

**M. Sc. Mathematics**

Syllabus

SCHOOL OF DISTANCE EDUCATION

**OPEN AND DISTANCE LEARNING**

**2023 – 2024 onwards**



**BHARATHIAR UNIVERSITY**

**A State University, Accredited with “A++” Grade by NAAC Ranked 21st among Indian Universities by MHRD-NIRF**

**Coimbatore - 641 046, Tamil Nadu, India**

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| **Program Educational Objectives (PEOs)** | |
| The **M. Sc. Mathematics** program describe accomplishments that graduates are expected to attain within five to seven years after graduation | |
| Provide a strong foundation in different areas of Mathematics, so that the students can compete with their contemporaries and excel in the various careers in Mathematics. |
| Motivate and prepare the students to pursue higher studies and research, thus contributing to the ever-increasing academic demands of the country. |
| Enrich the students with strong communication and interpersonal skills, broad knowledge and an understanding of multicultural and global perspectives, to work effectively in multidisciplinary teams, both as leaders and team members. |
| Facilitate integral development of the personality of the student to deal with ethical and professional issues, and also to develop ability for independent and lifelong learning. |



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| **Program Specific Outcomes (PSOs)** | |
| After the successful completion of **M. Sc. Mathematics** program, the students are expected to | |
| Communicate concepts of Mathematics and its applications. |
| Acquire analytical and logical thinking through various mathematical tools and techniques. |
| Investigate real life problems and learn to solve them through formulating mathematical models. |
| Attain in-depth knowledge to pursue higher studies and ability to conduct research.  Work as mathematical professional. |
| Achieve targets of successfully clearing various examinations/interviews for  placements in teaching, banks, industries and various other organizations/services. |



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| **Program Outcomes (POs)** | |
| On successful completion of the M. Sc. Mathematics program, the students will be able to | |
| Demonstrate in-depth knowledge of Mathematics, both in theory and application. |
| Attain the ability to identify, formulate and solve challenging problems in Mathematics. |
| Know the various specialised areas of advanced mathematics and its applications. |
| Analyze complex problems in Mathematics and propose solutions using research- based knowledge. |
| Obtain the accurate solutions for the community oriented problems via various mathematical models. |
| Work individually or as a team member or leader in uniform and multidisciplinary settings. |
| Crack lectureship and fellowship exams affirmed by UGC like CSIR-NET and SET. |
| Apply the Mathematical concepts, in all the fields of learning including higher  research, and recognize the need and prepare for lifelong learning. |
| Know the use of computers both as an aid and as a tool to study problems in Mathematics. |
| Inculcate the knowledge of formulation and apply the mathematical concepts which are suitable for real life applications. |

**SCHOOL OF DISTANCE EDUCATION**

**BHARATHIAR UNIVERSITY : : COIMBATORE 641 046**

OPEN AND DISTANCE LEARNING PROGRAMME (ODL)

**M. Sc. Mathematics Curriculum**

*(For the students admitted during the academic year 2023 – 24 onwards)*

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| **Title of the Course** | **Credits** | **Maximum Marks** | | |
| **CIA** | **ESE** | **Total** |
| **FIRST SEMESTER** |  |  |  |  |
| Abstract Algebra | 4 | 25 | 75 | 100 |
| Real Analysis | 4 | 25 | 75 | 100 |
| Ordinary Differential Equations | 4 | 25 | 75 | 100 |
| Numerical Methods | 4 | 25 | 75 | 100 |
| Elective-I : Number Theory | 4 | 25 | 75 | 100 |
| **SECOND SEMESTER** |  |  |  |  |
| Linear Algebra | 4 | 25 | 75 | 100 |
| Complex Analysis | 4 | 25 | 75 | 100 |
| Partial Differential Equations | 4 | 25 | 75 | 100 |
| Mechanics | 4 | 25 | 75 | 100 |
| Elective-II : Differential Geometry | 4 | 25 | 75 | 100 |
| **THIRD SEMESTER** |  |  |  |  |
| Topology | 4 | 25 | 75 | 100 |
| Fluid Dynamics | 4 | 25 | 75 | 100 |
| Mathematical Statistics | 4 | 25 | 75 | 100 |
| Graph Theory | 4 | 25 | 75 | 100 |
| Elective-III | 4 | 25 | 75 | 100 |
| **FOURTH SEMESTER** |  |  |  |  |
| Functional Analysis | 4 | 25 | 75 | 100 |
| Mathematical Methods | 4 | 25 | 75 | 100 |
| Optimization Techniques | 4 | 25 | 75 | 100 |
| Computer Programming\* (C++ Theory) | 4 | 25 | 75 | 100 |
| Computer Programming (C++ Practical) | 4 | 40 | 60 | 100 |
| Elective-IV | 4 | 25 | 75 | 100 |
| Project | 6 |  | 150 | 150\* |
| **Grand Total** | 90 | 540 | 1710 | 2250 |



First Semester



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| **Course code** | | **Paper 1: ABSTRACT ALGEBRA** | **Core** |
| **Pre-requisite** | | Basic knowledge in Modern Algebra at  Undergraduate level. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. To provide deep knowledge about various algebraic structures. 2. To introduce Galois Theory and to see its application to the solvability of polynomial equations by radicals. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand Sylows theorem and its applications | | | |
| Formulate some special types of rings and their properties. | | | |
| Acquire knowledge on extension fields and roots of polynomials | | | |
| Analyze the elements of Galois theory and Galois Groups over the rationals | | | |
| Understand the basic concepts of solvability by radicals and finite fields. | | | |
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| **Unit:1** | **Group Theory** | | |
| Another Counting Principle, Sylow’s Theorem: 1st, 2nd and 3rd parts of Sylow’s Theorems – double coset – the normalizer of a group. | | | |
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| **Unit:2** | **Group Theory (contd) and Ring Theory** | | |
| Direct Products: External and Internal direct Products, Euclidean Rings, A Particular Euclidean Rings, Polynomial rings. | | | |
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| **Unit:3** | **Ring Theory (contd) and Fields** | | |
| Polynomials over rational fields – extension fields – roots of polynomials – splitting fields. | | | |
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| **Unit:4** | **Fields (contd)** | | |
| More about roots – simple extension – fixed fields – symmetric rational functions – normal extension - Galois group – fundamental theorem of Galois theory. | | | |
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| **Unit:5** | **Fields (contd) and Selected Topics** | | |
| Solvability by radicals: Solvable group – the commutator subgroup – Solvability by radicals - Finite fields. | | | |
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| **Text Book(s)** | |
| 1 | I.N. Herstein, Topics in Algebra*,* Secnd Edition, John Wiley and Sons, New York, 1975. UNIT I: Chapter 2 : Sections 2.11, 2.12  UNIT II: Chapter 2 : Section 2.13  Chapter 3 : Sections 3.7 - 3.9 UNIT III: Chapter 3 : Section 3.10  Chapter 5 : Sections 5.1,5.3 UNIT IV: Chapter 5 : Sections 5.5,5.6 UNIT V: Chapter 5 : Section 5.7  Chapter 7 : Section 7.1 |
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| **Reference Books** | |
| 1 | Serge Lang, Algebra, Third Edition, Addison-Wesley, Mass, 1993. |
| 2 | John B. Fraleigh, A First Course in Abstract Algebra, Addison Wesley, Mass, 1982. |
| 3 | M. Artin, Algebra, Prentice-Hall of India, New Delhi, 1991. |
| 4 | V. K. Khanna and S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House Pvt Limited, 1993. |



