आंध्रप्रदेश केंद्रीय विश्वविद्यालय

CENTRAL UNIVERSITY OF ANDHRA PRADESH

Ananthapuramu

Postgraduate Programme Structure
as per the UGC Credit Framework (NEP 2020)

Vidya Dadati Vinayam
(Education Gives Humility)

M.Sc. Mathematics and Computing

Numbers have life; they're not just symbols on paper
- Shakunthala Devi

Programme Structure

(With effect from 2024-2025 Batch)

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CONTENTS

Introduction to the programme

The Department of Mathematics has started in the academic year 2021-22 offers a 2-year M.Sc. programme in Mathematics and Computing renamed from the traditional M.Sc. Mathematics programme, this updated curriculum reflects the growing importance and intersection of mathematics and computing in various fields including science, engineering, finance, and technology. This programme blends relevant mathematics and computer science courses covering theoretical, computational and practical aspects. Whereas the core mathematics courses are aimed at building a strong foundation in the subject, the laboratory-based courses give the exposure and training in application-oriented practical subjects. Students are exposed to advanced research topics through electives and a mandatory one-semester project work. It concentrates on areas where mathematics and computing are most relevant to each other. This is an interdisciplinary programme aiming to provide the strong Math's and computing skills required for the industries.

At the end of the programme, students acquire sound analytical and practical knowledge to formulate and solve challenging problems and are well prepared to take up jobs in software industries, research and development organizations or to pursue higher studies in mathematical and computing sciences.

While preparing the syllabus of the core courses and the basket of elective courses one has to take into account to provide the following points:

a) The core courses should help the students to write the competitive examinations (like CSIR-UGC NET) to pursue mathematics at the later years.
b) The course Statistics and Probability should contain more of applied probabilities rather than concepts involving deeper analysis.
c) The course Common Compulsory Course will provide knowledge to student to prepare for competitive exams
d) The elective courses should facilitate the student to seek for the jobs in case he/she does not want to continue mathematics.
e) The course also encourages the department to float elective courses that are inter-disciplinary.
f) The student-centric approach of the curriculum has been designed to equip learners with appropriate knowledge, skills and values of the discipline.

Programme Vision

It aims to bridge the gap between theoretical mathematical concepts and their practical applications in computing, equipping students to tackle complex real-world problems in various fields. Produce graduates who are adept at leveraging mathematical principles and computational tools to address complex challenges, innovate, and make meaningful contributions to academia, industry, and society.

Programme Objectives

Upon completion of the M.Sc. programme in Mathematics and Computing, the graduate will

- Have professional and ethical responsibility and able to adopt new skills and techniques.
- Be able to plan, organize, lead and work in team to carry out tasks to the success of the team.
- Understand the need for continuous learning and prepare himself/ herself with relevant in their personal skills as an individual, as a member or as a leader throughout the professional career.
- Be motivated to prepare himself/ herself to pursue higher studies and research to meet out academic demands of the country.
- Communicate mathematical ideas with clarity and able to identify, formulate and solve mathematical problems.
- Have knowledge in wide range of mathematical techniques and application of mathematical methods/tools in scientific and engineering domains.
- Have both analytical and computational skills in mathematical sciences.

Learning Outcomes

On successful completion of the programme students should be able to:

- Solve diverse mathematical problems and capable of analyzing the obtained results.
- Analyze and interpret the outcomes and develop new ideas based on the issues in broader social context.
- Apply the knowledge and design the methodology to the real-world problems.

- Use the learned techniques, skills and modern mathematical tools suitable to the problem encountered.
- Acquire problem solving skills, analytical thinking, creativity and mathematical reasoning.
- Write effective reports and documents, prepare effective presentations and communicate the findings efficiently.
- Develop confidence to crack the competitive exams like NET, GATE, SET, etc.

Pedagogy of the programme

The pedagogy of an M.Sc program in Mathematics and computing typically combines traditional lectures with interactive seminars, workshops, practical sessions, Student-centric learning, Group discussions, Guest lectures, Independent Studies and Interactive sessions, Project based learning, Research orientation, Seminars & workshops on current topics, Tutorial & assignments, Class test / Open book test. Overall, it emphasizes active learning, problem-solving, collaboration, and research, equipping students with the knowledge, skills, and mindset required for success in academia, industry, and beyond.

Programme Structure

- The M.Sc Mathematics and Computing is a two-year Programme divided into four semesters with a total of around 87 credits.
- The programme is designed with the combination of Core Courses, Discipline Specific Electives, Common Compulsory Courses, Multi-disciplinary Courses, and MOOCS.
- In Semester-II and Semester-III, students will select 1 Discipline Specific Elective as their functional specialization and will study all the courses mentioned.
- In Semester II and III,1 multi-disciplinary elective offered by other departments will be selected by the students.
- Students need to complete1 MOOCS Course in each I, II and III Semester.
- In semester IV students will undergo for 6 months Project Work/Dissertation work, allowing them to apply their acquired knowledge and skills in a practical setting and contribute meaningfully to the field of education.

M.Sc. Mathematics and Computing Semester and Course wise Credits

Semester	Discipline Core (DSC) (L+T+P)	Discipline Elective (DSE) / Elective (EL)	Common compulsory course (CCC)	Inter-Disciplinary Elective (IDE)	Project Work / Dissertation	Lab	Total Credits
I	DSC 1 (3) DSC 2 (3) DSC 3 (3) DSC 4 (3) DSC 5 (3)	DSC(MOOC-I) (2)	-	-	-	DSC 5 (1)	18
II	DSC 6 (3) DSC 7 (3) DSC 8 (3) DSC 9 (3)	DSC(MOOC-II) (2) DSE 1(3)	CCC 1 (2)	IDE 1 (2)	-	DSC 9 (1) CCC 1 (2) IDE 1 (1)	25
III	DSC 10 (3) DSC11 (3) DSC 12 (3) DSC 13 (3) DSC 14 (4)	DSC(MOOC-II) (2) DSE 2 (3)	-	IDE 2 (3)	-	DSC 12 (1)	25
IV	DSC 15 (3)	-	-	-	DSC 16 (16) Project Work/ Dissertation	-	19
Total	46	12	2	6	16	5	87

Programme Structure with Course Titles
M.Sc. Mathematics and Computing

S. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
Semester-I						
1	MAT101	Linear Algebra	3	2	1	
2	MAT102	Real Analysis	3	2	1	
3	MAT103	Abstract Algebra	3	2	1	
4	MAT104	Ordinary Differential Equations	3	2	1	
5	MAT105	Computer Programming in Python **Lab:** Computer Programming in Python	4	2	1	1
6	MAT106	MOOCS-I/Online/Elective #	2	2		
		Total	**18**	**12**	**5**	**1**
Semester-II						
1	MAT201	Linear Programming	3	2	1	
2	MAT202	Topology	3	2	1	
3	MAT203	Complex Analysis	3	2	1	
4	MAT204	Probability and Statistics Probability and Statistics with R Programming	4	2	1	1
5	MAT205	MOOCS-II/Online/Elective #	2	2		
6	**Discipline Specific Elective-I (any *One* of the paper from below list) @**		3#	2	1	
	MAT211	Number Theory Measure and Integration Calculus of Variations and Integral Equations Modules and Fields				
7	MAT212	Inter-Disciplinary Elective-I	3	2		1
8	MAT213	Introduction to Artificial Intelligence and Machine Learning	4	2	0	2
		Total	**25**	**16**	**5**	**4**

Note: # as per the choice of the student and the instructor
@ The number of elective courses may increase
Note: According to students' choice the Discipline Specific elective contact hours per week may change for #Theory.

S. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
Semester-III						
1	MAT301	Functional Analysis	3	2	1	
2	MAT302	Partial Differential Equations	3	2	1	
3	MAT303	Numerical Analysis and Scientific Computing **Lab:** Numerical Analysis and Scientific Computing with Python	4	2	1	1
4	MAT304	Fluid Mechanics	3	2	1	
5	MAT305	Mathematical Foundations for Computer Science	4	3	1	
6	MAT306	MOOCS-III/Online/Elective #	2			
7	**Discipline Specific Elective-II (any *One* of the paper from below list) @**		**3#**	2	1	
	MAT311	Statistical Inference Optimization Techniques Numerical Linear Algebra				
8.	MAT312	Inter-Disciplinary Elective	3	2	1	
Total			**25**	**15**	**7**	**1**
Semester-VI						
1	MAT401	Numerical Solutions for Differential Equations	3	2	1	
2	MAT402	Dissertation	16		4	12
Total			**19**	**2**	**5**	**12**

@ The number of elective courses may increase

Note: According to students' choice the elective-I and II contact hours per week may change for #Theory.

#As per the choice of the student and the instructor* Discipline Elective /Generic Elective

Students can be done additional MOOC courses, if they want to acquire additional credits

The students can take core courses in MOOCs

Note: #As per the choice of the students and the instructor

L: Lectures; S: Seminars; P: Practical's; T: Tutorials

Semester-Wise Credit Distribution

Semester	Total Credits	Cumulative credit at the end of the semester
1	18	18
II	25	43
III	25	68
IV	19	87

End Semester Examination

Maximum Marks: 60 Time: 3 Hours

Dissertation

Dissertation/Project report: Evaluation - 60marks
Viva-Voce - 40marks

Information to the Student

Programme: M.Sc. Mathematics and Computing

I. Eligibility: Bachelor's degree with a minimum of 60% marks in the aggregate of optional subjects with Mathematics/ Statistics as one of the subjects; OR with at least 55% of marks for those students who have done B.A. /B.Sc. (Hons) course in Mathematics / Statistics.

II. The minimum duration for completion of the programme is four semesters (two academic years) and the maximum duration is eight semesters (four academic years) or as per amendments made by the regulatory bodies from time to time.

