**VIJAYANAGARASRIKRISHNADEVARAYAUNIVERSITY**
**JNANA SAGARA CAMPUS, BALLARI-583105**

# Department of Studies in Mathematics

# SYLLABUS

Master of Science
(I-IV Semester)

With effect from the Academic Year 2024-25 onwards

Approved in BOS dated on …..../…../…..

**VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY, JNANASAGARA CAMPUS, BALLARI-583105**

**Department of Studies in Mathematics**

**Programme:** Master of Science in Mathematics

**Duration:** 2 Years (4 semesters)

**Programme Overview:**

M.Sc. Mathematics is a post graduate program where, candidates get a deeper knowledge of advanced mathematics through a vast preference of subjects such as geometry calculus, algebra, etc. the studentsbecome more skilled and specialized in a particular subject after the master degree program. Students learn about the problem-solving skills and reasoning skills which helps them to solve real-life problems. In this program, students learn to collect big data and analyze them with the help of differenttools and methods.

**Programme Educational Objectives (PEOs):**

After 3-4 years of completion of the programme:

1. Students are equipped with knowledge, skills and insight in Mathematics and related fields.
2. Students are able to work as a mathematical professional or as a scientific researcher.
3. Students develop the ability to utilize the mathematical problem-solving methods such as analysis, modeling, programming and mathematical software applications in addressing the practical issues.
4. Students are able to recognize the need for and to develop the ability to engage in life-long learning.

**Programme Outcomes (POs):**

At the end of the programme the students will be able to:

1. Acquire in depth knowledge of topics in the area of mathematical sciences, such as mathematical analysis, algebra, numerical methods, Differential equations and Mathematical methods etc.
2. Evaluate his/her own capability/efficiency of finding and evaluating new sources to further mathematical science, renew and develop his/her academic skills, combine insight from multiple disciplines and contribute to multidisciplinary collaboration.
3. Develop logical reasoning techniques and techniques for analyzing the situation.
4. Read, analyze, and write logical arguments to prove mathematical concepts.
5. Communicate mathematical ideas with clarity and coherence, both written and verbally.
6. Acquire capability to evaluate hypothesis, methods and evidence within their proper contexts inany situation.
7. Demonstrate the ability to conduct research independently and pursue higher studies toward Doctoral Degree in Mathematics.

**VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY**
**Department of Studies in Mathematics**
Jnana Sagara, Ballari - 583105

## Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) Proposed for PG Programs

### I-SEMESTER

| Semester No. | Category | Subject code | Title of the Paper | Marks | | | Teaching hours/week | | | Credit | Duration of exams (Hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | IA | Sem. Exam | Total | L | T | P | | |
| FIRST | DSC1 | 24MAT1C1L | Algebra | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC2 | 24MAT1C2L | Real Analysis | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC3 | 24MAT1C3L | Differential Equations | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC4 | 24MAT1C4L | Numerical Analysis | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC5 | 24MAT1C5L | Complex Analysis | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | SEC1 | 24MAT1S1LP | Python Programming | 20 | 30 | 50 | 1 | - | 2 | 2 | 1 |
| | DSCP1 | 24MAT1P1 | Numerical Analysis Lab Using PYTHON/R/ MATLAB | 20 | 30 | 50 | - | - | 4 | 2 | 4 |
| **Total Marks for I Semester** | | | | | | **600** | | | | **24** | |

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## Department of Studies in Mathematics

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**Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) Proposed for PG Programs**

**II-SEMESTER**

| Semester No. | Category | Subject code | Title of the Paper | Marks | | | Teaching hours/week | | | Credit | Duration of exams (Hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | IA | Sem. Exam | Total | L | T | P | | |
| SECOND | DSC6 | 24MAT2C6L | Linear Algebra | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC7 | 24MAT2C7L | Measure theory | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC8 | 24MAT2C8L | Mathematical Methods | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC9 | 24MAT2C9L | Topology | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC10 | 24MAT2C10L | Partial Differential Equations | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | SEC2 | 24MAT2S2LP | R-Programming | 20 | 30 | 50 | 1 | - | 2 | 2 | 1 |
| | DSCP2 | 24MAT2P2 | Mathematical Methods Lab using PYTHON/R/ MATLAB | 20 | 30 | 50 | - | - | 4 | 2 | 4 |
| **Total Marks for II Semester** | | | | | | **600** | | | | **24** | |

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**Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) Proposed for PG Programs**

**III-SEMESTER**

| Semester | Category | Subject code | Title of the Paper | Marks | | | Teaching hours/week | | | Credit | Duration of exams (Hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | IA | Sem. Exam | Total | L | T | P | | |
| THIRD | DSC11 | 24MAT3C11L | Functional Analysis | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC12 | 24MAT3C12L | Fluid Mechanics | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSE1 | 24MAT3E1L | (A) Classical Mechanics/<br>(B) Approximation Theory /<br>(C) Operator Theory | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSE2 | 24MAT3E2L | Differential Geometry/<br>Fuzzy sets & Structures /<br>Probability and Statistics | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | GEC1 | 24MAT3G1L | (A) Mathematical Physics/<br>(B) Mathematical Biology/<br>(C) Graph Theory<br>(WITHIN FACULTY) | 20 | 30 | 50 | 2 | - | - | 2 | 1 |
| | SEC3 | 24MAT3S3LP | Research Methodology | 20 | 30 | 50 | 1 | - | 2 | 2 | 1 |
| | DSCP3 | 24MAT3P3 | Linear Algebra Lab using PYTHON/R/ MATLAB | 20 | 30 | 50 | - | - | 4 | 2 | 4 |
| | DSCP4 | 24MAT3P4 | Differential Equations Lab using PYTHON/R/ MATLAB | 20 | 30 | 50 | - | | 4 | 2 | 4 |
| **Total Marks for III Semester** | | | | | | **600** | | | | **24** | |

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**Distribution of Courses/Papers in Post graduate Programme I to IV Semester as per Choice Based Credit System (CBCS) Proposed for PG Programs**

**IV-SEMESTER**

| Semester | Category | Subject code | Title of the Paper | Marks | | | Teaching hours/week | | | Credit | Duration of exams (Hrs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | IA | Sem. Exam | Total | L | T | P | | |
| FOURTH | DSC13 | 24MAT4C13L | Advanced Fluid Mechanics | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSC14 | 24MAT4C14L | Advanced numerical Analysis | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSE3 | 24MAT4E3L | (A) Mathematical Modeling / (B) Haar Wavelets and Artificial Neural Networks / (C) Graph Theory | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | DSE4 | 24MAT4E4L | (A) Number Theory & Combinatorics/ (B) Multivariable Calculus & Descriptive Statistics/ (C) Operations Research | 30 | 70 | 100 | 4 | - | - | 4 | 3 |
| | GEC2 | 24MAT4G2L | (A) Commercial Mathematics/ (B) Mathematical Statistics/ (C) Mathematics for Social Sciences (OUTSIDE FACULTY) | 20 | 30 | 50 | 2 | - | - | 2 | 1 |
| | DSCP5 | 24MAT4P5 | Advanced Numerical Analysis Lab Using PYTHON/R/ MATLAB | 20 | 30 | 50 | - | - | 4 | 2 | 4 |
| | Project | 24MAT4C1R | Research Project | 30 | 70 | 100 | | - | 8 | 4 | 4 |
| **Total Marks for IV Semester** | | | | | | **600** | | | | **24** | |

# SEMESTER-I

## DSC1: Algebra

| | |
|---|---|
| **Course:** Algebra | **Course Code:**24MAT1C1L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop a comprehensive understanding of abstract algebraic structures and their relationships with familiar number systems, emphasizing theoretical foundations and practical applications.
- Master the fundamental concepts of group theory, including isomorphisms, symmetric groups, and group actions, enabling students to analyze and solve complex algebraic problems.
- Understand and apply advanced concepts in extension of groups, including class equations, Sylow theorems, and composition series, preparing students for higher-level mathematical analysis.
- Demonstrate proficiency in ring and field theory, with particular emphasis on polynomial rings, principal ideal domains, and unique factorization domains.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Groups:** Recompilation of Definitions, examples and elementary properties. Isomorphism theorems and the correspondence theorem. Center of a group and commutator subgroup of a group Symmetric group $S_n$. Structure theorem for symmetric groups. Action of a group on a set. Examples, Orbit and stabilizer of an element. | 13 |
| **2** | **Extension of Groups:** Class equation of a finite group, Cauchy's theorem for finite groups, Sylow theorems, Applications Wilson's theorem, Subnormal series of a group, Solvable group, Composition Series of a group, Jordan-Holder theorem. | 12 |
| **3** | **Ring and Field Theory:** Recompilation of Definitions and examples of Rings and field, Polynomial ring R[X] over a ring in an indeterminate X, Principle ideal domain. Euclidean domain, The ring of Gaussian integers as Euclidean domain, Unique factorization domain. Primitive Polynomial, Gauss lemma. | 13 |
| **4** | **Polynomials over Fields:** F[X] is a unique factorizationdomain for a field F. Eienstien's criterion of irreducibility for polynomials over a UFD. **Field extensions:** Characteristic of a field. Field extensions. Finite extensions. Algebraic extensions. Transitivity theorems. Simple extensions. Roots of polynomials. Splitting field of a polynomial. Existence and uniqueness theorems. Existence of a field with $p^n$ element for a prime p and a positive integer n. | 14 |

**Text Books:**


1. I.N. Herstein, Topics in Algebra, 2nd Edition, John-Wiley & Sons, New York (2008).
2. M. Artin, Algebra, Prentice Hall of India (2004).
3. Surjeet singh and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House, 8th edition(2006).
4. S. K. Jain, P. B. Bhattacharya & S. R. Nagpaul, Basic Abstract Algebra, Cambridge

UniversityPress (2001).
5. S. Maclane and G. Birkhoff, Algebra, McMillan Co., New York (1999).
6. Hunger Ford, Abstract  Algebra, Cengage Publication (2015).

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Analyze and apply the fundamental concepts of group theory, including isomorphism theorems, symmetric groups, and group actions to solve mathematical problems. |
| CO2 | Demonstrate understanding of advanced group theory concepts by applying Sylow theorems, analyzing solvable groups, and working with composition series. |
| CO3 | Evaluate and manipulate various algebraic structures such as rings, fields, and polynomial rings, understanding their properties and relationships. |
| CO4 | Apply theoretical concepts of field extensions and polynomial factorization to solve problems in abstract algebra and related fields. |

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## DSC2: Real Analysis

| **Course:** Real Analysis | **Course Code:** 24MAT1C2L |
|---|---|
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Recognize and analyze convergent, divergent, bounded, Cauchy, and monotone sequences of real numbers.
- Study the properties of continuous functions on real line intervals and understand different types of discontinuities.
- Introduce and explore the role of uniform convergence in sequences and series of functions.
- Study how properties of functions transfer to limits and sums of sequence and series functions.
- Develop understanding of integration, differentiation, and bounded variation in the context of uniform convergence.

| Unit | Description | Hours |
|---|---|---|
| 1 | Sequences and series of real numbers, convergence, limit superior, limit inferior of sequence, some standard results on the convergence: Cauchy's theorems, standard theorems on test of absolute convergence, alternating series (Leibnitz test). | 13 |
| 2 | Characterization of limit and continuity of a function in terms of sequences, properties of continuous functions. Uniform continuity, monotonic functions. Types of discontinuity: first, second kind and removable discontinuity. | 13 |
| 3 | Sequences and series of functions: Pointwise and uniform convergence, questions on pointwise convergence in terms of limit, continuity, differentiability and integration. Cauchy's criteria for uniform convergence, criteria for uniform convergence of sequence of functions, Weierstrass M- test. | 13 |
| 4 | Uniform convergence and continuity, uniform convergence and Reimann integers, uniform convergence and differentiation, functions of bounded variations. | 13 |

**Text Books:**


1. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, 3rd edition, John- Wiley, 2005.
2. S. C. Malik and S. Arora, Mathematical Analysis, 4thedition, New Age International Publications, 2012.
3. W. Rudin, Principles of Mathematic Analysis, 3rd edition, McGraw Hill, 1986.
4. H. L. Royden, Real Analysis ,2nd edition, The McMillan Co. New York, 1968.
5. T. M. Apostol, Mathematical Analysis, 2nd edition, Narosa, 1996.
6. S. Abbott, Understanding Analysis, Springer, 2016.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply mathematical concepts involving convergence of sequences and series of real numbers. |
| CO2 | Analyze and compute limits of sequences of real functions and evaluate their continuity properties. |
| CO3 | Apply theorems to solve problems on limit, continuity, and differentiability of sequences of functions. |
| CO4 | Use appropriate tests and criteria to determine uniform convergence of sequences and series of functions. |

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## DSC3: Differential Equations

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|---|---|
| **Course:** Differential Equations | **Course code:** 24MAT1C3L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **Course Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examinations:** 70 Marks |

**Course Objectives:**

- Develop understanding of Ordinary Differential Equations (ODEs), their solutions, and various analytical and numerical methods for solving them.
- Master the concepts of initial value problems, existence and uniqueness theorems, and fundamental solutions of linear differential equations.
- Analyze oscillatory behavior of second-order equations and understand Sturm-Liouville boundary value problems.
- Study power series solutions of differential equations around ordinary and singular points using various methods.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Higher Order Linear Differential Equations**: Introduction Differential equations and their classification. Homogeneous equations and general solution, Initial value problems. The Wronskian, Fundamental set, Adjoint equation, self- adjoint equation and their properties. Solutions of non-homogeneous equations by Method of Variation of parameters, Method of Undetermined Coefficients, Existence and Uniqueness theorem. | 13 |
| **2** | **Oscillations of Second Order Equations:** Introduction, Oscillatory and non-Oscillatory differential equations: The Strum theory, Abel's formula, Strum separation and comparison theorem, Conversion of standard form to normal form. Orthogonality, orthogonal set of functions, orthonormal set of functions, Orthogonal and orthonormal set of function with respect to weight function. Boundary value problems; Sturm Liouville boundary value problem; Eigen functions and Eigen values, Green's function. | 13 |
| **3** | **Power series solution of Differential Equations:** Power series, Radius of convergence and interval of convergence, examples and theorems. Ordinary and singular points, Power series solution about an ordinary point. The working rule of solution by Frobenius method. The series solution about regular singular pint at infinity, examples. | 13 |
| **4** | **System of First Order Equations:** First order systems, linear system of homogeneous and non-homogeneous equations (matrix method) Non-linear equations - Autonomous systems - Phase plane - Critical points–stability-Liapunov direct method-Bifurcation of plane autonomous systems. | 13 |

**Text Books:**


1. Introduction to ordinary differential equations: Wiley publications IV edition, S L Ross, 1989.
2. Differential Equations, Mcgraw Hill, Publications, 2005, Simmons, G.F. and Stevan G Krantz, 2015.
3. An Introduction to Ordinary Differential Equations, Dover publications, Eurl A.