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| **Course code** | | **PAPER 2: REAL ANALYSIS** | **Core** |
| **Pre-requisite** | | Basic knowledge in Undergraduate Analysis. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Evaluate integral of a function of a real variable in the sense of Riemann Stieltjes integral and gain its properties. 2. Acquire Knowledge and demonstrate understanding the statement and proof of convergence theorems and its applications. 3. Understand the requirement and concept of Lebesgue measure, Measurable functions and Lebesgue integral. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Apply the Riemann Stieltjes integral and bring its properties and rectifiable curves. | | | |
| Remembering of sequences and series along with its properties | | | |
| Analyze the concept of linear transformation and find the extreme values of implicit functions. | | | |
| Understand the fundamental concept of Lebesgue measure. | | | |
| Evaluate the complex integration and the benefits of Lebesgue Integral | | | |
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| **Unit:1** | **Riemann Stiltjes Integral** | | |
| Definition and Existence of the Integral – properties of the integral – Integration and differentiation – Integration of vector valued function – rectifiable curves. | | | |
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| **Unit:2** | **Sequences and Series of Functions** | | |
| Uniform convergence and continuity – uniform convergence and integration - uniform convergence and differentiation – equicontinuous families of functions – The Stone Weierstrass theorem. | | | |
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| **Unit:3** | **Functions of Several Variables** | | |
| Linear transformation – contraction principle – Inverse function theorem – Implicit function theorem. | | | |
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| **Unit:4** | **Lebesgue Measure** | | |
| Outer measure – Measurable sets and Lebesgue measure – Measurable functions –Littlewood’s Theorem. | | | |
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| **Unit:5** | **Lebesgue Integral** | | |
| The Lebesgue integral of bounded functions over a set of finite measure – integral of a non – negative function – General Lebesgue Integral. | | | |
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| **Text Book(s)** | |
| 1 | Principles of Mathematical Analysis, McGraw Hill, New York, 1976.  Unit I &II : Chapter 6 & 7.  Unit III : Chapter 9 (Pages 204 to 227) |
| 2 | Real Analysis by H.L. Roydon, Third Edition, Macmillan, New York, 1988.  Unit IV : Chapter 3 (except Section – 4)  Unit V :Chapter 4 ( Sections 2, 3 & 4 only) |
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| **Reference Books** | |
| 1 | R. G. Bartle, Elements of Real Analysis, 2nd Edition, John Wily and Sons, New York, 1976. |
| 2 | Walter Rudin, Real and Complex Analysis, 3rd Edition, McGraw-Hill, New York, 1986. |



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| **Course code** | | **ORDINARY DIFFERENTIAL EQUATIONS** | **Core** |
| **Pre-requisite** | | Basic knowledge in differential equations at Undergraduate level. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Study Solutions of Linear differential equations with constant and variable coefficients. 2. Understand and able to apply various theoretical ideas that underlined in existence and uniqueness theorems, Linear independence and dependence, Wronskian etc., 3. Enables the students to develop the strong background on modeling, formulating, solving and interpreting physical problems. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Recall the types of linear homogeneous equations of second order equations with constant coefficients and apply the method to solve. | | | |
| Analyze non-homogeneous ODE using the method of undermined coefficients and annihilator method to solve the same. | | | |
| Understand and Apply the theorems on Initial value problem to ordinary differential equations. | | | |
| Comprehend the Euler equations, the Bessel’s equation and Regular, Singular points at infinity and to evaluate. | | | |
| Identify the research problem where differential equation can be used to model the problem. | | | |
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| **Unit:1** | **Linear Equations with Constant Coefficients** | | |
| Introduction - Second order homogenous equations - Initial value problem for second order equations - Linear dependence and independence - A formula for Wronskian.. | | | |
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| **Unit:2** | **Linear Equations with Constant Coefficients (Contd)** | | |
| The Non- homogenous equations of order two-homogenous and Non - homogenous equations of order n - Initial value problems for nth order equations- Annihilator method to solve non- Homogenous equation. | | | |
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| **Unit:3** | **Linear Equations with Variable Coefficients** | | |
| Initial value problem - Existence and uniqueness theorem - The Wronskian and linear independence - Reduction of the order of a homogenous equation - The non- Homogenous equation - Homogenous equations with analytic coefficients - The Legendre equations. | | | |
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| **Unit:4** | **Linear Equations with Regular Singular Points** | | |
| The Euler equations - Second order equations with regular singular points - Exceptional cases - The Bessel equation – The Bessel equation contd. | | | |
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| **Unit:5** | | **Existence and Uniqueness of Solutions to First Order Equations** |
| Equations with variable separated - Exact equations - The method of successive approximation - The Lipschitz Condition - Convergence of the successive approximation - Non-local existence of solutions - Approximations and uniqueness of solutions. | | |
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| **Text Book(s)** | | |
| 1 | Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India Private Limited, New Delhi 2008.  UNIT I: Chapter 2 : Sections 2.1 – 2.5.  UNIT II: Chapter 2 : Sections 2.6 – 2.8, 2.10,2.11.  UNIT III: Chapter 3 : Sections 3.1 – 3.8  UNIT IV: Chapter 4 : Sections 4.1 – 4.4, 4.6 – 4.8  UNIT V: Chapter 5 : Sections 5.1 – 5.8 | |
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| **Reference Books** | | |
| 1 | Williams E. Boyce and Richard C. Diprima, Elementary Differential Equations and Boundary Value Problems, 10th edition, John Wiley and Sons, New York 2012. | |
| 2 | S. G. Deo and V. Raghavendra, Ordinary Differential Equations and Stability Theory, Tata McGraw-Hill, New Delhi 1980. | |
| 3 | George F. Simmons, Differential Equations with Application and Historical Notes, Tata McGraw Hill, New Delhi 1974. | |



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| **Course code** | | **Numerical Methods** | Core |
| **Pre-requisite** | | Basic Knowledge in numerical methods at Undergraduate level. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. To make the students understand solving Algebraic and Transcendental equations. 2. To know about how and when to use various interpolation function finding the various numerical differentiation and integration formulae and using them to solve problems. 3. To understand the methods of finding solution to the differential equations of various orders. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Solve problems in numerical differentiation and integration | | | |
| Solve system of equations using various methods. | | | |
| Apply various methods to find numerical solution of first and second order ordinary differential equations. | | | |
| Explain the various methods for solving Boundary Value Problems and Characteristic Value Problems | | | |
| Understand the Explicit method and the Crank Nicolson method for solving partial differential equations. | | | |
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| **Unit:1** | **Solution of Nonlinear Equations, Numerical Differentiation and Integration** | | |
| **Solution of Nonlinear Equations**: Newton’s method – Convergence of Newton’s method – Bairstow”s Method for quadratic factors.  **Numerical Differentiation and Integration:** Derivatives from Differences tables – Higher order derivatives – Divided difference, Central-Difference formulas– Composite formula of Trapezoidal rule – Romberg integration – Simpson’s rules. | | | |
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| **Unit:2** | **Solution of System of Equations** | | |
| The Elimination method – Gauss and Gauss Jordan methods – LU Decomposition method – Matrix inversion by Gauss-Jordan method – Methods of Iteration – Jacobi and Gauss Seidal  Iteration – Relaxation method – Systems of Nonlinear equations. | | | |
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| **Unit:3** | **Solution of Ordinary Differential Equations** | | |
| Taylor series method – Euler and Modified Euler methods – Runge-kutta methods – Multistep methods – Milne’s method – Adams Moulton method. | | | |
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| **Unit:4** | **Boundary Value Problems and Characteristic Value Problems** | | |
| The shooting method – solution through a set of equations – Derivative boundary conditions – Characteristic value problems – Eigen values of a matrix by Iteration – The power method. | | | |
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| **Unit:5** | | **Numerical Solution of Partial Differential Equations** |
| Representation as a difference equation – Laplace’s equation on a rectangular region – Iterative methods for Laplace equation – The Poisson equation – Derivative boundary conditions – Solving the equation for time-dependent heat flow (i) The Explicit method (ii) The Crank Nicolson method – solving the wave equation by Finite Differences. | | |
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| **Text Book(s)** | | |
| 1 | Curtis F. Gerald, Patrick O. Wheatley, Applied Numerical Analysis, Fifth Edition, Addison Wesley, (1998). | |
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| **Reference Books** | | |
| 1 | S. C. Chapra and P. C. Raymond: Numerical Methods for Engineers, Tata McGraw Hill, New Delhi, 2000. | |
| 2 | S.S. Sastry: Introductory methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1998. | |
| 3 | P. Kandasamy et al., Numerical Methods, S.Chand & Co.Ltd., New Delhi, 2003. | |