III. A student should attend at least 75% of the classes, seminars, practical's in each course of study.

IV. All theory courses in the programme carry a Continuous Internal Assessment (CIA) component to a maximum of 40 marks and End Semester Examination (ESE) for a maximum of 60 marks. The minimum pass marks for a course are 40%.

V. All lab components carry a Continuous Internal Assessment (CIA) component to a maximum of 60 marks and End Semester Practical Examination (ESE) for maximum of 40 marks. The minimum pass marks for a course in 40%

VI. A student should pass separately in both Continuous Internal Assessment (CIA) and the End Semester Examination (ESE), i.e., a student should secure 16 (40% of 40) out of 40 marks for theory and 24 (40% of 60) out of 60 marks for lab components in the Continuous Internal Assessment (CIA). Therefore, a student should secure 24 (40% of 60) out of 60 marks for theory and 16 (40% of 40) out of 40 marks for lab components in the end semester examination.

VII. The student is given 3 Continuous Internal Assessment (CIA) tests per semester in each course from which the best 2 performances are considered for the purpose of calculating the marks in Continuous Internal Assessment (CIA). A record of the continuous assessment is maintained by the academic unit. The 3 internal tests are conducted for 15 Marks each, out of the best 2 tests scores are considered for 30 marks. Out of the remaining 10 marks, 5 marks are awarded for assignments, class presentations and class participation of the students and the remaining 5 marks are awarded for punctuality, and attendance of the student.

Marks for the Attendance will be considered as follows:

S.NO	ATTENDANCE %	MARKS
1	95% or more	5
2	90-94%	4
3	85-89%	3
4	80-84%	2
5	75-79%	1

VIII. A student failing to secure the minimum pass marks in the Continuous Internal Assessment (CIA) is not allowed to take the end semester examination of that course. He/she has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the End Semester Examination (ESE).

IX. Students failing a course due to lack of attendance should redo the course.

X. Re-evaluation is applicable only for theory papers and shall not be entertained for other components such as practical's/thesis/dissertation/internship, etc.

XI. An on-campus elective course is offered only if a minimum of ten or 40% of the students registered, whichever is higher, exercise their option for that course.

SEMESTER WISE DETAILED SYLLABUS

SEMESTER-I

Course Code: **MAT101** Core/ Elective: **Core** No. of Credits: **3**	Course Title **Linear Algebra**

Course Objectives

- Understand the geometry of spaces associated with a matrix and apply them in computing.
- Use eigenvalues and eigenvectors of a matrix to factorize it.
- Analyze the error and stability in matrix computations.
- Apply different factorization techniques of matrices to solve linear systems.
- Compute eigenvalues and eigenvectors and solve overdetermined systems.

Learning Outcomes

Upon completion of the course, students should be able to:

- Understand fundamentals of linear algebra and its computational applications.
- Apply eigenvalues and eigenvectors in matrix factorization.
- Analyze and address errors and stability issues in matrix computations.
- Utilize various matrix factorization techniques for solving linear systems.
- Solve overdetermined systems by computing eigenvalues and eigenvectors.

Course Outline

Unit-I

Vector Space - Subspaces Solving AX = 0 & AX = b Linear Independence - Basis and Dimension - The Four Fundamental Subspaces - Linear Transformation - Orthogonal Vectors Projections to a Line Projections and Least Squares - Orthogonal Bases Gram - Schmidt.

Unit-II

Eigenvalues and Eigenvectors - Diagonalization of a Matrix - Complex Matrices - Similarity Transformation - Test for positive definiteness - Singular Value Decomposition.

Unit-III

Errors in Computations - Computing Norm - Inner product and solution of Triangular System Efficiency and stability of an Algorithm - Conditioning - Perturbation Analysis - Perturbation Analysis of linear system.

Unit-IV

LU Factorization Methods - Scaling - Effects of the condition number on accuracy computing and estimating the condition number - Householder’s matrices and QR factorization classical.

Unit-V

Modified Gram-Schmidt Algorithm for QR factorization- Solution of AX=b using QR Factorization - Projections Using QR Factorization, SVD and its computation.

Suggested Reading

1. Strang, G. (2006). “Linear Algebra and Its Applications” (4^{th} ed.). Boston, MA: Cengage Learning.
2. Datta, B. N. (2012). *“Numerical Linear Algebra and Applications*” (2^{nd} ed). PHI Learning
3. Axler, S. (2015). *“Linear Algebra Done Right.”* Springer.

References

1. Demmel, J. W. (1997). *“Applied Numerical Linear Algebra”* (1^{st} ed). University Press.
2. Golub, G. H., & Van Loan, C. F. (2015). *“Matrix Computations”* (4^{th} ed). Hindustan Book Agency.

Online Resources

1. NPTEL Course by Prof. D. N Pandey & Prof. P. N. Agrawal, IIT Roorkee
2. NPTEL Course by Prof. V. Rao, IISc Bangalore

Course Code: **MAT102** Core/ Elective: **Core** No. of Credits: **3**	Course Title **Real Analysis**

Course Objectives

- To develop fundamental concepts in Real Analysis and make the student acquainted with tools of analysis which is essential for the study and appreciation of many related branches of mathematics and applications.
- To implement the theorems taught in the course to work associated problems, including proving results of suitable accessibility.
- To learn convergence series and sequences.

Learning Outcomes

After completion of the course student should be able to:

- Get a clear idea about real numbers and real valued functions.
- Know the countability and uncountability of the sets.
- Test the continuity and Riemann integration of a function.
- Obtain the skills of analyzing the concepts and applying appropriate methods for testing convergence of a sequence/series.
- Know the differences between open, closed and bounded sets.

Course Outline

Unit-I

Finite - Countable and Uncountable sets - Metric Spaces Neighbourhood of a point of a point Open sets and Closed sets, Compact sets - Wierstrass theorem - Cantor set - Connected sets - Convergent and Cauchy sequences - Diameter of set - Continuous functions - Continuity and Compactness - Continuity and Connectedness - Monotonic Functions.

Unit-II

Reimann - Steiltjes integral - Definition and Existence of integral - Properties of Integrals - Integration and differentiation - Rectifiable curves

Unit-III

Sequences and series of Functions: Uniform Convergence - Uniform Convergence and Continuity - Uniform Convergence and integration - Uniform Convergence and Differentiation - The Stone - Wierstrass Theorem.

Unit-IV

The directional derivatives - Directional derivatives and Continuity - The total derivative the total derivative expressed in terms of the partial derivatives - The Jacobian matrix - The Chain rule -The matrix form of chain rule -The Mean Value Theorem for differentiable functions - A sufficient condition for differentiability A sufficient condition for equality of mixed partial derivatives - Taylor’s formula for function form $R^n \rightarrow R$.

Unit-V

Functions with non-zero Jacobian Determinant The inverse function theorem - The Implicit Function Theorem - Extremum of real valued functions of several variables - Extremum problems with side Conditions

Suggested Reading

1. Rudin, W. (1976). Chapter 2, 4, 6 & 7 (excluding articles 7.19 to 7.25) of *"Principles of Mathematical Analysis"* (3rd ed). New York, NY: McGraw-Hill.
2. Apostol, T. M. (1976). Chapter 12 and 13 of "Mathematical Analysis" (Publisher's edition). Narora Publishing House.

References

1. Pugh, C. C. (2022). *"Real Mathematical Analysis".*
2. Fitzpatrick, P. M. (2009). "*Advanced Calculus*". Belmont, CA: Thomson Brooks/Cole.

Course Code: **MAT103** Core/ Elective: **Core** No. of Credits: **3**	Course Title **Abstract Algebra**

Course Objectives

- To learn the group, matrix groups and permutation groups.
- To learn the concepts and basic ideas involved in homomorphism and quotient rings.
- To understand the fundamental concepts of ideal and unique factorization domains.

Learning Outcome

On successful completion of this course the student should be able to:

- Acquire the basic knowledge and structure of groups, sub groups and cyclic groups.
- Get the behaviour of permutations and operations on them.
- Study the homomorphisms and isomorphisms with applications.
- Understand the applications of ring theory in various fields.
- Understand the ring theory concepts with the help of knowledge in group theory.

Course Outline

Unit-I

Group homomoprhisms - Automorphisms - Isomorphisms - Fundamental theorems of group homomoprhisms - Cayley's Theorem.

Unit-II

Group actions - class equations - Sylow theorems - Direct Products - Fundamental Theorem of Finite Abelian groups.

Unit-III

Rings ideals - prime and maximal ideals - quotient rings - unique factorization domain - principal ideal domain - Euclidean domain.

Unit-IV

Polynomial rings and irreducibility criteria - Integral domains - Fields - Euclidean domains.

Suggested Reading

1. Wallace, D. A. R. (1998). *"Groups, Rings and Fields."* Springer (SUMS).
2. Artin, M. (2010). *"Algebra"*. PHI.
3. Gallian, G. A. (2013). *"Contemporary Abstract Algebra"*. Narosa Publishers.

References

1. Bhattacharya, P. B., Jain, S. K., & Nagpaul, S. R. (2003). *"Basic Abstract Algebra."* Cambridge University Press.
2. Singh, S., & Zameeruddin, Q. (1994). *"Modern Algebra."* Vikas Publishing House.
3. Jacobson, N. (2009). "*Basic Algebra-I*" (2^{nd} ed). Dover Publications.
4. Holt, D. F., Eick, B., & O'Brien, E. A. (2005). *"Handbook of Computational Group Theory."* Chapman & Hall/CRC Press.

