Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Empowered 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 (2026 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2026-2027
(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.

Credit distribution structure for Two Years PG as per National Education Policy (2026 Pattern)
(M.Sc.)

PG Program for First Year														
Level	Sem.	Major (MD)	Major (Ele)				RM	OJT	RP					Cum.Cr.
6.0	I	8(T)+4 (P)/ 14(T)	2(T)+2 (T/P)/ 4(T)	--	--	---	4 (RM)(T)	--	--	--	--	--	--	20/ 22
	II	8(T)+4 (P) 14(T)	2(T)+2 (T/P) 4(T)	--	0	---	0	4 (OJT)		0	0	0	0	20/ 22
Cum. Cr. For PG Diploma		**24/28**	**8**				**4**	**4**						**40/44**
Exit option : PG Diploma (40-44 Credits) after Three Year UG Degree														
PG Program for Second Year														
6.5	III	8(T)+4(P)/ 14(T)	2(T)+2 (T/P)/ 4(T)						4 (RP)		0	0	0	20/ 22
	IV	8(T)+2(P)/ 12(T)	2(T)+2 (T/P)/ 4(T)						6 (RP)		0	0	0	20/ 22
Cum. Cr. For PG Degree		**22/26**	**8**						**10**					**40/44**
Cum. Cr. For 2 Yr. PG Degree		**46/54**	**16**				**4**	**4**	**10**					**80/88**
Exit option : PG Degree (80-88 Credits) after Three Year UG Degree														

Abbreviations: Yr.: Year; Sem.: Semester; MD : Mandatory, Ele : Electives, OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr., T : Theory, P : Practical

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Empowered Autonomous, NAAC A ++

Department of Mathematics
Course and Credit structure for
M.Sc. –I Mathematics NEP-2020 (2026 Pattern)

Level	Sem	Course Type	Course Code	Title of Course	Theory/Practical	No. of Credits
6.0	I	**Major (Mandatory)**	MAT-501-MRM	Measure Theory and Integration	Theory	4
			MAT-502-MRM	Group Theory	Theory	4
			MAT-503-MRM	Calculus of Several Variable	Theory	2
			MAT-504-MRM	Practical on Ordinary Differential Equation	Practical	2
			MAT-505-MRM	Practical on C programming	Practical	2
		Major (Elective)	MAT-506-MJE(A)	Applied Mathematics-I	Theory (Any One)	2
			MAT-506-MJE(B)	Mechanics-I		
			MAT-507-MJE(A)	Practical on Numerical Analysis Using Scilab	Practical (Any One)	2
			MAT-507-MJE(B)	Practical on Mathematical Foundations of Animation and Graphics Design		
		Research Methodology	MAT-508-RM	Research Methodology	Theory	4
				Total Credits Sem I		**22**
6.0	II	**Major (Mandatory)**	MAT-551-MRM	Complex Analysis	Theory	4
			MAT-552-MRM	Topology	Theory	4
			MAT-553-MRM	Ring Theory	Theory	2
			MAT-554-MRM	Practical on Partial Differential Equation	Practical	2
			MAT-555-MRM	Practical on C++ programming	Practical	2
		Major (Elective)	MAT-556-MJE(A)	Applied Mathematics-II	Theory (Any One)	2
			MAT-556-MJE(B)	Mechanics-II		
			MAT-557-MJE(A)	Practical on Computational Algebra Using SageMath	Practical (Any One)	2
			MAT-557-MJE(B)	Practical on Ring Theory		
		OJT	MAT-558-OJT	On Job Training	Practical	4
				Total Credits Sem II		**22**
			Cumulative Credits for PG Diploma- I and II			**22+22=44**

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Programme Specific Outcomes (PSOs): 2026 Pattern

According to National Education Policy 2020 Programme Outcomes for M.Sc. Programme (P.G.) 2026 Pattern w.e.f Academic Year 2026-2027

On successful completion of the Post-Graduate Programme in Science, the learners will be able to:

PO1 – Advanced Disciplinary Knowledge & Originality:
Demonstrating comprehensive and advanced knowledge in the chosen field of science, extending beyond the undergraduate level, providing a specialized foundation for developing and applying original ideas, particularly within a research context.

PO2 – Research, Analysis, and Complexity:
Ability to formulate hypotheses and design experiments while demonstrating the capacity to integrate knowledge and handle complex information, even when it is incomplete or limited.

PO3 – Problem Solving in New Contexts:
Apply theoretical knowledge and problem-solving abilities to unfamiliar, real-world, or multidisciplinary environments, moving beyond standard classroom scenarios to innovative applications.

PO4 – Technical Mastery and Scientific Reasoning:
Utilize modern tools, specialized techniques, and instruments with high proficiency, underpinned by a deep rationale and scientific reasoning for the choice of methodology.

PO5 – Integrated Communication:
Clearly and unambiguously communicate complex scientific conclusions, and the knowledge/rationale supporting them, to both specialist peers and non-specialist stakeholders.

PO6 – Ethical, Social, and Professional Judgment:
Adhere to strict ethical standards in research while reflecting on the social and environmental responsibilities linked to the application of scientific knowledge and professional judgments.

PO7 – Autonomous and Lifelong Learning:
Exhibit the learning skills necessary to pursue further study or professional development in a largely self-directed and autonomous manner.

PO8 – Employability, Innovation, and Entrepreneurship:
Translate advanced technical skills and independent thinking into professional excellence within industry, academia, or entrepreneurial ventures.

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CBCS Syllabus as per NEP 2020 for M.Sc. I
(2026 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-MRM
No. of Lectures	: 60
No. of Credits	: 4

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. 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:

CO1	Students will be able to understand the concept of Differentiation, Functions of Bounded Variation, and Absolutely Continuous Functions.
CO2	Students will be able to apply the theory in the course to solve a variety of problems than appropriate level of difficulty.
CO3	Understand σ-algebras, measurable sets, measures, outer measures, Lebesgue measure and its properties.
CO4	Students will be able to develop an appreciation of the basic concepts of measure theory. Apply measure theory to real world problems.
CO5	Understand Lebesgue integral, Monotone Convergence Theorem, Dominated Convergence Theorem, and Riemann integral for Riemann integrable functions.
CO6	Student will be able to describe the relationship between continuous function and general integrable functions.
CO7	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.

Mapping of Program Outcomes with Course Outcomes
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

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

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality
CO1: Ensures strong theoretical foundation useful in Fourier and Functional Analysis.
CO4, CO5, CO6: Emphasize construction and abstract development of Lebesgue measure.
CO7: Strengthens proof-writing and theorem-based understanding.
Thus, the course strongly contributes to advanced disciplinary knowledge.

