Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Autonomous)

Two Year Degree Program in Mathematics (Faculty of Science & Technology)

CBCS Syllabus

M.Sc. (Mathematics) Part-I Semester -I

For Department of Mathematics

Tuljaram Chaturchand College, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2023-2024 (Eligibility: B.Sc. (Mathematics))

Title of the Programme: M.Sc. (Mathematics)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Mathematics and related subjects, the Board of Studies in Mathematics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the first semester of M.Sc. Part-IMathematics, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

A Mathematics degree equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. Graduates in Mathematics find opportunities in various fields, including Financial Planner, Market Research Analyst, Data Scientist, teaching, Insurance underwriter, operations research analyst, software developer, and many other domains. After graduating with a degree in mathematics, students can embark on a multitude of rewarding and diverse career paths. The analytical and problem-solving skills honed during their studies equip them with a strong foundation for success in various fields. Many graduates choose to pursue careers in academia and research, where they can contribute to the advancement of mathematical knowledge through teaching, publishing papers, and conducting groundbreaking research. Others may opt for careers in the financial sector, such as investment banking or actuarial science, utilizing their expertise in mathematical modelling and statistical analysis to make informed decisions and manage risks. Additionally, the field of data science offers abundant opportunities for mathematics graduates, as they possess the ability to extract meaningful insights from complex data sets and develop algorithms that drive innovation in industries like technology, healthcare, and marketing. Moreover, mathematics graduates can find fulfilling careers in engineering, cryptography, software development, and operations research, to name just a few areas where their mathematical skills are highly sought after. Overall, a degree in mathematics opens doors to a wide range of intellectually stimulating and financially rewarding professions, allowing graduates to make significant contributions to society and thrive in a rapidly evolving world.

Overall, revising the Mathematics syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Programme Specific Outcomes (PSOs)

PSO 1-Proficiency in Mathematical Concepts: Graduates will have a deep understanding of fundamental mathematical concepts and theories across various branches of mathematics, including calculus, algebra, geometry, probability, and statistics.

PSO 2-Problem-Solving Skills: Graduates will possess strong problem-solving skills and the ability to apply mathematical principles to real-world situations. They can analyze complex problems, develop logical reasoning, and devise creative strategies to find solutions.

PSO 3-Mathematical Modeling: Graduates will be proficient in mathematical modeling, which involves using mathematical techniques to describe and analyze real-world phenomena. They can formulate and solve mathematical models to address problems in diverse fields, including physics, economics, engineering, and social sciences.

PSO4-Computational and Analytical Skills: Graduates will be skilled in using computational tools and software, such as programming languages, statistical software, and mathematical modeling software. They can leverage these tools to perform numerical analysis, data visualization, and simulations.

PSO 5-Communication and Presentation: Graduates will possess effective communication skills, both written and oral, to convey complex mathematical ideas and results to both technical and non-technical audiences. They can present mathematical arguments, proofs, and findings in a clear and concise manner.

PSO 6-Research and Inquiry: Graduates will have the ability to engage in mathematical research and inquiry. They can critically evaluate existing mathematical theories, develop new mathematical models, and contribute to the advancement of mathematical knowledge through independent research or collaborative projects.

PSO 7-Interdisciplinary Collaboration: Graduates will be adept at collaborating with professionals from other disciplines, such as scientists, engineers, economists, and computer scientists. They can effectively communicate and work in multidisciplinary teams to solve complex problems that require mathematical expertise.

PSO 8-Lifelong Learning: Graduates will have developed a strong foundation for lifelong learning in mathematics. They will have the skills to stay abreast of new developments in the field, adapt to emerging technologies and methodologies, and continue their professional growth through self-directed study or advanced academic pursuits.

PSO 9-Advanced Mathematical Techniques: Graduates will have a command of advanced mathematical techniques, such as differential equations, mathematical analysis, linear algebra, number theory, and optimization. They can apply these advanced mathematical tools to solve complex problems and contribute to specialized areas of research.

PSO 10-Mathematical Software Development: Graduates will possess programming skills and the ability to develop mathematical software or algorithms. They can design, implement, and optimize software applications that facilitate mathematical calculations, simulations, data analysis, and modeling.

PSO 11-Mathematical Education and Teaching: Graduates interested in pursuing a career in education will have the necessary skills to teach mathematics at various levels. They can design and deliver effective lessons, develop curriculum materials, and assess student progress in mathematics. They can also inspire and motivate students to develop an appreciation for the subject.