Course Code**: MAT104** Core/ Elective**: Core** No. of Credits**: 3**	Course Title **Ordinary Differential Equations**

Course Objectives

- Develop a deep understanding of first-order and higher-order ordinary differential equations, including various types such as separable variables, homogeneous, non-homogeneous, linear, Bernoulli's equation, exact equation, etc.
- Explore methods for solving ordinary differential equations, including integrating factors, series solutions using power series, Legendre polynomials, Frobenius method, Bessel functions, etc.
- Apply differential equation techniques to model and solve real-world problems across various disciplines such as physics, engineering, biology, and economics.
- Enhance analytical and problem-solving skills through the application of mathematical techniques to solve differential equations.

Learning Outcomes

Upon successful completion of this course, students should be able to:

- Solve first-order ordinary differential equations using various methods such as separation of variables, integrating factors, and Bernoulli's equation.
- Solve higher-order ordinary differential equations, both homogeneous and non-homogeneous, using techniques like power series, Frobenius method, and Bessel functions.
- Understand and apply the concept of exact equations and integrating factors to solve differential equations.
- Utilize series solutions, including Legendre polynomials and Bessel functions, to solve differential equations with specific boundary conditions.
- Analyze and solve linear systems of ordinary differential equations with constant coefficients.
- Apply differential equation techniques to model real-world phenomena and interpret the solutions in the context of the given problems.

Course Outline

Unit-I

Definition and basic concepts: Existence and uniqueness of solutions - Separable variables Homogeneous and non-homogeneous equations - Linear equations- Bernoulli's equation - Exact equations and integrating factors.

Unit-II

Second and Higher Order Equations: Homogeneous and non-homogeneous linear equations Linear systems with constant coefficients - Series solutions using power series method Legendre Equation and Legendre polynomials - Frobenius method- Bessel's Equation and Bessel function

Unit - III

Sturm-Liouville Problem - Introduction to Sturm-Liouville problem - Orthogonal eigenfunction expansions - Properties and applications

Unit - IV

Applications and Case Studies: Application of ODEs in various fields such as physics - engineering, biology, and economics Case studies and examples showcasing real-world problems and their mathematical modeling using ODEs.

Unit - V

Zeros of solutions - Sturm comparison and separation theorems and oscillations. Asymptotic Behavior: stability (linearized stability and Lyapunov methods) - Boundary Value Problems for Second Order Equations - Green ‘s function,

Suggested Reading

1. Boyce, W. E., & DiPrima, R. C. (2012). “*Elementary Differential Equations and Boundary Value Problems”* (10th ed.). Hoboken, NJ: Wiley.
2. Tenenbaum, M., & Pollard, H. (1985). *“Ordinary Differential Equations”.* Mineola, NY: Dover Publications.

References

1. Ince, E.L. (1956). *“Ordinary Differential Equations.”* Dover Publications.
2. Simmons, G. F. (2007). “*Differential Equations with Applications and Historical Notes”*. New York, NY: McGraw-Hill Education.
3. Bender, C.M., & Orszag, S.A. (1999). *“Advanced Mathematical Methods for Scientists and Engineers”*. New York, NY: Springer.

Course Code: **MAT105** Core/ Elective: **Core** No. of Credits: **4**	Course Title **Computer Programming in Python**

Course Objectives

- Introduce the fundamental concepts of Python.
- Provide a foundation to use basic building blocks of Python.
- Learn to write Python Scripts.
- Explore various exception handling mechanisms.
- Develop Python packages.

Learning Outcomes

Upon completion of the course, students should be able to:

- Understand the fundamental concepts of Python.
- Use basic building blocks of Python.
- Write Python scripts.
- Explore and implement various exception handling mechanisms.
- Develop Python packages.

Course Outline

Unit-I

Python variables, basic Operators - Python Data Types - declaring and using Numeric data types - int, float, etc - Basic Input-Output Operations - Basic Operators.

Unit-II

Boolean Values - if, else, and else if Simple for loops in Python For loop using ranges String-list and dictionaries - While loops in Python Loop manipulation using pass - continue - break and else.

Unit-III

Assigning values in strings - String manipulations - String special operators - String formatting operators - Triple Quotes, Raw String, Unicode String - Build-in-String methods

Unit-IV

Lists Introduction - Accessing values in the list - List manipulations - List Operations Indexing, slicing & matrices - Use of tuple data type - Programming using string, list, and dictionary in-built functions.

Unit-V

Built - in Functions and methods - Functions, writing functions in Python - Returning a result from a function - Pass by ‘value & pass by reference - Function arguments & its types Recursive functions - Simple programs using the built-in functions of packages matplotlib, numpy, pandas, etc.

Suggested Reading

1. Mitchell, W., Solin, P., Novak, M., et al. (2012). *“Introduction to Python Programming”*. NC Lab Public Computing.
2. Fredslund, J. (2007). *“Introduction to Python Programming.”*

References

1. Lusth, J. C. (2011). *“An Introduction to Python”.* The University of Alabama.
2. Kuhlman, D. (2008). *“Introduction to Python.”*

SEMESTER-II

Course Code : **MAT201** Core/ Elective **: Core** No. of Credits **: 3**	Course Title **Linear Programming**

Course Objectives

- Gain a comprehensive understanding of the basic concepts of linear programming including problem formulation, graphical method, and matrix notation.
- Master the simplex method and its variants such as the two-phase simplex method, revised simplex method, and the Big M-technique for solving linear programming problems efficiently.
- Learn to formulate and solve balanced and unbalanced transportation problems and assignment problems, including recognizing and addressing issues like degeneracy.
- Develop skills in analyzing sequencing problems involving job allocation to machines, understanding critical paths, and differentiating between CPM and PERT methodologies.
- Acquire proficiency in sensitivity analysis to evaluate the impact of changes in parameters on the optimal solution, and explore optimization techniques to enhance decision-making processes in operational research scenarios.

Learning Outcomes

Upon completion of the course, students should be able to:

- Students will be able to accurately formulate linear programming problems and represent them graphically or in matrix notation, distinguishing between bounded, unbounded, and optimal solutions.
- By the end of the course, students will demonstrate proficiency in applying the simplex method, two-phase simplex method, and other related techniques to solve linear programming problems efficiently.
- Students will be able to apply mathematical formulations and solution algorithms to address balanced and unbalanced transportation problems, assignment problems, and identify and resolve issues like degeneracy.
- Upon completion of the course, students will exhibit critical thinking skills in analyzing sequencing problems, identifying critical paths, and understanding the implications of different scheduling strategies on project completion times.
- Graduates will demonstrate advanced analytical skills through sensitivity analysis, enabling them to assess the impact of changes in parameters on solution optimality, and make informed decisions to enhance operational efficiency in real-world scenarios.

Course Outline

Unit-I

The Linear programming problem. Problem formulation - Graphical Method - Definitions of bounded - unbounded and optimal solutions -Linear programming in matrix notation. Definitions of Basic - non-basic variables - basic solutions - slack variables - surplus variables and optimal solution, Simplex method of solution of a linear programming problem, Big M-technique.

Unit-II

Two phase simplex method - Degeneracy and Cycling - Revised Simplex Method - Duality Theory Formulation of Dual Problem - Duality theorems - Primal Dual Method and Dual Simplex Method -Sensitivity Analysis.

Unit-III

Balanced and unbalanced Transportation problems. Feasible solution- Basic feasible solution Optimums solution - degeneracy in a Transportation problem -Mathematical formulation North West Corner rule - Vogell's approximation method, Method of Matrix minima algorithm of Optimality test.

Unit-IV

Balanced and unbalanced assignment problems -restrictions on assignment problem - Mathematical formulation -formulation and solution of an assignment problem (Hungarian method) - degeneracy in an assignment problem.

Unit-V

Integer and Dynamic Programming, Sensitivity analysis

Suggested Reading

1. Swarup, K., Gupta, P. K., & Mohan, M. (2001). *"Operations Research*" (9th ed). Chennai: Sultan Chand & Sons.
2. Gauss, S. I. (1964). *"Linear Programming*" (2nd ed). New York, NY: McGraw-Hill Book Company.
3. Taha, H. A. (2017). *"Operations Research: An Introduction"* (9th ed). Pearson.

References

1. Ravindran, D. T., Phillips, J. J., & Solberg, J. J. (1987). *"Operations Research: Principles and Practice":* (2nd ed). John Wiley & Sons.
2. Hillier, F. S., & Lieberman, G. J. (2001). *"Introduction to Operations Research"* (8th ed). McGraw-Hill.

Course Code : **MAT202** Core/ Elective: **Core** No. of Credits: **3**	Course Title **Topology**

Course Objective

- To equip students with a deep understanding of metric spaces and their fundamental properties, enabling them to analyze and manipulate sets within these spaces effectively.
- To enable students to comprehend the concept of continuity in mappings between spaces and its significance in various mathematical contexts.
- To familiarize students with the foundational concepts of topological spaces and their role in understanding the structure and properties of sets.
- To provide students with a thorough understanding of compact spaces and their properties, preparing them to solve problems involving compactness and related theorems.
- To facilitate students in developing proficiency in recognizing and analyzing separation and connectedness properties of spaces, as well as applying approximation theorems in mathematical analysis and related disciplines.

Learning Outcome

Upon completion of the course, students should be able to:

- Demonstrate proficiency in analyzing and manipulating metric spaces, including identifying open and closed sets, understanding convergence, and applying Cantor's Intersection Theorem.
- Apply the concepts of continuity to mappings between spaces, including the characterization of continuous functions on Euclidean and unitary spaces, and understanding inequalities such as Cauchy's and Minkowski's.
- Utilize topological spaces to understand the structure and properties of sets, including defining open bases and subbases, and recognizing weak topologies.
- Develop a comprehensive understanding of compact spaces, product spaces, and their properties, including Tychnoff's theorem and Ascoli's theorem.
- Apply the concepts of separation and connectedness to spaces, including identifying T-spaces, Hausdorff spaces, and their properties, and understanding approximation theorems like Weierstrass' and Stone-Weierstrass'

Course Outline

Unit-I

Metric Spaces – Open sets – Closed sets – Convergence, Completeness – Cantor’s Intersection Theorem – Nowhere dense sets – Baire’s Category Theorem.