Second Semester



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| **Course code** | | **LINEAR ALGEBRA** | **Core** |
| **Pre-requisite** | | A good familiarity with Calculus and Modern Algebra. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Develop a strong foundation in linear algebra that provide a basic for advanced studies. 2. Study of Linear Transformations, Algebra of Polynomials, Invariant space and their properties. 3. Give particular attention to canonical forms of linear transformations, diagonalizations of linear transformations, matrices and determinants. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand the basic concepts of Linear transformations, characteristic roots and matrices of linear transformation and its applications. | | | |
| Explain about the algebra of polynomials, polynomial ideals and prime factorization of a polynomial. | | | |
| Understand the basic concepts of determinants and its additional properties. | | | |
| Recognize the concepts of Invariant subspaces and diagonalization process. | | | |
| Analyze canonical Form, Jordan Form and Rational canonical Form. | | | |
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| **Unit:1** | **Linear Transformations** | | |
| Linear transformations – Isomorphism of vector spaces – Representations of linear transformations by matrices – Linear functionals. | | | |
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| **Unit:2** | **Algebra of Polynomials** | | |
| The algebra of polynomials –Polynomial ideals - The prime factorization of a polynomial - Determinant functions. | | | |
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| **Unit:3** | **Determinants** | | |
| Permutations and the uniqueness of determinants – Classical adjoint of a (square) matrix – Inverse of an invertible matrix using determinants – Characteristic values – Annihilating  polynomials. | | | |
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| **Unit:4** | **Diagonalization** | | |
| Invariant subspaces – Simultaneous triangulations – Simultaneous diagonalization – Direct-sum decompositions – Invariant direct sums – Primary decomposition theorem. | | | |
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| **Unit:5** | **The Rational and Jordan Forms** | | |
| Cyclic subspaces – Cyclic decompositions theorem (Statement only) – Generalized Cayley – Hamilton theorem - Rational forms – Jordan forms. | | | |
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| **Text Book(s)** | |
| 1 | Kenneth M Hoffman and Ray Kunze, Linear Algebra, Second Edition, Prentice-Hall of India Pvt. Ltd, New Delhi, 2013.  UNIT I: Chapter 3 : Sections 3.1-3.5  UNIT II: Chapter 4 : Sections 4.1, 4.2, 4.4, 4.5  Chapter 5 : Sections 5.1, 5.2  UNIT III: Chapter 5 : Sections 5.3, 5.4  Chapter 6 : Sections 6.1-6.3  UNIT IV: Chapter 6 : Sections 6.4 - 6.8  UNIT V: Chapter 7 : Sections 7.1 – 7.3 |
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| **Reference Books** | |
| 1 | M. Artin, Algebra, Prentice-Hall of India Pvt. Ltd., 2005. |
| 2 | S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra, Fourth Edition, Prentice-Hall of India Pvt. Ltd., 2009. |
| 3 | I. N. Herstein, Topics in Algebra, Second Edition, Wiley Eastern Ltd, New Delhi, 2013. |



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| **Course code** | | **COMPLEX ANALYSIS** | **Core** |
| **Pre-requisite** | | Basic knowledge in complex analysis at Undergraduate level. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Define and recognize the basic properties of the complex numbers 2. Enable the students to the differentiability of complex functions and the results related on the study. 3. Study Cauchy’s integral formula, local properties of analytic functions, general form of Cauchy’s theorem and evaluation of definite integral. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Remembering the concept of Analytic function and as a mapping on the plane and understand Mobius Transformation. | | | | |
| Understand Cauchy’s Integral Formula on open sets on the plane and know about poles , residues and singularities. | | | | |
| Apply the Cauchy’s integral formula in residue theorems and in evaluation of definite integrals. | | | | |
| Analyze and represent the sum function of a power series as an Analytic Function. | | | | |
| Study and Understand periodic function, Weierstrass  function and its applications. | | | | |
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| **Unit:1** | **Introduction to the Concept of Analytic Function, Conformality, Linear Transformations** | | |
| **Introduction to the concept of analytic function:** Limits and continuity – Analytic functions – Polynomials – Rational functions.  **Conformality:** Arcs and closed curves – Analytic functions in regions – Conformal Mapping – Length and Area.  **Linear Transformations:** The Linear group – The Cross ratio – Elementary Riemann Surfaces. | | | |
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| **Unit:2** | **Complex Integration and Cauchy’s Integral Formula** | | |
| **Complex Integration:** Line Integrals Rectifiable Arcs – Line Integrals as Functions of Arcs – Cauchy’s theorem for a rectangle - Cauchy’s theorem in a disk.  **Cauchy’s Integral formula:** The Index of a point with respect to a closed curve – The Integral formula – Higher derivatives Removable singularities, Taylor’s Theorem – Zeros and Poles – The Local Mapping– The Maximum principle – chains and cycles. | | | |
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| **Unit:3** | **The Calculus of Residues and Harmonic Functions** | | |
| **The Calculus of Residues:** The Residue theorem – The Argument principle – Evaluation of definite integrals.  **Harmonic functions:** The Definitions and basic Properties – Mean value property – Poisson’s Formula. | | | |