PSO 12-Mathematical Finance and Risk Analysis: Graduates with an interest in finance and economics will have specialized knowledge in mathematical finance and risk analysis. They can apply mathematical models, stochastic calculus, and statistical methods to analyze financial markets, manage investment portfolios, assess risk, and make informed financial decisions.

Anekant Education Society's
Tuljaram Chaturchand College, Baramati
(Autonomous)

Board of Studies (BOS) in Mathematics

From 2022-23 to 2024-25

Sr.No.	Name	Designation
1.	Mr. Sadashiv R. Puranik,	Chairman
2.	Ms. Varsha H. Shinde	Member
3.	Dr. Prakash B. Fulari	Member
4.	Ms. Shaila S. Jadhav	Member
5.	Ms. Nikita R. Shinde	Member
6.	Ms. Sonali V. Kate	Member
7.	Dr. Anil S. Khairnar	Vice-Chancellor Nominee
8.	Dr. Nitin S. Darkunde	Expert from other University
9.	Dr. Kishor D. Kucche	Expert from other University
10.	Mr. Amit Patil	Industry Expert
11	Dr. Haribhau R. Bhapkar	Meritorious Alumni
12.	Ms. Sharwari Markale	Student Representative
13.	Mr. Vishwajeet Nalawade	Student Representative

Anekant Education Society's

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

Credit Distribution Structure for (M.Sc. Mathematics) Part-I (2023 Pattern)

Year	Level	Sem.	Major		Research Methodology (RM)	OJT/ FP	RP	Cum. Cr.
			Mandatory	Electives				
I	6.0	Sem-I	MAT-501-MJM: Measure Theory and Integration(**Credit 04**) MAT-502-MJM: Advanced Calculus (**Credit 04**) MAT-503-MJM: Practical in Ordinary Differential Equations(**Credit 02**) MAT-504-MJM: Programming in C (**Credit 02**)	MAT-511-MJE (A): Numerical Analysis (**Credit04**) **OR** MAT-511-MJE (B): Group Theory(**Credit 04**)	MAT-521-RM: Research Methodology in Mathematics (**Credit 04**)	--	--	**20**
		Sem- II	MAT-551-MJM: Complex Analysis (**Credit 04**) MAT-552-MJM:Topology (**Credit 04**) MAT-553-MJM: Practical in Partial Differential Equations (**Credit 02**) MAT-554-MJM: Programming in C++ (**Credit 02**)	MAT-561-MJE(A): Linear Algebra(**Credit04**) **OR** MAT-561-MJE(B): Rings and Modules(**Credit04**)	--	MAT-581-OJT/FP **Credit 04**	--	**20**
Cum. Cr.			**24**	**8**	**4**	**4**	**--**	**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-I (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	MAT-501-MJM	Measure Theory and Integration	Theory	04
	Major (Mandatory)	MAT-502-MJM	Advanced Calculus	Theory	04
	Major (Mandatory)	MAT-503-MJM	Practical in Ordinary Differential Equations	Practical	02
	Major (Mandatory)	MAT-504-MJM	Programming in C	Practical	02
	Major (Elective)	MAT-511-MJE (A)	Numerical Analysis	Theory	04
		MAT-511-MJE (B)	Group Theory	Theory	
	Research Methodology (RM)	MAT-521-RM	Research Methodology	Theory	04
	Total Credits Semester I				**20**
II	Major (Mandatory)	MAT-551-MJM	Complex Analysis	Theory	04
	Major (Mandatory)	MAT-552-MJM	Topology	Theory	04
	Major (Mandatory)	MAT-553-MJM	Practical in Partial Differential Equations	Practical	02
	Major (Mandatory)	MAT-554-MJM	Programming in C++	Practical	02
	Major (Elective)	MAT-561-MJE(A)	Linear Algebra	Theory	04
		MAT-561-MJE(B)	Rings and Modules	Theory	
	On Job	MAT-581-	On Job Training	Training/	04

	Training (OJT)/Field Project (FP)	OJT/FP	Filed Project	Project	
	Total Credits Semester-II				**20**
Cumulative Credits Semester I and II					**40**

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.I
Semester	: I
Course Type	: Major (Mandatory)
Course Name	: Measure Theory and Integration
Course Code	: MAT-501-MJM
No. of Lectures	60
No. of Credits	4

Course Objectives:

1. To acquire knowledge of basic and advanced concepts in Measure Theorywhich 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. Be able to describe at least one approach to the construction of Lebesgue measure, the Lebesgue integral of a function and measure spaces.
5. To gain understanding of the abstract measure theory and main properties of the integral.
6. To construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.
7. Know the principal theorems as treated and their proofs and be able to use them in the investigation of examples.