Coddington, 1989.
4. Ordinary and Partial differential equations, S Chand Publishers, M D Raisinghania, 2018
5. Differential Equations, Cambridge University Press, A C King, J Billingham and S R Otto, 2008.
6. Differential Equations with Applications and Historical Note Tata Mcgraw Hill, Publications, 2005, Simmons, G.F.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply various methods to solve higher-order linear differential equations and analyze their properties using Wronskian and fundamental sets. |
| CO2 | Master the concepts of initial value problems, existence and uniqueness theorems, and fundamental solutions of linear differential equations. |
| CO3 | Analyze oscillatory behavior of second-order equations and understand Sturm-Liouville boundary value problems. |
| CO4 | Solve systems of first-order equations using matrix methods and analyze their stability using phase plane techniques. |

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## DSC4: Numerical Analysis

| **Course:** Numerical Analysis | **Course Code:**24MAT1C4L |
|---|---|
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop appropriate numerical methods to solve nonlinear and transcendental equations with analysis of convergence orders.
- Master various direct and iterative methods to solve linear systems of equations with error analysis.
- Study numerical techniques for computing eigenvalues and eigenvectors of matrices using different methods.
- Learn interpolation theory and various interpolation techniques using finite differences.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Solutions of Nonlinear/Transcendental Equations:** Fixed point iteration, Newton Raphson Method, Regula-Falsi Method, Muller's Method, Orders of convergence of each method and applications on each method. | 13 |
| **2** | **System of Linear algebraic equations:** Direct methods with error analysis: Gauss elimination method, Gauss Jordan method, Triangularization method and Cholesky method. Iteration methods with convergence analysis: Jacobi method, Gauss seidel method, and SOR method. | 13 |
| **3** | **Eigen values and Eigen vectors:** Eigen values and Eigen vectors, Bounds on Eigen values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices. Power method, inverse power method. | 13 |
| **4** | **Interpolation Theory:** Interpolation, Lagrange and Newton interpolations: linear interpolation, Quadratic interpolation, higher order interpolation. Finite difference operators, Relation between differences and derivatives. Interpolating polynomials using finite differences: Gregory-Newton forward / backward difference interpolation. Stirling and Bessel interpolations, Hermite interpolation. | 13 |

**Text Books:**


1. Introductory methods of Numerical Analysis, PHI Publisher, 2012, S. S. Sastry,
2. Numerical methods for scientific and Engineering Computation, New Age International Publishers, M K Jain, S R K Iyengar and R K Jain, 2014.
3. Numerical Mathematical Analysis 6th Edition, Oxford and IBH publisher, J B Scarborough, 1984.
4. Numerical methods in Engineering and Science, Khanna Publishers, B S Grewal, 2013.
5. Interpolation and Approximation, Courier Corporation Publishers, Philip Davis and Reuben Hersh, 1975

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply numerical methods to solve nonlinear equations using iterative techniques and analyze their convergence. |
| CO2 | Solve systems of linear algebraic equations using direct and iterative methods with error analysis. |
| CO3 | Compute eigenvalues and eigenvectors of matrices using various numerical methods such as power method and transformation techniques. |
| CO4 | Implement different interpolation techniques to approximate functions and analyze their effectiveness. |

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## DSC5: Complex Analysis

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|---|---|
| **Course:** Complex Analysis | **Course code:** 24MAT1C5L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To introduce the theory of analytic functions, harmonic conjugates, and the significance of Mobius transformations and conformal mappings.
- To understand key theorems in complex analysis, including Cauchy's theorem, Morera's theorem, and Liouville's theorem, and their implications for analytic functions.
- To familiarize with power series, their convergence, and the relationship with Taylor and Laurent series.
- To explore rational functions, singularities, and residues, applying these concepts to evaluate integrals and analyse analytic functions at singular points.

| Unit | Description | Hours |
|---|---|---|
| **1** | Analytic functions, Harmonic conjugates, Elementary functions, Mobius Transformation, Conformal mappings, Cauchy' s Theorem and Integral formula, Morera' s Theorem, Cauchy' s Theorem for triangle, Cauchy's Theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. Principles of analytic Continuation. Liouville's Theorem, Fundamental theorem of algebra. | 14 |
| **2** | Series, Uniform convergence, Power series, Radius of convergences, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series. | 12 |
| **3** | Rational Functions, Singularities, Poles, Classification of Singularities, Characterization of removable Singularities, poles, Behavior of an Analytic functions at an essential singular point. Entire and Meromorphic functions. The Residue Theorem. Evaluation of Definite integrals, Argument principle | 12 |
| **4** | Rouche' s Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications. Casoratti-Weierstrass theorem. Convex functions, Hadmard's Three circle theorem. Phragmen-Lindelof theorem Harmonic functions–Basic properties–Polar form–Mean value property–Poisson's formula–Schwartz's theorem. Jensen's formula, Poisson's- Jensen's formula. | 14 |

**Text Books:**


1. J.B. Conway. Functions of one complex variable, Narosa Publication,1987
2. L.V. Ahlfors, Complex Analysis, McGrawHill,1986.
3. J. W. Brown & R. V. Churchill. Complex Variables and Applications, McGrawHill,2017.
4. Kasana. Complex Variables, PrenticeHall,2015.
5. S. Ponnaswamy, Foundations of Complex Analysis, Narosa Publications, 2011.
6. S Kumarasan, A Pathway to Complex Analysis, TechnoWorld,2021.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | identify and analyse analytic functions, harmonic conjugates, and apply Mobius transformations and conformal mappings to solve complex problems. |
| CO2 | demonstrate an understanding of fundamental theorems in complex analysis, including Cauchy's theorem and Liouville's theorem, to study properties of analytic functions and their zeros. |
| CO3 | utilize power series expansions to represent analytic functions, determine their radius of convergence, and apply Taylor and Laurent series effectively. |
| CO4 | classify singularities, apply the residue theorem for evaluating definite integrals, and utilize key results like Rouche's theorem and the maximum modulus theorem in complex analysis. |

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## SEC1: Python Programming

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|---|---|
| **Course:** Python Programming | **Course Code:**24MAT1S1LP |
| **Teaching Hours/Week (L-T-P):** 1-0-2 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- To introduce students to Python programming, focusing on the basics such as identifiers, keywords, data types, operators, and control flow statements.
- To familiarize students with the NumPy and Matplotlib libraries for numerical computing and data visualization, enhancing their ability to solve numerical problems.
- To provide hands-on experience through practical programming exercises that reinforce fundamental programming concepts and algorithmic thinking.
- To develop problem-solving skills by implementing a variety of programs, including arithmetic operations, pattern printing, and mathematical computations.

| Unit | Description | Hours |
|---|---|---|
| **1** | Introduction to NumPy and Matplotlib package: History of Python Identifiers, Key words, Statements & Expressions, Variables, Operators, Keywords, Input-Output, Control Flow statements, Functions, Numerical problems on NumPy. | 13 |
| **2** | **List of Programs:**<br>1) program to develop calculator for basic arithmetic operations.<br>2) program to find the largest number among three given numbers.<br>3) program to check if a given string is a palindrome.<br>4) program to generate Fibonacci numbers up to a given number of terms.<br>5) program to check whether a number is prime or not.<br>6) program to check the number is even or odd.<br>7) Programs to print various patterns using loops (like pyramids, diamonds).<br>8) fun program where the user guesses a random number between a range.<br>9) program to calculate the factorial of a given number.<br>10) Program to word guessing game where the player tries to guess the letters of a word.<br>11) Program that sorts both letters and numbers from a mixed input string.<br>12) Program to convert binary number to decimal number and vice versa.<br>13) Program to find roots of quadratic equation.<br>14) Program to find area of one of the geometric figures (circle, triangle, rectangle and square) using switch statements.<br>15) Program to read the coefficients of a polynomial, print the polynomial and evaluate the polynomial at given value. | 26 |

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | demonstrate an understanding of Python programming fundamentals, including variables, control flow, and function creation. |
| CO2 | effectively use the NumPy and Matplotlib libraries to perform numerical operations and visualize data. |
| CO3 | apply problem-solving techniques to implement various programming tasks, reinforcing their knowledge of loops, conditionals, and functions. |
| CO4 | develop a portfolio of practical programs, showcasing their ability to solve real-world problems through programming in Python. |

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## DSCP1: Numerical Analysis Lab using PYTHON/ R/ MATLAB

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|---|---|
| **Course:** Numerical Analysis Lab using PYTHON/ R/ MATLAB | **Course Code:** 24MAT1P1 |
| **Teaching Hours/Week (L-T-P):** 0-0-4 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- To introduce students to numerical methods for finding roots of polynomials and solving systems of linear equations, emphasizing their mathematical foundations.
- To provide hands-on experience with various iterative methods, including fixed-point iteration, Newton-Raphson, and Regula Falsi, to solve polynomial equations.
- To familiarize students with matrix operations and techniques for finding eigenvalues and eigenvectors using methods such as Gauss elimination and the Jacobi method.
- To enhance programming skills by implementing numerical algorithms in Python, fostering problem-solving abilities and computational thinking.

| Unit | Description | Hours |
|---|---|---|
| **1** | **List of Programs:**<br>1) Program to find real root of a polynomial using fixed point iterative method.<br>2) Program to find real root /multiple roots of a polynomial using Newton Raphson Method.<br>3) Program to find real root of a polynomial using Regula Falsi method.<br>4) Program to find real root of a polynomial using Muller Method<br>5) Program to solve system of equations using Gauss Elimination Method.<br>6) Program to find inverse of the matrix using Gauss Jordan Method.<br>7) Program to solve system of linear algebraic equation using triangularization method.<br>8) Program to find solution of system of equations using Cholesky's method<br>9) Program to find solution of system of equations using Jacobi Iterative Method.<br>10) Program to find solution of system of equations using Gauss Seidal Method.<br>11) Program to solve system of linear algebraic equation using SOR method.<br>12) Program to find eigen values and eigen vectors of a matrix using jacobi method for symmetric matrices.<br>13) Program to find eigen values and eigen vectors of a matrix using householder’s method for symmetric matrices.<br>14) Program to find eigen values and eigen vectors of a matrix using power method.<br>15) Program to find eigen values and eigen vectors of a matrix using inverse power method. | 52 |

**Text Books:**


1. Gowrishankar S. Veena A -Introduction to Python Programming (2019).
2. Introductory methods of Numerical Analysis, PHI Publisher, 2012, S. S. Sastry.
3. Allen Downey, Jeff Elkner, and Chris Meyers -Learning with Python. (2015).
4. C.H. Swaroop -A Byte of Python. (2013)

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | demonstrate proficiency in implementing numerical methods for finding real roots of polynomials using various algorithms. |
| CO2 | successfully solve systems of linear equations using methods such as Gauss elimination, Jacobi iteration, and Cholesky's method. |
| CO3 | analyse and determine eigenvalues and eigenvectors of matrices using different numerical techniques, enhancing their understanding of linear algebra concepts. |
| CO4 | develop a portfolio of programs that showcase their ability to apply numerical methods to solve mathematical problems effectively. |

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# SEMESTER-II

## DSC6: Linear Algebra

| | |
|---|---|
| **Course:** Linear Algebra | **Course Code:** 24MAT2C6L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop a strong foundation in vector space theory through the study of row-reduced echelon matrices and subspace analysis
- Master the concepts and applications of linear transformations, including their matrix representations and properties
- Establish comprehensive understanding of eigenvalue theory and its applications in linear transformations
- Enable students to understand and apply matrix diagonalization techniques and various canonical forms

| Unit | Description | Hours |
|---|---|---|
| **1** | Consistency of linear system through row reduced echelon matrices. Computation of basis and dimension of some standard subspaces of: $R^n, R^{m\times n}$, function spaces. Coordinate of a vector. Existence theorem for basis of a vector space. | 13 |
| **2** | Construction of linear transformation, singular and non-singular transformations, rank and nullity theorem, representation of transformation by matrix. Change of basis and some related problems, similarity transformations. | 13 |
| **3** | Eigen values and eigen vectors of linear transformations, Annihilating polynomial, Cayley-Hamilton Theorem, minimal polynomial and some problems related to these concepts. Relation between eigenvalues and determinant, trace of matrices. | 13 |
| **4** | Diagonalization of a matrix, canonical forms, Jordan forms, quadratic forms, reduction and classification of quadratic forms. | 13 |

**Text Books:**

1. K. Hoffman and R. Kunze, Linear Algebra, PHI,
2. K. P. Gupta, Linear Algebra, Pragati Prakashan, 19 th revised edition, 2016.
3. N. Jacobson: Basic Algebra-I, HPC, 1984.
4. I.N. Herstein: Topics in Algebra, 2nd Edition, Vikas Publishing House, 1976.
5. Gilbert Strang, Linear Algebra and its applications, Pearson, Fourth Edition,2007.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Construct mathematical proofs and analyze vector spaces using row-reduced echelon form and basis theory. |
| CO2 | Demonstrate mastery in constructing linear transformations, understanding their properties, and applying change of basis techniques in vector spaces. |
| CO3 | Apply eigenvalue theory, the Cayley-Hamilton theorem, and minimal polynomial concepts to solve problems involving linear transformations and matrices. |
| CO4 | Master the techniques of matrix diagonalization and determine various canonical forms including Jordan canonical form for given matrices. |

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## DSC7: Measure Theory

| **Course:** Measure Theory and Integration | **Course Code:** 24MAT2C7L |
|---|---|
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop a comprehensive understanding of measure theory fundamentals, sigma algebras, and Borel sets
- Master the concepts of Lebesgue measure, outer measure, and their fundamental properties
- Build proficiency in understanding measurable functions and various modes of convergence
- Establish strong foundation in Lebesgue integration theory and classical convergence theorems

| Unit | Description | Hours |
|---|---|---|
| **1** | Sigma algebras, open subsets of the real line.$F_\sigma$ and $G_\delta$ sets, Borel sets, Outer measure of a subset of R ' Lebesgue outer measure of a subset of R Existence, non-negativity and monotonicity of Lebesgue outer measure; Relation between Lebesgue outer measure and length of an interval; Countable subadditivity of Lebesgue outer measure; translation invariance.(Lebesgue) measurable sets, (Lebesgue) measure; Complement, union, intersection and difference of measurable sets; denumerable union and intersection of measurable sets; countable additivity of measure; The class of measurable sets as a algebra, the measure of the inter section of a decreasing sequence of measurable sets. | 14 |
| **2** | Measurable functions; Scalar multiple, sum, difference and product of measurable functions. Measurability of a continuous function and measurability of a continuous image of measurable function. Convergence pointwise and convergence in measures of a sequence of measurable functions. Lebesgue Integral; Characteristic function of a set; simple function; Lebesgue integral of a simple function; Lebesgue integral of a bounded measurable function. | 14 |
| **3** | Lebesgue integral and Riemann integral of a bounded function defined on a closed interval; Lebesgue integral of a non-negative function; Lebesgue integral of a measurable function; Properties of Lebesgue integral. Convergence Theorems and Lebesgue integral; The bounded convergence theorem; Fatou's Lemma: Monotone convergence theorem; Lebesgue convergence theorem. | 12 |
| **4** | Differentiation of Monotone functions. Vitali covering lemma. Functions of Bounded variation. Differentiability of an integral. Absolute continuity and indefinite integrals.<br>$L_p$ space. Signed measure: positive and negative sets and theorems | 12 |

**Text Books:**


1. H. L. Royden: Real Analysis, Pearson Publication, 2017.
2. P.R. Halmos: Measure Theory, Springer, 2008.
3. W. Rudin. Real & Complex Analysis, Tata McGraw Hill Publishing Company Ltd, 2007.

