

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

**Autonomous**

**Course Structure for M.Sc.I Mathematics (2019 Pattern)**

Semester	Course Code	Title of Course	No. of Credits
I	MAT4101	Real Analysis	4
	MAT4102	Advanced Calculus	4
	MAT4103	Group theory	4
	MAT4104	Numerical Analysis	4
	MAT4105	Ordinary Differential Equations	4
	MAT4106	Practical: Programming in C	4
II	MAT4201	Complex Analysis	4
	MAT4202	Topology	4
	MAT4203	Rings and Modules	4
	MAT4204	Linear Algebra	4
	MAT4205	Partial Differential Equations	4
	MAT4206	Practical: Programming in C++	4

**Course Structure for M.Sc.II Mathematics**

III	MAT5301	Combinatorics	4
	MAT5302	Field Theory	4
	MAT5303	Functional Analysis	4
	MAT5304	Graph Theory	4
	MAT5305	Applied Mathematics I	4
	MAT5306	Practical: Python	4
IV	MAT5401	Number Theory	4
	MAT5402	Differential Geometry	4
	MAT5403	Fourier Analysis	4
	MAT5404	Lattice Theory	4
	MAT5405	Applied Mathematics II	4
	MAT5406	Project	4

**SYLLABUS (CBCS) FOR M.Sc.I MATHEMATICS  
(w.e.f. June, 2019)**

**Academic Year 2019-2020**

Class : M.Sc I (Semester- I)

Course Code: MAT4101

Course : I

Title of Course: Real Analysis

Credit : 4

No. of lectures: 60

**Course Objectives:**

1. To introduce fundamental concept of real analysis such as sequence, series of real numbers and their convergence, continuity, differentiability of real valued functions.
2. The main objective of the course is to provide basic foundation for real analysis which will prepare the students for several other advanced topics in mathematics. The course is designed to provide rigorous treatment of the subject in terms of theory and examples which gives the students the flavour of mathematical reasoning and intuition.
3. Studying the notion of continuous functions and their properties.
4. To provide a deeper and rigorous understanding of fundamental concepts viz. metric spaces, continuous functions, sequences and series of numbers as well as functions, and the Riemann-Stieltjes integral etc.
5. Studying theoretical foundation of the above said concepts and it will cultivate the rigorous mathematical logics and skills in the students.
6. Studying Bolzano –Weirstrass theorem and Cauchy criteria.
7. Studying the notion of continuous functions and their properties.

**Course Outcomes:**

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

- CO1 Students will be able to demonstrate an understanding of the theory of sequences, function spaces and Dimension.
- CO2 Students will be able to apply the theory in the course to solve a variety of problems than appropriate level of difficulty.
- CO3 Classify and explain open and closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. in a metric space.
- 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, Convergence Theorem, and Riemann integral for Riemann integrable functions.
- CO6 Student will be able to determine the Orthonormal Sequences, Inequalities and prove Parseval's Theorem.
- CO7 Determine questions related to different types of  $L^p$  spaces and demonstrate skills in constructing rigorous mathematical arguments

## TOPICS/CONTENTS:

1. Metric Spaces, Normed Spaces, Inner Product Spaces:  
Definitions and Examples, Sequence Spaces, Function Spaces, Dimensions.
2. Topology of Metric Spaces:  
Open, Closed and Compact sets, The Heine-Borale and Ascoli-Arzelà' Theorems,  
Separability, Banach and Hilbert Spaces.
3. Measure and Integration:  
Lebesgue Measure on Euclidean Space, Measurable and Lebesgue Integrable Functions,  
The Convergence Theorems, Comparison of Lebesgue Integral with Riemann integral,  
General Measure and Lebesgue  $L^p$ -Spaces.
4. Fourier Analysis in Hilbert space:  
Orthonormal Sequence, Bessel's Inequality, Parseval's Theorem, Riesz-Fischer Theorem,  
Classical Fourier Analysis.
5. Weierstrass Approximation Theorem, Generalized Stone-Weierstrass Theorem, Baire  
Category Theorem and its Applications, Contraction Mapping.