Course Outcomes:

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

1. Students will be able to understand the concept of Differentiation, Functions ofBounded Variation, and Absolutely Continuous Functions.
2. Students will be able to apply the theory in the course to solve a variety of problems than appropriate level of difficulty.
3. Understand σ-algebras, measurable sets, measures, outer measures, Lebesgue measure and its properties.
4. Students will be able to develop an appreciation of the basic concepts of measure theory. Apply measure theory to real world problems.
5. Understand Lebesgue integral, Monotone Convergence Theorem, Dominated Convergence Theorem, and Riemann integral for Riemann integrable functions.
6. Student will be able to describe the relationship between continuous function and general integrable functions.
7. Determine questions related to different types of L^p spaces.

Topics and Learning Points

Teaching Hours

UNIT1: 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

UNIT2: Integration of function on real variables **[14 Lectures]**
2.1 Integration of nonnegative function
2.2 General Integral
2.3 Integration of Series
2.4 Riemann and Lebesgue Integral

UNIT3: Differentiation **[14 Lectures]**
3.1 Functions of bounded variation
3.2 Lebesgue Differentiation Theorem
3.3 Differentiation Theorem
3.4 Differentiation and Integration

UNIT4: 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

UNIT5: Inequalities and L^p space **[10 Lectures]**
5.1 The L^p spaces
5.1 5.2 Convex function
5.2 Jensen's Inequality
5.3 The Inequalities of Holder and Minkowski
5.4 Completeness of $L^P(\mu)$

Text Book:

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.

References:

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.

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 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.

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.I
Semester	:	I
Course Type	:	Major (Mandatory)
Course Name	:	Advanced Calculus
Course Code	:	MAT-502-MJM
No. of Lectures		60
No. of Credits		4

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:

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

1. To apply these concepts to solve practical problems that arise in physics and other related areas.
2. Students will be able to understand change of variables by applying change of variable Theorems.
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.

Topics and Learning Points

Teaching Hours

UNIT1: 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.

UNIT2: 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 Integration of Series
2.5 The first and the second fundamental theorems of calculus for line integral
2.6 Necessary condition for a vector field to be gradient

UNIT3: 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.

UNIT4: Surface Integrals **[12 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

UNIT5: Application of Differential Calculus **[6 Lectures]**

5.1 Partial differential equation
5.2 a first order partial differential equation with constant coefficients
5.3 The one Dimensional wave equation.

T. M. Apostol, *Calculus,* Vol. II (2nd edition) , John Wiley and Sons, Inc.

Text Book:

Unit 1 - Sections 8.1 to 8.22
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

References:

1. T. M. Apostol, *Mathematical Analysis*, Narosa publishing house.
2. W. Rudin, *Principles of Mathematical Analysis*, McGraw-Hill.

	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.

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

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester : I

Course Type : Major (Mandatory)

Course Name : Practical in Ordinary Differential Equations

Course Code : MAT-503-MJM

No. of Lectures 60

No. of Credits 2

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 to Solve 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:

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

1. Find the complete solution of a nonhomogeneous differential equation as a linearcombinationofthecomplementaryfunctionandaparticularsolution.
2. Introduced to the complete solution of a nonhomogeneous differential equation with constant 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.

Topics and Learning Points

Teaching Hours

Unit 1 Linear equations with constant coefficients **[Lecture 14]**

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

Unit 2 Linear equations with variable coefficients **[Lecture 14]**

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
2.7 Legendre equation

Unit 3 Linear Equations with regular singular points **[Lecture 12]**

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

Unit 4 : Existence and uniqueness of solutions to first order equations **[Lecture 10]**

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

Unit 5 : Existence and uniqueness of solutions to systems, n^{th}order equations **[Lecture 10]**

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

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.

References:

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.

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

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. -I
Semester	I
Course Type	: Major (Mandatory)
Course Name	: Practical programming in C
Course Code	: MAT-504-MJM
No. of Lectures	60
No. of Credits	2

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:

1. Student will be able to understand and visualize the working of computers.
2. Student will be able to use fundamentals of C programming to implement algorithms in mathematics.
3. Student will be able to develop a C programming.
4. Student will be able to exploring C programming.
5. Student will be able to managing input and output operations.
6. To understand the basics of file handling mechanisms.
7. Student will be able manage I/O operations in C programming.