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| **Unit:4** | | **Series and Product Developments, Partial fractions and Factorization** |
| **Series and Product Developments:** Weierstrass Theorem – The Taylor Series – The Laurent Series.  **Partial fractions and Factorization:** Partial Fractions – Infinite Products – Canonical Products. | | |
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| **Unit:5** | | **Elliptic Functions** |
| **Simply Periodic Functions:** Representation by Exponentials-The Fourier Development - Functions of Finite Order.  **Doubly Periodic Functions:** The Period Module-Unimodular Transformations - The Canonical Basis-General Properties of Elliptic Functions.  **Weierstrass Theory:** The Weierstrass-function. | | |
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| **Text Book(s)** | | |
| 1 | L. V. Ahlfors, Complex Analysis, McGraw Hill, New York, 1979. UNIT I: Chapter 2 : Sections 1.1 – 1.4  Chapter 3 : Sections 2.1 – 2.4, 3.1, 3.2 and 3.4  UNIT II: Chapter 4 : Sections 1.1 – 1.5, 2.1 – 2.3, 3.1 – 3.4 and 4.1  UNIT III: Chapter 4 : Sections 5.1 – 5.3, 6.1 – 6.3  UNIT IV: Chapter 5 : Sections 1.1 – 1.3, 2.1 – 2.3  UNIT V: Chapter 7 : Sections 1.1 – 1.3 | |
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| **Reference Books** | | |
| 1 | S. Ponnusamy and H. Silverman, A Complex Variable with applications, Birkhauser, Boston, 2006. | |
| 2 | Karunakaran V, Complex Analysis, Narosa Publishing House Pvt. Ltd, Second Edition, New Delhi, 2006. | |
| 3 | Roopkumar R, Complex Analysis, Dorling Kinderley Pvt. Ltd, New Delhi, 2015. | |
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| **Course code** | | **PARTIAL DIFFERENTIAL EQUATIONS** | **Core** |
| **Pre-requisite** | | Knowledge in Undergraduate differential  equations. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Introduce different methods to solve partial differential equation. 2. Acquire knowledge in classification of partial differential equations and the methods to solve. 3. Enables the students to find the solution of Partial Differential Equation of practical application like in Engineering, Physics, etc., | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand and remember the physical situations with real world problems to construct mathematical models using partial differential equations and study the methods to solve. | | | |
| Analyze the type of partial differential equations and different methods to solve. | | | |
| Evaluate Laplace equation and analyze its applications. | | | |
| Apply variable separable method to solve Laplace and Diffusion equation | | | |
| Finding the appropriate method to solve the partial differential equations | | | |
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| **Unit:1** | **Partial Differential Equations of the First Order** | | |
| Partial Differential Equations – Origins of First Order Differential Equations – Cauchy’s Problem for first order equations – Linear Equations of the first order – Nonlinear partial differential equations of the first order – Cauchy’s method of characteristics – Compatible system of First order Equations – Solutions satisfying Given Condition, Jacobi’s method. | | | |
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| **Unit:2** | **Partial Differential Equations of the Second Order** | | |
| The Origin of Second Order Equations – Linear partial Differential Equations with constant coefficients – Equations with variable coefficients – Separation of variables – The method of Integral Transforms – Non – linear equations of the second order. | | | |
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| **Unit:3** | **Laplace’s Equation** | | |
| Elementary solutions of Laplace equation – Families of Equipotential Surfaces – Boundary value problems – Separation of variables – Surface Boundary Value Problems – Separation of  Variables – Problems with Axial Symmetry – The Theory of Green’s Function for Laplace Equation. | | | |
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| **Unit:4** | **The Wave Equation** | | |
| The Occurrence of the wave equation in Physics – Elementary Solutions of the One – dimensional Wave equations – Vibrating membrane, Application of the calculus of variations – Three dimensional problem – General solutions of the Wave equation. | | | |
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| **Unit:5** | | **The Diffusion Equation** |
| Elementary Solutions of the Diffusion Equation – Separation of variables – The use of Integral Transforms – The use of Green’s functions. | | |
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| **Text Book(s)** | | |
| 1 | Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill International Book Company, New Delhi, 1983. | |
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| **Reference Books** | | |
| 1 | M. D. Raisinghania, Advanced Differential Equations, S. Chand and Company Ltd., New Delhi, 2001. | |
| 2 | K. Sankara Rao, Introduction to Partial Differential Equations, Second edition, Prentice-Hall of India, New Delhi, 2006. | |
| 3 | J. N. Sharma and K. Singh, Partial Differential Equations for Engineers and Scientists, Narosa Publishing House, 2001. | |



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| **Course code** | | **MECHANICS** | **Core** |
| **Pre-requisite** | | Basic knowledge of Statics and Dynamics at Undergraduate level. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. understand the concepts of generalized coordinates, virtual work, Lagrange’s equations and Hamilton’s Principle. To discuss the applications of the above concepts with suitable examples. 2. Proficient in derivation and application of Hamilton-Jacobi equations 3. gain knowledge about canonical transformations, Lagrange and Poisson brackets. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| understand the basic concepts of the mechanical system, generalized coordinates, work, energy and momentum. | | | |
| solve and analyze the Lagrange’s equations and integrals of motion with examples. | | | |
| understand the Hamilton’s Principle and other variational principles and gain ability to analyze those principles to the problems arising in practical situations | | | |
| understand and develop the Hamilton’s Principal function and Hamilton Jacobi equation | | | |
| Get familiar with canonical transformations, conditions of canonicity of a transformation in terms of Lagrange and Poisson brackets. | | | |
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| **Unit:1** | **Introductory Concepts** | | |
| Mechanical system – Generalized Coordinates – Constraints – Virtual Work – Energy and Momentum. | | | |
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| **Unit:2** | **Lagrange’s Equations** | | |
| Derivations of Lagrange’s Equations: Derivations of Lagrange’s Equations – Examples – Integrals of Motion. | | | |
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| **Unit:3** | **Hamilton’s Equations** | | |
| Hamilton’s Principle – Hamilton’s Equations. | | | |
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| **Unit:4** | **Hamilton – Jacobi Theory** | | |
| Hamilton’s Principle function – Hamilton – Jacobi Equation – Separability. | | | |
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| **Unit:5** | **Canonical Transformations** | | |
| Differential forms and Generating Functions – Lagrange and Poisson Brackets. | | | |
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| **Text Book(s)** | |
| 1 | D. T. Greenwood, Classical Dynamics, Dover Publications, New York, 1997. Unit-I: Chapter 1: Sections 1.1 – 1.5  Unit-II: Chapter 2: Sections 2.1 – 2.3  Unit-III: Chapter 4: Sections 4.1 – 4.2  Unit-IV: Chapter 5: Sections 5.1 – 5.3  Unit-V: Chapter 6: Sections 6.1, 6.3 |
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| **Reference Books** | |
| 1 | F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975. |
| 2 | I. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice-Hall of India, New Delhi, 1963. |
| 3 | S. L. Loney, An Elementary Treatise on Statics, Kalyani Publishers, New Delhi, 1979. |



Third Semester



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| **Course code** | | **TOPOLOGY** | **Core** |
| **Pre-requisite** | | Basic knowledge of Real Analysis at  Undergraduate level. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:  1. To introduce the concepts of point-set topology with emphasis on continuous functions, homeomorphism ,connectedness, compactness, countability and separation axioms. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Acquire knowledge about various types of topological spaces and their properties | | | |
| Discuss connected spaces, the components of a space | | | |
| Apply the properties and derive the proofs of theorems. | | | |
| Construct a variety of examples and counter examples in topology | | | |
| Understand the properties of the compact spaces and analyse the different types of compactness. | | | |
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| **Unit:1** | **Topological Spaces and Continuous functions** | | |
| Types of Topological Spaces and Examples - Basics for a topology - The order topology -The product topology on X x Y - The subspace topology - Closed sets and limits points - Continuous  functions. | | | |
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| **Unit:2** | **Topological Spaces and Continuous functions (Contd) and Connectedness** | | |
| The Product Topology - The metric topology - Sequence lemma- Uniform limit theorem- Connected spaces - Connected subspaces of the real line - Components and Local connectedness. | | | |
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| **Unit:3** | **Compactness** | | |
| Compact spaces - Compact subspaces of the real line -Uniform continuity theorem - Limit Point Compactness – complete metric spaces –compactness in metric spaces. | | | |
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| **Unit:4** | **Countability and Separation Axioms** | | |
| First and Second countable spaces - Lindeloff and Separable spaces - Countability axioms - The separation axioms - Normal spaces - The Uryshon’s lemma. | | | |
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| **Unit:5** | **Countability and Separation Axioms and Tychonoff Theorem** | | |
| The Urysohn Metrization Theorem - Tietze Extension Theorem - The Tychonoff theorem – Stone Cech compactifications. | | | |
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| **Text Book(s)** | |
| 1 | James R. Munkres, Topology, Second Edition, Prentice-Hall of India, New Delhi, 2006. |
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| **Reference Books** | |
| 1 | G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill Edition, New Delhi, 2004. |
| 2 | Fred H. Croom, Principles of Topology, Cengage India Pvt Ltd, New Delhi, 2009. |
| 3 | Seymour Lipschutz, Schaum's Outline of Theory and Problems of General Topology, McGraw-Hill Edition, New Delhi, 2006. |