PO2: Research, Analysis & Complexity
CO3: Develops analytical problem-solving ability.
CO4 and CO6: Involve rigorous construction techniques.
CO7: Requires understanding and applying advanced theorems.
Students learn to handle abstract and complex mathematical frameworks.

PO3: Problem Solving in New Contexts
CO3 directly focuses on solving simple and complex problems.
CO7 enables application of principal theorems in new examples.
Hence, strong contribution to mathematical problem-solving ability.

PO4: Technical Mastery & Scientific Reasoning
CO4 and CO6 involve structured construction methods.
CO5 and CO7 focus on theoretical properties and proofs.
This enhances scientific reasoning and mathematical rigor.

PO5: Integrated Communication
CO4 requires conceptual explanation of Lebesgue measure construction.
CO7 requires presentation of theorem proofs.
Thus, mathematical communication skills are moderately developed.

PO6: Ethical, Social & Professional Judgment
Although primarily theoretical, the course promotes academic integrity, logical precision, and disciplined reasoning. Ethical standards in mathematical research are indirectly supported.

PO7: Autonomous & Lifelong Learning
CO7 encourages independent theorem application.
CO1 and CO2 prepare students for advanced topics.
The course fosters readiness for further research and lifelong learning.

PO8: Employability, Innovation & Entrepreneurship
Though theoretical, measure theory is fundamental for research careers, data science, probability theory, and advanced mathematical modeling.
Problem-solving and analytical skills enhance employability in academia and research sectors.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2026 Pattern)

Name of the Programme	:	M.Sc (Mathematics)
Program Code	:	PSMAT
Class	:	M.Sc.I
Semester	:	I
Course Type	:	Major (Mandatory)
Course Name	:	Group Theory
Course Code	:	MAT-502-MRM
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 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 Lectures]**

    1.1 Introduction to Group
    1.2 Finites groups
    1.3 Subgroups
    1.4 Cyclic groups.
    1.5 Properties of cyclic groups.

UNIT2: Permutation Groups   **[14 Lectures]**

    2.1 Definition
    2.2 Notation and properties
    2.3 Isomorphisms and Properties
    2.4 Automorphisms

UNIT3: Cosets and Lagrange's Theorem   **[10 Lectures]**

    1.1 Properties of cosets
    1.2 Lagrange's Theorem and consequences
    1.3 Application of coset to permutation Group

UNIT4: External direct Product, Normal Subgroup's and Factor Groups   **[12 Lectures]**

    4.1 Properties of external direct product.
    4.2 Normal subgroups
    4.3 Factor Group and Application of factor Group
    4.4 Internal direct product

UNIT5: Sylow Theorem   **[14 Lectures]**

    5.1 Conjugacy Classes
    5.2 The Class Equation
    5.3 The Sylow theorem
    5.4 Application of Sylow Theorem
    5.5 Groups of orders p^2 and pq.

Text Book:

Joseph Gallian – Contemporary Abstract Algebra (Narosa Publishing House). P.B. Bhattacharya.
    Unit 1: Section 1.1to 4.2
    Unit 2: Section5.1to 6.3
    Unit 3: Section 7.1to 7.3
    Unit 4: Section8.1to 8.3
    Unit 5: Section 24.1to 24.4

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*

Mapping of Program Outcomes with Course Outcomes
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

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

Justification for the mapping
PO1 – Advanced Disciplinary Knowledge
CO1: Applying internal direct product theorem requires deep theoretical understanding of group structure.
CO2: Symmetry analysis uses algebraic concepts but is more application-oriented.
CO3: Determining cyclic nature and generators demands strong conceptual algebra knowledge.
CO4: Working with generators reflects advanced structural understanding.
CO5: Recognizing dihedral groups requires familiarity with standard abstract algebra forms.
CO6: Symmetry investigation applies theory rather than developing it.
CO7: Constructing groups under conditions demonstrates mastery of group axioms.
PO2 – Research, Analysis, and Complexity
CO1: Direct product theorem involves multi-step structural analysis.
CO2: Symmetry analysis requires reasoning but limited complexity.
CO3: Identifying generators involves logical deduction.
CO4: Product expressions require structured but standard reasoning.
CO5: Recognizing dihedral structure involves comparative abstract analysis.
CO6: Investigating symmetry develops research-style reasoning.
CO7: Generating groups requires hypothesis-based mathematical thinking.
PO3 – Problem Solving in New Contexts
CO1: Theorem application supports solving unfamiliar algebraic problems.
CO2: Symmetry problems directly connect mathematics to geometric contexts.
CO3: Generator problems involve unfamiliar structural cases.
CO4: Generator-based expressions solve new algebraic scenarios.
CO5: Recognizing group types supports classification problems.
CO6: Symmetry investigations apply theory to real geometric systems.
CO7: Constructing groups requires solving non-routine mathematical problems.
PO4 – Technical Mastery & Scientific Reasoning
CO1: Theorem application reflects rigorous algebraic methodology.
CO2: Symmetry analysis requires logical reasoning.
CO3: Generator identification uses systematic procedures.
CO4: Working with generators demonstrates formal algebraic technique.
CO5: Recognizing dihedral groups shows structural classification skill.
CO6: Symmetry investigations involve conceptual reasoning.
CO7: Group construction requires logical structure but fewer formal tools.

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PO5 – Integrated Communication

CO2: Explaining symmetry requires conceptual description.

CO6: Symmetry investigation involves interpretation.

CO7: Constructing groups requires explanation of reasoning.

PO7 – Autonomous and Lifelong Learning

CO1: Theorem application requires independent practice.

CO2: Symmetry exploration encourages curiosity.

CO3: Generator problems promote self-learning.

CO4: Symbolic operations need practice.

CO5: Recognition of structures supports conceptual growth.

CO6: Investigations motivate deeper exploration.

CO7: Constructing groups strongly develops independent mathematical thinking.

PO8 – Employability, Innovation, Entrepreneurship

CO1: Abstract reasoning and structural thinking support technical careers.

CO7: Ability to construct mathematical models enhances innovation and research potential.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2026 Pattern)

Name of the Programme	: M.Sc (Mathematics)
Program Code	: PSMAT
Class	: M.Sc.I
Semester	I
Course Type	: Major (Mandatory)
Course Name	: Calculus of Several Variables
Course Code	: MAT-503-MRM
No. of Lectures	30
No. of Credits	2

Course Objectives:

1. To introduce the concept of scalar and vector fields and their differentiation.
2. To develop understanding of directional derivatives and gradient of scalar fields.
3. To study derivatives of vector fields and matrix form of the chain rule.
4. To explain the concept of path and line integrals.
5. To interpret line integrals in physical applications such as work done.
6. To understand path independence and fundamental theorems of line integrals.
7. To apply double integrals and Green's Theorem to compute area and solve plane problems.