Topics and Learning Points

	Teaching Hours
UNIT 1: Introductory concepts in C.	**16**
1.1 C Fundamentals.	
1.2 The C characters set.	
1.3 Constants, variables and keywords	
1.4 The first C program, compilation and execution.	
UNIT 2: Operators and Expressions	**16**
2.1 Associativity of operators	
2.2 Hierarchy of operators revisited	
2.3 The conditional operators.	
UNIT 3: The decision control structure	**16**
3.1 The if statement	
3.2 The if-else statement	
3.3 Nested if-else statement	
3.4 Use of logical operator and else if clause	
UNIT 4: Control statements, Functions	**10**
1.1 Loops	
1.2 While loop, for loop,nesting of loops.	
1.3 The odd loop.	
1.4 What is function.	
1.5 Why use function.	
UNIT 5:Program Structures	**2**
Preparing and running a program.	

Text Book:

Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, PrenticeHall.

References:

1. ByronsS. Gottfried, Programming with C, Schaum's Outline Series.
2. S.A.Teukolsky**,** *Numerical recipes in C,* W.H.Press.
3. Yeshwant Kanetkar, *Let us C*, BPB Publications.

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 envolving programming challenges and user needs.

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

Name of the programme :M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester I

Course Type : Major (Elective)

Course Name : Numerical Analysis

Course Code : MAT-511-MJE(A)

No. of Lectures 60

No. of Credits 4

Course Objectives:

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

Course Outcomes:

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

1. Student will be able to handle Machine Learning algorithms using Numerical Analysis.
2. Student will be able to construct a function which closely fits given n- points in the plane by using interpolation method.
3. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
4. Implement numerical methods in Scilab and other mathematical software.
5. Solve a linear system of equations using an appropriate numerical method.
6. Student will be able solve an algebraic or transcendental equation using an appropriate numerical method.
7. Student will be able to approximate a function using an appropriate numerical

Topics and Learning Points

Teaching Hours

Unit 1 : Root of Nonlinear Equation **[Lectures 12]**

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.

Unit 2 : Direct and Iterative Solution of Linear Equation **[Lectures 16]**

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

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

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

Unit 4 : Numerical Differentiation and Integration: **[Lectures 14]**

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

Unit 5: Numerical Solution of ODE and BVP **[Lectures 10]**

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.

References:

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* , PearsonEducation (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.

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. -I
Semester	I
Course Type	: Major (Elective)
Course Name	: Group Theory
Course Code	: MAT-511-MJE(B)
No. of Lectures	60
No. of Credits	4

Course Objectives:

1. Be able to state the group axioms and to verify whether a given set and binary operation form a group.
2. Define subgroup, identity element, inverse, associativity, order of an element, order of a group, group table, inverse and cyclic groups.
3. Understanding of theoretical part of Groups and how to use them to solve problems.
4. Present concepts of and the relationships between operations satisfying various properties.
5. Be able to define and compute with cyclic groups, the additive group mod n, the multiplicative group mod p, the symmetric group, the dihedral group.
6. Studying and manipulating abstract concepts involving symmetry.
7. Understanding of theoretical part of various Sylow's Theorems.

Course Outcomes:

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

CO1. Apply the Internal Direct Product Theorem in simple cases.
CO2. Analyze the symmetry of a plane figure.
CO3. Decide whether given group is Cyclic and find a generator for a subgroup.
CO4. Express products of elements of a Group define by a generators.
CO5. Recognize the Dihedral group when describe using a standard form.
CO6. Investigate symmetry using group theory.
CO7. Generate groups given specific conditions.

Topics and Learning Points

	Teaching Hours
UNIT1: Groups	**10**
1.1 Semi groups and groups.	
1.2 Homomorphism.	
1.3 Subgroups and Cosets.	
1.4 Cyclic groups.	
1.5 Permutation groups.	
1.6 Generators and relations.	
UNIT2: Normal Subgroups	**14**
2.1 Normal subgroups and quotient groups.	
2.2 Isomorphism theorem.	
2.3 Automorphism	
2.4 Conjugacy and G-sets.	
UNIT3: Normal Series	**10**
3.1 Normal series	
3.2 Solvable groups.	
3.3 Nilpotent groups.	
UNIT4: Permutation Groups	**12**
4.1 Cyclic decomposition.	
4.2 Alternating group A_n.	
4.3 Simplicity of A_n.	
UNIT5: Structure theorems of groups	**14**
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: Section4.1to4.6
Unit 2: Section5.1to5.4
Unit 3: Section6.1to6.3
Unit 4: Section7.1to7.3
Unit 5: Section8.1to8.5

References:

- I. S. Luthar and I. B. S. Passi: *Algebra(Volume1)Groups*, (Narosa Publishing House)
- I. N. Herstein: *Topics in Algebra* (Wiley-Eastern Ltd)
- N. S. Gopala Krishnan: *University Algebra* (Wiley-Eastern Ltd)
- Fraleigh: *A First Course in Abstract Algebra*
- Dummit and Foote: *Abstract Algebra* (Wiley-Eastern Ltd).