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| **Course code** | | **FLUID DYNAMICS** | **Core** |
| **Pre-requisite** | | Knowledge in Kinematics and Differential  equations at Undergraduate level. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. able to know the fundamental concepts of fluids and its properties. 2. develop the problems solving skill in fluid dynamics. 3. know the real-life applications of fluid dynamics. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Recall the basic concepts of velocity, density and curvilinear co-ordinates. | | | | |
| Understand the concepts and equations of fluid dynamics | | | | |
| Analyze and understand the concepts of the force experienced by a two- dimensional fixed body in a steady irrotational flow. | | | | |
| Analyze the approximate solutions of the Navier – Stokes equation. | | | | |
| Analyze and apply the appropriate method to solve integral equation of boundary layer, Blasius equation and its series solution. | | | | |
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| **Unit:1** | **Bernoulli's Equation and Equations of Motion** | | |
| Introductory Notions – Velocity – Stream Lines and Path Lines – Stream Tubes and Filaments – Fluid Body – Density – Pressure. Differentiation with respect to the time – Equation of continuity  – Boundary conditions – Kinematical and physical – Rate of change of linear momentum – Equation of motion of an inviscid fluid. | | | |
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| **Unit:2** | **Equations of Motion (Contd)** | | |
| Euler’s momentum Theorem – Conservative forces – Bernoulli’s theorem in steady motion – energy equation for inviscid fluid – circulation – Kelvin’s theorem – vortex motion – Helmholtz equation. | | | |
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| **Unit:3** | **Two-Dimensional Motion** | | |
| Two Dimensional Motion – Two Dimensional Functions – Complex Potential – basic singularities – source – sink – Vortex – doublet – Circle theorem. Flow past a circular cylinder  with circulation – Blasius Theorem – Lift force. (Magnus effect) | | | |
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| **Unit:4** | **Dynamics of Real Fluids** | | |
| Viscous flows – Navier-Stokes equations – Vorticity and circulation in a viscous fluid – Steady flow through an arbitrary cylinder under pressure – Steady Couette flow between cylinders in relative motion – Steady flow between parallel planes. | | | |
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| **Unit:5** | **The Laminar Boundary Layer in Incompressible Flow** | | |
| Boundary Layer concept – Boundary Layer equations – Displacement thickness, Momentum thickness – Kinetic energy thickness – integral equation of boundary layer – flow parallel to semi | | | |

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| infinite flat plate – Blasius equation and its solution in series. | |
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| **Text Book(s)** | |
| 1 | **Units I and II:** L. M. Milne Thomson, Theoretical Hydro Dynamics, Macmillan Company, 5th Edition (1968).  Chapter I : Sections 1.0 – 1.3., 3.10-3.41 (omit 3.32)  Chapter III : Sections 3.42 – 3.53 (omit 3.44) |
| 2 | **Units III, IV and V:** Modern Fluid Dynamics Volume I, N. Curle and H. J. Davies, D. Van Nostrand Company Limited., London, 1968.  Chapter III : Sections 3.1 – 3.7.5 (omit 3.3.4, 3.4, 3.5.2,3.6)  Chapter V : Sections 5.2.1– 5.3.3  Chapter VI : Sections 6.1 – 6.3.1 (omit 6.2.2., 6.2.5) |
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| **Reference Books** | |
| 1 | F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, New Delhi, 2004. |
| 2 | A. J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics, Springer- Verlag, New York, 1993. |
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| **Course code** | | **MATHEMATICAL STATISTICS** | **Core** |
| **Pre-requisite** | | Basic Knowledge in Statistics and Probability theory. |  |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Enables to learn different aspects of statistics. 2. Acquire knowledge about moments and properties of theoretical distributions. 3. Study unbiasedness and consistency of limiting distributions. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Remembering the understanding the basic concepts such as statistics, probability and random variables. | | | |
| Applying the concepts and methods to find the moments of the distributions. | | | |
| Study multivariate distributions and the independence of random variables. Further evaluating the marginal distributions from bivariate distributions. | | | |
| Analyze and study the properties of some discrete as well as continuous distributions | | | |
| Understand the convergence of distributions and central limit theorem. | | | |
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| **Unit:1** | **Probability and Distributions** | | |
| Introduction - Set Theory - The Probability Set Function - Conditional Probability and Independence –Random Variables - Discrete Random Variables- Continuous Random Variables. | | | |
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| **Unit:2** | **Probability and Distributions (continued) and Multivariate Distributions** | | |
| **Probability and Distributions:** Expectation of a Random Variables - Some Special Expectations - Important Inequalities.  **Multivariate Distributions:** Distributions of Two Random Variables - Transformations: Bivariate Random Variables - Conditional Distributions and Expectations - Independent Random Variables. | | | |
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| **Unit:3** | **Some Special Distributions** | | |
| The Binomial and Related Distributions - The Poisson Distribution - The Γ, χ2, and β Distributions - The Normal Distribution. | | | |
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| **Unit:4** | **Some Special Distributions (continued), Unbiasedness, Consistency and Limiting Distributions** | | |
| **Some Special Distributions (continued):** t and F-Distributions.  **Unbiasedness, Consistency and Limiting Distributions:** Expectations of Functions - Convergence in Probability - Convergence in Distribution - Central Limit Theorem. | | | |
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| **Unit:5** | | **Some Elementary Statistical Inferences** |
| Sampling and Statistics – More on Confidence Intervals - Introduction to Hypothesis Testing - Additional Comments About Statistical Tests - Chi-Square Tests – The Method of Monte Carlo. | | |
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| **Text Book(s)** | | |
| 1 | Robert V. Hogg, Allen T. Craig and Joseph W. McKean, Introduction to Mathematical Statistics, Sixth Edition, Pearson Education, 2005.  Unit-I: 1.1 – 1.7  Unit-II: 1.8 – 1.10, 2.1 – 2.3, 2.5  Unit-III: 3.1 – 3.4  Unit-IV: 3.6, 4.1 – 4.4  Unit-V: 5.1, 5.4 – 5.8 | |
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| **Reference Books** | | |
| 1 | Michael J. Crawley, The R Book, John Wiley & Sons, Second Edition (2013). | |
| 2 | Marek Fisz, Probability Theory and Mathematical Statistics, John Wiley. | |
| 3 | Vijay K. Rohatgi and A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, Wiley India, Second Edition (2001). | |
| 4 | M. Rajagopalan and P. Dhanavanthan, Statistical Inference, PHI Learning Pvt. Ltd., New Delhi (2012). | |