4. I. K. Rana. An introduction to measure and integration, Narosa publishing House, 2007.
5. K. P. Gupta and Gupta. Measure and Integration, Krishna Prakashan Media (P) Ltd, II, Shivaji Road, Meerut (U.P) India, 2020.
6. A. K. Mallik, S. K. Gupta, S. R. Singh, S. C. Mallik. Measure Theory and Integration, Wiley India Pvt Ltd, 2020.
7. Debarra G. Measure Theory and Integration, New Age Publication, 2013.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Analyze and construct proofs involving measure spaces, sigma algebras, and demonstrate understanding of Borel sets and their properties. |
| CO2 | Apply the concepts of Lebesgue measure and outer measure to determine measurability of sets and functions. |
| CO3 | Evaluate and compare Lebesgue and Riemann integrals while establishing their relationships and properties. |
| CO4 | Apply fundamental theorems of integration including Monotone Convergence, Fatou's Lemma, and Lebesgue Dominated Convergence. |

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## DSC8: Mathematical Methods

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|---|---|
| **Course:** Mathematical Methods | **Course Code:** 24MAT2C8L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Enable students to solve linear equations with variable coefficients and nonlinear boundary value problems
- Develop understanding of integral equations and transform methods for solving mathematical problems
- Master the principles of calculus of variations and their applications in optimization problems
- Build strong foundation in classical mechanics concepts including Lagrangian and Hamiltonian formulations

| Unit | Description | Hours |
|---|---|---|
| **1** | **Integral equations:** Linear integral equation of the first and second kind of Fredholm and Volterra type, kernels and its types, solution of Fredholm and Volterra equations using resolvent kernel, separable kernel, symmetric kernel, method of successive approximations, convolution type equations, solution of integro-differential equations with the aid of Laplace transformation. Characteristic numbers and eigenfunctions. | 13 |
| **2** | **Calculus of variations:** Variation of a functional, extremum of functional, variational problems, Euler's equation, standard variational problems including geodesics, minimal surface of revolution, hanging chain problems. | 13 |
| **3** | **Classical Mechanics:** Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations. | 13 |
| **4** | **Integral Transforms:** General definition of Integral transforms, Kernels, etc. Laplace, Fourier, Mellin and Hankel transforms to solve ODE's and PDE's – with practical examples. **Perturbation Method:** Introduction, Regular and singular perturbation methods: Parameter and co-ordinate perturbations. Regular perturbation solution of first and second order differential equations involving constant and variable coefficients. | 13 |

**Text Books:**


1. Advanced Mathematical methods for scientists and Engineers, Springer Publishers, 1999, C M Bender, S A Orszag, 1999.
2. Integral Transforms and their applications, Taylor and Franscis, L Debnath and D Bhatta, 2007.
3. Linear integral equations theory and techniques, Academic Press, New York, R.P. Kanwal: 1971.
4. Mathematical methods, Himalaya Publishing House, 1st Edition, V ravindranath and P Vijayalakshmi, 2012.

5. I.N. Sneddon – The use of Integral Transforms, Tata McGraw Hill, Publishing Company Ltd, New Delhi, 1974
6. R.P. Kanwal: Linear integral equations theory and techniques, Academic Press, New York, 1971.
7. Integral Equations, Shanthi, Krishna Publications, Swaroop and S R Singh,2014.
8. Integral Transforms Krishna Publishers, 34th Edition, A R Vasishtha and R K Gupta. 2015.
9. D.S. Chandrasekharaiah and L. Debnath: Continuum Mechanics, Academic Press, 1994.
10. A.J.M. Spencer: Continuum Mechanics, Longman, 1980.
11. Goldstein, Classical Mechanics, Addison – Wesley, 3rd Edition, 2001.


**Course Outcomes (CO's): At the end of the course, students will be able to:**

| CO | Statement |
|---|---|
| CO1 | Solve linear integral equations using various methods including resolvent kernel, separable kernel, and Laplace transformation techniques. |
| CO2 | Apply variational principles to solve optimization problems through Euler's equations and analyze problems with moving boundaries. |
| CO3 | Implement Lagrangian and Hamiltonian formulations to solve problems in classical mechanics and analyze rigid body motions. |
| CO4 | Apply integral transforms (Laplace, Fourier, Mellin, Hankel) to solve ordinary and partial differential equations. |

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## DSC9: Topology

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|---|---|
| **Course:** Topology | **Course Code:** 24MAT2C9L |
| **Teaching Hours/Week(L-T-P):**4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30Marks | **Semester End Examination:** 70Marks |

**Course Objectives:**

- To introduce students to metric spaces, exploring properties of metrics, open and closed sets, and accumulation points in metric spaces.
- To analyze Euclidean topology in R, covering concepts such as interior, exterior, boundary, closure, and theorems related to connectedness and compactness.
- To provide a foundation in topological spaces, focusing on concepts like bases, sub-bases, subspaces, and key properties of open and closed sets.
- To examine continuous mappings, homeomorphisms, and separation axioms, as well as compactness and connectedness in the context of topological spaces.

| Unit | Description | Hours |
|---|---|---|
| **1** | Metric spaces: Topology induced by metric space. Some basic properties of metrics, subspaces, neighbourhood, open balls and closed balls, definition of closed sets and open sets, their behaviour under intersections and unions, accumulation point, derived sets, dense sets. | **13** |
| **2** | Euclidean topology on R: open, closed subsets of R. computation of interior, exterior, boundary and closure for some subsets of R. dense subsets of R. Bolzano-Weierstrass theorem, Heine-Borel theorem and connected subsets of R. | **13** |
| **3** | Topological spaces: definition and examples, open sets, closed sets, neighbourhoods, closure, interior, exterior and boundary of a set, accumulation point, derived sets. Bases, sub-bases, subspaces. | **13** |
| **4** | Continuous maps, open and closed maps, homeomorphism, first and second countable spaces. Separation axioms: $T_0, T_1, T_2, T_3$ and $T_4$ spaces, Connectedness, Compactness. | **13** |

**Text Books:**


1. K.D. Joshi, Introduction to General Topology, Wiley Eastern, (1983).
2. JamesR. Munkres, Topology,2ndEdition, Pearson International, (2000).
3. J. Dugundji, Topology, Prentice-Hall of India, (1966).
4. GeoreF. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, (1963).
5. J.L. Kelley, General Topology, VanNostrand, (1995).
6. N. Bourbaki, General Topology, Part I, Addison-Wesley, (1966).
7. S.W. Davis, Topology, Tata Mc Graw Hill, (2006).
8. S. Shirali, Satish and H.L. Vasudeva, Metric S paces, Springer-Verlag London, (2006).
9. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, NewDelhi,(2014).

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | demonstrate understanding of metric spaces by analysing open and closed sets, accumulation points, and the behaviour of subsets in metric spaces. |
| CO2 | apply topological concepts in R, computing interiors, exteriors, boundaries, and closures, and proving the Bolzano-Weierstrass and Heine-Borel theorems. |
| CO3 | identify and utilize properties of topological spaces, using bases, sub-bases, and analysing derived sets within various contexts. |
| CO4 | classify spaces using separation axioms and apply concepts of compactness and connectedness, as well as recognize continuous and open maps in topological frameworks. |

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## DSC10: Partial Differential Equations

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|---|---|
| **Course:** Partial Differential Equations | **Course Code:** 24MAT2C10L |
| **Teaching Hours/Week(L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30Marks | **SemesterEndExamination:**70Marks |

**Course Objective(s):**

- To introduce students to the classification and solution methods for linear and non-linear first-order partial differential equations (PDEs).
- To develop an understanding of second-order PDEs, focusing on their origin, classification, and reduction to canonical forms.
- To equip students with methods to solve elliptic, parabolic, and hyperbolic PDEs using separation of variables, Laplace, and Fourier transformations.
- To explore advanced techniques for non-linear second-order PDEs, focusing on Mange's method and its different solution cases.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Linear and non-Linear First Order Partial Differential Equations:** Introduction, Classification of first order, Solution of first order PDE: Lagrange’s method, Integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces. Non-linear PDE of first order: Charpit’s method, Compatible system of first order PDE, and their condition. Cauchy initial Value problem for first order PDE. | 13 |
| **2** | **Second Order Partial Differential Equations:** Introduction, Origin of Second Order Equations, Equations with Variable Coefficients and its different types. Classification of second order PDE in two independent variables, Reduction to its canonical form: method for reducing Parabolic, elliptic and Hyperbolic, equations to its Canonical Forms. | 13 |
| **3** | **Solutions of Elliptic, Parabolic and Hyperbolic PDEs:** Solutions of Elliptic, Parabolic and Hyperbolic PDEs by the methods of (i) Separation of Variables (ii) Laplace Transformation and (iii) Fourier Transformation. Solution of Elliptic, Parabolic and Hyperbolic equations in cylindrical and spherical polar coordinates. | 13 |
| **4** | **Non-Linear PDE of second order:** Introduction, Mange’s method of integrating Rr+Ss+Tt =V by different types, (i) leads to two distinct intermediate integrals and both of them are used to get the desired solution (ii) leads to two distinct intermediate integrals and only one is employed to get the desired solution (iii) leads to two identical intermediate integrals, and (iv) fails to yield two identical intermediate integrals, illustrative through examples. | 13 |

**Text Books:**

1. Introduction to Partial Differential Equations, PHI Publications, 3 rd Edition K Sankar Rao, 2017.
2. Partial Differential Equations for Scientists and Engineers: Dover Publications, Stanley J. Farlow, 1993.
3. An elementary course in Partial Differential Equations, 2nd Edition, Narosa Publishers, T Amaranath, 2013.
4. Elements of Partial Differential Equations, MCGrawhill publishers, I.N. Sneddon,

1957.
5. Ordinary and Partial Differential Equations, S Chand Publishers, 7th Edition, M D Raisinghania, 2014
6. Partial Differential Equation, Aerical Mathematical Society,2nd Edition, L C Ivans, 2010

**Course Outcomes (CO's): At the end of the course, students will be able to:**

| CO | Statement |
|---|---|
| CO1 | classify and solve first-order PDEs, apply Lagrange's and Charpit's methods, and handle initial value problems. |
| CO2 | Students will effectively classify and reduce second-order PDEs to their canonical forms, identifying parabolic, elliptic, and hyperbolic types. |
| CO4 | demonstrate proficiency in solving elliptic, parabolic, and hyperbolic PDEs, including applications in cylindrical and spherical coordinates. |
| CO5 | apply Mange's method to solve non-linear second-order PDEs and differentiate solution cases using intermediate integrals. |

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## SEC 2: R-Programming

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|---|---|
| **Course:** R-Programming | **Course Code:** 24MAT2S2LP |
| **Teaching Hours/Week(L-T-P):**1-0-2 | **No. of Credits:** 02 |
| **Internal Assessment:** 20Marks | **Semester End Examination:** 30Marks |

**Course Objectives:**

- To introduce students to the fundamentals of R programming, including installation, variable creation, and basic data structures like vectors, matrices, and data frames.
- To develop students' abilities in data import/export and control flow commands such as loops and conditional statements in R.
- To equip students with skills in data visualization using R, covering histograms, bar-plots, box-plots, and pie diagrams with customization options.
- To provide hands-on practice with R functions through practical exercises, including matrix operations, vector manipulation, and constructing informative plots.

| Unit | Description | Hours |
|---|---|---|
| 1 | Introduction: Basic fundamentals, installation and use of R software, Creation of new variables, vectors, matrices, data frames, lists, accessing elements of a vector or matrix, import and export of files, for loop, repeat loop, while loop, if command, if else command, R-functions. | 7 |
| 2 | The plot command, histogram, bar-plot, box-plot, pie diagram, inserting mathematical symbols in a plot, adding text/legend to a plot and other customization of a plot. | 6 |
| 3 | List of Programs:<br>1. Find the addition and subtraction of two matrices.<br>2. Find the product of two matrices.<br>3. Find the inverse of the matrix.<br>4. Check the given number is prime of not.<br>5. Print the Fibonacci sequence.<br>6. Find the sum of two vectors.<br>7. Find the product of two vectors.<br>8. Write R codes that takes the coefficients of a quadratic equation, and outputs an appropriate message for the cases of (i). two distinct roots $\mathbf{b^2-4ac>0}$ (ii) coincident roots $\mathbf{b^2-4ac=0}$ or (iii). complex roots $\mathbf{b^2-4}\boldsymbol{ac}\mathbf{<0}$<br>9. From the pre-summarized data note column and row names. Make the columns of the object available by name. Construct plots. Add axes label and legends.<br>10. From the pre-summarized data in a table draw bar plot and histogram plot. Add axes label and legends.<br>11. R Program to create a Histogram.<br>12. R Program to create a bar-plot.<br>13. R Program to create a box-plot.<br>14. R Program to insert mathematical symbols in a plot.<br>15. R Program to create a pie diagram. | 26 |

**Text Books:**


1. Zuur, A.F., Leno, E.N. & Meesters, A Beginner's Guide to R. Springer, E.H.W.G. 2010.

2. Mark Gardener, Beginning R – The Statistical Programming Language, Wiley, 2013.
3. R for Beginners, Emmanuel Paradis. https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf
4. The Book of R: A First Course in Programming and Statistics, Tilman M. Davies, No Starch Press, Inc. https://web.itu.edu.tr/~tokerem/The_Book_of_R.pdf
5. https://www.tutorialspoint.com/r/r_tutorial.pdf
6. Using R for Numerical Analysis in Science and Engineering, Victor A. Bloomfield, A Chapman & Hall Book. http://hsrm-mathematik.de/SS2020 /semester4 / Datenanalyse-und-Scientific Computing-mit-R/book.pdf
7. Robert Knell, Introductory R: A Beginner's Guide to Data Visualisation, Statistical Analysis and Programming in R, Amazon Digital South Asia Services Inc, 2013
8. The R Software-Fundamentals of Programming and Statistical Analysis -Pierre Lafaye de Micheaux, Rémy Drouilhet, Benoit Liquet, Springer 2013.

