem is essential for critical thinking and problem-solving because it gives more accurate analysis and informed problem-solving across disciplines. CO6: Understanding types of L^p spaces plays a vital role for critical thinking and problem-solving, as they provide powerful mathematical tools for further classification into spaces.

PO4: Research-related skills and Scientific temper
CO1: Studying theory of sequences, function spaces and Dimension cultivates research-related skills and a scientific temper by equipping individuals with advanced mathematical

tools crucial for conducting rigorous analyses and investigations in diverse scientific disciplines.
CO2: Applying various concepts fosters problem-solving approach by equipping individuals with powerful mathematical tools and helpful to solve real-world problems across various disciplines.
CO3: Classifying and studying open, closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. developed the scientific approach.
CO7: Understanding types of L^p spaces plays a vital role in advanced mathematical research, facilitating precise modeling and analysis in scientific inquiries and investigations.

PO5: Trans-disciplinary knowledge
CO5: Study of open, closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. is crucial for trans-disciplinary knowledge as it equips individuals with a foundational mathematical concept to an equivalence in metric space.

PO9: Self-directed and Life-long learning:
CO4: Studying concepts of measure theory supports self-directed and life-long learning by equipping individuals with powerful mathematical tools that can be applied across a wide range of contexts and disciplines, promoting ongoing personal and professional development.

Class: M.Sc-I (Sem I) **Subject:** Mathematics
Course: Advance Calculus **Course Code:** -PSMT112

Course Objectives:
1. To understand theory in Vector calculus.
2. To use important theorems such as Greens Theorem, Divergence, Stokes Theorem for problem-solving.
3. To learn multidimensional Integrals and Surface integrals.
4. Use stokes theorem to give a physical interpretation of the curl of a vector field.
5. Compute the curl and divergence of vector fields.
6. Use the fundamental theorem of line integrals.
7. Use greens theorem to evaluate line integrals along simple closed contours on the plane.

Course Outcomes:
1. To apply these concepts to solve practical problems that arise in physics and other related areas.
2. To apply these concepts to solve practical problems that arise in physics and other related areas.
3. Students will able to use the chain rule by applying necessary rules.
4. Students will be able to differentiate vectors to understand gradient, divergence and curl by using appropriate rules.
5. Students will be able to compute line integrals of vector functions and also solve real world problems by using definition and in differential forms.
6. Students will be able to compute surface integrals of vector fields by developing the notion of integral.
7. Students will be able to use greens and stokes theorems by combining vector differential calculus and vector integral calculus.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO6: Students can compute surface integrals of vector fields by developing the concept of integration within disciplinary knowledge.

CO2: Understanding change of variables via the application of Change of Variable Theorems within disciplinary knowledge facilitates advanced problem-solving techniques and enhances comprehension of complex mathematical transformations essential in various scientific and engineering domains.

PO2: Critical Thinking and Problem solving

CO4: Mastering vector differentiation for gradient, divergence, and curl through appropriate rules fosters critical thinking and problem-solving skills crucial for analysing intricate physical systems in scientific and engineering contexts.

CO7: Utilizing Green's and Stokes' theorems by integrating vector calculus enhances critical thinking, problem-solving abilities, and the comprehension of interconnected concepts vital for advanced analysis in diverse scientific and engineering applications.

PO4: Research-related skills and Scientific temper

CO1: Applying these concepts to solve practical problems in physics and related fields cultivates research-related skills and nurtures a scientific temperament, fostering analytical and investigative approaches essential in scientific exploration.

CO3: Mastering the chain rule equips students with crucial research-related skills and nurtures a scientific temper, enabling intricate analysis and understanding of complex interdependencies crucial in scientific inquiry

PO5: Trans-disciplinary knowledge

CO4: Differentiating vectors to comprehend gradient, divergence, and curl through relevant rules fosters trans-disciplinary knowledge, facilitating comprehensive understanding applicable across diverse scientific domains.