**Text Book:** *Beginning Functional Analysis*, Karen Saxe, Springer International Edition.

(Chapters: 1 to 4, 6.1, 6.2, 6.5)

## Reference Books:

1. *Principles of Mathematical Analysis*, W. Rudin, Mc'Graw Hill.
  2. *Topology of Metric Spaces*, S. Kumaresan, Narosa Publishing.
  3. *Introduction to Topology and Modern Analysis*, G. F. Simmons, Mc'Graw Hill.
-

Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

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

**Subject:** Mathematics

**Course:** Real analysis

**Course Code:** -MAT4101

**Mapping Table:**

**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	PO 9
CO 1	3	3		2					
CO 2	3	3		3					
CO 3	3	3		3	3				
CO 4	3	2							3
CO 5	3	2							
CO 6									
CO 7		2		2					2

**Justification for the mapping**

**PO1: Disciplinary Knowledge**

CO1: Students have comprehensive knowledge and understanding of subject area, the ability to engage with different traditions of thought, and enhancing critical thinking.

CO2: Students have the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.

CO3: Studying open set, closed set and compactness in metric space is essential in disciplinary knowledge as it provides a deeper understanding of concepts in metric spaces.

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 Lebesgue integral, and Riemann integral for Riemann integrable functions is fundamental in disciplinary knowledge as they play a pivotal role in advanced mathematical and scientific computations, offering valuable tools for solving complex problems and modelling real-world phenomena.

**PO2: Critical Thinking and Problem solving**

CO1: Learning the sequences and function spaces enhances critical thinking and problem-solving skills.

CO2: Applying various concepts fosters critical thinking and problem-solving by equipping individuals with powerful mathematical tools that enable the analysis and resolution of complex, 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. 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.

CO4: Studying the concepts of measure theory is essential for critical thinking and problem-solving as it equips individuals with a powerful technique for efficiently evaluating complex integrals.

CO5: Understanding the convergence theorem is essential for critical thinking and problem-solving because it gives more accurate analysis and informed problem-solving across disciplines.

CO7: Understanding types of  $\square^p$  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  $\square^p$  spaces plays a vital role in advanced mathematical research, facilitating precise modeling and analysis in scientific inquiries and investigations.

#### **PO5: Trans-disciplinary knowledge**

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

#### **PO9: Self-directed and Life-long learning:**

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

CO7: Understanding different types of  $\square^p$  spaces and demonstrate skills in constructing rigorous mathematical arguments contributes to self-directed and life-long learning by providing individuals with advanced mathematical knowledge that can be continually applied and expanded upon, fostering a commitment to ongoing intellectual growth and problem-solving capabilities.

Class : M.Sc I (Semester- I)

Course Code: MAT4102

Course : II

Title of Course: Advanced Calculus

Credit : 4

No. of lectures: 60

### Course Objectives:

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

### Course Outcomes:

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

### TOPICS/CONTENTS:

1. Derivative of a scalar field with respect to a vector, Directional derivative, Gradient of a scalar field, Derivative of a vector field, Matrix form of the chain rule, Inverse function theorem and Implicit function theorem.
2. Path and line integrals, The concept of work as a line integral, Independence of path, The first and the second fundamental theorems of calculus for line integral, Necessary condition for a vector field to be a gradient.
3. Double integrals, Applications to area and volume, Green's Theorem in the plane, Change of variables in a double integral, Transformation formula, Change of variables in an n-fold integral.
4. The fundamental vector product, Area of a parametric surface, Surface integrals, The theorem of Stokes, The curl and divergence of a vector field, Gauss divergence theorem, Applications of the divergence theorem.
5. Applications of differential Calculus: Partial differential equations ,A first order partial

differential equation with constant coefficients, The one Dimensional wave equation.

**Text Book:**

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

Chapter 1: Sections 8.1 to 8.22

Chapter 2: Sections 10.1 to 10.11 and 10.14 to 10.16

Chapter 3: Sections 11.1 to 11.5 and 11.19 to 11.22 and 11.26 to 11.34

Chapter 4: Sections 12.1 to 12.15, 12.18 to 12.21

Chapter 5: Sections 9.1 to 9.5

(For Inverse function theorem and Implicit function theorem refer the book "Mathematical Analysis" by T. M. Apostol.)

**Reference Books :**

1. T. M. Apostol: Mathematical Analysis (Narosa publishing house)

2. W. Rudin: Principles of Mathematical Analysis (Mc-Graw Hill)

3. A. Devinatz: Advanced Calculus, (Holt, Rinehart and Winston), 1968

---

Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

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

**Subject:** Mathematics

**Course:** Advanced calculus

**Course Code:** MAT4102

**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	PO 9
CO 1				1					
CO 2	2								1
CO 3				1					
CO 4		2			2				
CO 5									1
CO 6	1								1
CO 7		2			1				

**Justification for the mapping**

**PO1: Disciplinary Knowledge**

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

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

**PO2: Critical Thinking and Problem solving**

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

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

**PO4: Research-related skills and Scientific temper**

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

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

**PO5: Trans-disciplinary knowledge**

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



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

**PO9: Self-directed and Life-long learning:**

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

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

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

Class : M.Sc I (Semester- I)