Unit-II

Continuous mappings – Spaces of continuous functions – Euclidean and Unitary spaces. Cauchy's - inequality – Minkowski's inequality Topological Spaces: Definition and examples Elementary Concepts – Open bases and Open subbases – Weal topologies - Function Algebra C(X, R) and C(X,C).

Unit-III

Compact spaces – Product spaces – Tychnoff's theorem and Locally Compact spaces Compactness for Metric spaces – Lebesgue Covering Lemma – Ascoli's theorem.

Unit-IV

Separation - T-spaces and Hausdroff spaces - Completely regular spaces and Normal spaces Urysohr's lemma and The Tietze's Extension theorem – Urysohr's Embedding theorem.

Unit-V

Connected spaces - Components of a space - Totally disconnected spaces - Locally connected spaces. Approximation - The Weirstrass approximation theorem - Real Stone-Weirstrass theorem - Complex Stone -Weirstrass theorem

Suggested Reading

1. Simmons, G. F. (1963). Chapter 2, 3, 4, 5, 6, Articles 3.4 & 3.6 of Chapter 3 of *"Introduction to Topology and Modern Analysis."* McGraw-Hill Book Company, Inc. International Standard Edition.
2. Munkres, J. R. (2018). *"Elements of Algebraic Topology."* CRC Press.

References

1. Willard, S. (1970). *"General Topology".* Addison-Wesley.

Course Code : **MAT203** Core/ Elective : **Core** No. of Credits : **3**	Course Title **Complex Analysis**

Course Objectives

- To lay the foundation for this subject, to develop clear thinking and analyzing capacity for further study.
- Cauchy's Theorem guaranteeing that certain integrals along closed paths are zero. This striking result leads to useful techniques for evaluating real integrals based on the 'calculus of residues'.
- Important results are the Mean Value Theorem, leading to the representation of some functions as power series (the Taylor series), and the Fundamental Theorem of Calculus which establishes the relationship between differentiation and integration.

Learning Outcomes

After completion of the course student should be able to:

- Analyze limits and continuity for complex functions as well as consequences of continuity.
- Applying the concept and consequences of analyticity and the Cauchy- Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra.
- Evaluating integrals along a path in the complex plane and understand the statement of Cauchy's Theorem
- Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Course Outline

Unit-I

Metric in complex plane. Stereographic projection. Fractional linear transformation.

Unit-II

Analytic functions Cauchy-Riemann equations, harmonic functions Elementary functions: Exponential function, Hyperbolic and trigonometric functions, Logarithms, Branch and branch cuts. Power series: Domain and Radius of convergence, Characterization of analyticity via power series.

Unit-III

Integration: Curves in the complex plane, Integral along piecewise smooth curves, Contour integration, Cauchy’s theorem, Cauchy’s integral formulas.

Unit-IV

Zeroes of analytic functions, Identity theorem, Maximum modulus theorem, Schwarz’s lemma and some applications, Isolated singularities, Laurent series.

Unit-V

Residues and Real Integrals: Residue theorem, Calculation of residues, Evaluation of improper integrals. Conformal Mapping.

Suggested Reading

1. Sarason, D. (2010). *"Complex Function Theory."* TRIM Series.
2. Conway, J. B. (1978). *"Functions of One Complex Variable"* (2nd ed.). Graduate Texts in Mathematics, 11. Springer-Verlag.
3. Shastri, A. R. (2010). *"Basic Complex Analysis of One Variable."* Department of Mathematics, Indian Institute of Technology, Bombay

References

1. Stein, E. M., & Shakarchi, R. (2003). *"Complex Analysis: Princeton Lectures in Analysis.''* Princeton University Press.
2. Ahlfors, L. V. (1966). "*Complex Analysis: An Introduction to the Theory of Analytic Functions of One Complex Variable*" (2nd ed.). McGraw-Hill Book Co.

Course Code : **MAT204** Core/ Elective : **Core** No. of Credits : **4**	Course Title **Probability and Statistics**

Course Objectives

- To provide an understanding of the basic concepts in probability, conditional probability and independent events.
- To focus on the random variable, mathematical expectation, and different types of distributions, sampling theory and estimation theory.
- To acquaint students with various statistical methods and their applications in different fields.
- To design a statistical hypothesis about the real world problem and also it is inevitable to have the knowledge of hypothesis testing for any research work.

Learning Outcomes

The students will be able to but not limited to:

- Apply key concepts of probability, including discrete and continuous random variables, probability distributions, conditioning, independence, expectations, and variances.
- Define and explain the different statistical distributions (e.g., Normal, Binomial, Poisson) and the typical phenomena that each distribution often describes.
- Define and demonstrate the concepts of estimation and properties of estimators.
- Apply the concepts of interval estimation, confidence intervals, hypothesis testing and p-value.

Course Outline

Unit-I

Basic Combinatorics - Classical and Axiomatic definitions of probability - Properties of Probability function. Conditional probability - Bayes Rule - Independence of Events and multiplication rule - Random Variables - Cumulative distribution function and its properties - Probability mass and Probability density functions – Expectation - moments and moment generating function. Distribution of a function of a random variable.

Unit-II

Independence of random variables - covariance and correlation - Functions of random variables and their distributions - Multinomial distributions. Bivariate normal distributions and their properties - Weak Law of large numbers - Central limit theorem and their applications.

Unit-III

Descriptive statistics - Graphical representation of the data - histogram and relative frequency histogram - measures of location, variability skewness and kurtosis - Population, sample parameters - Random sampling - sampling distributions of a statistic - t, F and χ^2 distributions and their interrelations.

Unit-IV

Point estimation method of moments maximum likelihood estimator – unbiasedness consistency - Large sample and exact confidence intervals for mean, proportions -Testing of hypotheses - Neyman Pearson fundamental lemma - Likelihood ratio tests for one sample and two sample problems for normal populations. P value. Chi-square test of goodness of fit.

Unit-V

Lab Component: Exposure to R Programming discussed in this course.

Suggested Reading

1. Ross, S. (2018). *"A First Course in Probability"* (10^{th} ed.). Pearson.
2. Gupta, S. C., & Kapoor, V. K. (2020). "*Fundamentals of Mathematical Statistics."* Sultan Chand & Sons.

References

1. Casella, G., & Berger, R. L. (2002). *"Statistical Inference. Thomson Learning,"* Duxbury, Wadsworth Group.

Course Code **: MAT211** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Number Theory**

Course Objective

- To prepare students typically revolves around understanding the fundamental properties and structures of integers and their relationships.
- Students often explore topics such as prime numbers, divisibility, congruences, Diophantine equations, and theorems like Fermat's Little Theorem and the Chinese Remainder Theorem.
- Mastering the principles and techniques of solving Diophantine equations, including Brahmagupta's equation (Pell's equation), Fermat's method of descent, and in-depth analysis of the Mordell equation, enabling students to tackle complex mathematical problems with confidence and precision.

Learning Outcome

After completion of the course student should be able to:

- Studying number theory equips you with a deep understanding of the properties and relationships of integers.
- Key outcomes include enhanced problem-solving skills, a grasp of advanced mathematical concepts, and the ability to analyze complex systems.
- It also lays the groundwork for further exploration in mathematics and related disciplines.

Course Outline

Unit-I

Infinitude of primes - discussion of the Prime Number Theorem - infinitude of primes in specific arithmetic progressions - Dirichlet's theorem (without proof) - Arithmetic functions, Mobius inversion formula.

Unit-II

Euler's phi function - Congruences theorems of Fermat and Euler - Wilson's theorem - linear congruences - quadratic residues - law of quadratic reciprocity.

Unit-III

Binary quadratics forms - equivalence - reduction - Fermat's two square theorem - Lagrange's four-square theorem - Ramanuja Roger identities.

Unit-IV

Continued fractions - rational approximations - Liouville's theorem - discussion of Roth's theorem - transcendental numbers - transcendence of "e" and "pi".

Unit -V

Diophantine equations: Brahmagupta's equation (also known as Pell's equation), The equation, Fermat's method of descent, discussion of the Mordell equation.

Suggested Reading

1. Adams, W. W., & Goldstein, L. J. (1972). "*Introduction to the Theory of Numbers"* (3rd ed). Wiley Eastern.
2. Baker, A. (1984). *"A Concise Introduction to the Theory of Numbers."* Cambridge University Press.

References

1. Niven, I., & Zuckerman, H. S. (1980). *"An Introduction to the Theory of Numbers"* (4th ed). Wiley.

Course Code : **MAT211** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Measure and Integration**

Course Objectives

- To gain understanding of the abstract measure theory, definition and main properties of the integral.
- To construct Lebesgue's measure on the real line and in n-dimensional Euclidean Space.
- To explain the basic advanced directions of the theory.

Learning Outcomes

After completion of the course student should be able to:

- Understand the basic concepts underlying the definition of the general Lebesgue integral.
- Prove basic results of measure and integration theory.
- Demonstrate understanding of the statement and proof of the fundamental integral convergence theorems, and their applications.

Course Outline

Unit-I

Review of Riemann Integral Lebesgue Measure - Lebesgue outer measure - Lebesgue measurable sets - Existence of non-Lebesgue measurable set - Measure on an arbitrary σ-algebra - Generated σ-algebra and Borel σ-algebra - Dirac delta measure - finite measure, probability measure and sigma-finite measure - Complete measure and completion.

Unit-II

Measurable Functions - Pointwise convergence and almost everywhere convergence-Egoroffs theorem - Convergence in measure.