Course Outcomes:

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

CO1   Differentiate scalar and vector fields using appropriate mathematical techniques.
CO2   Compute directional derivatives and gradients and interpret their geometrical meaning.
CO3   Apply matrix form of the chain rule in multivariable calculus problems.
CO4   Evaluate line integrals along given paths.
CO5   Analyze conservative vector fields and verify path independence using fundamental theorems.
CO6   Evaluate double integrals to determine area and volume of regions.
CO7   Apply Green's Theorem to convert line integrals into double integrals and solve related problems.

Topics and Learning Points

Teaching Hours

UNIT1: Differential Calculus of Scalar and Vector Field **[10 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 chain rule

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

UNIT3: Multiple Integrals **[08 Lectures]**
3.1 Double Integrals
3.2 Applications to area and volume
3.3 Green's Theorem in the plane

Text Book:

T. M. Apostol, *Calculus*, Vol. II (2nd edition) , John Wiley and Sons, Inc.
Unit 1 - Sections 8.1 to 8.19
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

References:

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

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

Justification for the mapping

PO1 – Advanced Disciplinary Knowledge & Originality
   CO1: Develops advanced understanding of scalar and vector field theory.
   CO2: Strengthens conceptual depth through gradients and directional derivatives.
   CO3: Enhances higher-level mathematical reasoning using matrix chain rule.
   CO4: Builds advanced knowledge of line integrals in vector calculus.
   CO5: Deepens theoretical understanding of conservative fields and fundamental theorems.
   CO6: Expands expertise in multivariable integration for area and volume.
   CO7: Demonstrates advanced application of Green's Theorem beyond basic calculus.

PO2 – Research, Analysis, and Complexity
   CO1: Encourages analytical comparison of scalar and vector fields.
   CO2: Develops hypothesis-based reasoning through gradient analysis.
   CO3: Requires structured analytical thinking in multivariable problems.
   CO4: Involves systematic evaluation of integrals along complex paths.
   CO5: Strengthens analytical verification of path independence.
   CO6: Enhances ability to handle complex region-based integrations.
   CO7: Promotes transformation and analysis of integrals using Green's Theorem.

PO3 – Problem Solving in New Contexts
   CO1: Applies field concepts to physical and engineering contexts.
   CO2: Solves optimization and rate-of-change problems.
   CO3: Applies multivariable chain rule in interdisciplinary problems.
   CO4: Solves real-world circulation and work-related problems.
   CO5: Applies conservative field concepts in physics applications.
   CO6: Solves geometric and applied area-volume problems.
   CO7: Converts line integrals into double integrals for efficient problem solving.

PO4 – Technical Mastery and Scientific Reasoning
   CO1: Uses mathematical tools to analyze vector functions.
   CO2: Applies precise computational techniques in gradient evaluation.
   CO3: Utilizes matrix methods with logical reasoning.
   CO4: Demonstrates technical skill in evaluating line integrals.
   CO5: Applies theorem-based reasoning for verification.
   CO6: Uses integration techniques for multidimensional analysis.
   CO7: Selects appropriate methodology (Green's Theorem) for simplification.

PO5 – Integrated Communication
   CO1: Explains differences between scalar and vector fields clearly.
   CO2: Interprets geometrical meaning of gradients effectively.
   CO3: Communicates multivariable relationships logically.
   CO4: Presents stepwise solutions of line integrals clearly.
   CO5: Justifies theorem applications with clarity.
   CO6: Interprets results of area and volume integrals accurately.
   CO7: Communicates theorem-based transformations systematically.

PO7 – Autonomous and Lifelong Learning
   CO1: Motivates deeper exploration of vector calculus concepts.
   CO2: Encourages independent problem-solving practice.
   CO3: Develops self-learning ability in advanced calculus methods.
   CO4: Enhances analytical confidence through practice.
   CO5: Encourages independent verification of results.
   CO6: Promotes further study in higher-dimensional mathematics.
   CO7: Inspires exploration of advanced theorems beyond syllabus.

PO8 – Employability, Innovation, and Entrepreneurship

CO1: Builds foundation for applied mathematical modelling.

CO2: Develops analytical skills required in technical professions.

CO3: Strengthens computational thinking useful in data science and engineering.

CO4: Enhances problem-solving skills relevant to industry applications.

CO5: Supports modelling in physics and engineering systems.

CO6: Builds quantitative reasoning skills for research careers.

CO7: Provides advanced analytical tools useful in computational and applied sciences.

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AES's T. C. College (Empowered Autonomous), Baramati. CBCS Syllabus 2026 Pattern as per NEP 2020

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2026 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester I

Course Type : Major (Mandatory)

Course Name : Practical on Ordinary Differential Equations

Course Code : MAT-504-MRM

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 differential equations 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:

CO1   Find the complete solution of a nonhomogeneous differential equation as a linearcombinationofthecomplementaryfunctionandaparticularsolution.

CO2   Introduced to the complete solution of a nonhomogeneous differential equation with constant coefficients by the method of undetermined coefficients.

CO3   Classify the differential equations with respect to their order and linearity.

CO4   Explain the meaning of solutions of Differential equations.

CO5   Use the method of variation of parameter to find the solution of higher order linear differential equations with variable coefficients.

CO6   Analyze stability of solutions, including equilibrium points and limit cycles.

CO7   Develop analytical and problem-solving skills through the application of ODE theory to real-world scenarios.

Topics and Learning Points

Theory:

Teaching Hours
[12 Lecture]

1. Second order homogenous equation
2. Linear dependence and independence, wronskian
3. Non-homogenous equation of order two
4. Reduction of order method, variation of parameter method
5. Legendre equation
6. Regular singular point
7. Variable separable method , exact equation
8. Method of successive approximation
9. Lipschitz condition
10. Existence and uniqueness of solution

List of Practicals: **[48 Lecture]**

1. Solve second-order homogeneous linear differential equations with constant coefficients using the characteristic equation method.
2. Solve initial value problems for second-order equations and verify uniqueness of solution.
3. Verify linear dependence and independence of given solutions using the Wronskian.
4. Solve non-homogeneous linear differential equations of order 2 and order n using undetermined coefficients and variation of parameters.
5. Solve homogeneous linear equations with variable coefficients using known solution methods.
6. Apply reduction of order to find a second linearly independent solution.
7. Verify linear independence of solutions using Wronskian and solve analytic-coefficient equations.
8. Solve special differential equations such as Legendre equations and interpret their solutions.
9. Solve Euler (Cauchy–Euler) equations and compare with constant coefficient cases.
10. Find series solutions of second-order differential equations near regular singular points including exceptional cases.
11. Solve Bessel's equation and compute Bessel function values for specific inputs.
12. Verify existence and uniqueness of solutions for first-order equations and systems using Lipschitz condition, successive approximations, and vector form representation.