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| **Course code** | | **GRAPH THEORY** | **Core** | |
| **Pre-requisite** | | Self-explanatory course **Ve** |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. To provide deep knowledge about fundamental concepts of Graphs and Trees. 2. To introduce Matchings, Coloring, and Chromatic Number and to see its application in higher order thinking. | | | | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Understand the basic concepts of Graphs and Trees | | | |
| Analyze vertex and edge connectivity concepts | | | |
| Acquire knowledge in Matching and Colourings | | | |
| Apply Chromatic Number | | | |
| Determining the planar, non-planar, and directed graphs | | | |
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| **Unit:1** | **Graphs, Subgraphs and Trees** | | | |
| **Graphs, Subgraphs**: Graphs and Simple Graphs– Graph Isomorphism – The Incidence and Adjacency matrices, Subgraphs – Vertex Degrees – paths and Connection – Cycles.  **Trees:** Trees – Cut edges and Bonds – cut vertices – Cayley’s formula. | | | | |
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| **Unit:2** | **Connectivity, Euler tours and Hamilton Cycles** | | | |
| **Connectivity:** Connectivity – Blocks.  **Euler tours and Hamilton Cycles:** Euler tours - Hamilton Cycles. | | | | |
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| **Unit:3** | **Matchings and Edge Colourings** | | | |
| **Matchings:** Matchings coverings in Bipartite Graphs – Perfect Matchings.  **Edge colourings:** Edge chromatic number – Vizing’s theorem. | | | | |
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| **Unit:4** | **Independent sets, Cliques and Vertex Colourings** | | | |
| **Independent sets, Cliques:** Independent sets – Ramsey’s theorem.  **Vertex Colourings:** Chromatic Number – Brook’s Theorem – Hajo’s Conjecture – Chromatic Polynomials – Girth and Chromatic number. | | | | |
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| **Unit:5** | **Planar Graphs and Directed Graphs** | | | |
| **Planar Graphs:** Plane and planar Graphs – Dual Graphs – Euler’s formula – Brides – Kuratowski’s theorem (Proof omitted) – The Five Colour Theorem and the Four Colour Conjecture.  **Directed Graphs:** Directed Graphs.  Simple problems in the exercise of all units can also be included. | | | | |
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| **Text Book(s)** | |
| 1 | J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, American Elsevier Company Inc., New York, 1976.  Unit-I: Sections: 1.1 – 1.7, 2.1 – 2.4  Unit-II: Sections: 3.1 – 3.2, 4.1 – 4.2  Unit-III: Sections: 5.1 – 5.3, 6.1 – 6.2  Unit-IV: Sections: 7.1 – 7.2, 8.1 – 8.5  Unit-V: Sections: 9.1 – 9.6, 10.1 |
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| **Reference Books** | |
| 1 | Frank Harary, Graph Theory, Addison-Wesley, Reading, 1969. |
| 2 | M.Murugan, Graph Theory and Algorithms, Second Edition, Muthali Publishing House, Chennai, 2018. |
| 3 | K. R. Parthasarathy, Basic Graph Theory, Tata McGraw Hill, New Delhi, 1994. |
| 4 | Douglas B. West, Introduction to Graph Theory, Prentice Hall of India, 2001. |
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Fourth Semester



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| **Course code** | | **FUNCTIONAL ANALYSIS** | **Core** |
| **Pre-requisite** | | Know the basic concepts of Real Analysis and  Linear Algebra at Undergraduate level **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:  1. To get an overview of normed spaces and familiarize on Banach space, Hilbert space , conjugate space ,bounded linear operators and spectral theory. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Familiarize with the concepts of normed linear spaces and operators on normed linear space | | | |
| Demonstrate an understanding of the concepts of Hilbert spaces and Banach spaces, and their role in mathematics | | | |
| Apply the theorems. | | | |
| Obtain Orthogonal complements, Orthonormal sets and conjugate space. | | | |
| Understand the concepts of linear operators, self adjoint, unitary operators , isometric isomorphism on Hilbert spaces ,Determinants ,the spectrum of an operator, Banach algebra . | | | |
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| **Unit:1** | **Banach Spaces** | | |
| Banach spaces – The definition and some examples – Continuous linear transformations –  The Hahn-Banach theorem –Dual spaces- The natural imbedding of N in N\*\* - The open mapping theorem - Closed Graph theorem. | | | |
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| **Unit:2** | **Hilbert spaces** | | |
| The conjugate of an operator – Uniform boundedness Principal - Hilbert spaces – The definition and some simple properties – Orthogonal complements and complements - Orthonormal sets and sequences – Maximal Orthonormal sets. | | | |
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| **Unit:3** | **Hilbert spaces (Contd)** | | |
| The Conjugate space H\* - Representation of functional on Hilbert spaces -The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections. | | | |
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| **Unit:4** | **Finite-Dimensional Spectral Theory** | | |
| Matrices – Determinants and the spectrum of bounded operator – The spectral theorem. | | | |
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| **Unit:5** | **General Preliminaries on Banach Algebras** | | |
| The definition and some examples of Banach algebra – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius. | | | |
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| **Text Book(s)** | |
| 1 | G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, London, 1963.  Unit I: Sections: 46 – 50.  Unit II: Sections: 51 – 54.  Unit III: Sections: 55 – 59.  Unit IV: Sections: 60 – 63.  Unit V: Sections: 64 – 68. |
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| **Reference Books** | |
| 1 | C. Goffman and G. Pedrick, A First Course in Functional Analysis, Prentice Hall of India, New Deli, 1987. |
| 2 | G. Bachman and L. Narici, Functional Analysis, Academic Press, New York, 1966. |
| 3 | L. A. Lusternik and V.J. Sobolev, Elements of Functional Analysis, Hindustan Publishing Corporation, New Delhi, 1971. |



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| **Course code** | | **MATHEMATICAL METHODS** | **Core** |
| **Pre-requisite** | | Basic Knowledge in Calculus and Differential equations. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Give an introduction to mathematical methods for solving application-oriented problems 2. Able to know the concepts line Integral Transforms, Integral Equations and calculus of variations. 3. Develop the alternatives to solve the real-life problems. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand and Apply various transforms and Integral equations to solve problems in all respects. | | | | |
| Recognize and solve the special cases of Volterra Integral equations by the method of resolvent kernel, method of successive approximations and by using transforms. | | | | |
| Understand the relations between the Hankel, Fourier transform and their applications in evaluating the equations. | | | | |
| Understand the formulation of variational problems, the variation of functional and its properties. | | | | |
| Demonstrate and apply the methods in all application problems in day-today life. | | | | |
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| **Unit:1** | **Integral Equations** | | |
| Types of Integral equations – Integral Fredholm Alternative - Approximate method – Equation with separable Kernel - Volterra integral equations – Fredholm’s theory. | | | |
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| **Unit:2** | **Application of Integral Equations to Ordinary Integral Equations and Singular Integral Equations** | | |
| Initial value problems Boundary value problems – singular integral equations – Abel Integral equation. | | | |
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| **Unit:3** | **Fourier Transforms** | | |
| Fourier Transforms, Fourier sine and cosine transforms – Fourier transforms of derivatives - convolution integral – Parseval’s Theorem - Solution of Laplace Equations by Fourier transform. | | | |
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| **Unit:4** | **Hankel Transforms** | | |
| Properties of Hankel Transforms – Hankel transformation of derivatives of functions - The Parseval’s relation – relation between Fourier and Hankel transforms - Axisymmetric Dirichlet problem for a half space - Axisymmetric Dirichlet problem for a thick plate. | | | |
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| **Unit:5** | | **Calculus of Variations** |
| Variation and its properties – Euler’s(Euler Lagrange’s) equation – functionals dependent on the functions of several independent variables – variational problems in parametric form –applications. | | |
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| **Text Book(s)** | | |
| 1 | **Units I and II:** Ram P. Kanwal, Linear Integral Equations Theory and Technique, Academic Press, New York, 1971.  Unit I: Chapter 2: 46 – 50.  Unit II: Chapter 3: 51 – 54. | |
| 2 | **Units III and IV:** I. N. Sneddon, The Use of Integral Transforms, McGraw-Hill, New York, 1972.  Unit III: Chapter 2: 2.3 – 2.5, Chapter 3: 3.3 – 3.4.  Unit IV: Chapter 5: 5.1 – 5.2, Chapter 8: 8.1 – 8.2. | |
| 3 | **Unit V:** L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, Moscow, 1970.  Unit V: Chapter 6: 6.1 – 6.3, 6.4 – 6.7. | |
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| **Reference Books** | | |
| 1 | Calculus of Variations, A.S. Gupta, Prentice Hall of India, New Delhi, 2005. | |
| 2 | Integral Equations and Boundary value problems, M.D. Raisinghania, S. Chand and Company, 2007. | |
| 3 | M.L. Krasnov, Problems and Exercises in Integral Equations, Mir Publication Moscow 1971. | |