Unit-III

Integral of measurable functions - Monotone convergence theorem - Fatou’s lemma, Measures induced by positive measurable functions - Radon-Nykodym theorem for σ-finite measures - Integral of real and complex valued measurable functions - Dominated convergence theorem - HÖlders and Minkowski’s inequalities - L^p-spaces and their completeness.

Unit-IV

Indefinite Integral of Integrable Functions - Indefinite integral of integrable functions, Functions of bounded variation - absolutely continuous functions - Fundamental theorem for Lebesgue integration.

Unit-V

Product measure space - Product σ-algebra and product measure - Fubini’s theorem; Convolution of integrable functions.

Suggested Reading

1. De Barra, G. (1981). *"Measure and Integration."* Wiley Eastern.
2. Thamban Nair, M. (2020). *"Measure and Integration: A First Course".* Taylor & Francis, CRC Press.

References

1. Royden, H. L. (1995). *"Real Analysis"* (3rd ed., Chapters 3, Sections 1-5). Prentice-Hall of India.
2. Rudin, W. (1987). *"Real and Complex Analysis*" (3rd ed., Chapters 1, 3). McGraw-Hill, International Editions.
3. Stein, E., & Shakarchi, R. (2005). "*Real Analysis: Measure Theory, Integration, and Hilbert Spaces"* (Chapters 1-3, 6). Princeton University Press.

Course Code **: MAT211** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Calculus of Variation and Integral Equations**

Course Objectives

- This Course introduces the basic concepts of Relationship between Linear Differential equations and Volterra Integral Equations.
- The Method of Successive approximations, Eulers Integrals Beta and Gamma Functions and their Elementary Properties, Green's Function, Euler's equation-special cases
- The problem of minimum, surface of revolution, Minimum energy problem-Brachistochrone problem. Variational problem, Application of Calculus of Variation-Hamilton's principle-Lagrange's equation- Hamilton's equations.

Course Outcomes

After completion of the course student should be able to:

- Conceptual Understanding of Relationship between Linear Differential equations and Volterra Integral Equations**,** and solutions by using resolvent kernels**.**
- Apply Laplace Transformation to get the solution of Integro-Differential Equations, Volterra Integral Equation of the First kind.
- Discuss Eulers Integrals, Abel's problem, Iterated Kernels.

Course Outline

Unit-I

Green's Function - Construction of Green's Function for Ordinary Differential Equations-Special Case of Green's Function Definition of Functionals - Strong and weak variations-Derivations of Euler's equation- other forms of Euler's equation-special cases- Examples-Fundamental lemma of calculus of variation.

Unit-II

The problem of minimum surface of revolution - Minimum energy problem Brachistochrone problem. Variational problem - Variational problems involving several functions Isoperimetric Problem-Variational problems in parametric form Euler Poisson equation-Application of Calculus of Variation-Hamilton's principle-Lagrange's equation- Hamilton's equations.

Unit-III

Basic Concepts - Relationship between Linear Differential equations and Volterra Integral Equations - Resolvent Kernel of Volterra Integral Equation - Determination of some Resolvent Kernels - Solution of Integral Equation by Resolvent Kernel - The Method of Successive approximations - Convolution type equations-Solution of Integro-Differential Equations with the aid of Laplace Transformation-Volterra Integral Equation of the First kind-VIE of First kind of the Convolution type.

Unit-IV

Eulers Integrals - Beta and Gamma Functions and their Elementary Properties -Relationship between Beta and Gamma Functions-Abel's problem - Abel's Integral Equation and its generalizations-Fredholm Integral Equations of Second kind. Fundamentals-Methods of Fredholm Determinants-Iterated Kernels -Constructing the Resolvent Kernels with the aid Iterated Kernels-Integral Equations with Degenerated Kernels-Hammerstein Type Equations Characteristic numbers and Eigen functions and its properties-Solution of Homogenous Equations with Degenerated Kernels.

Suggested Reading

1. Krasnov, M., Kiselev, A., & Mekarenko, G. (1971). *"Problems and Exercises in Integral Equations."* Visalaandhra Publishing House.
2. Elsgolts, L. (2003). *"Differential Equations and Calculus of Variations."* Mir Publishers.
3. Mesterton-Gibbons, M. (2009). "*A Primer on the Calculus of Variations and Optimal Control Theory"* (Vol. 50). American Mathematical Society.

References

1. Warup, S. (2008). "*Integral Equations*". Krishna Prakashan Media (P) Ltd.
2. Rahman, M. (2007). *"Integral Equations & Their Applications."* WIT Press.
3. Collins, P. J. (Year). "*Differential & Integral Equations."* Oxford University Press.
4. Kanwal, R. P. (Year). *"Linear Integral Equations: Theory & Techniques."* Academic Press.
5. Stone, M., & Goldbart, P. (Copyright 2002-2008). *"Mathematics for Physics".* Pimander-Casaubon.

Course Code **: MAT211** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Modules and Fields**

Course Objectives

- Develop a deep understanding of modules and fields, including their properties and applications.
- Explore various concepts related to modules over different algebraic structures.
- Investigate the properties and structures of fields, including extensions and applications.

Learning Outcomes

Upon completion of the course, students should be able to:

- Demonstrate a thorough understanding of module theory, including free modules, quotient modules, and isomorphism theorems. Analyze and prove properties of modules over principal ideal domains and apply them to solve problems.
- Understand and apply Noetherian and Artinian rings/modules, the Hilbert basis theorem, and the Jordan-Holder theorem. Comprehend the concepts of projective and injective modules and their significance in algebraic structures.
- Understand field extensions, algebraic and transcendental elements, and algebraic extensions. Analyze finite fields, cyclotomic fields, and the splitting field of polynomials.
- Explain the fundamental theorems of Galois theory, including the solvability by radicals and solutions of cubic and quartic polynomials. Apply geometric constructions in the context of field theory.

Course Outline

Unit-I

Review of basic concepts in algebraic structures - Modules, submodules, and quotient modules - Free modules, generating sets, and bases - Cartesian products and direct sums of modules

Unit-II

Simple and semi simple modules - Isomorphism theorems for modules - Modules over principal ideal domains and applications - Noetherian and Artinian rings/modules - Hilbert basis theorem and Jordan-Holder theorem

Unit-III

Definition and properties of projective modules - Characterizations of projective modules - Definition and properties of injective modules - Characterizations of injective modules

Unit-IV

Finite fields - field extensions - basic properties of degree of field extensions. Field extensions and algebraic elements - Algebraic and transcendental extensions - Finite fields and cyclotomic fields Splitting field of a polynomial - Algebraic closure of a field and its uniqueness

Unit-V

Normal – separable and purely inseparable extensions - Primitive elements and simple extensions - Fundamental theorem of Galois theory - Solvability by radicals Solutions of cubic and quartic polynomials - Insolvability of quintic and higher degree polynomials Geometric constructions and their applications.

Suggested Reading

1. Musili, C. (1994). *"Introduction to Rings and Modules."* Narosa Publishing House.
2. Dummit, D. S., & Foote, R. M. (2004). *"Abstract Algebra"* (3rd ed.). John Wiley & Sons Inc.
3. Herstein, I. N. (1991). *"Topics in Algebra."* John Wiley & Sons.

References

1. Lang, S. (2004). *"Algebra"* (3rd ed.). Springer-Verlag (India).
2. Jacobson, N. (1991). "*Basic Algebra II"*. Hindustan Publishing Corporation.

Course Code: **MAT213** Core/ Elective: **(CCC-I)** No. of Credits: **4**	Course Title **Introduction to Artificial Intelligence and Machine Learning**

Course Objectives

- To familiarize students with the fundamental concepts, theories, and applications of artificial intelligence. Students will gain insight into the various subfields of AI, such as machine learning, natural language processing, computer vision, and robotics.
- To introduce students to the basics of Python programming, enabling them to write code, solve problems, and understand programming constructs. This objective emphasizes building a programming foundation as a prerequisite for implementing AI algorithms.

Learning Outcomes

After completion of the course, students will be able to:

- Students will have a clear understanding of the fundamental concepts and terminology of Artificial Intelligence, enabling them to discuss and comprehend AI-related topics.
- Students will be proficient in writing Python programs, understanding syntax, and applying programming constructs. This skill set will serve as a solid foundation for further programming endeavors.

Course Outline

Unit-I

Definition - Future of Artificial Intelligence - Characteristic of Intelligent Agents - Typical Intelligent Agents - Problem Solving Approach to Typical AI problems. Problem solving by Searching - Uninformed and informed strategies and implementation - Path planning-Constraint Satisfaction Problems (CSP).

Unit- II

Logical Agents - Propositional and first order Predicate logic – inference - Knowledge representation and Automated Planning - Uncertain Knowledge and Reasoning - Quantifying uncertainty - probabilistic reasoning

Unit- III

Machine learning basics - Learning from examples - forms of learning (supervised, unsupervised, reinforcement learning) - simple models (linear & logistic regression) - Deep Learning AI applications: Natural Language Processing - Language Models - Machine Translation; Speech Recognition; Computer Vision - Image classification.

Unit- IV

Introduction -The Python Programming Language, History, features, Installing Python, Running Python program, Debugging: Syntax Errors, Runtime Errors, Semantic Errors - Experimental Debugging, Formal and Natural Languages, The Difference between Brackets, Braces, and Parentheses. Values and Types - Variables, Variable & Keywords Type conversion - Operator and Operands - Expressions - Interactive - Mode and script Mode, Order of Operations. if, if- else, nested if - else - for, while, nested-loops. Terminating loops, skipping specific conditions.

Unit-V

Function Calls - Type Conversion Functions - Math Functions - Adding New Functions, Definitions and Uses - Flow of Execution, Parameters and Arguments - Variables and Parameters. Strings - String Slices - Strings are immutable and Searching – Looping and counting String methods - the in operator - String Comparison - String operations Values and Accessing Elements, Lists are mutable, traversing a List, Deleting elements from List Built-in List Operators, Concatenation, In Operator, Built-in List functions and methods.