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

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

Justification for the mapping
PO1-Advanced Disciplinary Knowledge & Originality
CO1- Demonstrate advanced understanding of higher order linear differential equations.
CO2- Analyse homogeneous and non-homogeneous differential equations rigorously.
CO3- Apply theoretical foundations of ODEs beyond undergraduate level.
CO4- Interpret existence and uniqueness theorems of differential equations.
CO5- Examine qualitative behavior of solutions including stability.
CO6-Extend ODE concepts to mathematical modeling problems.
CO7-Develop original analytical approaches for solving complex ODEs.
PO2 – Research, Analysis, and Complexity
CO1-Formulate mathematical models using differential equations.
CO2-Analyze real-world systems using ODE frameworks.
CO3-Investigate stability and equilibrium of dynamical systems.
C04-Apply analytical methods such as variation of parameters.
CO5-Compare multiple solution techniques critically.
CO6-Handle incomplete data using mathematical assumptions.
CO7-Design research-based problem-solving approaches in ODE theory.
PO3 – Problem Solving in New Contexts
CO1-Apply ODE methods to interdisciplinary applications.
CO2-Solve unfamiliar real-world differential equation problems.
CO3-Interpret physical meaning of mathematical solutions.
CO4-Use analytical reasoning in non-standard scenarios.
CO5-Adapt classical methods to new problem settings.
CO6-Model engineering and scientific phenomena mathematically.
CO7-Evaluate effectiveness of solution techniques in applied contexts.
PO4 – Technical Mastery and Scientific Reasoning
CO1-Use mathematical software tools for solving ODEs.
CO2-Apply advanced analytical techniques systematically.

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CO3-Justify selection of appropriate solution methods.
CO4-Interpret graphical representation of solutions.
CO5-Analyze phase portraits and dynamical behavior.
CO6-Employ numerical techniques where analytical methods fail.
CO7-Demonstrate logical reasoning in mathematical derivations.

PO5 – Integrated Communication

CO1-Present solutions of differential equations clearly.
CO2-Explain mathematical reasoning in written form.
CO3-Interpret complex results in simplified language.
CO4-Prepare technical reports on ODE applications.
CO5-Communicate modeling assumptions effectively.
CO6-Participate in mathematical discussions confidently.
CO7-Present research findings using proper terminology.

PO7 – Autonomous and Lifelong Learning

CO1-Study advanced ODE topics independently.
CO2-Explore current research trends in differential equations.
CO3-Develop self-learning strategies in mathematics.
C04-Apply critical thinking in advanced studies.
CO5-Engage in continuous skill development.
CO6-Pursue higher research in applied mathematics.
CO7-Adapt to evolving mathematical methodologies.

PO8 – Employability, Innovation, and Entrepreneurship

CO1-Apply ODE knowledge in industry-based problems.
CO2-Use analytical skills in technical professions.
CO3-Develop innovative mathematical solutions.
CO4-Support research and development activities.
CO5-Demonstrate problem-solving skills in professional roles.
CO6-Apply mathematical modeling in consultancy work.
CO7-Integrate mathematical expertise into entrepreneurial ventures.

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AES's T. C. College (Empowered Autonomous), Baramati. CBCS Syllabus 2026 Pattern as per NEP 2020

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 on C - programming
Course Code	: MAT-505-MRM
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:

CO1 Student will be able to understand and visualize the working of computers.
CO2 Student will be able to use fundamentals of C programming to implement algorithms in mathematics.
CO3 Student will be able to develop a C programming.
CO4 Student will be able to exploring C programming.
CO5 Student will be able to managing input and output operations.
CO6 To understand the basics of file handling mechanisms.
CO7 Student will be able manage I/O operations in C programming.

Topics and Learning Points

**Teaching Hours
[12 Lecture]**

Thoery:

1. C fundamentals , C Characters set
2. Constants , keyword and variables
3. Compilation and execution
4. Associativity and hierarchy of operators
5. Conditions operators
6. The if-else, nested if-else statements
7. Loops-while loop, for loop and odd loop
8. Operations on Functions.

List of Practicals: **[48 Lecture]**

i. Study and implementation of basic structure of a C program.
ii. Demonstration of C character set and ASCII value printing.
iii. Program illustrating use of constants, variables, and keywords.
iv. Writing, compiling, and executing the first C program.
v. Demonstration of different types of operators in C.
vi. Program to verify operator precedence and associativity.
vii. Implementation of conditional (ternary) operator in decision making.
viii. Program using simple if–else statement.
ix. Program using nested if–else and logical operators.
x. Programs demonstrating loops (while, for, and nested loops).
xi. Program illustrating special loop cases (odd loop behavior / infinite loop concept).
xii. Implementation of user-defined functions and their applications.

Text Book:

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

References:

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

Mapping of Program Outcomes with Course Outcomes
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

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

Justification for the mapping
PO1 – Advanced Disciplinary Knowledge & Originality
CO1-Explain the internal architecture and working principles of computers.
CO2-Analyze the structure and syntax of C programming language.
CO3-Apply programming constructs such as loops and functions effectively.
CO4-Evaluate different data types and memory management concepts.
CO5-Interpret algorithmic logic using structured programming.
CO6-Develop optimized C programs for mathematical applications.
CO7-Design structured solutions using modular programming techniques.
PO2 – Research, Analysis, and Complexity
CO1-Analyze computational problems and formulate suitable algorithms.
CO2-Compare different programming approaches for efficiency.
CO3-Debug complex programs systematically.
CO4-Examine logical errors and runtime errors critically.
CO5-Integrate mathematical algorithms into C programs.
CO6-Interpret program output under varying input conditions.
CO7-Apply analytical thinking in handling incomplete or complex problems.
PO3 – Problem Solving in New Contexts
CO1-Develop C programs for real-world applications.
CO2-Apply programming concepts to interdisciplinary problems.
CO3-Implement mathematical models using C language.
CO4-Solve unfamiliar computational problems independently.
CO5-Adapt programming logic to new environments.
CO6-Design innovative coding solutions.
CO7-Evaluate performance of programs in practical scenarios.
PO4 – Technical Mastery and Scientific Reasoning
CO1-Utilize IDEs and compilers efficiently.
CO2-Apply file handling mechanisms in C programming.
CO3-Implement input and output operations effectively.
CO4-Use debugging tools for error detection.
CO5-Demonstrate structured programming methodology.
CO6-Apply pointers and memory allocation techniques.
CO7-Justify selection of programming constructs logically.
PO5 – Integrated Communication

CO1-Document C programs clearly with comments.
CO2-Present algorithms in structured format.
CO3-Explain program logic orally and in written form.
CO4-Prepare technical reports for programming projects.
CO5-Interpret computational results in simple language.
CO6-Communicate debugging steps systematically.
CO7-Present project demonstrations confidently.