**Course Outcomes (COs): At the end of the course, students will be able to:**

| CO | Statement |
|---|---|
| CO1 | set up and operate R software, creating and manipulating variables, vectors, matrices, data frames, and lists. |
| CO2 | demonstrate proficiency in implementing loops, conditional statements, and custom functions for solving basic computational problems in R. |
| CO3 | create customized visualizations, including histograms, bar-plots, and pie diagrams, effectively adding labels, legends, and mathematical symbols. |
| CO4 | apply R programming techniques to solve practical problems, perform matrix and vector calculations, and visualize data with appropriate plots. |

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## DSCP2: Mathematical Methods using Python/R/Matlab

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|---|---|
| **Course:** Mathematical Methods using Python/R/Matlab | **Course Code:** 24MAT2P2 |
| **Teaching Hours/Week(L-T-P):**0-0-4 | **No. of Credits:** 02 |
| **Internal Assessment:** 20Marks | **Semester End Examination:** 30Marks |

**Course Outcomes:**

- To develop skills in solving Fredholm and Volterra integral equations using various methods.
- To apply Laplace and Fourier transforms for solving integro-differential equations and partial differential equations.
- To explore geometric concepts through the computation of geodesics and minimal surfaces.
- To gain proficiency in perturbation methods for both ordinary and partial differential equations.

| Unit | Description | Hours |
|---|---|---|
| 1 | List of Programs:<br>1. Find the solution of Fredholm integral equation by Successive approximation method.<br>2. Find the solution of Fredholm integral equation by Resolvent Kernel method.<br>3. Find the solution of Fredholm integral equation by Separable kernel method.<br>4. Find the solution of Volterra integral equation by Successive approximation method.<br>5. Find the solution of Volterra integral equation by Resolvent Kernel method.<br>6. Find the solution of Volterra integral equation by Separable kernel method.<br>7. Find the solution of integro-differential equations with the aid of Laplace Transformation.<br>8. Find the geodesics on a two-dimensional surface, such as circle.<br>9. Find the minimal surface of revolution around the x-axis.<br>10. Compute the variation of a functional defined as $J(y)=\int_a^b F(x,y,y')\,dx$<br>11. Solve Euler's equation for a specific functional.<br>12. Simulate the shape of a hanging chain (Catenary).<br>13. Solve a simple first order ordinary differential equation by using Laplace Transform.<br>14. Solve a partial differential equation using Fourier Transform.<br>15. Solve an integral equation using Mellin Transform.<br>16. Solve a first order differential equation using Regular Perturbation method.<br>17. Solve a second order differential equation using regular perturbation method. | 52 |

| | | |
|---|---|---|
| | 18. To Solve Boundary Value Problem using Singular Perturbation Method. | |

**Text Books:**

1. Advanced Mathematical methods for scientists and Engineers, Springer Publishers, 1999, C M Bender, S A Orszag, 1999.
2. Integral Transforms and their applications, Taylor and Franscis, L Debnath and D Bhatta, 2007.
3. Linear integral equations theory and techniques, Academic Press, New York, R.P. Kanwal: 1971.
4. Mathematical methods, Himalaya Publishing House, 1st Edition, V ravindranath and P Vijayalakshmi, 2012.
5. I.N. Sneddon – The use of Integral Transforms, Tata McGraw Hill, Publishing Company Ltd, New Delhi, 1974

**Course Outcomes (COs): At the end of the course, students will be able to:**

| CO | Statement |
|---|---|
| CO1 | demonstrate the ability to solve integral equations using successive approximation, resolvent kernel, and separable kernel methods. |
| CO2 | effectively apply Laplace and Fourier transforms to solve complex differential equations. |
| CO3 | analyse and compute geodesics and minimal surfaces, enhancing their understanding of geometry in calculus. |
| CO4 | Stsolve boundary value problems and ordinary differential equations using regular and singular perturbation methods, showing proficiency in advanced mathematical techniques. |

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# SEMESTER-III

## DSC11: Functional Analysis

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|---|---|
| **Course:** Functional Analysis | **Course Code:** 24MAT3C11L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop thorough understanding of normed linear spaces and Banach spaces fundamentals
- Master the key theorems of functional analysis including Hahn-Banach and Open Mapping theorems
- Build strong foundation in Hilbert space theory and orthogonality concepts
- Establish proficiency in operator theory and spectral analysis

| Unit | Description | Hours |
|---|---|---|
| **1** | Normed linear Spaces. Banach Spaces: Definition and examples. Quotient Spaces. Convexity of the closed unit sphere of a Banach Space Example of normed linear spaces which are not Banach space, Holder's inequality. Minkowski's inequality. Linear transformations on a normed linear space and characterization of continuity of such transformations, Linear functional, The conjugate space N*. | 13 |
| **2** | The set *B* (*N, N')* of all bounded linear transformations of a normed linear space N into normed linear space *N*′. The natural imbedding of N into N**. Reflexive spaces. 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. | 13 |
| **3** | 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. orthogonal complements, complete orthonormal sets, Orthogonal decomposition of a Hilbert space. Characterization of complete orthonormal set. Gram-Schmidt orthogonalization process the conjugate space H* of a Hilbert space H. Riesz Representation of a functional f as f(x) = (x, y) with y unique. The Hilbert space H*. | 14 |
| **4** | Bessel' s inequality, Interpretation of T* as an operator on Self-adjoint operators. Positive operators. Normal operators. Unitary operators and their properties. 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. | 12 |

**Text Books:**


1. G. F. Simmons, Introduction to Topology and Modern Analysis (McGraw-Hill Intl. Edition) 2017.
2. S. Kumaresan & D. Sukumar, Functional Analysis: A First Course, Narosa Publication, 2020.
3. G. Backman and L. Narici: Functional Analysis, Dover Publications 2012.
4. B.V. Limaye: Functional Analysis, New Age International (P) Limited, Publishers,

2004.
5. W. Rudin: Introduction to Functional Analysis, McGraw-Hill 2017.
6. E. Kreyszig: Introduction to Functional Analysis with Applications, John Wiley & Sons 2007.

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Analyze normed linear spaces and Banach spaces by applying fundamental inequalities and examining their completeness properties. |
| CO2 | Apply major theorems of functional analysis (Hahn-Banach, Open Mapping, Closed Graph, Uniform Boundedness) to solve theoretical problems. |
| CO3 | Examine Hilbert spaces using orthogonality concepts, including orthonormal bases and the Gram-Schmidt process. |
| CO4 | Analyze operators on Hilbert spaces by studying their properties, including self-adjoint, normal, and unitary operators. |

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## DSC12: Fluid Mechanics

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|---|---|
| **Course:** Fluid Mechanics | **Course Code:** 24MAT3C12L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To develop students' understanding of fundamental fluid properties, flow characteristics, and fluid motion kinematics through Lagrangian and Eulerian approaches.
- To enable students to master the equations of inviscid fluid motion, including Euler's equations, Lagrange's hydrodynamical equations, and Bernoulli's theorem.
- To impart knowledge of two-dimensional fluid motion analysis using stream functions and complex potentials.
- To teach the concepts of sources, sinks, and image theory in two-dimensional fluid flow.

| Unit | Description | Hours |
|---|---|---|
| **1** | Introduction, Some basic properties of fluid, Viscous and inviscid fluids, Viscosity, Newtonian and non-Newtonian fluids, Real and ideal fluids, and some important types of flows. Kinematics of fluid motion: Lagraingian method, Eulerian method, velocity and acceleration of a fluid particle, material, local and convective derivatives and illustrative examples. The equation of continuity in different coordinates, some symmetrical forms of the equation of continuity, Illustrative through examples. Streamline, path line, streak line, velocity potential, Vortex line, Vortex tube, Vortex filament and illustrative example. | 14 |
| **2** | Equations of motion of inviscid fluids: Euler's equation of motion, Euler's equation of motion in Cylindrical and Spherical coordinates. Equation of motion under impulsive forces and illustration through examples. The energy equation, Lagaranges hydrodynamical equations, Cauchy's integrals, Helmholtz vorticity equations. Bernoulli's equation and theorem and illustrations with applications. | 14 |
| **3** | Motion in Two Dimensions: Stream function and its physical significance, complex potential, Cauchy Reimann equation in polar form, complex potential for some uniform flows illustrative through examples. | 12 |
| **4** | Source and sinks in two dimensions, Complex potential due to a source, doublet in two dimensions and illustrative through examples. Images and its advantages, Image of a source with respect to a line and image of a doublet with respect to a line. | 12 |

**Text Books:**


1. Fluid Dynamics, S Chand Publisher, twelfth Edition, M D Raisinghania, 2022.
2. Viscous Fluid Dynamics, Oxford and IBH Publishers, J L Bansal, 2022.
3. Text Book on Fluid Dynamics, CBS Publishers, F Chorlton, 2018.
4. Fluid Mechanics McGraw Hill Book Company, Walther Kaufmann, 1958.
5. An Introduction to Fluid Dynamics, Cambridge University press, G K Batchelor, 2009.
6. A text Book of Fluid Mechanics and Hydraulic Mechanics, Laxmi Publications, R K Bansal,2018.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | State Newton's law of viscosity and demonstrate understanding of fundamental fluid properties, flow characteristics, and fluid motion kinematics through Lagrangian and Eulerian approaches |
| CO2 | Solve complex fluid dynamics problems using Euler's equations, Bernoulli's theorem, and energy equations for various flow conditions |
| CO3 | Analyze two-dimensional fluid flow using stream functions and complex potentials while applying Cauchy-Riemann equations |
| CO4 | Evaluate source-sink flows and implement image theory to solve fluid flow problems around boundaries |

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## DSE1: (A) Classical Mechanics

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|---|---|
| **Course:** Classical Mechanics | **Course Code:** 24MAT3E1AL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To introduce students to tensor calculus and its applications in mechanics
- To develop understanding of continuum mechanics and deformation concepts
- To teach fundamental physical laws and their applications in mechanics
- To familiarize students with equations of linear elasticity and fluid mechanics

| Unit | Description | Hours |
|---|---|---|
| **1** | Coordinate transformations, Cartesian tensors, Basic Properties, Transpose, Symmetric and Skew tensors, Isotropic tensors, Deviatoric Tensors, Gradient, Divergence and Curl in Tensor Calculus, Integral Theorems. | 12 |
| **2** | Continuum Hypothesis, Configuration of a continuum, Mass and density, Description of motion, Material and spatial coordinates, Translation, Rotation, Deformation of a surface element, Deformation of a volume element, Isochoric deformation, Stretch and Rotation, Decomposition of a deformation, Deformation gradient, Strain tensors, Infinitesimal strain, Compatibility relations, Principal strains. | 13 |
| **3** | Material and Local time derivatives Strain, rate tensor, Transport formulas, Streamlines, Path lines, Vorticity and Circulation, Stress components and Stress tensors, Normal and shear stresses, and Principal stresses. Fundamental basic physical laws, Law of conservation of mass, Principles of linear and angular momentum. | 13 |
| **4** | Equations of linear elasticity, Generalized Hooke's law in different forms, Physical meanings of elastic moduli, and Navier's equation. Equations of fluid mechanics, Viscous and non-viscous fluids, Stress tensor for a no-viscous fluid, Euler's equations of motion, Equation of motion of an elastic fluid, Bernoulli's equations, Stress tensor for a viscous fluid, Navier-Stokes equation. | 14 |

**Text Books:**

1. D.S. Chandrasekharaiah and L. Debnath: Continuum Mechanics, Academic Press, 1994.
2. A.J.M. Spencer: Continuum Mechanics, Longman, 1980.
3. Goldstein, Classical Mechanics, Addison – Wesley, 3rd Edition, 2001.
4. F. Chorlton, Text Book of Dynamics, (ELBS Edition), G. Van Nostrand and co. (1969).

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply tensor calculus techniques to solve problems in mechanics and understand integral theorems |
| CO2 | Analyze continuum hypothesis, deformation concepts and strain tensors in mechanical systems |
| CO3 | Evaluate material derivatives, stress tensors and apply conservation laws in mechanical systems |
| CO4 | Solve problems using equations of linear elasticity and fluid mechanics including Navier-Stokes equations |

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## DSE1: (B) Approximation Theory

| | |
|---|---|
| **Course:** Approximation Theory | **Course Code:** 24MAT3E1BL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Understand objects required for approximation theory.
- Develop proficiency in constructing and analysing bases for Hilbert space.
- Gain a thorough understanding of best approximation.
- Learn ridge functions in approximating multivariable functions.

| Unit | Description | Hours |
|---|---|---|
| 1 | **Function spaces:** Topology of normed spaces, geometry of unit balls, convergence in normed spaces, equivalent of two norms, completion of normed space. Computation of closure and density of some standard subsets in a normed space. Linear operators on normed spaces. Bernstein polynomials, Weierstrass approximation theorem. Series in normed spaces. Inner product spaces, orthonormal system in Hilbert space. | 13 |
| 2 | **The Hilbert Space $L2$(R):** Basics on of $L2$(R), celebrated inequalities in $L2$(R), linear operators on $L2$(R), density of polynomials in $L2$((a, b)). Construction of orthonormal basis for $L2\ (-\pi, \pi)$, $L2$((a, b)) and $L2\ (0, \pi)$. Characterization of dense subsets in Hilbert space. Compact sets, Heine-Borel theorem, compact operators and their applications. | 13 |
| 3 | **Orthogonal Projections:** Recapitulation operators. Orthogonal subspaces. Orthogonal basis for subspaces of Hilbert space. Bessel's sequence. Properties of Orthogonal projection on Hilbert space into its subspace. Taylor polynomials from orthogonal projection, trigonometric polynomials, least squares. | 13 |
| 4 | **Ridge functions:** Role of ridge functions in approximating multivariable functions. Topology on space $C$(X) of all continuous real valued functions on the normed liner space X. Convergence in $C$(X), subalgebra of $C$(X). Construction of fundamental sets in $C$(X), for different normed spaces X using ridge functions. Sigmoid function, modulus continuity, Debao Chen theorem and applications. | 13 |

**Text Books:**


1. Ole Christensen; Functions, Spaces, and Expansions: Mathematical Tools in Physics and Engineering, Birkhauser, 2010.
2. Ward Cheney and Will Light, A Course in Approximation Theory, University Press, 2013.
3. Kendall Atkinson and Weimin Han, Theoretical Numerical Analysis: A Functional Analysis Framework, Springer, 2001.
4. V.K. Krishnan, A Textbook of Functional Analysis: A Problem-Oriented Approach, PHI, 2014.
5. H. N. Mhaskar and D.V. Pai, Fundamentals of Approximation Theory, CRC/ Narosa, 2000.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Write clear and precise proof(s) of celebrated theorems in approximation theory. |
| CO2 | Ability to construct subspaces of precise dimensions in Hilbert space. |
| CO3 | Gaining of knowledge between error minimization through orthogonal projections. |
| CO4 | Determination ridge functions for approximating functions of several variables. |

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## DSE1: (C) Operator Theory

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|---|---|
| **Course:** Operator Theory | **Course Code:** 24MAT3E1CL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Develop a comprehensive understanding of operators on Hilbert spaces, including self-adjoint, normal, unitary, and positive operators, and their properties.
- Study spectral theory, focusing on the spectrum, eigenvalues, and key theorems like the spectral radius formula and spectral mapping theorem.
- Analyze finite rank and compact operators, applying the Riesz-Schauder theory and spectral theorem, and explore singular value decomposition.
- Gain familiarity with Banach and - algebras, Gelfand theory, and the functional calculus for elements in Banach and C-algebras.