Suggested Reading

1. Russell, S., & Norvig, P. (2022). *"Artificial Intelligence: A Modern Approach"* (4th ed.). Prentice Hall.
2. Jones, M. T. (2008). *"Artificial Intelligence: A Systems Approach"* (Computer Science) (1st ed.). Jones and Bartlett Publishers, Inc.
3. Meier, B. A. (2017). *"Python GUI Programming Cookbook"* (2nd ed.). Packt Publishing.

References

1. Goel, L. (2021). *"Artificial Intelligence: Concept and Applications".* Wiley.
2. Nilsson, N. J. (2009). "*The Quest for Artificial Intelligence."* Cambridge University Press.
3. Barry, P. (2016). *"Head First Python: A Brain-Friendly Guide."* O'Reilly Media,
4. Inc. Lutz, M. (2013). "*Learning Python: Powerful Object-Oriented Programming."* O'Reilly Media, Inc.

SEMESTER-III

Course Code : **MAT301** Core/ Elective **: Core** No. of Credits **: 3**	Course Title **Functional Analysis**

Course Objective

- To prepare students to handle Functional Analysis, Fourier series and their convergence, Laplace and Fourier transforms Wavelets analysis and Continuous probability theory.
- Students will acquire the ability to apply mathematical techniques such as Holder's inequality, Minkowski's inequality, Schwarz's inequality, and the Gram-Schmidt orthogonalization process to analyze and solve problems in normed linear spaces and Hilbert spaces.
- By studying concepts like adjoint operators, self-adjoint operators, positive operators, and unitary operators, students will develop proficiency in operator theory, enabling them to analyze properties and behaviors of operators on Banach and Hilbert spaces.

Learning Outcome

After completion of the course student should be able to:

- Take courses in advanced functional analysis, partial differential equations etc.
- Study abstract measure theory and probability theory.
- Gain a comprehensive understanding of operator theory, including the properties of adjoint operators, self-adjoint operators, positive operators, and unitary operators, and their significance in functional analysis and applications in various fields such as quantum mechanics and signal processing

Course Outline

Unit-I

Normed linear spaces - Banach Spaces - Quotient Spaces - Convexity of the closed unit sphere of a Banach Space - Examples of normed linear spaces which are not Banach. Holder's inequality - Minkowski's inequality - Linear transformations on a normed linear space and characterization of continuity of such transformations.

Unit-II

Hahn -Banach theorem and its consequences - Projections on a Banach Space - The open mapping theorem and the closed graph theorem - The uniform boundedness theorem - The conjugate of an operator - properties of conjugate operator.

Unit-III

Inner product spaces - Hilbert Spaces - Definition and Examples - Schwarz's inequality. Parallelogram Law - polarization identity - Convex sets, a closed convex subset of a Hilbert Space contains a unique vector of the smallest norm. Orthogonal sets in a Hilbert space. Bessel's inequality - orthogonal complements - complete orthonormal sets - Orthogonal

decomposition of a Hilbert space. Characterization of complete orthonormal set.
Gram-Schmidt orthogonalization process.

Unit-IV

The conjugate space H* of a Hilbert space H - Representation of a functional f as f(x) = (x, y) with y unique - The Hilbert space H*. Interpretation of T* as an operator on H - The adjoint operator T* on B (H) - Self-adjoint operators Positive operators. Normal operators - Unitary operators and their properties.

Unit-V

Projections on a Hilbert space- Invariant subspace. Orthogonality of projections - Eigen values and eigen space of an operator on a Hilbert Space - Spectrum of an operator on a finite dimensional Hilbert Space - Finite dimensional spectral theorem.

Suggested Reading

1. Simmons, G. F. (1998). "*Introduction to Topology and Modern Analysis.*" McGraw-Hill.
2. Limaye, B. V. (1996). "*Functional Analysis*" (2nd ed.). New Age International.

References

1. Bachmann, G., & Naricii, L. (1996). *"Functional Analysis."* Academic Press.
2. Bollabas, B. (1999). *"Linear Analysis (Indian edition)".* Cambridge University Press.
3. Taylor, A. E., & Lay, D. C. (1980). *"Introduction to Functional Analysis"* (2nd ed.). Wiley.
4. Conway, J. B. (1997). *"A Course in Functional Analysis"* (2nd ed.). Springer.
5. Simon, B. (2015). "*Real Analysis with a 68-Page Companion Booklet: A Comprehensive Course in Analysis, Part 1".* American Mathematical Society.

Course Code **: MAT302** Core/ Elective **: Core** No. of Credits **: 3**	Course Title **Partial Differential Equations**

Course Objective

- To develops the ability to solve partial differential equations of first and second order by standard methods.
- To prepare students to solve problems arising from many applications such as mathematical models of physical or engineering processes.

Learning Outcome

After completion of the course student should be able to:

- Solve partial differential equations of first and second order.
- Model initial and boundary value problems.
- Understand the Heat and Wave equations and its properties.

Course Outline

Unit-I

First Order Partial Differential Equations Basic definitions - Origin of PDEs - Classification Geometrical interpretation - The Cauchy problem - the method of characteristics for Semi linear - quasi linear and Non-linear equations - complete integrals - Examples of equations to analytical dynamics - discontinuous solution and shockwaves.

Unit-II

Second Order Partial Differential Equations Definitions of Linear and Non - Linear equations, Linear Superposition principle - Classification of second-order linear partial differential equations into hyperbolic - parabolic and elliptic PDEs - Reduction to canonical forms solution of linear Homogeneous and non-homogeneous with constant coefficients - Variable coefficients, Monge's method.

Unit-III

Diffusion equation: Fundamental solution by the method of variables - integral transforms Duhamel's principle - Solution of the equation in cylindrical and spherical polar coordinates.

Unit-IV

Wave equation: Solution by the method of separation of variables - integral transforms The Cauchy problem - Wave equation in cylindrical - spherical polar co-ordinates.

Unit-V

Laplace equation: Solution by the method of separation of variables - transforms. Dirichlet's, Neumann's - Churchills problems, Dirichlet's problem for a rectangle - half plane and circle - Solution of Laplace equation in cylindrical - spherical polar coordinates. Solution of boundary value problems: - Green's function method for Hyperbolic- Parabolic and Elliptic equations.

Suggested Reading

1. Sneddon, I. N. (2006). *“Elements of PDE's”.* McGraw-Hill Book Company Inc.
2. Debnath, L. (2007). *“Nonlinear PDE's for Scientists and Engineers.”* Birkhäuser, Boston.
3. John, F. (1971). *“Partial Differential Equations.”* Springer.

References

1. Sneddon, I. N. (2006). *“Elements of Partial Differential Equations”.* Dover Publications.
2. John, F. (1979). *“Partial Differential Equations”* (3rd ed.). Narosa Publications.
3. Nandakumaran, K., & Datti, P. S. (2020). “*Partial Differential Equations: Classical Theory with a Modern Touch”*. Cambridge University Press.
4. Zauderer, E. (1989). *“Partial Differential Equations of Applied Mathematics”* (2nd ed.). John Wiley & Sons.
5. Evans, L. C. (1998). “*Partial Differential Equations (Graduate Studies in Mathematics, Vol. 19)”.* American Mathematical Society.

Course Code : **MAT303** Core/ Elective : **Core** No. of Credits : **4**	Course Title **Numerical Analysis and Scientific Computing**

Course Objectives

- To know about various types of Errors, Calculate the error correction and get actual root of the equation.
- To understand different methods of solution of the equations and compare them.
- To get the detailed knowledge about different numerical methods which are used in engineering field, with emphasis on how to prepare program for different methods.

Learning Outcome

After completion of the course student should be able to

- Use numerical methods in modern scientific computing.
- Be familiar with finite precision computing, numerical solutions of nonlinear equations in a single variable, numerical interpolation and approximation of functions, numerical integration and differentiation etc.
- Be familiar with programming with numerical packages like MATLAB.

Course Outline

Unit-I

Principle of Scientific Computing: Errors: Floating-point approximation of a number - Loss of significance and error propagation - Stability in numerical computation.

Unit-II

Linear Systems: Gaussian elimination with pivoting strategy - LU factorization - Residual corrector method - Solution by iteration (Jacobi and Gauss -Seidal with convergence analysis) - Matrix norms - error in approximate solution - Eigen value problem (Power method)

Unit-III

Nonlinear Equations: Bisection method - Fixed-point iteration method - Secant method, Newton's method - Rate of convergences - Solution of a system of nonlinear equations, Unconstrained optimization - Interpolation by Polynomials: Lagrange interpolation - Newton interpolation and divided differences - Error of the interpolating polynomials.

Unit-IV

Data fitting and least-squares approximation problem - Differentiation and Integration: Difference formulae - Some basic rules of integration - Gaussian rules - Composite rules Error formulas - Differential Equations: Euler method - Runge-Kutta methods- Multi -step methods, Predictor-Corrector methods Stability and convergence - Two-point boundary value problems.

Unit-V

Lab Component: Exposure to Python and implementation of Algorithms discussed in this course.

Suggested Reading

1. Atkinson, K. E. (1989). *"An Introduction to Numerical Analysis"* (2^{nd} ed.). Wiley-India.
2. Conte, S. D., & de Boor, C. (1981). *"Elementary Numerical Analysis – An Algorithmic Approach"* (3^{rd} ed.). McGraw-Hill.
3. Jain, M. K., Satteluri, R. K. Iyengar, & Jain, R. K. (2007). *"Numerical Methods: Problems and Solutions."* New Age International.