CO7: Utilizing Green's and Stokes' theorems by integrating vector calculus enhances critical thinking, problem-solving abilities, and the comprehension of interconnected concepts vital for advanced analysis in diverse scientific and engineering applications.

PO9: Self-directed and Life-long learning:

CO2: Mastering change of variables through theorem application nurtures self-directed learning and instills a foundation for lifelong adaptation in problem-solving across various disciplines.

CO5: Mastering line integrals in both their definitions and differential forms fosters lifelong learning by enabling the application of mathematical concepts to solve diverse real-world problems across disciplines.

CO6: Understanding surface integrals of vector fields cultivates a lifelong learning approach, empowering continual adaptation and application of mathematical concepts in various problem-solving scenarios across disciplines.

Class: M.Sc-I (Sem I) **Subject:** Mathematics
Course: Group Theory **Course Code:** -PSMT113

Course Objectives:

1. Define the basic concepts of groups, including group elements, binary operations, and the identity element.
2. Introduce the notion of group axioms and explore examples of groups.
3. Introduce the concept of cosets and examine their role in group theory..
4. Explore the relationships between groups using homomorphisms.
5. Study permutation groups and their significance in the context of symmetric groups.

Course Outcomes:

1. Students should demonstrate a clear understanding of the fundamental concepts of groups, including group elements, binary operations, and the identity element.
2. Students should be able to analyze and apply group operations, understanding properties such as associativity and the existence of inverses.
3. Identify and analyze subgroups, demonstrating comprehension of their properties and significance within group theory.
4. Students should be proficient in defining and working with group homomorphisms and isomorphisms, and should understand their role in relating different groups.
5. Apply group theory concepts to solve real-world problems, such as those in chemistry, physics, cryptography, and other relevant fields.
6. Students should develop strong problem-solving skills and be capable of constructing rigorous mathematical proofs related to group theory.
7. Students should be able to apply group theory concepts to solve real-world problems, such as those in chemistry, physics, cryptography, and other relevant fields.

Mapping of Program Outcomes with Course Outcomes

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

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Analyzing and applying group operations, including understanding properties such as associativity and the existence of inverses, enhances students' disciplinary knowledge by fostering a deep comprehension of abstract algebraic structures, laying the foundation for

advanced mathematical concepts and their real-world applications.
CO3: Identifying and analyzing subgroups showcases a profound grasp of group theory, enabling students to discern the structural intricacies of mathematical systems and appreciate the importance of subgroups in elucidating broader mathematical concepts and applications.
CO5: Applying group theory concepts to real-world problems in chemistry, physics, cryptography, and other fields enhances disciplinary knowledge by demonstrating the practical utility of abstract algebra, fostering critical thinking skills, and enabling students to address complex problems in diverse scientific and applied contexts.
CO6: Fostering strong problem-solving skills and proficiency in constructing rigorous mathematical proofs related to group theory empowers students with a foundational discipline knowledge, cultivating logical reasoning and analytical abilities essential for advanced mathematical exploration and applications across various scientific domains.
CO7: Applying group theory to real-world problems in chemistry, physics, cryptography, and other fields enhances disciplinary knowledge, equipping students with practical problem-solving tools and demonstrating the broad applicability of abstract algebra in diverse scientific and applied contexts.

PO2: Critical Thinking and Problem solving
CO2: Analyzing and applying group operations, along with understanding properties like associativity and inverses, fosters critical thinking and problem-solving skills by requiring students to navigate abstract algebraic structures, make logical connections, and employ mathematical principles to address complex problems within the realm of group theory.
CO4: Proficiency in defining and working with group homomorphisms and isomorphisms, coupled with an understanding of their role in relating different groups, cultivates critical thinking and problem-solving skills by challenging students to discern structural patterns.
CO6: Developing strong problem-solving skills and constructing rigorous mathematical proofs related to group theory fosters critical thinking by requiring students to analyze abstract structures, identify logical connections, and systematically present coherent arguments, cultivating a deep understanding of mathematical concepts and enhancing their ability to solve complex problems within the discipline.