| Unit | Description | Hours |
|---|---|---|
| **1** | Operators on Hilbert spaces: self-adjoint, normal, unitary, isometry, partial isometry, projections, positive operators. Subnormal and hyponormal operators. | 13 |
| **2** | Spectral Results: Eigen spectrum and spectrum; spectral radius formula; spectral mapping theorem; spectrum of various operators on Hilbert space. | 12 |
| **3** | Finite rank operators, compact operators; Riesz-Schauder theory for compact operators; spectral theorem for compact self-adjoint and compact normal operators; singular value decomposition of compact operators; Trace class & Hilbert Schmidt operators. Semi inner product space | 13 |
| **4** | Banach algebras, spectrum of a Banach algebra element, Holomorphic functional calculus, Gelfand theory of commutative Banach algebras.<br>***- Algebras**: Structure B*- Algebra and C* algerabs, | 14 |

**Text Books:**


1. Daniel. Operator Theory, Springer 2015.
2. M. A. Bastos. Operator theory, Functional Analysis and Applications, Birkhluser Publication.
3. G. Bachman and L. Narici: Functional Analysis, Dover Publications 2012.
4. B.V. Limaye, Functional Analysis, New Age International Limited
5. S.K. Berbenon, Lectures in Functional Analysis and Operator Theory, Narosa, 1979.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Classify and analyse various types of operators on Hilbert spaces, applying properties of self-adjoint, normal, and isometric operators. |
| CO2 | Apply spectral results, including spectral mapping and the spectral radius formula, to determine the spectrum of operators. |
| CO3 | Solve problems involving compact operators using the Riesz-Schauder theory, spectral theorem, and singular value decomposition. |
| CO4 | Demonstrate understanding of Banach algebras, apply Gelfand theory to commutative algebras, and perform functional calculus on Banach algebra elements. |

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## DSE2: (A) Differential Geometry

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|---|---|
| **Course:** Differential Geometry | **Course Code:** 24MAT3E2AL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Understand fundamental concepts of calculus on Euclidean spaces, including differentiable functions, tangent vectors, and vector fields.
- Study properties of curves in $E^3$, covering reparameterization, velocity, and the Frenet frame, along with curvature and torsion.
- Learn the geometry of isometries in $E^3$ such as translations, rotations, and transformations, including orientation and congruence of curves.
- Explore calculus on surfaces in $E^3$, including tangent vectors, differential forms, and mapping properties of common surfaces like spheres and cylinders.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Calculus on Euclidean Space:** Euclidean space. Natural coordinate functions. Differentiable functions. Tangent vectors and tangent spaces. Vector fields. Directional derivatives and their properties. Curves in $E^3$. Velocity and speed of a curve. Reparameterization of a curve. 1-forms and Differential forms. Wedge product of forms. Mappings of Euclidean spaces, Derivative map. | 13 |
| **2** | **Frame Fields:** Vector field along a curve. Tangent vector field, Normal vector field and Binormal vector field. Curvature and torsion of a curve. The Frenet formulas, Frenet approximation of unit speed curve and Geometrical interpretation. Properties of plane curves and spherical curves, Covariant derivatives, connection forms | 13 |
| **3** | **Euclidean Geometry:** Isometries of $E^3$ - Translation, Rotation and Orthogonal transformation. The Tangent map of an isometry, Orientation, Orientation preserving and reversing isometries, Euclidean Geometry, Congruence of Curves | 13 |
| **4** | **Calculus on a Surface:** Coordinate path. Monge path. Surface in $E^3$. Special surfaces-sphere, cylinder and surface of revolution. Parameter curves, velocity vectors of parameter curves, Patch computation. Differentiable functions and tangent vectors, Differential forms on a surface, Mappings of surfaces. | 13 |

**Text Books:**

1. Barrett O' Neil: Elementary Differential Geometry. Revised Second Edition, Academic Press, New York and London, 2006.
2. T. J. Willmore: An introduction to Differential Geometry. Dover Publications, 2013.
3. D. J. Struik: Lectures on Classical Differential Geometry, Second edition, Addison Wesley, Reading, Massachusetts, 1961.
4. Nirmala Prakash: Differential Geometry- an integrated approach. Tata McGraw-Hill, New Delhi, 1981.

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Apply calculus tools in Euclidean spaces to analyse differentiable functions, vector fields, and directional derivatives. |
| CO2 | Calculate curvature, torsion, and use Frenet formulas for understanding the properties and geometry of curves in $E^3$. |
| CO3 | Use isometries and transformations to solve problems in Euclidean geometry, understanding orientation-preserving and reversing transformations. |
| CO4 | Compute tangent vectors, differential forms, and mappings on surfaces, and analyse geometric properties of standard surfaces in $E^3$. |

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## DSE2:(B) Fuzzy Sets and Structures

| | |
|---|---|
| **Course:** Fuzzy Sets and Structures | **Course Code:** 24MAT3E2BL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Introduce the foundational concepts of fuzzy sets, including types, membership functions, and basic operations like union, intersection, and complement.
- Explore fuzzy relations and functions, covering concepts like fuzzy equivalence relations, composition, and differentiation of fuzzy functions.
- Study fuzzy numbers and their operations, including arithmetic operations, types of fuzzy numbers, and fuzzy equations.
- Provide an overview of fuzzy logic, multi-valued logic, and the integration of fuzzy systems with neural networks, including fuzzy neural nets.

| Unit | Description | Hours |
|---|---|---|
| 1 | Fuzzy sets: Introduction, Crisp set, Fuzzy set, Types of Fuzzy sets, Characteristics and Significance of the Paradigm shift, Membership functions, Properties of a cuts, Standard operation of fuzzy sets, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, t- norms and t- conforms, Extension principle for fuzzy sets. | 13 |
| 2 | Fuzzy Relations and Functions: Crisp and fuzzy relations, Projections and cylindrical Extension, binary fuzzy relations, membership matrices and sagittal diagram, inverse and composition of fuzzy relations, Binary fuzzy relations on a single set, Fuzzy equivalence relation, Fuzzy relation equations, Concept of fuzzy functions, Kinds of fuzzy function, Fuzzy extrema of function, Integration and Differentiation of fuzzy function | 14 |
| 3 | Fuzzy Numbers: Concept of fuzzy number, Operation of fuzzy number, Triangular fuzzy number, other types of fuzzy number, Arithmetic operations on intervals, Arithmetic operations on fuzzy numbers, Lattice of fuzzy numbers, Fuzzy Equations, | 12 |
| 4 | Fuzzy logic and Neural Nets: An overview of classical logic, Boolean algebra, Multivalued logics, Interval-valued fuzzy logic, Canonical forms, Notes on probabilistic logic, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Variables and hedges, Introduction to Neural Nets, Layered, Feedforward, Neural Nets, Fuzzy Neural Nets. | 13 |

**Text Books:**


1. James J. Buckley Esfandiar Eslami -An Introduction Fuzzy Logic and Fuzzy Sets- (2002).
2. H. Lee -First course on Fuzzy Theory and Applications, Springer- Verlag Berlin Heidelberg- Kwang (2005).
3. Hung T. Nguyen Elbert A. Walker -A First Course in Fuzzy Logic (2006)
4. Hung T. Nguyen, Nadipuram R. Prasad Carol L. Walker, Elbert A. Walker -A First

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply foundational probability concepts, using set theory, Bayes' theorem, and independence concepts in practical probability scenarios. |
| CO2 | Compute probability distributions, expectations, variances, and covariances for both discrete and continuous random variables. |
| CO3 | Calculate and interpret measures of central tendency for frequency distributions and understand their advantages and limitations. |
| CO4 | Measure dispersion and correlation, interpreting results using standard deviation, coefficient of variation, and correlation coefficients with real data examples. |

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## GEC1: (A) Mathematical Physics

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|---|---|
| **Course:** Mathematical Physics | **Course Code:** 24MAT3G1AL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Introduce the Laplace transform and its properties, including linearity, shifting theorems, and transformations of functions of exponential order.
- Study the applications of Laplace transforms to solve differential equations involving periodic and special functions.
- Learn Fourier transforms, including finite and infinite types, sine and cosine transforms, and their key properties and inverse transforms.
- Explore additional integral transforms like the Z-transform and Mellin transform and their uses in signal processing and systems analysis.

| Unit | Description | Hours |
|---|---|---|
| **1** | Laplace Transform: Integral Transform, Laplace Transform definitions, Linearity Property of Laplace Transform, piecewise continues functions, existence of Laplace transforms, Functions of Exponential order, Function of class A, first shifting theorem, Second translation, Change of scale property and its examples, Periodic Functions, Some special functions. | 15 |
| **2** | Fourier Transforms: Finite and Infinite Fourier transforms, Fourier sine and cosine transforms, properties inverse transforms. Z - transforms. Meline transforms. | 11 |
| **Text Books:**<br>1. Jon Mathews, Mathematical Method of physics.<br>2. Boas, Mathematical Method in physical sciences. | | |

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply the Laplace transform and its properties to analyse piecewise continuous functions, exponential functions, and functions of class A. |
| CO2 | Solve differential equations and periodic function problems using Laplace transform techniques and shifting theorems. |
| CO3 | Use Fourier transforms, including sine and cosine forms, to handle both finite and infinite interval problems and determine inverse transforms. |
| CO4 | Utilize Z-transforms and Mellin transforms in practical applications, particularly in discrete-time systems and signal processing. |

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## GEC1: (B) Mathematical Biology

| | |
|---|---|
| **Course:** Mathematical Biology | **Course Code:** 24MAT3G1BL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Introduce the concept of mathematical modelling, emphasizing the formation, solution, and interpretation of mathematical models across various fields.
- Explore different types of mathematical models, their limitations, and their applications in real-world scenarios, particularly in population biology.
- Examine stability and classification of equilibrium points in mathematical models, including the relationship between eigenvalues and critical points.
- Study single-species population models, both non-age structured and age structured, and their applications, including basic concepts of fluid dynamics in modeling blood flow.

| Unit | Description | Hours |
|---|---|---|
| **1** | Mathematical Modeling:<br>Introduction, Some fundamental concepts, Mathematical modelling, Formation of a Mathematical model, Solution of a Mathematical Model, Interpretation of the solution, Types of Models, Limitations of Models, Areas of modeling. Some simple Mathematical Models. | 12 |
| **2** | Mathematical Aspects of Population Biology:<br>Mathematical Modelling in Biology, Stability and Classification of Equilibrium points. Relationship between eigen values and critical points. Single- Species Models (Non-age structured): Exponential growth Model, Single-Species Models (Age Structured): Continus-Time Continuous-Age-Scale population Models, Introduction to some Basic concepts of Fluid Dynamics: Model for Blood flow - Formation. | 14 |

**Text Books:**

1. James D Murray. Mathematical Biology, Springer, 2002.
2. Mathematics of Medicine and biology: J.G. Gefares, I.N. Sneddon.
3. J. N. Kapur. Mathematical Models in Biology and Medicine, New Delhi, Affiliated East-West Press, 1985.
4. J.D. Logan & W.R. Wolesensky. Mathematical Methods in Biology, Publisher: John Wiley & Sons Inc..

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Formulate and analyse mathematical models for a variety of scenarios, understanding the significance of model creation and interpretation in problem-solving. |
| CO2 | Classify and evaluate equilibrium points in models, utilizing eigenvalues to assess stability and behaviour of population dynamics. |
| CO3 | Apply exponential growth and age-structured models to describe single-species populations, demonstrating an understanding of their biological implications. |
| CO4 | Integrate basic fluid dynamics concepts into population biology models, particularly in modelling blood flow, showcasing interdisciplinary applications of mathematical modelling. |

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## GEC1: (C) Graph Theory

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|---|---|
| **Course:** Graph Theory | **Course Code:** 24MAT3G1CL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Introduce fundamental concepts in graph theory, including graphs, subgraphs, degree sequences, and the distinctions between connected and disconnected graphs.
- Explore specific types of graphs, such as Euler graphs and Hamiltonian paths/circuits, and understand their applications, including the Traveling Salesman Problem.
- Study the properties and characterization of trees, including spanning trees, fundamental circuits, and distance measures within trees.
- Familiarize students with matrix representations of graphs (incidence, adjacency, circuit matrices) and introduce basic algorithms for connectedness, spanning trees, and shortest paths.

| Unit | Description | Hours |
|---|---|---|
| **1** | Introduction to Graphs, Subgraphs, Degree Sequences and Graphic Sequences, Walks, Paths and Circuits, Connected Graphs, Disconnected Graphs, Euler Graph, Hamiltonian Paths and Circuits, The Traveling Salesman Problem. Trees, Characterization of Trees, Distance and Centers in a Trees, Spanning Trees, Fundamental Circuits, Finding all Spanning Tree of a Graph. | 13 |
| **2** | Incidence Matrix, Adjacency Matrix, Circuit Matrix, Fundamental Circuit Matrix, An Application to a Switching Network. Some Basic Algorithms: Algorithm of Connectedness and Components, A Spanning Tree, A Set of Fundamental Circuits, Shortest Path from a Specifies Vertex to another Specifies Vertex. | 13 |

**Text Books:**


1. Narasing Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, India (1995)
2. F. Harary: Graph Theory, Addison Wesley, Reading mass (1969)
3. F. Buckley and F. Harary: Distance in Graphs, Addison-Wesley (1990)
4. J. A. Bondy and V. S. R. Murthy: Graph Theory with Applications, MacMillan,
5. London.
6. S. Arumugam & S. Ramachandran. Invitation to Graph Theory, Scitech Publications (India) PVT. LTD, 2013.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Demonstrate the ability to identify and analyse different types of graphs, including walks, paths, circuits, and their properties. |
| CO2 | Apply concepts of Euler and Hamiltonian graphs to solve practical problems, including the formulation of the Traveling Salesman Problem. |
| CO3 | Characterize and compute spanning trees, fundamental circuits, and distances in tree structures, showcasing their importance in network design. |
| CO4 | Utilize graph matrix representations to analyse graphs and implement basic algorithms for determining connectedness, constructing spanning trees, and finding shortest paths in graphs. |

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## SEC3: Research Methodology

| | |
|---|---|
| **Course:** Research Methodology | **Course Code:**24MAT3S3LP |
| **Teaching Hours/Week (L-T-P):** 1-0-2 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Provide an overview of research fundamentals, including objectives, motivation, types of research, significance, and the research process.
- Explore criteria for good research and the steps for selecting a viable research problem, along with various sources of literature and citation indices.
- Introduce key statistical concepts relevant to research, focusing on measures of central tendency, dispersion, normal distribution, and relationships between variables.
- Familiarize students with hypothesis testing concepts, including various statistical tests such as Student's t-test, Chi-square test, and ANOVA.