References

1. Chapra, S. C. (2017). *"Applied Numerical Methods with MATLAB for Engineers and Scientists."* McGraw-Hill Science Engineering.
2. Burden, R. L., & Faires, J. D. (2001). *"Numerical Analysis (7^{th} ed.)."* Thomson.
3. Gupta, R. S. (2009). *"Elements of Numerical Analysis".* Macmillan India Ltd.

Course Code : **MAT304** Core/ Elective **: Core** No. of Credits **: 3**	Course Title **Fluid Mechanics**

Course Objectives

- Covering Legendre transformations, Hamiltonian equations of motion, conservation theorems, and the Hamiltonian formulation of relativistic mechanics, students will grasp fundamental principles of classical mechanics.
- Introduce students to mathematical tools such as variational principles and the principle of least action for deriving Hamiltonian equations, enabling them to apply these tools in analyzing mechanical systems.
- Provide a comprehensive understanding of fluid dynamics, including kinematics, equations of motion, circulation concepts, irrotational flow, and viscous flows, to equip students with the knowledge necessary for analyzing fluid behavior.

Learning Outcome

After completion of the course student should be able to:

- Students will be able to comprehend and apply Legendre transformations, Hamiltonian equations of motion, cyclic coordinates, and conservation theorems to analyze mechanical systems using Hamiltonian mechanics.
- By deriving Hamiltonian equations from variational principles and understanding the principle of least action, students will gain proficiency in applying mathematical principles to derive equations of motion in classical mechanics.
- Students will acquire a thorough understanding of fluid motion description methods, including Lagrangian and Eulerian approaches, and be able to apply these concepts to analyze fluid behavior in one, two, and three-dimensional flows.
- Upon completion of the course, students will be adept in applying circulation theorems, understanding irrotational flow, and solving problems related to circulation and velocity potential in fluid dynamics.

Course Outline

Unit-I

Legendre transformations and the Hamilton equations of motion - Cyclic coordinates and Conservation theorems - Routhe’s Procedure and oscillations about steady motion - The Hamiltonian formulations of Relativistic Mechanics - Derivation of Hamiltonian equation from variational principles - The principle of Least action.

Unit-II

The equation of canonical transformations - Examples of canonical transformations - The simplistic approach to canonical transformations - Prisson Brackets and other canonical invariants.

Unit-III

Kinematics of the fluids: Method of describing fluid motion - Lagrangian method - Eulerian deformation - Stream lines - Path lines and Streak lines - The Material derivative and acceleration Vorticity in Polar coordinates - Vorticity in orthogonal Curvilinear Coordinates. One dimensional inviscid incompressible flow: Equation of Continuity - Stream tube flow Equations of Motion - Euler's equation - Bernoulli's equation - Applications of Bernoulli's equation.

Unit-IV

Two- and three-dimensional incompressible flow: Basic equations and concepts of flow Equation of Continuity – Eulerian equation of motion - Circulation theorem - Circulation concepts - Stroke's theorem - Kelvin's theorem - Constancy of Circulation - Velocity potential - Irrotational flow - The moment theorem - The moment of momentum theorem Simple flows - Laplace's equation - Laplace equation in Cartesian Coordinates - Boundary Conditions.

Unit-V

The Complex potential for 2-D - irrotational incompressible flow - Complex Velocity potentials for standard 2-D flows - Milne-Thomson Circle theorem - The Blasius theorem viscous flows - Stress - Rate of Strain - Relation between stress and rate of strain Navier Stoke's Equations - Some solvable problems in viscous flows - Steady motion between parallel planes - Poisuille flow - Viscous flow between Concentric rotational Cylinders Karman integral theorem.

Suggested Reading

1. White, F. M., Ng, C. O., & Saimek, S. (2011). *"Fluid Mechanics."* McGraw-Hill.
2. Yuan, S. W. (1976). *"Foundations of Fluid Mechanics."* Prentice Hall.
3. Yih, C. S. (1969). *"Fluid Mechanics."* McGraw-Hill.

References

1. Goldstein, H. (2018). *"Classical Mechanics"* (2nd ed.). Narosa Publishing House. (Chapter 8, Articles 9.1, 9.2, 9.4, and 9.5)
2. Chorlton, F. (1985). *"Fluid Dynamics. CBS Publishers & Distributors"*, New Delhi. (Chapter 2, Articles 3.1–3.5 of Chapter 3, Articles 4.2, 4.5 of Chapter 4, Articles 5.3, 5.11 of Chapter 5, Articles 8.1–8.7, 8.9, 8.10–8.16)

Course Code : **MAT305** Core/ Elective **: core** No. of Credits **: 4**	Course Title **Mathematical Foundations for Computer Science**

Course Objectives

- To provide students with an overview of discrete mathematics.
- To learn about the topics such as logic and proofs, sets and functions, and the probability.
- To work with sets, relations for solving applied problems and investigate their properties.
- To introduce basic concepts of graphs, digraphs and trees.

Learning Outcomes

After completion of the course student should be able to:

- Analyze logical propositions via truth tables.
- Prove mathematical theorems using mathematical induction.
- Understand the statistics as a science of decision making in the real life problems with the description of uncertainty.

Course Outline

Unit-I

Sets and propositions: Combinations of sets - Finite and Infinite sets - uncountable infiniteSets - principle of inclusion and exclusion and applications - mathematical induction. Propositions - fundamentals of logic - first order logic - ordered sets. Counting: Basics of counting, Pigeonhole principle -Permutations and combinations – Pascal’s Identity - Ramsey Theory and applications

Unit-II

Generating functions: coefficients of generating functions – applications of generating functions. Recurrence relations: Solving Recurrence Relations- Linear Homogeneous and Non-Homogeneous Recurrence relations - solution by the method of generating functions, sorting algorithm.

Unit-III

Relations and functions: properties of binary relations - equivalence relations and partitions, partial and total ordering relations - Transitive closure and Warshal’s algorithm. Chains, Lattices and algebraic systems - principle of duality - basic properties of algebraic systems, distributive and complemented lattices - lattices.

Unit-IV

Graph Theory: Basic terminology - multigraphs and weighted graphs - paths and circuits, shortest paths in weighted graphs - Connectivity, Menger’s Theorem - Eulerian paths and circuits, Hamiltonian paths and circuits,shortest-Path Problems.

Unit-V

Planarity-Trees and cut-sets, rooted trees, path lengths in rooted trees - spanning trees and minimum spanning trees -Prims & Kruskal’s algorithms.

Suggested Reading

1. Mott, J. L., Kandel, A., & Baker, T. P. (2006). "*Discrete Mathematics for Computer Scientists.*" PHI.
2. Liu, C. L. (1985). *"Elements of Discrete Mathematics."* McGraw Hill.

References

1. Liu, C. L. (2008). *"Elements of Discrete Mathematics."* Tata McGraw-Hill Education Pvt. Ltd.
2. Cameron, P. (1994). "*Combinatorics Topics, Techniques, Algorithms.*" Cambridge University Press.
3. Matousek, J., & Nesetril, J. (1998). *"Invitation to Discrete Mathematics."* Oxford University Press.
4. van Lint, J. H., & Wilson, R. M. (2001). *"Combinatorics (2nd ed.)."* Cambridge University Press.
5. Aigner, M., & Ziegler, G. M. (2014). *"Proofs from the Book"* (5th ed.). Springer

Course Code **: MAT311** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Statistical Inference**

Course Objectives

- Develop a comprehensive understanding of fundamental statistical concepts, distributions, and inference methods.
- Acquire proficiency in estimation techniques, hypothesis testing procedures, and interpretation of statistical results.
- Gain practical skills in conducting various statistical tests and constructing confidence intervals for population parameters.
- Explore the application of both parametric and non-parametric statistical methods in real-world scenarios.
- Foster critical thinking and problem-solving abilities through hands-on statistical analysis and interpretation of results.

Learning Outcomes

After completion of the course student should be able to:

- Proficient in distinguishing between population and sample, interpreting parameters and statistics, and applying sampling distributions for statistical inference.
- Ability to evaluate estimators for unbiasedness, consistency, and efficiency, and apply estimation techniques like method of moments and maximum likelihood estimation effectively.
- Competent in interpreting hypothesis testing concepts, calculating significance levels and power of statistical tests, and understanding null and alternative hypotheses, critical regions, and types of errors.
- Skilled in conducting large sample tests for means and proportions, interpreting confidence intervals, applying small sample tests like t-tests and $\chi 2$-tests for hypothesis testing, and appropriately using non-parametric tests such as the runs test, sign test, and Wilcoxon-signed rank test for various statistical analyses.

Course outline

Unit-I

Population – Sample – Parameter – statistic - Sampling distribution - Standard error. convergence in probability and convergence in distribution - law of large numbers - central limit theorem (statements only). Student's t- distribution, F – Distribution, χ^2-Distribution: Definitions, properties and their applications.

Unit-II

Theory of estimation: Estimation of a parameter - criteria of a good estimator – unbiasedness consistency, efficiency, &sufficiency - Statement of Neyman's factorization theorem. Estimation of parameters by the method of moments - maximum likelihood (M.L), properties of MLE's. Binomial, Poisson &Normal Population parameters estimate by MLE method. Confidence Intervals.

Unit-III

Testing of Hypothesis**:** Concepts of statistical hypotheses - null and alternative hypothesis, critical region - two types of errors - level of significance and power of a test. One and two tailed tests - Neyman-Pearson's lemma. Examples in case of Binomial Poisson - Exponential and Normal distributions.

Unit- IV

Large sample Tests: large sample test for single mean - difference of two means - confidence intervals for mean(s). Large sample test for single proportion - difference of proportions. standard deviation(s) - correlation coefficient(s**).** Small Sample tests: t-test for single mean, difference of means and paired - test. χ^2 – test for goodness of fit and independence of attributes. F-test for equality of variances.