Course Code: MAT4103

Course : III

Credit : 4

Title of Course : Group Theory

No. of lectures: 60

**Course Objectives:**

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

**Course Outcomes:**

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

**TOPICS/CONTENTS:**

1. Revision of definition and examples of groups, subgroups.
2. Cyclic Groups, Classification of subgroups of cyclic groups.
3. Permutation Groups
4. Isomorphism, Cayley's theorem, properties of isomorphisms, automorphism
5. Cosets and Lagrange's theorem. Orbit-stabilizer theorem, the rotation group of a cube and a soccer ball.
6. External Direct Products
7. Normal subgroups and factor groups, Internal direct products
8. Group Homomorphism
9. Fundamental theorem of finite abelian groups
10. Sylow theorems
11. Applications of Groups: Symmetries of square, The dihedral groups. A check-digit scheme based on  $D_5$ , The rotation group of a cube and a soccer ball, Data Security, Public key cryptography.

**Text Books:** Joseph Gallian – Contemporary Abstract Algebra (Narosa Publishing House). Chapter 2 to 11, 24, 25.

**Reference Books:**

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

Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

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

**Subject:** Mathematics

**Course:** Group Theory

**Course Code:** MAT4103

**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	PO 9
CO 1									
CO 2	2	1							
CO 3	1								
CO 4		2		1					
CO 5	2	1			2				
CO 6	2	2	1	3				2	2
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 analysing 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.

CO5: Applying group theory concepts to real-world problems in chemistry, physics, cryptography, and other fields enhances critical thinking and problem-solving skills by necessitating the adaptation of abstract mathematical principles to address complex, practical challenges, fostering analytical reasoning and creative problem-solving abilities.

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.

CO7: Applying group theory concepts to real-world problems in chemistry, physics, cryptography, and other fields develops research-related skills and a scientific temper by encouraging systematic analysis, innovative problem-solving, and the application of abstract mathematical principles to address practical challenges, fostering a research-oriented mindset.

### **PO5: Trans-disciplinary knowledge:**

CO5: 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, preparing students for ongoing intellectual growth and adaptability in diverse academic and professional contexts.



Class : M.Sc I (Semester- I)

Course Code: MAT4104

Course : IV

Title of Course : Numerical Analysis

Credit : 4

No. of lectures: 64

**Course Objectives:**

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

**Course Outcomes:**

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

- CO1 Student will be able to handle Machine Learning algorithms using Numerical Analysis.
- CO2 Student will be able to construct a function which closely fits given  $n$ - points in the plane by using interpolation method
- CO3 Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- CO4 Implement numerical methods in Scilab and other mathematical software.
- CO5 Solve a linear system of equations using an appropriate numerical method.
- CO6 Student will be able solve an algebraic or transcendental equation using an appropriate numerical method.
- CO7 Student will be able to approximate a function using an appropriate numerical method.

**TOPICS/CONTENTS:**

**1. Root of Nonlinear Equations:** Introduction, Methods of Solution, Iterative methods, Evaluation of Polynomials, Bisection method, False Position method, Newton Raphson Method, Secant Method, Fixed Point Method, System of Nonlinear Equations, Roots of Polynomials

**2. Direct Solution of Linear Equations:** Existence of Solution, Solution by elimination, Basic Gauss Elimination method, Gauss elimination with pivoting, Gauss-Jordan Method, Triangular Factorization Methods, Round-off Errors and Refinement, Matrix Inversion Method

**3. Iterative Solution of Linear Equations:** Jacobi Iterative method, Gauss-Seidel Method, Convergence of Iteration Methods

**4. Curve Fitting Interpolation:** Polynomial forms, linear interpolation, Lagrange Interpolation Polynomial, Newton Interpolation Polynomial, Interpolation with equidistant points

**5. Numerical Differentiation:** Differentiating Continuous functions, Forward difference quotient, Central difference quotient, Error analysis

**6. Numerical Integration:** Newton-Cotes Methods, Trapezoidal Rule, Simpsons 1/3 rule, Simpsons 3/8 rule



**7.Numerical Solution of Ordinary Differential Equations:** Taylor Series Method, Euler's Method, Heun's Method, Polygon Method, Runge-Kutta Methods

**8.Boundary-value and Eigenvalue Problems:** Shooting Method, Finite Difference Method, Solving Eigenvalue Problems, Power method