PO3: Social competence:
CO6: Developing strong problem-solving skills and constructing rigorous mathematical proofs related to group theory enhances social competence by fostering collaborative learning environments, promoting effective communication of complex ideas, and encouraging teamwork, which are essential skills for engaging positively within academic and professional communities.

PO4: Research-related skills and Scientific temper :
CO4: Proficiency in defining and working with group homomorphism's and isomorphisms, along with understanding their role in relating different groups, hones research-related skills and a scientific temper by fostering the ability to explore abstract structures
CO6: Developing strong problem-solving skills and constructing rigorous mathematical proofs related to group theory cultivates research-related skills and a scientific temper by instilling a methodical approach to inquiry, precision in analysis, and the ability to contribute meaningfully to the advancement of mathematical knowledge.

PO5: Trans-disciplinary knowledge:
C05: Applying group theory concepts to solve real-world problems in various fields like chemistry, physics, and cryptography promotes trans-disciplinary knowledge by

demonstrating the versatility of abstract mathematical principles and their applicability across diverse domains, fostering a holistic understanding of the interconnectedness of mathematical concepts with other disciplines.

PO6: Personal and professional competence:
CO7: Applying group theory concepts to real-world problems cultivates personal and professional competence by honing practical problem-solving skills, fostering adaptability, and preparing students to address complex challenges in their professional pursuits, thereby enhancing their overall competency and efficacy.

PO9: Self-directed and Life-long learning:
CO6: Developing strong problem-solving skills and constructing rigorous mathematical proofs in group theory cultivates self-directed and life-long learning by fostering an independent and continuous exploration of abstract mathematical concepts.
CO7: Applying group theory to real-world problems instills self-directed and life-long learning by challenging students to independently adapt abstract mathematical concepts.

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

Course: Numerical Analysis **Course Code:** -PSMT114

Course Objectives:

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

Course Objectives:

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

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

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

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

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

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

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

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

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Proficiency in handling Machine Learning algorithms using Numerical Analysis in disciplinary knowledge equips students with the essential computational skills to enhance the efficiency, accuracy, and interpretability of machine learning models, fostering a robust foundation for applying data-driven solutions in diverse domains.

CO2: The ability to construct a function closely fitting given n-points through interpolation enhances disciplinary knowledge by empowering students with a practical and versatile tool

for approximating and analysing real-world data, facilitating applications in various scientific, engineering, and mathematical domains.
CO3: A solid understanding of common numerical methods is essential in disciplinary knowledge as it equips individuals with practical tools to address real-world mathematical problems, offering efficient and effective approaches to tackle complex computations that may be challenging or impractical to solve analytically.
CO6:Solving algebraic or transcendental equations using numerical methods in disciplinary knowledge empowers students with practical problem-solving skills, essential for applications in various scientific and engineering disciplines, facilitating accurate solutions to complex mathematical models and real-world problems.
CO7: The ability to approximate a function using numerical methods is essential in disciplinary knowledge as it empowers students to bridge theoretical concepts with practical applications, fostering a deeper understanding of mathematical models and their real-world implications..

PO2: Critical Thinking and Problem solving
CO2: Constructing a function through interpolation cultivates critical thinking and problem-solving skills by requiring students to strategically analyse and synthesize information, make informed decisions about function behaviour, and devise precise mathematical models to approximate and interpolate data points, fostering a deeper understanding of mathematical relationships.
CO4: Implementing numerical methods in software like Scilab enhances critical thinking and problem-solving skills by enabling students to apply abstract mathematical concepts to real-world problems, fostering the ability to analyse, optimize, and evaluate solutions using computational tools in diverse scientific and engineering contexts.
CO5: Solving a linear system of equations using a numerical method enhances critical thinking and problem-solving skills by requiring the evaluation and selection of appropriate algorithms, fostering a systematic approach to analyze complex mathematical problems, and encouraging the development of efficient strategies for addressing real-world challenges.
CO7: The ability to approximate a function using numerical methods cultivates critical thinking and problem-solving skills by requiring students to evaluate algorithmic choices, assess precision-accuracy trade-offs, and apply mathematical reasoning to address real-world problems with diverse applications.