PO7 – Autonomous and Lifelong Learning
CO1-Explore advanced features of C programming independently.
CO2-Practice self-learning using programming resources.
CO3-Upgrade coding skills through continuous practice.
CO4-Participate in coding competitions or workshops.
CO5-Learn new programming paradigms beyond syllabus.
CO6-Adapt to emerging software technologies.
CO7-Pursue higher studies in computer science fields.

PO8 – Employability, Innovation, and Entrepreneurship
CO1-Develop industry-relevant programming skills.
CO2-Create software solutions for small-scale applications.
CO3-Apply coding knowledge in technical job roles.
CO4-Support automation using programming skills.
CO5-Develop problem-solving skills for IT industry.
CO6-Design small utility programs independently.
CO7-Demonstrate readiness for professional software development roles.

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2026 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester   I

Course Type : Major (Elective)

Course Name : Applied Mathematics-I

Course Code : MAT-506-MJE(A)

No. of Lectures : 30

No. of Credits : 2

Course Objectives:

1. To introduce fundamental concepts of spherical trigonometry and their mathematical structure.
2. To develop understanding of spherical triangles and related identities.
3. To explain celestial sphere concepts and coordinate systems used in astronomy.
4. To familiarize students with astronomical measurements such as zenith, azimuth, and horizon.
5. To study motion of celestial bodies, especially the Sun and stars.
6. To build analytical skills for solving problems involving spherical geometry.
7. To connect mathematical theory with practical applications in astronomy and geodesics.

Course Outcomes:

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

CO1   Students will be able to apply spherical trigonometric identities to solve geometric problems.
CO2   Students will analyse right-angled and general spherical triangles.
CO3   Students will demonstrate understanding of celestial coordinate systems.
CO4   Students will interpret astronomical phenomena like rising and setting of stars.
CO5   Students will calculate changes in zenith distance and azimuth.
CO6   Students will explain motion of the Sun and twilight phenomena mathematically.
CO7   Students will develop problem-solving and analytical reasoning skills relevant to astronomy and advanced mathematics.

Topics and Learning Points

Teaching Hours

Unit 1 : Spherical Trigonometry   **[12 Lecture]**
  1.1 Definitions and Fundamental Formulae.
  1.2 Right angles and triangles

Unit 2 : Spherical Astronomy   **[18 Lecture]**
  2.1   Cellestial Sphere
  2.2   Coordinate Systems
  2.3   Rising and Setting of Stars
  2.4   Rate of Change of Zenith and Azimuth
  2.5   Motion Of Sun
  2.6   Twilight
  2.7   Dip of Horizon

Text Book:

Spherical Astronomy by M. L. Khanna Published by Jai Prakash Nath and Company Meerut
        Unit 1: Section 1.1 to 1.2
        Unit 2: Section 2.1 to 2.7

References:

Textbook on Spherical Astronomy, Sixth edition, W. M. Smart, Cambridge University Press.

Mapping of Program Outcomes with Course Outcomes
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

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

Justification for the mapping

PO1: Advanced Disciplinary

CO1: Applying spherical trigonometric identities requires advanced mathematical knowledge beyond undergraduate level and demonstrates mastery of specialized concepts.

CO2: Analysing right-angled and general spherical triangles reflects deep theoretical understanding of higher geometry and mathematical reasoning.

CO3: Understanding celestial coordinate systems demands advanced conceptual knowledge of mathematical astronomy and spatial frameworks.

CO4: Interpreting astronomical phenomena uses disciplinary knowledge, but focuses more on application than on development of new theoretical understanding.

CO5: Calculating zenith distance and azimuth involves precise application of advanced mathematical formulas and domain-specific techniques.

CO6: Explaining motion of the Sun and twilight mathematically shows high-level conceptual integration of astronomy with mathematical modelling.

CO7: Developing analytical and problem-solving skills directly reflects mastery of advanced disciplinary knowledge and readiness for research-level thinking.

PO2 – Research, Analysis, and Complexity

CO1: Applying identities requires analytical thinking and structured reasoning but limited research complexity.

CO2: Triangle analysis develops hypothesis-based reasoning and handling of complex geometrical cases.

CO3: Understanding coordinate systems involves interpretation of structured astronomical data.

CO4: Interpreting phenomena involves analytical observation but limited experimental design.

CO5: Calculations of azimuth and zenith distance demand handling multiple variables and complex mathematical relations.

CO6: Mathematical explanation of solar motion requires integration of concepts and analytical modeling.

CO7: Analytical reasoning skills directly support research thinking and complex problem handling.

PO3: Problem Solving in New Contexts

CO1: Identities can be applied to non-routine geometric problems.

CO2: Triangle analysis helps solve unfamiliar spatial problems.

CO3: Primarily conceptual knowledge; limited real-world problem solving.

CO4: Astronomical interpretation connects theory with real sky observations.

CO5: Practical calculations directly solve real astronomical positioning problems.

CO6: Solar motion problems require applied mathematical reasoning.

CO7: Problem-solving ability directly aligns with this outcome.

PO4: Technical Mastery and Scientific Reasoning

CO1: Requires methodical use of formulas and mathematical techniques.

CO2: Structured geometric analysis demonstrates technical competence.

CO3: Coordinate systems require precise scientific reasoning and methodological understanding.

CO4: Phenomenon interpretation involves applying scientific logic.

CO5: Precise calculations demonstrate strong technical mastery.

CO6: Mathematical modeling of celestial motion shows advanced methodological reasoning.

CO7: Analytical skills support technical understanding.

PO5: Integrated Communication

CO1: Limited communication requirement beyond solution steps.

CO2: Primarily analytical rather than explanatory.

CO3: Understanding coordinate systems requires conceptual explanation.

CO4: Interpreting phenomena involves describing scientific conclusions.

CO5: Mostly computational work.

CO6: Requires explanation of mathematical reasoning.

CO7: Analytical reasoning skills support clear academic communication.

PO8 – Employability, Innovation, and Entrepreneurship

CO1: Advanced mathematical skills support technical careers.

CO3: Analytical geometry useful in research and data science.

CO3: Astronomical coordinate knowledge useful in scientific fields.

CO4: Interpretation skills useful in applied sciences.

CO5: Precision calculations relevant for technical professions.

CO6: Mathematical modelling applicable in research careers.

CO7: Strong analytical ability enhances employability and innovation potential.