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.

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.I
Semester	I
Course Type	: Research Methodology (RM)
Course Name	: Research Methodology in Mathematics
Course Code	: MAT-521-RM
No. of Lectures	60
No. of Credits	4

Course Objectives:

1. To understand some basic concepts of research and its methodologies.
2. Be able to identify and discuss the complex issues inherent in selecting a research problem, selecting research design, and implementing a research project.
3. Identify and discuss the role and importance of research.
4. Be able to write a research report and thesis.
5. To understand the fundamentals of logical reasoning in pure mathematics.
6. Develop the necessary skill to conduct, review and publish research.
7. To learn and understand the research publication ethics and tools like Latex.

Course Outcomes:

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

1. Learn Typesetting of journal articles, technical reports, thesis, books, and slide presentations using Latex.
2. Comprehend and explain research articles in their academic discipline.
3. Demonstrate the ability to choose methods appropriate to research problems.
4. Take up and implement a research project or study.
5. Collect the data, edit it properly and analyse it accordingly.
6. Develop skills in qualitative and quantitative data analysis and presentation
7. Understand fundamentals of logical reasoning in pure and applied mathematics.

Topics and Learning Points

	Teaching Hours
UNIT1: Foundation of research	**12**
1.1 Meaning and Objectives of research	
1.2 Significance of research	
1.3 Types of research, Characteristic of mathematical methods	
1.4 Research process, Defining Research problem	
UNIT2: Mathematical statements	**14**
2.1 If then statements, Sufficient and necessary conditions	
2.2 Contrapositive, Converse, Negation	
2.3 Direct and indirect proof, Principle of induction	
2.4 Inductive reasoning, Counter examples	
UNIT3: Research design and Method of Data Collection	**14**
3.1 Need for research design	
3.2 Different research designs	
3.3 Collection of data, observation method, Questionnaires	
3.4 Numerical and graphical data analysis using software's	
UNIT4: Preparation of thesis and Research papers	**10**
4.1 Guideline for writing the Abstract	
4.2 Layout of the report, methodology, result and discussion	
4.3 Style of referencing, Bibliography	
4.4 Research Ethics,Software for detection of Plagiarism	
UNIT5: Latex for Writing paper, Thesis, and Report	**10**
1.1 Introduction to Latex	
1.2 Document structure	
1.3 Mathematical Concepts	
1.4 Inserting Reference, Presentation using Beamer	

References:

1. C.R. Kothari, *Research methodology (second revised edition)*, New Age publishers, 2004.
2. James R. Munkres, *Topology*, Second edition, Prentice Hall of India, 2002.
3. Michael P. Marder, *Research methods for science*, Cambridge University press, 2011.
4. Bordens, K.S. and Abbott B.B., *Research Design and Methods*, A process approach, 8 edition, McGraw-Hill, 2011.

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

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: LaTeX skills are crucial for academic research (PO1).

CO3: Choosing the right methods requires disciplinary knowledge. Most COs map directly to PO1, as the course is designed to build foundational knowledge in research methodology, data analysis, and logical reasoning.

PO2: Critical Thinking and Problem solving:

CO1: Comprehend and explain research articles in their academic discipline. Understanding and explaining research builds disciplinary knowledge (PO1) and sharpens critical thinking. COs related to research problem-solving, method selection, and data analysis align with PO2, as these tasks require analytical thinking and reasoning. It also supports continuous learning and enhances research skills.

PO4: Research-related skills and Scientific temper

CO2: It also supports continuous learning and enhances research skills. COs focused on understanding research design, collecting and analyzing data, and preparing research reports align with PO4, as these tasks are essential research-related skills.

PO5: Trans-disciplinary knowledge

CO4: Research projects apply disciplinary knowledge critical thinking, and cross-disciplinary knowledge (PO5).

PO9: Self-directed and life –long learning :

CO1: LaTeX skills are crucial for contribution to professional skills needed for life-long learning (PO9).

CO2: It also supports continuous learning and enhances research skills PO9.

CO3: It also fosters self-directed learning (PO9).

CO4: Research projects apply disciplinary knowledge, and also promote research-related skills and life-long learning (PO9).

CO5: Data collection and analysis require a strong element of critical thinking and life-long learning (PO9).

CO6: It also supports continuous skill development (PO9).

CO7: It also supports self-directed and life-long learning (PO9).

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