PO3: Social competence
CO1: Handling Machine Learning algorithms through Numerical Analysis in the context of social competence enhances interdisciplinary communication by equipping students to navigate the intersection of mathematics and technology, fostering the ability to collaborate effectively on data-driven projects and promoting understanding and application of machine learning in societal contexts.
CO4: Implementing numerical methods in Scilab and other mathematical software in the context of social competence demonstrates the ability to leverage technology for collaborative problem-solving, fostering effective communication and teamwork in interdisciplinary settings for addressing societal challenges that demand computational approaches.
CO7: Approximating a function through numerical methods in the context of social competence cultivates the ability to communicate complex mathematical concepts effectively, facilitating collaboration and interdisciplinary dialogue by bridging the gap between technical expertise and practical applications, thus fostering a more inclusive and accessible approach to mathematical discussions within diverse social settings.

PO4: Research-related skills and Scientific temper

CO2: Constructing a function through interpolation method cultivates research-related skills and scientific temper by necessitating the exploration and application of mathematical techniques, encouraging a systematic investigation into data patterns, and fostering an inquisitive mindset towards developing models that capture the underlying structures in scientific phenomena.

CO7 : Approximating a function using a numerical method cultivates research-related skills and scientific temper by instilling a meticulous and evidence-based approach to analysing mathematical models, fostering the ability to critically assess the accuracy and limitations of computational methods, essential for advancing research in various scientific domain.

PO5: Trans-disciplinary knowledge

CO4: Implementing numerical methods in Scilab and other mathematical software promotes trans-disciplinary knowledge by bridging the gap between diverse domains, fostering the integration of mathematical techniques into various fields, and enhancing interdisciplinary collaboration through the application of computational tools for problem-solving across different disciplines.

CO6: Solving algebraic or transcendental equations with numerical methods in trans-disciplinary knowledge equips students with a versatile problem-solving tool applicable across diverse fields, fostering an interdisciplinary mindset and enhancing their ability to address complex challenges that involve mathematical modeling and analysis.

PO7: Effective Citizenship and Ethics

CO5: Solving a linear system of equations through numerical methods in the context of effective citizenship and ethics demonstrates a commitment to data-driven decision-making, promoting transparency and accountability in addressing societal challenges that may involve mathematical modelling and quantitative analysis.

PO9: Self-directed and life –long learning :

CO1: Proficiency in handling Machine Learning algorithms through Numerical Analysis supports self-directed and lifelong learning by empowering students to adapt to evolving technologies, fostering a continuous learning mindset to explore and apply advanced computational techniques independently throughout their professional careers.

CO4: Implementing numerical methods in software like Scilab for self-directed and lifelong learning fosters digital literacy and adaptability, empowering individuals to acquire new technical skills independently, stay abreast of technological advancements, and engage in continuous learning throughout their lives.

Class: M.Sc-I (Sem I) **Subject:** Mathematics
Course: Ordinary Differential Equations **Course Code:** -PSMT115

Course Objectives:

1. To introduce the theory of linear and nonlinear ODE.
2. To provide students with an introduction to the theory of ordinary differentialequations through applications.
3. Create and analyze mathematical models using higher order differential equations toSolve application problems such as harmonic oscillator and circuits.
4. To learn about about linear and non-linear differential equation.
5. Solving differential equation using numerical methods.
6. Solving a system of linear equations and eigen values.
7. Study Picard theorem and solving integral problems using it.

Course Outcomes:

1. Find the complete solution of a nonhomogeneous differential equation as a linear combination of the complementary function and a particular solution.
2. Introduced to the complete solution of a nonhomogeneous differential equation withconstant coefficients by the method of undetermined coefficients.
3. Classify the differential equations with respect to their order and linearity.
4. Explain the meaning of solutions of Differential equations.
5. Use the method of variation of parameter to find the solution of higher order linear differential equations with variable coefficients.
6. Analyze stability of solutions, including equilibrium points and limit cycles.
7. Develop analytical and problem-solving skills through the application of ODE theory to real-world scenarios.