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AES's T. C. College (Empowered Autonomous), Baramati. CBCS Syllabus 2026 Pattern as per NEP 2020

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2026 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester   I

Course Type : Major (Elective)

Course Name : Mechanics-l

Course Code : MAT-506-MJE(B)

No. of Lectures : 30

No. of Credits : 2

Course Objectives:

1. To introduce the fundamental principles of classical mechanics and their mathematical formulation.
2. To develop understanding of equations of motion using Lagrange's formulation.
3. To explain conservation laws and their significance in dynamical systems.
4. To familiarize students with constraints, generalized coordinates, and degrees of freedom.
5. To study virtual work, energy principles, and their applications.
6. To understand variational principles and their role in physical problems.
7. To enhance problem-solving skills in advanced mechanics using analytical methods.

Course Outcomes:

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

CO1   Students will be able to derive equations of motion for mechanical systems using Lagrangian methods.

CO2   Students will analyse systems with different types of constraints and coordinates.

CO3   Students will apply conservation laws of momentum and energy to solve problems.

CO4   Students will interpret physical systems using generalized coordinates and virtual work concepts.

CO5   Students will solve variational problems including brachistochrone and related applications.

CO6   Students will evaluate mechanical systems involving moving boundaries and multiple variables.

CO7   Students will develop mathematical reasoning skills applicable to advanced studies in mechanics and physics.

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AES's T. C. College (Empowered Autonomous), Baramati. CBCS Syllabus 2026 Pattern as per NEP 2020

Topics and Learning Points

Teaching Hours

UNIT1: Lagrange's Formulation   **[18 Lecture]**
- 1.1 Equation of Motion and conservation Theorems,
- 1.2 Equation of Motion of a Particle,
- 1.3 Equation of Motion of a System of Particle, Significance of research
- 1.4 Conservation Theorem of Linear Momentum of the system of particles,
- 1.5 Angular Momentum of the system of Particle,
- 1.6 Constraint Motion, Examples of motion under constraints,
- 1.7 Holonomic and Non – Holonomic Constraints, Scleronomic and Rheonomic Constraint.,
- 1.8 Degrees of Freedom and Generalized Co – ordinates.
- 1.9 Transformation Relations, Virtual work, Principle of Virtual Work, D" Alembert's Principle.
- 1.10 Conservation of Energy, Kinetic Energy as a Homogeneous quadratic function of generalized velocities.
- 1.11 Another way of proving conservation Theorem for Energy, Lagrange's Equations for Non – holonomic Constraints.

UNIT2: Variational Principles   **[12 Lecture]**
- 2.1 Generalization of Theorem, Minimum surface of revolution.
- 2.2 Brachistochrine Problem, A case of variable end points along vertical lines , Integrand as a function of more than two dependent variables,Contrapositive, Converse, Negation
- 2.3 Isoperimetric problems, variational problems with moving boundaries.
- 2.4 Functional dependent on functions of two dependent variables.

Textbook:

Problems in Classical Mechanics by L. N. Katkar (Narosa Publication) Chapter 1 To 2
1. **Unit 1**: Section 1.1 to 1.11
2. **Unit 2**: Section 2.1 to 2.4

References:

1. Classical Mechanics (3rd Ed.) by Herbert Goldstein, Charles Poole, John Safko (Pearson Education)
2. Classical Mechanics by Gupta, Kumar and Sharma (A Pragati Edition])
3. Classical Mechanics by Rana Joag (Mc Graw Hill India).

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

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

Justification for the mapping:
PO1 – Advanced Disciplinary
CO1:Deriving equations of motion using Lagrangian methods requires deep conceptual understanding of advanced classical mechanics and calculus of variations, demonstrating mastery beyond undergraduate level.
CO2:Analyzing constrained systems involves sophisticated knowledge of coordinate transformations and constraint classification, reflecting strong disciplinary expertise.
CO3: Applying conservation laws demands firm theoretical knowledge of fundamental physics principles and mathematical formulations.
CO4: Interpreting systems using generalized coordinates shows advanced conceptual grasp of analytical mechanics frameworks.
CO5:Solving variational problems such as the brachistochrone requires specialized knowledge of functional optimization and theoretical mechanics.
CO6: Evaluating systems with moving boundaries involves complex multi-variable mathematical modeling and advanced mechanics principles.
CO7:Developing mathematical reasoning reflects mastery of advanced disciplinary knowledge necessary for higher research and theoretical studies.
PO2 – Research, Analysis, and Complexity
CO1: Formulating Lagrangian equations requires analytical reasoning and structured problem modeling similar to research processes.
CO2: Constraint analysis involves handling complex conditions and multi-step reasoning.
CO3: Applying conservation laws requires analytical thinking but involves comparatively standard frameworks.
CO4: Interpreting systems involves conceptual analysis rather than complex problem design.
CO5: Variational problems demand hypothesis formulation, optimization strategies, and advanced analytical reasoning.
CO6: Multi-variable mechanical systems require integration of concepts and management of complex mathematical relationships.
CO7:Analytical reasoning skills directly align with research-oriented problem solving.
PO3 – Problem Solving in New Contexts
CO1: Lagrangian methods can be applied to unfamiliar systems but focus mainly on theoretical derivation.
CO2: Constraint analysis prepares students to solve new mechanical system configurations.
CO3: Conservation laws are widely used to solve real-world physics problems.

CO4: Generalized coordinate interpretation supports application but remains conceptual.

CO5: Variational techniques are powerful tools for solving unconventional optimization problems.

CO6: Systems with moving boundaries require application of theory to novel scenarios.

CO7:Problem-solving skills inherently support tackling unfamiliar and multidisciplinary problems.

PO4 – Technical Mastery and Scientific Reasoning

CO1: Lagrangian formulation demonstrates mastery of systematic mathematical methodology.

CO2: Constraint handling reflects technical competence in advanced analytical mechanics.

CO3: Conservation law applications involve reasoning but limited methodological variety.

CO4: Use of generalized coordinates shows precise scientific reasoning and formal technique.

CO5: Variational calculus requires rigorous methodology and logical derivation steps.

CO6: Multi-variable systems demonstrate strong technical modeling skills.

CO7: Analytical reasoning supports scientific thinking but is less technique-specific.

PO5 – Integrated Communication

CO4: Interpretation of systems requires conceptual explanation.

PO7 – Autonomous and Lifelong Learning

CO1: Learning advanced derivations requires independent study.

CO2: Constraint analysis promotes self-guided exploration.

CO3: Applying laws builds confidence for further learning.

CO4: Conceptual understanding encourages deeper independent study.

CO5: Variational problems stimulate curiosity for advanced mathematics.

CO6: Complex systems motivate continued learning.

CO7: Analytical reasoning directly supports lifelong academic growth.

PO8 – Employability, Innovation, and Entrepreneurship

CO1: Lagrangian mechanics is valuable in physics and engineering careers.

CO2: Constraint analysis skills apply in modeling and simulations.