**Text Book:** Numerical Methods, E Balagurusamy, Mc Graw Hill , Sections: 6.1-6.3, 6.5-6.10,7.1-7.8, 7.10,8.1-8.5,9.1-9.7,11.1,11.2,12.1-12.5,13.2-13.6,14.1-14.4,14.6

**Reference Books:**

- 1) S. S. Sastry, Introduction Methods of Numerical Analysis ( 4th Edition) Prentice
  - 2) Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Prentice Hall 2007.
  - 3) K .E. Atkinson: An Introduction to Numerical Analysis.
  - 4) J. I. Buchaman and P. R. Turner, Numerical Methods and Analysis.
  - 5) M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for scientific & Engineering Computation, 5<sup>th</sup> Edition New Age International Publication.
-

Credit System Syllabus (2019 Pattern)  
**Mapping of Program Outcomes with Course Outcomes**

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

**Subject:** Mathematics

**Course:** Numerical Analysis

**Course Code:** -MAT4104

**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	PO 9
CO 1	3		2						2
CO 2	3	2		2					
CO 3	3								
CO 4		3	2		2				3
CO 5		3					2		
CO 6	3				2				
CO 7	3	3	3	3					

**Justification for the mapping**

**PO1: Disciplinary Knowledge**

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

CO2: The ability to construct a function closely fitting given n-points through interpolation enhances disciplinary knowledge by empowering students with a practical and versatile tool for approximating and analysing real-world data, facilitating applications in various scientific, engineering, and mathematical domains.

CO3: A solid understanding of common numerical methods is essential in disciplinary knowledge as it equips individuals with practical tools to address real-world mathematical problems, offering efficient and effective approaches to tackle complex computations that may be challenging or impractical to solve analytically.

CO6: Solving algebraic or transcendental equations using numerical methods in disciplinary knowledge empowers students with practical problem-solving skills, essential for applications in various scientific and engineering disciplines, facilitating accurate solutions to complex mathematical models and real-world problems.

CO7: The ability to approximate a function using numerical methods is essential in disciplinary knowledge as it empowers students to bridge theoretical concepts with practical applications, fostering a deeper understanding of mathematical models and their real-world implications..

**PO2: Critical Thinking and Problem solving**

CO2: Constructing a function through interpolation cultivates critical thinking and problem-solving skills by requiring students to strategically analyse and synthesize information, make informed decisions about function behaviour, and devise precise mathematical models to

approximate and interpolate data points, fostering a deeper understanding of mathematical relationships.

CO4: Implementing numerical methods in software like Scilab enhances critical thinking and problem-solving skills by enabling students to apply abstract mathematical concepts to real-world problems, fostering the ability to analyse, optimize, and evaluate solutions using computational tools in diverse scientific and engineering contexts.

CO5: Solving a linear system of equations using a numerical method enhances critical thinking and problem-solving skills by requiring the evaluation and selection of appropriate algorithms, fostering a systematic approach to analyze complex mathematical problems, and encouraging the development of efficient strategies for addressing real-world challenges.

CO7: The ability to approximate a function using numerical methods cultivates critical thinking and problem-solving skills by requiring students to evaluate algorithmic choices, and apply mathematical reasoning to address real-world problems with diverse applications.

### **PO3: Social competence**

CO1: Handling Machine Learning algorithms through Numerical Analysis in the context of social competence enhances interdisciplinary communication by equipping students to navigate the intersection of mathematics and technology, fostering the ability to collaborate effectively on data-driven projects and promoting understanding and application of machine learning in societal contexts.

CO4: Implementing numerical methods in Scilab and other mathematical software in the context of social competence demonstrates the ability to leverage technology for collaborative problem-solving, fostering effective communication and teamwork in interdisciplinary settings for addressing societal challenges that demand computational approaches.

CO7: Approximating a function through numerical methods in the context of social competence cultivates the ability to communicate complex mathematical concepts effectively, facilitating collaboration and interdisciplinary dialogue by bridging the gap between technical expertise and practical applications, thus fostering a more inclusive and accessible approach to mathematical discussions within diverse social settings.

### **PO4: Research-related skills and Scientific temper**

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

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

### **PO5: Trans-disciplinary knowledge**

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

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

**PO7: Effective Citizenship and Ethics**

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

**PO9: Self-directed and life –long learning :**

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

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





Class : M.Sc I (Semester- I)

Course Code: MAT4105

Course : V

Title of Course : Ordinary Differential Equations

Credit : 4

No. of lectures: 64

**Course Objectives:**

- 1) Define differential equations and classify them as ordinary or partial differential equations..
- 2) Introduce the concept of a solution to a differential equation.
- 3) Explore applications of first-order differential equations in various fields.
- 4) Discuss the properties and behaviour of solutions.
- 5) Discuss the existence and uniqueness theorems for solutions to ordinary differential equations.
- 6) Study power series solutions for ordinary differential equations.
- 7) Analyze the convergence and divergence of series solutions.