| Unit | Description | Hours |
|---|---|---|
| 1 | **Introduction to Research**:<br>Introduction – Objectives, Motivation, Types of research, significance, research process. Criteria of Good Research. Selection of a research problem. Sources of literature – Journals, Conferences, Books, Literature Survey engines- Scopus, web of Science, Google Scholar, PubMed, NCBI, Scihub, etc. Science citation index: Citations, h-index, i10 index, impact factor. | 7 |
| 2 | Statistics in Research - Measures of Central Tendency, Measures of dispersion - Normal distribution, Gaussian distribution, Skewness of a distribution. Measures of relationship – Correlation and regression – simple regression analysis (linear regression). Hypotheses – basic concepts of testing of hypotheses, procedure for hypothesis testing, Tests of hypotheses - Student's t-test, Chi-square test, ANOVA test. | 6 |
| 3 | **Practical:**<br>1. Program to calculate the mean, standard deviation, and variance of a dataset<br>2. Program to calculate the variance of a dataset<br>3. Program that demonstrates curve fitting to perform linear regression<br>4. Program to compute the normal distribution given the mean and standard deviation.<br>5. Program to compute and plot a Gaussian distribution given the mean and standard deviation.<br>6. Program that generates, visualizes, and allows you to adjust the skewness of a distribution<br>7. Program demonstrating hypothesis testing and interpreting p-values<br>8. program to perform a Student's t-test | 26 (Lab) |

| | | |
|---|---|---|
| | 9. Program to perform a one-way ANOVA test.<br>10. Program that performs a Chi-square test | |

**Text Books:**

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New Age International Publishers, (2009).
2. Shanthibhushan Mishra, Shashi Alok, Handbook of Research Methodology, I Ed, 2017, Edu creation Publishers.
3. Basic Statistical Tools in Research and Data Analysis (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/).
4. Introduction to Statistical methods with MATLAB (MATLAB and Simulink Training (mathworks.com)

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Demonstrate a clear understanding of the research process, including how to identify and formulate research problems based on significance and motivation. |
| CO2 | Conduct comprehensive literature reviews using various sources and tools, and critically evaluate research based on citation metrics like h-index and impact factor. |
| CO3 | Apply statistical measures to analyse data, understanding the implications of central tendency, dispersion, and distribution characteristics in research contexts. |
| CO4 | Execute hypothesis testing using appropriate statistical tests, interpreting results to validate or refute research hypotheses and draw meaningful conclusions. |

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## DSCP3: Linear Algebra Lab using PYTHON/ R/ MATLAB

| **Course:** Linear Algebra Lab using PYTHON/ R/ MATLAB | **Course Code:** 24MAT3P3 |
|---|---|
| **Teaching Hours/Week (L-T-P):** 0-0-4 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Develop practical skills in linear algebra by performing various operations on vectors and matrices, including determining angles, ranks, nullities, and checking orthogonality.
- Enhance understanding of the properties of linear systems by testing consistency, linear dependency, and span of vectors within given sets.
- Implement algorithms for vector space transformations, including Gram-Schmidt orthogonalization, transition matrices, and the application of eigenvalues and eigenvectors in matrix analysis.
- Gain experience in numerical methods for solving systems of ordinary differential equations and fitting polynomials to functions, employing computational tools like MATLAB.

| Unit | Description | Hours |
|---|---|---|
| 1 | List of Programs:<br>1. Find the angle between two vectors in n-dim space and check the orthogonality.<br>2. Find the rank and nullity of a matrix through its row reduced echelon form.<br>3. Test whether or not vector v is in the span of a set of vectors.<br>4. Discuss the nature of consistency for system of linear equations.<br>5. Check the linear dependency of set of vectors.<br>6. Determine whether or not the system of linear equations Ax=b, where A=ones (3,2) b=[1;2;3]; possesses an exact solution x.<br>7. Compute and print the basis and dimension of each four fundamental subspaces associated with a matrix.<br>8. Find the coordinate matrix of a vector in a vector space of dimension 4 with respect to some basis.<br>9. Check a given vector orthogonal to column space of a given matrix.<br>10. Compute the transition matrix from one vector space to another vector space.<br>11. Compute some parameters of a matrix using its eigenvalues and eigenvectors such as trace, determinant and condition number, algebraic multiplicity etc.<br>12. Read set of vectors in a Euclidean space and check the nature of orthogonality.<br>13. Write a function to illustrate Gram-Schmidt orthogonalization process in a Euclidean space of dimension 4.<br>14. Verify the Bessel's inequality.<br>15. Compute some polynomials and canonical forms associated with a given matrix.<br>16. Solve simple system of ordinary differential equations using exponential matrix. | 52 |

| | | |
|---|---|---|
| | 17. Construct a Vandermonde matrix, Toeplitz matrix, Hilbert matrix and find their traces.<br>18. Read a matrix A. Determine whether or not the matrix A is diagonalizable. If so, find a diagonal matrix D that is similar to A.<br>19. Fit a cubic polynomial for sin(2t) over [0, pi/2].<br>20. Let A be a real matrix. Use MATLAB function ref to extract all<br>(a) columns of A that are linearly independent<br>(b) rows of A that are linearly independent. | |

**Text Books:**

1. D.R. Hill and D.E. Zitarelli, Linear Algebra Labs with MATLAB, 2nd edition, Prentice.
2. Hall, Upper Saddle River, NJ, 1996.
3. Gilbert Strang, Linear Algebra and its applications,4th edition, Thomson,2006.

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Successfully calculate angles between vectors, determine their orthogonality, and find the rank and nullity of matrices, demonstrating a foundational understanding of linear algebra concepts. |
| CO2 | Evaluate the consistency of linear systems, ascertain the linear independence of vectors, and verify whether vectors belong to a specific span, applying theoretical knowledge in practical scenarios. |
| CO3 | Utilize matrix operations and algorithms, including the Gram-Schmidt process and eigenvalue analysis, to manipulate and analyse vector spaces effectively. |
| CO4 | Implement computational techniques to solve differential equations, construct special matrices, and perform polynomial fitting, enhancing analytical and programming skills in mathematical applications. |

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**DSCP4: Differential Equations Lab using PYTHON/ R/ MATLAB**

| | |
|---|---|
| **Course:** Differential equations Lab using PYTHON/ R/ MATLAB | **Course Code:** 24MAT3P4 |
| **Teaching Hours/Week (L-T-P):** 0-0-4 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- Equip students with the skills to programmatically solve first and second-order ordinary differential equations (ODEs) using various numerical methods and initial value problems (IVPs).
- Enable students to visualize solutions to ODEs and IVPs through graphical representation, enhancing their understanding of the behaviour of differential equations.
- Introduce different numerical techniques, including Euler's methods, Picard’s method, and various Runge-Kutta methods, for approximating solutions to differential equations.
- Foster critical thinking and problem-solving abilities by engaging students in programming exercises that require the application of theoretical concepts to practical scenarios in differential equations.

| Description | Hours |
|---|---|
| **List of Programs:**<br>1. Write a program to solve the first order ordinary differential equation.<br>2. Write a program to solve the first order initial value problem and use plot command for plotting the solution of IVP.<br>3. Write a program to solve the second order ordinary differential equation.<br>4. Write a program to solve the second order initial value problem and use plot command for plotting the solution of IVP.<br>5. Write a program to solve the higher order initial value problem and use plot command for plotting the solution of IVP.<br>6. Write a program to solve the first order system of ordinary differential equation and use plot command for plotting the solution of IVP.<br>7. Program to find approximate solution of a differential equation with initial condition by Picard’s method of successive approximation.<br>8. Program to find the numerical solution of a differential equation with initial condition by Euler’s method.<br>9. Program to find the numerical solution of a differential equation with initial condition by Euler’s modified method.<br>10. Program to find the numerical solution of a differential equation with initial condition by Runge-Kutta II order method. | 52 |

| | |
|---|---|
| 11. Program to find the numerical solution of a differential equation with initial condition by Runge-Kutta III order method.<br>12. Program to find the numerical solution of a differential equation with initial condition by Runge-Kutta IV order method. | |

**Text Books:**

1. Allen Downey, Jeff Elkner, and Chris Meyers -Learning with Python. (2015)
2. C.H. Swaroop -A Byte of Python. (2013).
3. Eric Matthews -Python Crash Course. (2016).
4. Advanced Mathematical methods for scientists and Engineers, Springer Publishers, 1999, C M Bender, S A Orszag, 1999.
5. Hans-Petter Halvorsen, Python for Science and Engineering, 2019. ISBN: 978-82-691106-5-4.
6. John C. Polking, Ordinary Differential Equations Using MATLAB, Pearson Education, 2009.
7. Alexander Stanoyevitch, Introduction to Numerical Ordinary and Partial Differential Equations Using MATLAB, Wiley, 2011.

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Successfully write and execute programs to solve first and second-order ordinary differential equations and initial value problems, demonstrating proficiency in numerical methods. |
| CO2 | Create visual representations of ODE solutions using plotting commands, allowing for a deeper comprehension of the dynamics and characteristics of the equations. |
| CO3 | Apply various numerical techniques, including Euler's methods and Runge-Kutta methods, to compute approximate solutions for a range of differential equations with initial conditions. |
| CO4 | Develop critical analytical skills through hands-on programming experiences, enabling students to effectively tackle complex differential equation problems in computational settings. |

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# SEMESTER-IV

## DSC13: Advanced Fluid Mechanics

| | |
|---|---|
| **Course:** Advanced Fluid mechanics | **Course Code:** 24MAT4C13L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To develop understanding of stress tensors and rate of strain in viscous fluids
- To teach Navier-Stokes equations and their applications in fluid dynamics
- To introduce concepts of dynamical similarity and exact solutions
- To familiarize students with laminar boundary layer theory

| Unit | Description | Hours |
|---|---|---|
| **1** | General theory of Stress and Rate of strain: Newton's law of viscosity, body and surface forces, Definitions of stress , stress vector and components of stress tensor, state of stress at a point, transformation of stress components, plane stress, principal stress and principal directions of the stress tensor, Nature of strain, Transformation of the rate of strain components, Stokes law of viscosity, The rate of strain quadric Translation, rotation and rate of deformation , and illustrative with applications. | 11 |
| **2** | The Navier Stokes equations of motion of a viscous fluid**,** The energy equation, equation of state for perfect fluid, diffusion of vorticity, equations of vorticity and circulation, dissipation of energy in Cartesian form, illustrative through examples. Vorticity transport equation, Diffusion of a vertex filament. Summary of basic equations governing the flow of viscous fluid in cartesian co-ordinates. | 11 |
| **3** | Dynamical similarity, Reynolds principle of similarity and its significance, inspection analysis in case of flow of viscous compressible fluid. Some exact solutions of Navier-Stokes equations: Determination of velocity distribution in steady laminar flow of viscous incompressible fluid: Plane Couette flow, generalized plane Couette flow, plane Poiseuille flow, illustrative with example, flow through a circular pipe The Hagen-Poiseuille flow, laminar steady flow between two co- axial circular cylinders, illustration with examples. | 15 |
| **4** | Laminar Boundary Layers: Prandtl's boundary layer concept. Derivation of two-dimensional boundary layer equation for velocity &temperature by order magnitude approach. Boundary layer thickness, Displacement thickness, Energy thickness, boundary layer flow past a fiat plate- Blasius solution. Similar solutions of the boundary layer equations, Separation of boundary layer flow (physical and analytical approach), Boundary layer flow over a wedge. | 15 |

**Text Books:**


1. Text Book on Fluid Dynamics, CBS Publishers, F Chorlton, 2018.
2. Fluid Mechanics McGraw Hill Book Company, Walther Kaufmann, 1958.
3. An Introduction to Fluid Dynamics, Cambridge University press, G K Batchelor2009.
4. Fluid Dynamics S Chand Publisher, 2nd Edition, M D Raisinghania, 2020.

5. Viscous Fluid Dynamics, Oxford and IBH Publishers, J L Bansal2004
6. A text Book of Fluid Mechanics and Hydraulic Mechanics, Laxmi Publications, R K Bansal,2018.
7. Fluid Mechanics, Khanna Publishers, Jain A K, 2998.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Analyze stress tensors and rate of strain components in viscous fluids and apply Newton's law of viscosity |
| CO2 | Solve fluid flow problems using Navier-Stokes equations and vorticity transport equations |
| CO3 | Apply principles of dynamical similarity and determine exact solutions for various laminar flow conditions |
| CO4 | Evaluate boundary layer problems using Prandtl's concept and analyze flow separation phenomena |

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## DSC14: Advanced Numerical Analysis

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|---|---|
| **Course:** Advanced Numerical Analysis | **Course Code:** 24MAT4C14L |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To introduce advanced numerical integration techniques and their analysis
- To develop understanding of numerical solutions for IVP and ODE
- To teach numerical methods for boundary value problems in ODE and PDE
- To familiarize students with curve fitting and regression analysis

| Unit | Description | Hours |
|---|---|---|
| **1** | Numerical Integration: Newton-cotes integration methods- Trapezoidal method, Simpson 1/3rd and 3/8th rule and Weddle rule. Gaussian integration methods and their analysis, Gauss-Legendre, Gauss-Hermite, Gauss-Laguerre and Gauss-Chebyshev integration methods and their analysis. | 13 |
| **2** | Numerical Solution of IVP for ordinary differential Equations: Initial Value problems- Taylors series method, Euler method, modified Euler method, Stability of 1st and 2nd order method, Runge-Kutta methods (2nd and 4th order), R-K method for simultaneous and higher order differential equations, Adam-Bashforth method, Milne predictor - Corrector methods, Finite difference method, | 14 |
| **3** | Numerical solution of Boundary value problems for ODE and PDE: ODE- Shooting method, Galerkin method. PDE- Classification of partial differential equation, Derivation of finite difference approximations to its derivatives, solution of Laplace equation by Jacobi s method, Guass seidal method, Solution of heat equation by Schmidt method, Solution of wave equation by finite difference method. | 13 |
| **4** | Curve fitting, Regression analysis: curve fitting, Regression analysis, inferences based on the least squares estimation, nonlinear regression, curve fitting by a sum of exponentials, fitting a straight line- second degree curve-exponential curve-power curve by method of least squares. | 12 |

**Text Books:**


1. Introductory methods of Numerical Analysis, PHI Publisher, 2012, S. S. Sastry,
2. Numerical Methods for Scientists and Engineers, PHI Publishers, K Sankara Rao, 2007.
3. Numerical methods for scientific and Engineering Computation, New Age International Publishers, M K Jain, S R K Iyengar and R K Jain, 2014.
4. Numerical Mathematical Analysis 6th Edition, Oxford and IBH publisher, J B Scarborough, 1984.
5. Numerical methods in Engineering and Science, Khanna Publishers, B S Grewal, 2013.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Apply advanced numerical integration methods and analyze their accuracy |
| CO2 | Solve initial value problems using various numerical methods and analyze their stability |
| CO3 | Implement numerical solutions for boundary value problems in ODEs and PDEs |
| CO4 | Analyze data using curve fitting and regression techniques |

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## DSE3: (A) Mathematical Modeling

| | |
|---|---|
| **Course:** Mathematical Modeling | **Course Code:** 24MAT4E3AL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To introduce mathematical modeling concepts using differential equations
- To develop understanding of population dynamics and epidemic models
- To teach modeling techniques using second-order ODEs
- To familiarize students with difference equations and graph theory in modeling

| Unit | Description | Hours |
|---|---|---|
| **1** | Ordinary differential equation, Linear growth model, Growth of science and scientists, Non-linear growth and decay models, Diffusion of glucose or a medicine in the bloodstream. | 13 |
| **2** | Modeling in population dynamics, Prey-predator models, Competition models, Multi Species models, Modeling of epidemics, Simple epidemic models, A model for diabetic-mellitus. | 13 |
| **3** | Modeling in second order O.D.E., Modeling of planetary motion, Motion under central force, Circular motion, Elliptic motion of a satellites, rectilinear motion. | 13 |
| **4** | Modeling through difference equations, Linear difference equation, Harrod model, cob-web model, Modeling through graphs, seven bridge problem, representing results of tournament, Genetic graph, Food web, Communication network, Matrices associated with a directed graph, Detection of clique. | 13 |

**Text Books:**


1. J. N. Kapur, Mathematical Modeling, Wiley Eastern Limited, New Age International Pvt. Ltd., Reprint 2013.
2. J. N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press, New Delhi, 1985.
3. R. Olink, Mathematical Models in Social and Life Sciences, 1978.