CO3: Conservation laws are foundational for technical professions.

CO4: Generalized coordinate understanding is useful in research fields.

CO5: Optimization methods support applied science careers.

CO6: Multi-variable modeling is useful in computational and engineering domains.

CO7: Strong analytical reasoning is highly valued in industry, research, and innovation environments.

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2026 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester I

Course Type : Major (Elective)

Course Name : Practical on Numerical Analysis Using Scilab

Course Code : MAT-507-MJE(A)

No. of Lectures : 60

No. of Credits : 2

Course Objectives:

1. To understand the fundamental concepts of numerical methods and their computational importance.
2. To develop the ability to implement root-finding methods using Scilab.
3. To apply direct and iterative methods for solving systems of linear equations.
4. To construct interpolation polynomials and apply numerical differentiation and integration techniques.
5. To solve initial value and boundary value problems numerically.
6. To analyze convergence, stability, and error estimation of numerical algorithms.
7. To enhance programming skills using Scilab for scientific and mathematical computations.

Course Outcomes:

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

CO1 Implement various root-finding algorithms (Bisection, False Position, Newton–Raphson, Secant, Fixed Point) using Scilab.

CO2 Solve systems of linear equations using Gauss Elimination, Gauss–Jordan, Jacobi, and Gauss–Seidel methods.

CO3 Apply interpolation techniques such as Lagrange method for curve fitting problems.

CO4 Perform numerical integration using Simpson's rule and related techniques.

CO5 Solve ordinary differential equations using Runge–Kutta and other numerical methods.

CO6 Analyze numerical errors and evaluate the accuracy and convergence of computational methods.

CO7 Develop efficient Scilab programs for solving real-world mathematical and engineering problems.

Topics and Learning Points

Theory: **Teaching Hours**
                                                                          [12 Lecture]
1. Basics of Numerical Methods and Scilab Introduction
2. Bisection Method, False Position Method
3. Newton–Raphson Method, Secant and Fixed Point Iteration Methods
4. Gauss Elimination Method, Gauss–Jordan Method
5. Jacobi Iterative Method, Gauss–Seidel Iterative Method
6. Lagrange Interpolation Method,
7. Simpson's 1/3 Rule for Numerical Integration
8. Runge–Kutta Fourth Order Method

List of Practical's: **[48 Lecture]**

1. Scilab Program for Bisection Method

2. Scilab Program for False Position Method

3. Scilab Program for Newton–Raphson Method

4. Scilab Program for Secant Method

5. Scilab Program for Fixed Point Iteration Method

6. Scilab Program for Gauss Elimination Method

7. Scilab Program for Gauss–Jordan Method

8. Scilab Program for Jacobi Iterative Method

9. Scilab Program for Gauss–Seidel Method

10. Scilab Program for Lagrange Interpolation Method

11. Scilab Program for Numerical Integration using Simpson's 1/3 Rule

12. Scilab Program for Runge–Kutta Fourth Order Method.

Reference:

1. E Balagurusamy, *Numerical Methods*, 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

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

Justification for the mapping :
PO1 – Advanced Disciplinary Knowledge & Originality
CO1 provides strong theoretical foundations.
CO3–CO5 extend undergraduate knowledge into advanced computational mathematics.
CO6 strengthens understanding of convergence and stability analysis, essential for higher research-level studies.
PO2 – Research, Analysis, and Complexity
Students analyze error estimation, convergence, and stability of numerical algorithms (CO6). Interpolation, integration, and ODE methods (CO4 & CO5) require handling approximation complexity.Programming and algorithm design (CO7) involve analytical thinking and structured experimentation
PO3 – Problem Solving in New Contexts
CO2 focuses on solving nonlinear equations computationally.
CO3 and CO4 address systems of equations and approximation techniques.
CO5 solves practical initial and boundary value problems.
CO7 enhances applied programming-based problem-solving ability.
PO4 – Technical Mastery and Scientific Reasoning
CO2 and CO7 develop strong programming skills.
CO6 builds scientific reasoning through convergence and error analysis.
CO3–CO5 involve logical selection of appropriate numerical techniques
PO5 – Integrated Communication:CO2 and CO7 require clear explanation of numerical implementation and outputs to peers and examiners.
PO6 – Ethical, Social, and Professional Judgment:
CO7 (Indirect Mapping):Through programming assignments and computational work, students are guided to follow ethical coding practices, avoid plagiarism, and maintain professional standards in scientific computing.
PO7 – Autonomous and Lifelong Learning:
Students learn computational tools independently and explore numerical techniques beyond classroom examples.
CO7 promotes self-learning in programming.
CO6 prepares students for advanced research in numerical and computational mathematics.
PO8 – Employability, Innovation, and Entrepreneurship
CO2 and CO7 build computational expertise.
CO3 and CO4 strengthen applied analytical skills useful for innovation and professional development.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2026 Pattern)

Name of the programme : M.Sc (Mathematics)

Programme Code : PSMAT

Class : M.Sc.I

Semester I

Course Type : Major (Elective)

Course Name : Practical on Mathematical Foundations of Animation and Graphics Design

Course Code : MAT-507-MJE(B)

No. of Lectures : 60

No. of Credits : 2

Course Objectives:

1. To understand the mathematical concepts underlying animation and computer graphics.
2. To apply linear algebra and geometry in transformation of objects.
3. To study curves and interpolation methods used in motion design.
4. To model motion using calculus and differential equations.
5. To implement mathematical visualization using computational tools.
6. To develop analytical and programming skills in graphical modeling.
7. To integrate mathematical theory with animation applications.

Course Outcomes:

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

CO1   Apply vector and matrix operations for 2D and 3D transformations.
CO2   Construct and analyze parametric curves and surfaces.
CO3   Use interpolation and spline techniques in animation paths.
CO4   Model motion using calculus-based techniques.
CO5   Implement graphical transformations computationally.
CO6   Develop small mathematical animation modules.
CO7   Understand mathematical foundations of computer graphics systems.

Topics and Learning Points

Theory:

Teaching Hours
[12 Lecture]

1. 2D and 3D coordinate systems, Vector representation and operations
2. Homogeneous coordinates, Quadratic and cubic curves
3. Linear interpolation, Lagrange.
4. Circular motion, Simple harmonic motion
5. Projectile Motion, Motion under gravity simulation
6. Parametric surfaces

List of Practical's: **[48 Lecture]**

1. Coordinate Systems and Vector Visualization (Geo-Gebra & Python): Plotting geometric objects.
2. 2D Transformations using Matrices: Translation, Rotation, Scaling, Reflection and Shearing
3. Composition of Transformations: Combined transformations in animation
4. Parametric Curves: Parametric representation of line, circle, ellipse and animation by varying parameter.
5. Polynomial Curves and Bézier Curves: Visualization using GeoGebra
6. Interpolation Techniques
7. Trigonometric Functions in Motion
8. Calculus-Based Motion Modeling
9. Differential Equation Modeling
10. 3D Geometry and Transformations
11. Surface Modeling: Visualization using Geogebra
12. Mini Animation Project: Design of a mathematical animation model, Integration of transformations, curves, and motion laws, Demonstration.