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| **Course code** | | **OPTIMIZATION TECHNIQUES** | **Core** |
| **Pre-requisite** | | Basic knowledge in Operation Research at Undergraduate level. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. To make the students understand solving LPP using various methods. 2. To understand the application of queuing theory in real life situation and methods of solving related problems. 3. To understand the concept of Kuhn tucker method. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Explain various techniques to solve real life problems expressed in terms of LPP. | | | |
| Solving LPP through Dynamic Programming | | | |
| Apply the fundamental concept of Inventory control. | | | |
| Understanding the queuing theory | | | |
| Solving NLPP using Kuhn–Tucker Method | | | |
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| **Unit:1** | **Integer Programming** | | |
| Introduction – Integer Programming Formulations – Gomory’s construction–Fractional cut method(all integer)–The Cutting – Plane Algorithm – Branch–and–Bound Technique – Zero– One Implicit Enumeration Algorithm. | | | |
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| **Unit:2** | **Dynamic Programming** | | |
| Introduction – Application of Dynamic Programming: Capital Budgeting Problem – Reliability Improvement Problem – Stage–coach Problem – Cargo Leading Problem – Minimizing Total Tardiness in Single Machine Scheduling Problem – Optimal Subdividing Problem – Solution of Linear Programming Problem through Dynamic Programming. | | | |
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| **Unit:3** | **Inventory** | | |
| Introduction–Inventory Decisions–Cost Associated– with Inventories – Factors Affecting inventory – Economic Order Quantity–Deterministic Inventory Problems with No Shortages– Deterministic inventory Models with shortages–EOQ with Price Breaks–Multi Item  Deterministic problems–Inventory Problems with Uncertain Demand. | | | |
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| **Unit:4** | **Queuing Theory** | | |
| Introduction – Queuing System–Elements of Queuing System – Operating Characteristics of Queuing System – Classification of Queuing Models– Model–I (M/M/1):(∞/FIFO), Model–II (M/M/1) : (N/FIFO), Model–III (M/M/C):(∞/FIFO), Model–IV (M/M/C):(N/FIFO). Problems in above four models. | | | |
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| **Unit:5** | | **Nonlinear Programming** |
| Introduction – Lagrangian Method –Jacobi Method– Kuhn–Tucker Method – Quadratic Programming – Separable Programming – Chance–Constrained Programming or Stochastic Programming. | | |
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| **Text Book(s)** | | |
| 1 | Hamdy A. Taha, Operations Research, Sixth edition, Prentice–Hall of India private Limited, New Delhi,1997. | |
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| **Reference Books** | | |
| 1 | Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand & Sons, Educational Publishers, New Delhi. | |
| 2 | Prem Kumar Gupta, D. S. Hira Operations Research, Seventh Edition, S. Chand & Company Pvt. Ltd, 2014. | |
| 3 | F. S. Hillier and J. Lieberman, Introduction to Operation Research, Seventh Edition, Tata– McGraw-Hill Publishing Company, New Delhi, 2001. | |
| 4 | R. Panneerselvam, Operations Research, Second Edition, PHI Learning Private Limited, Delhi, 2015. | |
| 5 | I. Griva, S. G. Nash and A. Sofer, Linear and Nonlinear Optimization, SIAM Publication, 2018. | |
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| **Course code** | | **COMPUTER PROGRAMMING (C++ THEORY)** | **Core** |
| **Pre-requisite** | | Basic knowledge in C++ Programming such as Tokens, Expressions, Control Structure, Classes and Objects. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. To give the students an awareness of the object oriented programming. 2. To enable the students to write the C++ programs using classes, functions and interfaces. 3. To make applications using C++ programs. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand and apply the C++ structure, tokens, expressions, control structures | | | | |
| Ability to declare various prototyping, friend and virtual functions | | | | |
| Create Classes, objects, arrays of objects, constructors, and Destructors | | | | |
| Analyze over loading operators and inheritance | | | | |
| Deliberate files, pointers and templates. Create, design and develop quality programs in C++ | | | | |
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| **Unit:1** | **Tokens, Expressions and Control Structure** | | |
| **Basic Concept of Object-Oriented Programming**- Basic Concept of OOPS-Benefits of OOP – Applications of OOP. **Tokens, Expressions and Control Structure:** Introduction – Tokens – Keywords – Identifiers and Constants – Basic Data Types – User Defined Data Types – Derived Data Types – Declaration of Variables – Dynamic Initialization of Variables – Reference Variables – Operators - Scope Resolution Operator- Control Structures. | | | |
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| **Unit:2** | **Functions in C++** | | |
| **Functions in C++:** Introduction – The Main Function – Function Prototyping – Call by Reference– Return by Reference – Inline Functions – Default Arguments – const Arguments – Recursion – Function Over Loading – Friend and Virtual Functions – Math Library Functions. | | | |
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| **Unit:3** | **Classes and Objects & Constructors and Destructors** | | |
| **Classes and Objects:** Introduction – C Structures Revisited – Specifying a Class –Defining Member Functions – A C++ Program with Class – Making An Outside Function Inline –Nesting Of Member Functions – Private Member Functions – Arrays Within A Class –Arrays of Objects – Objects as Function Arguments – Friend Functions.  **Constructors and Destructors:** Introduction – Constructors – Parameterized Constructors – Multiple Constructors in a Class – Constructors with Default Arguments – Dynamic Initializations of Objects – Copy Constructor – Destructors. | | | |
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| **Unit:4** | | **Operator Overloading, Inheritance and Extending Classes** |
| **Operator Overloading:** Introduction – Defining Operator Overloading – Overloading Unary Operators – Overloading Binary Operators – Overloading Binary Operators Using Friends – Manipulating of Strings Using Operators – Rules for Overloading Operators.  **Inheritance - Extending Classes:** Introduction – Defining Derived Classes – Single Inheritance  – Making a Private Member Inheritable – Multilevel Inheritance – Multiple Inheritance – Hierarchical Inheritance – Hybrid Inheritance – Virtual Base Classes – Abstract Classes. | | |
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| **Unit:5** | | **Streams and Working with files** |
| **Streams:** Introduction – C++ Streams – C++ Stream Classes. **Working with files:** Classes for File Stream Operations - Opening and Closing a File – File Modes – File Pointers and their Manipulations – Sequential Input and Output Operations –Random Access. | | |
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| **Text Book(s)** | | |
| 1 | E. Balaguruswamy, Object–Oriented Programming with C++, Sixth Edition, Tata McGraw- Hill Publishing Company Limited.  Unit I : 1.4 – 1.6, 3.1 – 3.14 and 3.24  Unit II : 4.1 – 4.11  Unit III : 5.1 – 5.9, 5.13 – 5.15, 6.1 – 6.7 and 6.11  Unit IV : 7.1 – 7.7 and 8.1 – 8.10  Unit V : 10.1 – 10.3 and 11.1 – 11.8 | |
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| **Reference Books** | | |
| 1 | Programming with C++ by D. Ravichandran, -Tata McGraw Hill publishing company limited, New Delhi. | |
| 2 | Object Oriented Programming with C++ by S.S.Vinod Chandra, New age. | |