**Course Outcomes:**

1. Solving ODEs to analyze and design engineering systems, including control systems, structural mechanics, and fluid dynamics.
2. Distinction between ordinary and partial differential equations.
3. Solve second-order linear and non-linear ODEs using various methods, such as undetermined coefficients and variation of parameters.
4. Understand the basics of systems of first-order ODEs and their solutions.
5. Understand the conditions for the existence and uniqueness of solutions to ODEs.
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/CONTENTS:**

**Review :** General remarks on solutions of differential equations, Families of curves, Orthogonal trajectories.

**1.Second Order Linear Equations:**

The general solution of the homogeneous equations, Use of a known solution to find another solution, Homogeneous equations with constant coefficients. The method of undetermined coefficients. The method of variation of parameters.

**2. Qualitative properties of solutions of Ordinary differential equations of order two :**

Sturm Separation theorem. Normal form. Standard form, Sturm's comparison theorem.

**3.Power Series Solutions and special functions:**

Review of power series, Series solutions of first order equations, Second order linear equations. Ordinary points, Regular singular point, Indicial equations. Gauss Hypergeometric equation. The point at infinity. Legendre polynomials, properties of Legendre polynomials, Bessel Functions, Properties of Bessel Functions.

**4.Systems of First Order Equations:**

General remarks on systems, Linear systems, Homogeneous linear system with constant coefficients.

**5. The Existence and Uniqueness of solutions:**

The method of successive approximations, Picards theorem, Existence and uniqueness of Second order initial value problems.

**Text Book:**

G. F. Simmons : Differential Equations with applications and Historical notes (Tata - McGraw Hill).

**Sections:** 1 to 3, 7 to 11, 14 to 19 , 24 , 25, 26 to 32, 54 to 57, 68 to 70

**Reference Books**

1. G. Birkhoff and G.C. Rota : Ordinary differential equations.  
( John Wiley and Sons)
  2. S. G. Deo, V. Lakshmikantham, V. Raghvendra. Text book of Ordinary Differential Equations. Second edition. Tata Mc-Graw Hill.
  3. E. A. Coddington : An Introduction to Ordinary Differential Equations  
(Prentice Hall).
-



Credit System Syllabus (2019 Pattern)  
**Mapping of Program Outcomes with Course Outcomes**

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

**Subject:** Mathematics

**Course:** Ordinary Differential Equation

**Course Code:** -MAT4105

**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	PO 9
CO 1	2								
CO 2					1				
CO 3									
CO 4	2				1				
CO 5									
CO 6	3	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 behavior and facilitating optimization for enhanced system performance

CO4: Proficiency in understanding and solving systems of first-order Ordinary Differential Equations (ODEs) is crucial for modeling and analyzing complex dynamic systems in various engineering disciplines, ensuring accurate predictions and informed decision-making.

CO6: Analyzing 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:Environment 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 :**

CO7: Developing analytical and problem-solving skills through the application of ODE theory to real-world scenarios fosters self-directed and life-long learning, empowering individuals to adapt to evolving challenges and continuously enhance their expertise in diverse fields.





Class : M.Sc I (Semester- I)

Course Code: MAT4106

Course : VI

Title of Course : Practical- Programming in C

Credit : 4 No. of lectures: 64

**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.

Data types in C

4. To understand Mathematical and logical operator.
5. To study use of if statement and loop.

**Course Outcomes:**

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

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

**TOPICS/CONTENTS:**

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

**Text Book:**

Yeshwant Kanetkar, Let us C, BPB Publications

**Reference Books :**

- i) Byron S. Gottfried, Programming with C, Schaum's Outline Series
- ii) W.H.Press, S.A.Teukolsky et.al, Numerical recipes in C, The art of scientific computing

Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes****Class:** M.Sc-I (Sem I)**Subject:** Mathematics**Course:** Practical Programming in C**Course Code:** -MAT4106**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	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 analyse 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**

CO7: 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  $\pi$  and exponentiation) with language and communication

knowledge (user input and output) to demonstrate the integration of trans-disciplinary concepts, reflecting the importance of combining different fields of knowledge for comprehensive problem-solving.

**PO9: Self-directed and life –long learning :**

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