Unit- V

Non-parametric tests- their advantages - disadvantages - comparison with parametric tests. Measurement scale- nominal - ordinal - interval and ratio. One sample runs test - sign test and Wilcoxon-signed rank tests (single and paired samples). Two independent sample tests: Median test - Wilcoxon –Mann-Whitney U test, Wald Wolfowitz's runs test.

Suggested Reading

1. BA/BSc II year statistics – "*Statistical methods and inference*" - Telugu Academy by A. Mohanrao, N.Srinivasa Rao, Dr Sudhakar Reddy, Dr T.C. RavichandraKumar.
2. K.V.S. Sarma: "*Statistics Made Simple: Do it yourself"* on PC.PHI.

References

1. *"Fundamentals Of Mathematical Statistics"* Paperback S.C.Gupta & V.K. Kapoor (Paperback, S.C Gupta, V.K. Kapoor) (Paperback, S.C Gupta)
2. *"Outlines of statistics"* Vol II: Goon Guptha, M.K.Guptha, Das GupthaB.
3. *"Introduction to Mathematical Statistics"*: Hoel P.G.
4. Hogg Tanis Rao: "*Probability and Statistical Inference*". 7th edition. Pearson.

Course Code **: MAT311** Core/ Elective **: Elective** No. of Credits **: 3**	Course Title **Optimization Techniques**

Course Objectives

- Understand various optimization techniques and applications in engineering.
- Analyze characteristics of general linear programming problems.
- Apply mathematical concepts to formulate optimization problems.
- Explore methods for solving unconstrained minimization problems.
- Appreciate a variety of performance measures for optimization problems.

Learning Outcomes

Upon completion of the course, students should be able to:

- Apply optimization techniques in engineering problems.
- Analyze and compare different methods for solving optimization problems.
- Implement optimization algorithms through programming.
- Understand the importance of optimization in various engineering applications.

Course Outline

Unit-I

Introduction to Optimization - Importance of optimization - Classical Methods and Linear programming Problems - Design Variables, Constraints, Objective Function, Problem Formulation - Calculus method, Kuhn-Tucker conditions, Method of Multipliers.

Unit-II

Sequencing problem - n jobs through 2 machines - n jobs through 3 machines - two jobs through m machines - n jobs through m machines. Definition of network, event, activity, critical path, total float and free float – difference between CPM and PERT - Problems.

Unit-III

Single Variable Optimization Problems - Optimality Criterion - Bracketing Methods, Region Elimination Methods, Interval Halving - Gradient-Based Methods: Newton-Raphson, Bisection, Secant, Cubic search.

Unit-IV

Multivariable and Constrained Optimization - Multi-variable and Constrained Optimization Techniques - Direct Search Methods, Simplex Search Methods - Gradient-Based Methods: Steepest Descent, Newton's Method, Conjugate Gradient - Kuhn-Tucker conditions, Penalty Function, Lagrangian Multiplier.

Unit-V

Inventory control and Queuing Theory

Suggested Reading

1. K. Swarup, P.K. Gupta, Man Mohan (2001.) *"Operations Research,"* Ninth edition, Sultan Chand & Sons, Chennai.
2. S.I. Gauss, (1964.) "*Linear Programming,"* Second Edition, McGraw-Hill Book Company, New York.
3. Hamdy A Taha (2017) "*Operations Research-An Introduction*", 9th Ed, Pearson (Chs 1-8, 12, 14, 17).

References

1. S. S. Rao (2008.) *"Engineering Optimization: Theory and Practice,"* Wiley.
2. K. Deb, (2012.) *"Optimization for Engineering Design: Algorithms and Examples,"* Prentice Hall, 2nd edition.
3. C.J. Ray, (2007) *"Optimum Design of Mechanical Elements,"* Wiley.
4. R. Saravanan (2006) "*Manufacturing Optimization through Intelligent Techniques,"* Taylor & Francis,
5. D. E. Goldberg (1989) *"Genetic Algorithms in Search, Optimization, and Machine Learning,"* Addison-Wesley.

Course Code : **MAT311** Core/ Elective: **Elective** No. of Credits: **3**	Course Title **Numerical Linear Algebra**

Course Objectives

- Master basic and advanced matrix operations and apply matrix operations to solve diverse problems.
- Understand key concepts like determinants, ranks, and vector spaces and apply concepts to analyze linear systems effectively.
- Learn numerical representation and mitigate errors in computations and analyze stability and convergence in numerical algorithms.
- Study matrix norms and convergence properties and perform sensitivity analysis and assess stability.
- Apply advanced decomposition methods for problem-solving and utilize techniques like SVD and QR factorization effectively.

Learning Outcomes

Upon completion of the course, students should be able to:

- Perform matrix operations accurately and efficiently.
- Grasp fundamental concepts and their applications in linear systems.
- Understand numerical representation and mitigate errors effectively.
- Analyze matrix norms, convergence, and stability confidently.

Course Outline

Unit-I

Existence and uniqueness of least squares solutions - "Pseudoinverse and the least square problem" - sensitivity of the least square problem - Computational Methods for over determined Problems - Computing selected eigenvalues and eigenvectors - Jacobi Gauss-Seidel and SOR (Successive Overrelaxation) methods.

Unit -II

Signed integer representation Computer representation of numbers Floating point representation Round-off error - Error propagation in computer arithmetic, Addition and multiplication of floating-point numbers - Conditioning and condition numbers-I Conditioning and condition numbers-II, Stability of numerical algorithms-I, Stability of numerical algorithms-II, Vector norms - I, Vector norms – II.

Unit-III

Matrix Norms - I, Matrix Norms-II, Convergent Matrices - I, Convergent Matrices - II, Stability of non-linear system Condition number of a matrix: Elementary properties, Sensitivity analysis-I, Sensitivity analysis-II, Residual theorem - Nearness to singularity

Unit-IV

Estimation of the condition number - Singular value decomposition of a matrix - I, Singular value decomposition of a matrix - II - Orthogonal Projections - Algebraic - geometric properties of matrices using SVD - SVD and their applications - Perturbation theorem for singular values - Outer product expansion of a matrix - Least square solutions-I - Least square solutions-II.

Unit -V

Pseudo - inverse and least square solution - Householder matrices and their applications, Householder QR factorization - I - Householder QR factorization - II - Basic theorems on eigenvalues - QR method Power method - Rate of convergence of Power method, Applications of Power method with shift - Jacobi method-I - Jacobi method-II.

Suggested Reading

1. V. Sundara Pandian (2008). *"Numerical Linear Algebra,"* PHI.
2. Biswa Nath Dutta (2010). "*Numerical Linear Algebra and Applications,"* SIAM.

References

1. Roger A. Horn and Charles R. Johnson (1994) "*Matrix Analysis"* Cambridge University Press.
2. William Ford (2014.) *"Numerical Linear Algebra with Applications",* Academic Press.

SEMESTER - IV

Course Code **: MAT401** Core/ Elective **: Core** No. of Credits **: 3**	Course Title **Numerical Solutions for Differential Equations**

Course Objectives

- To understand the fundamental concepts of differential equations and their numerical solutions and various numerical methods for solving ordinary and partial differential equations.
- To develop proficiency in implementing numerical algorithms using computational tools and analyze the accuracy, stability, and convergence of numerical methods.
- To apply numerical techniques to solve practical problems from engineering and scientific domains.

Learning Outcomes

Upon completion of the course, students should be able to:

- Demonstrate understanding of different types of differential equations and their applications in modeling real-world phenomena.
- Evaluate the accuracy, stability, and convergence of numerical methods and select the most suitable method for a given problem.
- Utilize computational tools and programming languages to implement numerical algorithms for solving differential equations and analyze and interpret numerical results obtained from computational simulations, identifying trends and patterns.
- Apply numerical techniques to solve practical problems from engineering, physics, and other scientific domains, demonstrating the ability to translate real-world problems into mathematical models and computational solutions.

Course Outline

Unit-I

Introduction to Differential Equations: Definition and classification of differential equations. Initial value problems (IVPs) and boundary value problems (BVPs) - Analytical versus numerical solutions.

Unit-II

Numerical Methods for Initial Value Problems (IVPs): Euler's method and its extensions (improved Euler, Runge-Kutta methods) - Multistep methods (Adams-Bashforth, Adams-Moulton methods) - Stability and convergence analysis.

Unit-III

Numerical Methods for Boundary Value Problems (BVPs) - Finite difference methods for BVPs - Shooting method and finite element method - Application of boundary conditions.

Unit-IV

Partial Differential Equations (PDEs) - Classification of PDEs (elliptic, parabolic, hyperbolic). - Finite difference methods for solving PDEs. - Explicit and implicit methods for time-dependent problems.

Unit-V

Advanced Techniques for PDEs: Finite element method for PDEs - Spectral methods and collocation methods - Stability and convergence analysis of numerical PDE solvers.

Suggested Reading

1. Butcher, J. C. (2016). *Numerical methods for ordinary differential equations*. John Wiley & Sons.
2. Jain, Mahinder Kumar. (2003) "*Numerical methods for scientific and engineering computation"*. New Age International.
3. Smith, G. D. (1985). *Numerical solution of partial differential equations: finite difference methods*. Oxford university press.
4. *"*Reddy, J. N. (1993). An introduction to the finite element method. *New York*, *27*, 14.

References

1. Press, W. H. (1989). "*Numerical recipes in Pascal: the art of scientific computing"* (Vol. 1). Cambridge university press.
2. LeVeque, R. J. (2007). "*Finite difference methods for ordinary and partial differential equations: steady-state and time-dependent problems*." Society for Industrial and Applied Mathematics.
3. Farlow, S. J. (1993). "*Partial differential equations for scientists and engineers*." Courier Corporation.