**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Develop and analyze mathematical models using differential equations |
| CO2 | Apply modeling techniques to population dynamics and epidemic scenarios |
| CO3 | Solve real-world problems using second-order ODE models |
| CO4 | Implement difference equations and graph theory in practical modeling situations |

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## DSE3:(B) Haar Wavelets and Artificial Neural Networks.

| | |
|---|---|
| **Course:** Haar Wavelets and Artificial Neural Networks. | **Course Code:** 24MAT4E3BL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- Understand objects required for Haar spaces.
- Develop proficiency in constructing and analysing Haar wavelet transform.
- Gain a thorough understanding of existence of minima and argmin.
- Role of universal approximation theorem in approximating functions.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Haar Spaces**: The Haar space $\mathbf{V_0}$, orthogonal basis for $\mathbf{V_0}$ projection from $L2(R)$ into $\mathbf{V_0}$. General Haar space $\mathbf{V_J}$, elements in $\mathbf{V_J}$, orthonormal basis for $\mathbf{V_J}$, Dyadic intervals, Nestedness of spaces $\mathbf{V_J}$ and other properties. Separation of $\mathbf{V_J}$ and dense: approximating a finite energy function by piecewise constants. | 13 |
| **2** | **Haar MRA**: The Haar wavelet space $\mathbf{W_0}$, projecting functions in $\mathbf{V_1}$ into $\mathbf{V_0}$, residual and wavelet function, residual space, orthogonal basis for $\mathbf{W_0}$. Haar scaling function and dilation equation. Relation between three spaces: $\mathbf{V_1}$, $\mathbf{V_0}$, $\mathbf{W_0}$. General Haar wavelet space $\mathbf{W_J}$, o. Discrete Haar wavelet transform and applications. | 13 |
| **3** | **Optimization**: Recapitulation of local minima of differential functions. Convex sets, convex functions. Properties of convex sets and convex functions. Existence of minimization of convex function. Counter examples supporting do not have minimum values. Newton –Raphon method and Gradient Descent method for univariate and multivariate functions for computing minima of objective function. | 13 |
| **4** | **Artificial Neural Network**: Biological Neuron, Artificial Neuron, various artificial models. Structure of neural network. Various activation functions. Backpropagation algorithm. Logic gates reconstruction, Universal approximation theorem and applications. | 13 |

**Text Books:**


1. David K. Ruch and Patrick J. Fleet, Wavelet Theory: An Elementary Approach with Applications, John Wiley and Sons, 2009.
2. Ward Cheney and Will Light, A Course in Approximation Theory, University Press, 2013.
3. Gilbert Strang, Linear Algebra and Learning from Data, Academic Publishers, 2020.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Write clear and precise proof(s) of celebrated theorems related to Haar spaces. |
| CO2 | Ability to compress the functions using Haar wavelet transform. |
| CO3 | Gaining of knowledge of gradient descent algorithm. |
| CO4 | Determination artificial neural network for a given continuous function with precision. |

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## DSE3: (C) Graph Theory

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|---|---|
| **Course:** Graph Theory | **Course Code:** 24MAT4E3CL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To study various graph factorizations, coverings, and matchings, and understand their applications in graph theory.
- To explore the concepts of planar graphs, including criteria for planarity, Euler's polyhedron formula, and applications in graph embeddings.
- To analyze graph colorings, adjacency matrices, and spectral properties, including chromatic polynomials, eigenvalues, and their impact on graph structure.
- To examine the interaction between groups and graphs, focusing on automorphisms, graph operations, and topological indices for characterizing graph properties.

| Unit | Description | Hours |
|---|---|---|
| 1 | **Factorization:** 1-factorization,2-factorization, decomposition and labeling of graphs, **Coverings:** Vertex covering, edge covering, independence number and matchings and matching polynomials. | 12 |
| 2 | **Planarity:** Planar graphs, outer planar graphs, Kuratowaski criterion for planarity and Eulers polyhedron formula. **Graph valued functions:** Line graphs, subdivision graph and total graphs. | 12 |
| 3 | **Colouring's and Spectra of Graphs:** Chromatic numbers and chromatic polynomials. Adjacency matrix, incidence matrix, characteristic polynomials, Eigen values, graph parameters, strongly regular graphs and Friendship Theorem. | 16 |
| 4 | **Groups and Graphs:** Automorphism group of a graph, operations on permutation graphs, the group of a composite graph. Topological indices and Adriatic indices of a various graphs. | 12 |

**Text Books:**


1. Diestel: Graph Theory, Springer-Verlag, Berlin.
2. F. Harary: Graph Theory, CRC Press (2018)
3. R. Gould: Graph Theory, The Benjamin/Cummings Publ. Co. Inc. Calif (1988)
4. O. Ore: Theory of Graphs, Amer-Maths. Soc. Collg. Publ. -38, providence (1962)
5. D. Cvetkovic, M. Doob and H. Sachs, Spectra in Graphs, Academic Press, New York(1980)
6. Tulasiraman and M. N. S. Swamy: Graphs, Networks and Algorithms, John Wiley (1989)
7. BelaBollobas, Modern Graph Theory, Springer (1998)

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to factorize graphs, analyse coverings and matchings, and apply matching polynomials in problem-solving. |
| CO2 | Students will apply Kuratowski' s theorem and Euler's formula to determine planarity and understand embeddings for planar and outer-planar graphs. |
| CO3 | Students will compute chromatic numbers, graph spectra, and eigenvalues, and use these to interpret graph parameters and regularity. |
| CO4 | Students will understand graph automorphisms, apply group theory in graph operations, and calculate topological indices to assess graph structures. |

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## DSE4:(A) Number Theory and Combinatorics

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|---|---|
| **Course:** Number Theory and Combinatorics | **Course Code:** 24MAT4E4AL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To understand divisibility, primes, and modular arithmetic, including algorithms for GCD, prime factorization, and number-theoretic functions.
- To explore the principles of congruences, residue systems, and theorems related to modular arithmetic, such as the Chinese Remainder and Euler-Fermat theorems.
- To develop skills in solving recurrence relations and using generating functions, with applications in combinatorics and difference equations.
- To introduce logic, proof techniques, counting principles, and foundational discrete mathematics concepts such as posets and lattices.

| Unit | Description | Hours |
|---|---|---|
| **1** | Divisibility and Primes: Division algorithm, Greatest common divisor, Euclid's algorithm, Least Common Multiples, Linear Diophantine equations. Prime numbers, Prime-power factorizations, Distribution of primes, Fermat and Mersenne primes, Primality testing and factorization. | 12 |
| **2** | Congruences: Basic properties of congruences, Divisibility test with the congruence relation, Residue classes and complete residue systems, Linear congruences, Chinese Remainder theorem, Fermat's theorem, Reduced residue systems, the Euler-Fermat theorem, Wilson's theorem, Lagrange's theorem, Polynomial congruence mudulo m. Number theoretic functions: Functions $\tau(n)$, $\sigma(n)$, Euler-totient function (Phi-function), Mobius function, Mobius inversion formula, Mangoldt function $\Lambda(n)$, Liouville's function $\lambda(n)$. Properties of these functions. | 14 |
| **3** | Modeling with recurrence relations with examples of Fibonacci numbers and the tower of Hanoi problem, Solving recurrence relations. Divide and -Conquer relations with examples (no theorems). Generating functions, definition with examples, solving recurrence relations using generating functions, exponential generating functions. Difference equations. Definition and types of relations. Representing relations using matrices and digraphs, Closures of relations, Paths in digraphs, Transitive closures, Warshall' s Algorithm. Order relations, Posets, Hasse diagrams, external elements, Lattices. | 14 |
| **4** | Logic: Introduction to logic, Rules of Inference (for quantified statements), Validity of Arguments, Normal forms. Methods of proof: Direct, Indirect proofs, Proof by contradiction, Proof by cases etc. Counting Techniques: The product rule, The sum rule, The inclusion– exclusion principle, The Pigeonhole Principle and examples. Simple arrangements and selections. Arrangements and selections with repetitions, Distributions, Binomial Coefficients | 12 |

**Text Books:**

1. Ajay Kr Chaudhuri, Introduction to Number Theory, New Central Book Agency (P) Ltd., Kolkata, 2012.
2. J.P. Tremblay and R.P. Manohar: Discrete Mathematical Structures with applications to computer science, McGraw Hill, 1975.
3. 3.Kenneth Rosen: Discrete Mathematics and its Applications, McGraw-Hill, 6th edition, 2004.
4. J.H. Van Lint & R.M. Wilson: A course on Combinatorics, Cambridge University Press, 2006.
5. 2.G. A. Jones and J. M. Jones, Elementary Number Theory, Springer UTM, 2007.
6. 5.Tom M. Apostol, Introduction to Analytic Number Theory, Springer, 1989.
7. 5.D. Burton, Elementary Number Theory, McGraw-Hill, 2005.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to apply divisibility rules, prime factorization, and use Euclid's algorithm to solve problems in number theory. |
| CO2 | Students will analyse congruence properties, solve modular arithmetic equations, and apply theorems to simplify computations. |
| CO3 | Students will solve recurrence relations, construct generating functions, and apply difference equations to model problems. |
| CO4 | Students will construct proofs, apply counting techniques, and represent relations with Hasse diagrams and digraphs in various contexts. |

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## DSE4: (B) Multi Variable Calculus and Descriptive Statistics

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|---|---|
| **Course:** Multi Variable Calculus and Advanced statistics | **Course code:** 24MAT4E4BL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To explore Euclidean topology in $R^n$, understanding interior, exterior, and boundary points, and apply key theorems like Bolzano-Weierstrass and Heine-Borel.
- To develop foundational skills in calculus, focusing on limits, continuity, differentiation, and optimization in vector-valued functions with applications.
- To understand univariate data analysis, focusing on measures of position, dispersion, skewness, and kurtosis to describe and interpret data distributions.
- To analyze bi-variate and multivariate data, exploring correlation, regression, and residual analysis, with applications in real-world data interpretation.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Topology on $R^n$:** Euclidean space $R^n$ as a real vector space and a real inner vector space. Euclidean topology on $R^n$. Computation of interior, exterior and boundary points for some subsets of $R^{n.}$ Bolzano-Weierstrass property for subsets of $R^n$. Heine-Borel theorem for subsets of $R^n$. | 13 |
| **2** | Calculus: Functions f: E → $R^m$ from a subset E of $R^n$ into $R^m$. Component functions. Limits, continuity and differentiation results with examples for vector valued functions. Implicit function theorem, rank theorem. Results on Jacobian. Local maxima/minima. | 13 |
| **3** | **Univariate Data Analysis:** Describing positions: Measures of partition values – Quartiles, Deciles & Percentiles, definition, formulae. Describing Variability: Measures of dispersion – Absolute & relative measures, Range, Quartile Deviation, Mean Deviation and Standard Deviation, definition, formulae, properties, merits and demerits. Describing shape: Measures of Skewness: Meaning, need, types of skewness, absolute and relative measures. Measures of Kurtosis: Need, types of kurtosis, measurement of kurtosis. Standard theoretical examples. Box Plots. | 13 |
| **4** | **Bi-variate and Multivariate Data Analysis:** Introduction to Correlation, Correlation Coefficient for qualitative data: Spearman's rank correlation coefficient and its properties. Simple linear regression analysis- regression equations by method of least squares, linear regression coefficients and its properties. Plane of regression and its derivation, estimation of a and b in case of three variables, partial regression coefficient, Residual, properties of residuals, Standard deviation of residuals, Multiple and partial correlation, definition, derivation and their standard properties. | 13 |

**Text Books:**

1. Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics Volume I and II. The World Press Private
2. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi. 2002
3. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi. 2014

4. Statistical Methods, Gupta S.P.: Sultan Chand and Sons, New Delhi, 2021.
5. Chatterji, P.N.: Mathematical Statistics, Rajhans Prakashana Mandir, Educational Publishers, Meerut.
6. Goel, B.S., Satyaprakash and Roshan lal: Mathematical Statistics, Pragati Prakashana, Meerut.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to compute topological properties in $R^n$ and apply fundamental theorems to analyse subsets of Euclidean space. |
| CO2 | Students will perform calculus operations on vector-valued functions and apply the Implicit Function and Jacobian theorems in optimization contexts. |
| CO3 | Students will interpret univariate data using measures of central tendency, dispersion, skewness, and kurtosis, including visualizations through box plots. |
| CO4 | Students will analyse relationships in bi-variate and multivariate data, perform linear regression, and calculate correlation coefficients for effective data interpretation. |

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## DSE4: (C) Operations Research

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|---|---|
| **Course:** Operations Research | **Course code:** 24MAT4E4CL |
| **Teaching Hours/Week (L-T-P):** 4-0-0 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objective(s):**

- To introduce the fundamentals of linear programming, including formulation, graphical methods, and solution techniques like simplex and Big-M methods.
- To develop problem-solving skills in transportation and assignment problems, focusing on initial feasible solutions and sensitivity analysis.
- To explore network optimization problems, including shortest route, maximal flow, and algorithms for solving cyclic networks.
- To understand concepts in game theory and queuing theory, including Markov chains, Poisson processes, and queuing models for decision-making in real-world scenarios.

| Unit | Description | Hours |
|---|---|---|
| **1** | **Linear Programming:** Introduction, formulation of Linear programing problem (LPP), general mathematical model of LLP, canonical and standard form of LPP, Graphical method, standard LPP and basic solution, simplex method, Big-M method, Duality in linear programming. | **13** |
| **2** | **Transportation Problem:** Introduction, existence of feasible solutions, transportation table, finding initial basic feasible solution,<br>**Assignment problem**-mathematical formulation of the assignment problem, methods of solving assignment problem, variations of the assignment problems, sensitivity in assignment problems. | **13** |
| **3** | **Networks:** Network minimization, shortest route problem, shortest route Algorithms for cyclic networks, maximal flow problem, Dijkstra's algorithm, Floyd's algorithm for finding shortest route in the network. | **13** |
| **4** | **Game theory:** Introduction, 2 x 2 Game, Solution of Game, Network Analysis by Linear Programming, Brow's Algorithm. Shortest route and Maximal flow Problems, CPM and PERT.<br>**Queuing Theory:** Introduction to Stochastic Process, Markov chain, t.p.m., c-k equations, Poisson process, Birth and Death process, Concept of queues, Kendall's notation, m/m/1, m/m/s queues and their variants. | **13** |