Mapping of Program Outcomes with Course Outcomes

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

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Solving Ordinary Differential Equations (ODEs) enables in-depth analysis and design of engineering systems, such as control systems, structural mechanics, and fluid dynamics, providing essential insights into dynamic behaviour and facilitating optimization for enhanced system performance

CO6: Analysing the stability of solutions, including equilibrium points and limit cycles, is

essential in disciplinary knowledge for assessing the robustness and reliability of dynamic systems, guiding the design and control strategies for engineering applications.
CO7: Developing analytical and problem-solving skills through the application of Ordinary Differential Equation (ODE) theory to real-world scenarios is integral to disciplinary knowledge, fostering the ability to address and optimize complex engineering challenges with practical and effective solutions.

PO2: Critical Thinking and Problem solving
CO6: Analysing the stability of solutions, encompassing equilibrium points and limit cycles, demands critical thinking and problem-solving skills, enabling a nuanced evaluation of system dynamics and the formulation of effective strategies for stability enhancement in diverse engineering applications.
CO7: Applying Ordinary Differential Equation (ODE) theory to real-world scenarios cultivates critical thinking and problem-solving skills, enhancing the capacity to analyse, strategize, and formulate effective solutions for diverse challenges in a dynamic and practical context.

PO4: Research-related skills and Scientific temper
CO7 : Applying ODE theory to real-world scenarios cultivates research-related skills and a scientific temper, fostering the ability to explore, investigate, and contribute valuable insights to advance the understanding and application of differential equations in practical and research-oriented contexts.

PO5: Trans-disciplinary knowledge
CO2: Understanding the distinction between ordinary and partial differential equations is essential for trans-disciplinary knowledge, providing a foundational comprehension that spans diverse fields and facilitates the effective application of differential equations across various scientific and engineering domains.
CO4:Mastering the fundamentals of first-order Ordinary Differential Equations (ODEs) and their solutions provides a trans-disciplinary toolkit, fostering a versatile understanding applicable across various scientific and engineering domains.
CO6: Analysing stability in solutions, including equilibrium points and limit cycles, contributes to trans-disciplinary knowledge by providing a universal framework applicable to diverse scientific and engineering systems, ensuring robustness and reliability across various domains

PO8:Envionment and Sustainability :
CO6: Analysing stability of solutions, including equilibrium points and limit cycles, is crucial for environmental and sustainability considerations, ensuring resilient and optimal performance in engineered systems to promote long-term ecological balance.

PO9: Self-directed and life –long learning :
CO6: Analyzing stability of solutions, including equilibrium points and limit cycles, promotes self-directed and life-long learning by instilling a proactive mindset, encouraging continuous exploration and mastery of dynamic system behaviors across evolving contexts
CO7: Developing analytical and problem-solving skills through the application of ODE theory to real-world scenarios fosters self-directed and life-long learning, empowering individuals to adapt to evolving challenges and continuously enhance their expertise in diverse fields

Class: M.Sc-I (Sem I) **Subject:** Mathematics
Course: Practical programming in C **Course Code:** -PSMT116

Course Objectives:
1. To understand basic programming in C.
2. To study mathematics using programming.
3. To use programming to make useful software in industry and use of Mathematics in them makes them more reliable and user friendly.
4. Programming basics and the fundamentals of C.
5. Data types in C
6. To understand Mathematical and logical operatory.
7. To study use of if statement and loop.

Course Outcomes:

By the end of the course, students will be able to:
CO1-Understand and visualize the working of computers.
CO2-Use fundamentals of C programming to implement algorithms in mathematics.
CO3-Develop a C program.
CO4-Exploring C programming.
CO5-Managing input and output operations.
CO6-Understand the basics of file handling mechanisms.
CO7-Solve repetitive work using C programming.