References:

1. Mathematics for Computer Graphics and Multimedia, by *R.S. Chandel & G.M. Bhawe, Narosa Publishing House.*

Mapping of Program Outcomes with Course Outcomes

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

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

Justification for the mapping:

PO1: Advanced Disciplinary Knowledge & Originality:
This course strengthens advanced mathematical concepts such as linear algebra, calculus, interpolation, and geometry.

CO1 & CO2 develop deep understanding of vector spaces, matrix algebra, and parametric geometry.
CO3 & CO4 apply higher-level mathematical analysis in motion modeling.
CO7 builds strong conceptual foundations in computer graphics mathematics.
Thus, students demonstrate advanced disciplinary knowledge beyond undergraduate level.
PO2: Research, Analysis & Complexity:
CO2 & CO3 require analysis of curve behavior and interpolation accuracy.
CO4 involves modeling real-world motion using calculus and differential equations.
CO5 includes algorithmic implementation and complexity understanding.
Students learn to analyze and handle complex mathematical and graphical systems.
PO3: Problem Solving in New Contexts:
CO1 & CO3 apply algebra and interpolation to graphical transformations.
CO5 & CO6 involve solving practical animation problems using computational tools.
Students move beyond classroom theory to innovative graphical applications.
PO4: Technical Mastery & Scientific Reasoning:
CO1 & CO2 develop transformation techniques and curve modeling skills.
CO4 applies calculus-based scientific reasoning in motion analysis.
CO5 & CO6 enhance technical proficiency through animation module development.
Thus, students gain high-level technical and analytical competence.
PO5: Integrated Communication:
CO5 involves explaining computational implementation.
CO6 includes project presentation and viva voce.
This improves scientific communication skills for both technical and non-technical audiences.
PO6: Ethical, Social & Professional Judgment:

CO6 encourages professional standards in project development and presentation.

Though indirect, ethical awareness in computational and graphical applications is fostered.

PO7: Autonomous & Lifelong Learning:

CO6 promotes self-directed development of animation modules.

CO7 builds conceptual understanding enabling further study in graphics, data visualization, or computational mathematics.

Students develop lifelong learning skills.

PO8: Employability, Innovation & Entrepreneurship:

CO5 builds practical programming and transformation skills.

CO6 promotes creative and innovative animation development.

Students acquire industry-relevant skills and entrepreneurial thinking.

Topics and Learning Points

Teaching Hours

UNIT1: Foundation of research   [12 Lecture]
1.12   Meaning and Objectives of research
1.13   Significance of research
1.14   Types of research, Characteristic of mathematical methods
1.15   Research process, Defining Research problem

UNIT2: Mathematical statements   [14 Lecture]
2.5 If then statements, Sufficient and necessary conditions
2.6 Contrapositive, Converse, Negation
2.7 Direct and indirect proof, Principle of induction
2.8 Inductive reasoning, Counter examples

UNIT3: Research design and Method of Data Collection   [14 Lecture]
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 Lecture]
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 Lecture]
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, 8th edition, McGraw-Hill, 2011.

Mapping of Program Outcomes with Course Outcomes

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

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

Justification for the mapping

PO1 – Advanced Disciplinary Knowledge & Originality
CO1-Demonstrate advanced understanding of research methodology principles.
CO2-Analyze research literature critically within the discipline.
CO3-Apply theoretical knowledge to formulate research problems.
CO4-Integrate mathematical reasoning into applied research contexts.
CO5-Interpret advanced qualitative and quantitative techniques.
CO6-Develop structured academic documents using LaTeX.
CO7-Generate original insights through systematic investigation.

PO2 – Research, Analysis, and Complexity
CO1-Formulate research hypotheses based on literature review.
CO2-Design appropriate research methodologies.
CO3-Analyze complex datasets using suitable tools.
CO4-Evaluate research findings critically.
CO5-Handle incomplete or uncertain data logically.
CO6-Compare qualitative and quantitative research approaches.
CO7-Interpret statistical and analytical outputs accurately.

PO3 – Problem Solving in New Contexts
CO1-Apply research tools to interdisciplinary problems.
CO2-Develop innovative solutions to research questions.
CO3-Implement mathematical modeling in applied research.
CO4-Adapt research design to real-world challenges.
CO5-Solve unfamiliar analytical problems independently.
CO6-Translate theoretical frameworks into practical applications.
CO7-Evaluate alternative approaches to research problems.

PO4 – Technical Mastery and Scientific Reasoning
CO1-Utilize LaTeX for professional academic documentation.
CO2-Apply statistical software/tools for data analysis.
CO3-Implement file structuring and referencing techniques correctly.
CO4-Demonstrate systematic research planning.
CO5-Justify methodological choices scientifically.

CO6-Apply logical reasoning in data interpretation.
CO7-Use presentation tools effectively for academic dissemination.

PO5 – Integrated Communication
CO1-Prepare structured research papers and reports.
CO2-Present research findings clearly in written form.
CO3-Explain technical concepts to specialist audiences.
CO4-Communicate research outcomes to non-specialists effectively.
CO5-Develop clear slide presentations using LaTeX/Beamer.
CO6-Interpret analytical results in simplified language.
CO7-Participate in academic discussions confidently.

PO6 – Ethical, Social, and Professional Judgment
CO1-Apply ethical standards in research conduct.
CO2-Ensure proper citation and referencing practices.
CO3-Avoid plagiarism in academic writing.
CO4-Maintain confidentiality in data handling.
CO5-Reflect on societal implications of research outcomes.
CO6-Demonstrate professional responsibility in project work.
CO7-Follow institutional and publication guidelines.

PO7 – Autonomous and Lifelong Learning
CO1-Engage in self-directed research activities.
CO2-Explore emerging research tools independently.
CO3-Upgrade analytical skills continuously.
CO4-Pursue advanced studies in research methodology.
CO5-Develop critical thinking habits.
CO6-Participate in workshops and academic seminars.
CO7-Adapt to evolving research trends.

PO8 – Employability, Innovation, and Entrepreneurship
CO1-Apply research skills in academic and industry settings.
CO2-Develop consultancy-based analytical solutions.
CO3-Use documentation skills for professional reporting.
CO4-Support research and development projects.
CO5-Demonstrate analytical competency in job roles.
CO6-Initiate independent research or startup ideas.
CO7-Translate academic knowledge into professional excellence.