**Text Books:**


1. S.D. Sharma, Operations Research, KEDAR NATH Publishers.
2. J. K. Sharma: Operations Research: Theory and Applications, Macmillan India Ltd. (2006)
3. Kanti Swarup, P.K. Gupta and Mamohan, Operations Research, S. Chand & Sons, (1980).
4. S. Kalavathy, Operations Research, Vikas (2001).
5. C. K. Mustafi: Operations Research, Wiley – Eastern (1998)

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to formulate and solve linear programming problems using standard methods like simplex and Big-M and interpret dual solutions. |
| CO2 | Students will demonstrate skills in optimizing transportation and assignment problems, applying sensitivity analysis to evaluate solution stability. |
| CO3 | Students will apply algorithms like Dijkstra's and Floyd's for network analysis and solve shortest route and maximal flow problems in networks. |
| CO4 | Students will solve basic problems in game theory and apply queuing models, using concepts of stochastic processes to analyse and optimize queue systems. |

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## GEC2: (A)Commercial Mathematics

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|---|---|
| **Course:** Commercial Mathematics | **Course code:** 24MAT4G2AL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- To develop foundational skills in general mental ability, covering logical reasoning, series completion, coding-decoding, and problem-solving in seating arrangements and blood relations.
- To enhance spatial and logical thinking through direction sense tests, Venn diagrams, and data sufficiency problems.
- To build arithmetic abilities in core topics like numbers, simplification, percentages, ratios, and interest calculations.
- To enable students to interpret and analyze data using tabulation, bar graphs, pie charts, and line graphs effectively.

| Unit | Description | Hours |
|---|---|---|
| **1** | General Mental Ability-I Series Completion, Coding and Decoding, Blood relations, Seating Arrangement, Comparison type questions. General Mental Ability-II Directions sense test, logical venn diagrams, data sufficiency. | 13 |
| **2** | Arithmetical Ability: Numbers, Simplification, Average, Problems on ages, Percentage, Probability. Profit and loss, ratio and proportion, time and work, simple interest compound interest. Data Interpretation Tabulation, Bar graphs, Pie charts, line graphs. | 13 |

**Text Books:**

1. Quantitative Aptitude by Dr. RS Aggarwal, Revised edition, ISBN81-219-2498-7
2. A Modern Approach to Verbal Reasoning by Dr. RS Aggarwal, S. Chand and Company pvt. Ltd., ISBN 81-219-0552-4.
3. Fast Track Objective Arithmetic by Rajesh Verma Arihant Publishers ISBN: 9789312149836, 9789312149836.
4. Arithmetic Subjective and Objective for Competitive Examinations by R.S. Aggarwal (Revised Edition).
5. Objective Arithmetic: Numerical Ability Tests for Competitive Examinations by R. S. Aggarwal. S. Chand Limited, 1990.
6. Teach yourself Quantitative Aptitude by Arun Sharma.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to solve problems in series completion, coding, and seating arrangement with accuracy and speed. |
| CO2 | Students will apply logical reasoning to direction tests, Venn diagrams, and data sufficiency, improving their decision-making skills. |
| CO3 | Students will handle arithmetic problems involving ratios, percentages, interest, profit-loss, and probability, with real-life applications. |
| CO4 | Students will effectively interpret data presented in graphical forms, supporting analytical thinking and data-driven conclusions. |

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## GEC2:(B) Mathematical Statistics

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|---|---|
| **Course:** Mathematical Statistics | **Course code:** 24MAT4G2BL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- To classify and organize data through understanding types and frequency distributions, both grouped and ungrouped.
- To enable students to visualize data by constructing various diagrams and graphs, understanding their uses and limitations.
- To introduce measures of central tendency and dispersion, allowing students to summarize data using means, medians, and deviations.
- To explore concepts of correlation and regression, providing tools to examine relationships between variables and interpret errors.

| Unit | Description | Hours |
|---|---|---|
| **1** | Classification of Data: Objects and Functions, Types, Frequency Distribution- Un grouped and Grouped series, Terms. Diagrams and Graphs: Diagrams - Meaning, Utilities, Limitation, Construction, Types-one dimensional, Two-dimensional, others. Graphs-Meaning, Utilities, Limitation, Construction, Types-Time series, Frequency Distribution-Histogram, Frequency polygon, Frequency curve and ogives, Terms. | 13 |
| **2** | Measures of Central Tendency: Introduction, Types of Averages, Arithmetic Mean- Simple and Weighted, Median and Mode, terms. Measures of Dispersions: Introduction, Range, Quartile Deviation, mean deviation, standard deviation and Coefficient of variation, terms.<br>Correlation and Regression Analysis: MeaningTypes-Probable Error. | 13 |

**Text Books:**


1. C.M. Chikkodi and B.G Satyaprasad, "Business Stastics", Himalaya Publishing House, (2005).
2. D.S. Chandrasekharaiah and L. Debnath, "Continuum Mechanics", Academic Press, (1994).
3. Probability and Statistics (Schaum's Outline Series)
4. Rao, A First Course in Probability and Statistics, Cambridge University Press, New Delhi.
5. E. Rukmangadachar, Probability and Statistics Paperback–2012, pearsons education.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will be able to classify data effectively and organize it into appropriate frequency distributions for analysis. |
| CO2 | Students will gain skills in creating and interpreting diagrams and graphs to visually communicate data insights. |
| CO3 | Students will apply measures of central tendency and dispersion to describe data distributions and assess variability. |
| CO4 | Students will analyse relationships between variables using correlation and regression, evaluating the reliability of predictions and potential errors. |
| CO5 | Students will be able to classify data effectively and organize it into appropriate frequency distributions for analysis. |

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## GEC2:(C) Mathematics for Social Sciences

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|---|---|
| **Course:** Mathematics for Social Sciences | **Course code:** 24MAT4G2CL |
| **Teaching Hours/Week (L-T-P):** 2-0-0 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 Marks |

**Course Objectives:**

- To provide a foundational understanding of mathematical concepts, including exponents, polynomials, functions, limits, continuity, and derivatives.
- To introduce students to integral calculus and optimization techniques, including the Lagrangian Multiplier method for constrained optimization.
- To familiarize students with linear algebra concepts such as vectors, matrices, determinants, and the methods to solve linear systems.
- To enable students to apply mathematical techniques to solve economic and real-world problems involving optimization and linear systems.

| Unit | Description | Hours |
|---|---|---|
| **1** | Basics, exponents, polynomials, functions, limits, continuity, and derivatives Rules, integration, rules, economic applications. Optimisation, maxima and minima constrained, Lagarangian Multiplier method first and second order conditions, solving numerical problems. | 13 |
| **2** | Linear algebra, vectors, matrix definition types relations and operations, trace, partitioned matrices, determinants, rank properties, inverse properties of inverse, solution to a system of linear equations, Existence of uniqueness of solution, Cramer's rule, inversion method. | 13 |

**Text Books:**


1. Edward T. Dowling: Calculus for Business, Economics and Social Sciences, Schaum's Outline Series, TMH, 2005.
2. Edward T. Dowling: Introduction to Mathematical Economics, Tata McGraw Hills.
3. G. Hadley: Linear Algebra, Narosa Publishing House.
4. A.C. Chiang: Fundamental Methods of Mathematical Economics, McGraw-Hill.
5. Ismor Fischer: Basic Calculus Refresher, http://www.stat.wisc.edu/ifischer/calculus.
6. Srinath Baruah: Basic Mathematics and its Applications in Economics, Macmillan.
7. Taro Yamane: Mathematics for Economists, Seconded., PHI.


**Course Outcomes (CO): After completion of this course students will be able to**

| **CO** | **Statement** |
|---|---|
| CO1 | Students will demonstrate competence in basic calculus operations, including finding limits, derivatives, and integrals. |
| CO2 | Students will apply optimization techniques to solve problems related to maxima and minima, particularly in economic contexts. |
| CO3 | Students will perform matrix operations, understand the properties of determinants, and utilize methods like Cramer's rule to solve linear equations. |
| CO4 | Students will gain problem-solving skills, particularly in determining the existence and uniqueness of solutions to mathematical and economic models. |

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**DSCP5: Advanced Numerical Analysis Lab using PYTHON/ R/ MATLAB**

| | |
|---|---|
| **Course:** Advanced Numerical Analysis Lab using PYTHON/R/ MATLAB | **Course code:** 24MAT4P5 |
| **Teaching Hours/Week (L-T-P):** 0-0-4 | **No. of Credits:** 02 |
| **Internal Assessment:** 20 Marks | **Semester End Examination:** 30 |

**Course Objectives:**

- To develop programming skills for implementing numerical methods to evaluate integrals and solve ordinary differential equations (ODEs) using various techniques.
- To understand and apply the Trapezoidal rule, Simpson's rules, and Weddle's rule for integral evaluation in practical programming scenarios.
- To enhance knowledge of initial value problems through programming solutions using methods like Euler, Runge-Kutta, and Predictor-Corrector methods.
- To implement numerical methods for boundary value problems, including finite difference, shooting, and Galerkin's methods, to provide a comprehensive understanding of numerical analysis.

| Unit | Description | Hours |
|---|---|---|
| 1 | List of Programs:<br>1. Program to evaluate the given integral using Trapezoidal rule and Weddle's rule<br>2. Program to evaluate the given integral using Simpson's 1/3 and 3/8th rule<br>3. Program to find the approximate solution of a differential equation with initial condition by Taylors series method.<br>4. Program to solve initial value problem using Euler Method.<br>5. Program to solve initial value problem using Modified Euler Method<br>6. Program to find solution of initial value problem using Runge-Kutta II order Method.<br>7. Program to find solution of initial value problem using Runge-Kutta IV order Method.<br>8. Program to find solution of initial value problem using Predictor-Corrector method.<br>9. Program to find solution of initial value problem using Milne's Method.<br>10. Program to find the boundary value problem of ODE by finite difference method.<br>11. Program to find the boundary value problem of ODE by Shooting method.<br>12. Program to find the boundary value problem of ODE by Galerkin's method.<br>13. Program to find the numerical solution of Laplace equation by Jacobis method.<br>14. Program to find the numerical solution of wave equation using Finite difference method | 52 |

**Text Books:**

1. Gowrishankar S. Veena A -Introduction to Python Programming (2019).
2. Adam Stewart -Python Programming (2016).
3. Allen Downey, Jeff Elkner, and Chris Meyers -Learning with Python. (2015)
4. C.H. Swaroop -A Byte of Python. (2013)
5. Eric Matthews -Python Crash Course. (2016)
6. Kenneth A. Lambert, Cengage -Fundamentals of Python: First Programs (Introduction to Programming) (2011)
7. Introduction to Partial Differential Equations, PHI Publications, 3 rd Edition K Sankar Rao, 2017.
8. Partial Differential Equations for Scientists and Engineers, Dover Publications, Stanley J. Farlow, 1993.
9. An elementary course in Partial Differential Equations, 2nd Edition, Narosa Publishers, T Amaranath, 2013.
10. Elements of Partial Differential Equations, MC Grawhill publishers, I.N. Sneddon, 1957.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Students will successfully write programs to evaluate integrals using numerical techniques, demonstrating proficiency in both Trapezoidal and Simpson's rules. |
| CO2 | Students will solve initial value problems for ODEs using multiple numerical methods, showing the ability to implement Taylor’s series, Euler, and Runge-Kutta methods. |
| CO3 | Students will apply advanced numerical techniques, such as the Predictor-Corrector method and Milne’s Method, to obtain accurate solutions for differential equations. |
| CO4 | Students will gain experience in solving boundary value problems using different methods, including the finite difference method and Galerkin’s method, equipping them with essential skills for tackling real-world mathematical modelling problems. |

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**Project:**

| | |
|---|---|
| **Course:** Research Project | **Course code:** 24MAT4C1R |
| **Teaching Hours/Week (L-T-P):** 0-0-8 | **No. of Credits:** 04 |
| **Internal Assessment:** 30 Marks | **Semester End Examination:** 70 Marks |

**Course Objectives:**

- To develop students' skills in conducting comprehensive literature surveys to understand existing research in a specified area.
- To guide students in defining clear and concise research problems based on identified gaps in the literature.
- To enhance students' abilities in analyzing experimental data using scientific and statistical methods.
- To strengthen students' proficiency in effectively communicating research findings, both orally and in written form.

**Course Outcomes (CO): After completion of this course students will be able to**

| CO | Statement |
|---|---|
| CO1 | Conduct literature survey on specified area of research. |
| CO2 | Define or state the research problem. |
| CO3 | Analyze experimental observations by scientific methods. |
| CO4 | Communicate (oral and written) the results of investigation |

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# CBCS Question Paper Pattern for PG Semester End Examination with Effect from the AY 2024-25

## Disciplines Specific Core (DSC) and Discipline Specific Elective (DSE)

| | |
|---|---|
| **Paper Code:** | **Paper Title:** |
| **Time: 3 Hours** | **Max. Marks: 70** |

**Answer any *FIVE* of the following questions, each question carries equal marks.**

| | |
|---|---|
| Q1. | 14 Marks |
| Q2. | 14 Marks |
| Q3. | 14 Marks |
| Q4. | 14 Marks |
| Q5. | 14 Marks |
| Q6. | 14 Marks |
| Q7. | 14 Marks |
| Q8. | 14 Marks |

**Note:**

1. ***Two questions from each unit* i.e.**

   **Question No. 1 & 2, shall be from Unit-I,**

   **Question No. 3 & 4, shall be from Unit-II,**

   **Question No. 5 & 6, shall be from Unit-III,**

   **Question No. 7 & 8, shall be from Unit-IV.**

2. **The Questions may be a whole or it may consists of sub questions such as a,b, c etc…**

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# Generic Elective Course (GEC)

**Paper Code:** **Paper Title:**

**Time: 1 Hours** **Max. Marks: 30**

**SECTION – A**

**Answer all the following questions, each question carries one marks. 5x1=5**

Q1.

a)

b)

c)

d)

e)

**SECTION – B**

**Answer any Five of the following questions, each question carries two marks. 5x2=10**

Q2.

Q3.

Q4.

Q5.

Q6.

Q7.

Q8.

**SECTION – C**

**Answer any three of the following questions, each question carries five marks. 3x5=15**

Q9.

Q10.

Q11.

Q12.

Q13.

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# Skill Enhancement Courses (SECs)

**Paper Code:** **Paper Title:**

**Time: 1 Hours** **Max. Marks: 30**

**There shall be Theory examinations of Multiple Choice Based Questions [MCQs] with Question Paper set of A, B, C and D Series at the end of each semester for SECs for the duration of One hour (First Fifteen Minutes for the Preparation of OMR and remaining Forty-Five Minutes for Answering thirty Questions). The Answer Paper is of OMR (Optical Mark Reader) Sheet.**

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