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

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Disciplinary Knowledge: Understanding and visualizing the working of computers is crucial for informed decision-making and innovation in various fields, as it enables comprehension of the fundamental principles governing information processing, storage, and communication in modern technological systems.
CO2: Implementing algorithms in mathematics using the fundamentals of C programming allows for efficient and precise numerical computations, leveraging the language's control structures and data manipulation capabilities to solve complex mathematical problems with computational precision.
CO3: Certainly! To provide you with a C program, I'll need more specific details about the task or problem you'd like the program to address. Could you please provide more information or specify the purpose of the C program?

CO4: Disciplinary Knowledge: "Exploring C programming enhances fundamental understanding of computer science principles and provides a strong foundation for system-level development."
CO5: "Effective management of input and output operations in Disciplinary Knowledge ensures streamlined data flow, optimizing information exchange and enhancing overall system efficiency."
CO6: File handling mechanisms are fundamental in computer science, enabling the creation, reading, updating, and deletion of files, providing a structured way to store and retrieve data, facilitating efficient information management in software applications.
CO7: C programming allows for the automation of repetitive tasks through the creation of efficient and reusable code, reducing manual effort and increasing productivity in Disciplinary Knowledge.

PO2: Critical Thinking and Problem solving
CO1: Critical Thinking and Problem Solving: Understanding and visualizing the working of computers is crucial for these skills as it enables individuals to analyze complex information, identify patterns, and devise effective solutions in a rapidly evolving technological landscape.
CO2: Utilizing fundamental C programming principles in mathematical algorithms fosters critical thinking and problem-solving by enabling precise, efficient, and structured computational solutions, promoting a deeper understanding of mathematical concepts through implementation..
CO3: Certainly! However, you haven't specified a particular problem or scenario for the C program. Critical thinking and problem-solving can be applied to various situations. Could you please provide more details or specify the problem you'd like the C program to address? This will help me generate a more relevant and meaningful program for you.
CO4: Studying C programming fosters critical thinking and problem-solving skills by cultivating a structured approach to logic, algorithm design, and debugging, essential for effective and efficient software development.
CO5: Effective management of input and output operations is crucial for critical thinking and problem solving as it ensures accurate data processing, facilitates informed decision-making, and enhances overall system efficiency.
CO6: Critical thinking and problem-solving skills are enhanced through understanding file handling mechanisms as they empower individuals to efficiently manipulate, organize, and process data, fostering effective decision-making and problem resolution in various contexts.
CO7: C programming automates repetitive tasks, enhancing efficiency and reducing errors through streamlined execution of instructions, fostering critical thinking by enabling focus on complex problem-solving aspects rather than manual, routine operations.

PO3: Social competence
C07: In C programming, automating repetitive tasks through code can significantly improve efficiency and reduce errors, promoting social competence by enabling individuals to focus on more meaningful and creative aspects of their work, fostering collaboration, and contributing to overall productivity and innovation in the community.

PO4: Research-related skills and Scientific temper
CO3: Certainly! Below is a simple C program that prints a one-line justification for the importance of research-related skills and scientific temper the program uses the `printf` function to display the justification message. Feel free to modify or expand upon it as needed.
CO7 : In research-related skills and scientific temper, utilizing C programming can automate repetitive tasks, enhancing efficiency and reproducibility through streamlined data processing

and analysis..

PO5: Trans-disciplinary knowledge
CO3: This C program combines mathematical knowledge (calculation of the area of a circle using the mathematical constant π and exponentiation) with language and communication knowledge (user input and output) to demonstrate the integration of trans-disciplinary concepts, reflecting the importance of combining different fields of knowledge for comprehensive problem-solving.

PO9: Self-directed and life –long learning :
CO5: This C program exemplifies self-directed and life-long learning by incorporating robust input and output operations, fostering adaptability and continual skill development in response to evolving programming challenges and user needs.

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