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| **Course code** | **COMPUTER PROGRAMMING (C++ PRACTICAL)** | **Core** |
| **Pre-requisite** | Basic knowledge in programming |
| **Course Objectives:** | | |
| The main objectives of this course are to:   1. To enable the students to solve problems in C++ using different numerical methods. 2. To make the mathematical calculations simpler. | | |
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| 1. **friend FUNCTION usage**: Create two classes to store the value of distances in meters- centimetres and feet-inches. Write a program that can create the values of the class objects and add one object with another. Use a friend function to carry out addition operation. The result may be stored in any object depending on the units in which results are required. The display should be in the order of meters & centimetre and feet & inches depending on the order of display. 2. **OVERLOADING OBJECTS**: Create a class that contains one float data member. Overload all the four arithmetic operators so that operate on the objects of the class. 3. **OVERLOADING CONVERSIONS**: Design a class **Polar** which describes a point in a plane using polar co-ordinates **radius** and **angle**. Use the overloaded + operator to add two objects of **Polar**. Note that we cannot add polar values of two points directly. This requires first the conversion of points into rectangular co-ordinates and finally converting the result into polar co-ordinates. You need to use following trigonometric formulae: *= r \* cos (a); = r \* sin (a);*= ; = ∗ + ∗ . 4. **OVERLOADING VECTOR**: Define a class for Vector containing scalar values. Apply overloading concepts for Vector Addition, Multiplication of a Vector by a scalar quantity, replace the values in a Position Vector. 5. **OVRELOADING MATRIX**:   Create a class **MAT** of size m \* n. Define all possible matrix operations for **MAT** type objects. Verify the identity: *(A-B) 2 = A2+B2 – 2AB.*   1. **INHERITANCE**: Create three classes: **alpha, beta** and **gamma**, each containing one data member. The class **gamma** should be inherited from both **alpha** and **beta**. Use a constructor function in the class **gamma** to assign values to the data members of all the classes. Write a program to print the value of data members of all the three classes. 2. **FILE HANDLING**: Write a program to create a disk file containing the list of names and telephone numbers in two columns, using a class object to store each set of data. Design an interactive menu to access the file created and to implement the following tasks: 3. Determine the telephone number of the specified person. 4. Determine the name if a telephone number is known. 5. Update the telephone number, whenever there is a change. | | |
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Elective Courses



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| **Course code** | | **Elective 1: NUMBER THEORY** | **Elective** |
| **Pre-requisite** | | Basic knowledge in Number system, divisibility  and some related functions. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. To give Introduction to Elementary Number Theory. 2. To show how certain number theorems can be applied within Cryptography. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Find quotients and remainders and greatest common divisors applying Euclidean Algorithm | | | |
| Understand the definitions of congruence, residue classes and least residues | | | |
| Analyze the concept of Prime Power Moduli and Quadratic Residues | | | |
| Determine multiplicative inverses, modulo n and use to solve linear congruence. | | | |
| Acquire knowledge on Linear Diaphantine equation | | | |
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| **Unit:1** | **Divisibility** | | |
| Divisibility and Euclidean algorithm. | | | |
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| **Unit:2** | **Congruences** | | |
| Congruences, Euler’s theorem, Wilson’s Theorem. Solutions of congruences, Congruences of  Degree 1. Chinese Remainder Theorem, The functions (n), Congruences of higher degree. | | | |
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| **Unit:3** | **Congruences (contd), Quadratic Reciprocity** | | |
| Prime power moduli, Prime modulus. Quadratic residues - Quadratic reciprocity. | | | |
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| **Unit:4** | **Jacobi Symbol and Some Functions of Number Theory** | | |
| The Jacobi symbol – Greatest integer function - Arithmetic functions – The Moebius Inversion formula. | | | |
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| **Unit:5** | **Arithmetic Functions and Diophantine Equations** | | |
| Multiplication of arithmetic functions, Linear Diophantine equations – The equation x2 + y2 = z2 - The equation x4 + y4 = z2. | | | |
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| **Text Book(s)** | |
| 1 | Ivan Niven and Herbert Zuckerman, An Introduction to the Theory of Numbers, John Wiley and Sons Inc., 1972.  Unit-I: Chapter I: Sections: 1.1 – 1.3 Unit-II: Chapter II: Section: 2.1 – 2.5  Unit-III: Chapter II: Section: 2.6 – 2.7, Chapter III: Section: 3.1 – 3.2 Unit-IV: Chapter III: Section: 3.3, Chapter IV: Section: 4.1 – 4.3 Unit-V: Chapter IV: Section: 4.4, Chapter V: Section: 5.1 – 5.6 |
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| **Reference Books** | |
| 1 | T. M. Apostol, Introduction to Analytic Number Theory, Springer Verlag, 1976. |
| 2 | Kenneth H. Rosen, Elementary Number Theory and its Applications, Addison Wesley Publishing Company, 1968. |
| 3 | George E. Andrews, Number Theory, Hindustan Publishing, New Delhi, 1989. |



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| **Course code** | | | **ELECTIVE 2: DIFFERENTIAL GEOMETRY** | **Elective** | |
| **Pre-requisite** | | | Basic knowledge of differential calculus and geometry |
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| The main objectives of this course are to:   1. Gain knowledge about curves and its characterizations. 2. Get sufficient knowledge on Elementary Theory of surfaces. 3. Make the students to familiarize with space curves and curves on surfaces. | | | | | |
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| **Expected Course Outcomes:** | | | | | |
| On the successful completion of the course, student will be able to: | | | | | |
| Define and understand basic definitions of the theory of curves. | | | | |
| Interpret the notions of surface of revolution and direction coefficients. | | | | |
| Analyze the elements of Analytic representation. | | | | |
| Acquire knowledge on first fundamental form and second fundamental form. | | | | |
| Explain Meusnier’s theorem and Euler’s Theorem on elementay theory of surface. | | | | |
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| **Unit:1** | | **Curves** | | | |
| Analytic representation - Arc Length – Osculation plane. | | | | | |
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| **Unit:2** | | **Curves (Continued)** | | | |
| Curvature torsion – Formulas of Frenet - Contact – Natural equations – Helices – General solutions of Natural equations. | | | | | |
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| **Unit:3** | | **Curves (Continued) and Elementary Theory of Surface** | | | |
| Evolutes and Involutes - Elementary theory of surface: Analytic representation. | | | | | |
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| **Unit:4** | | **Elementary Theory of Surface (Continued)** | | | |
| First fundamental form – Normal, Tangent plane – Developable surfaces - Second fundamental form. | | | | | |
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| **Unit:5** | | **Elementary Theory of Surface (Continued)** | | | |
| Meusnier’s theorem – Euler’s Theorem – Dupin’s indicatrix – Some surfaces. | | | | | |
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| **Text Book(s)** | | | | | |
| 1 | Dirk J. Struik, Lectures on Classical Differential Geometry, Addison Wesley Publishing Company, 1961. | | | | |

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| **Reference Books** | |
| 1 | Differential Geometry by T.J. Willmore, Oxford University Press (Seventeenth Impression - 2002). |
| 2 | Differential Geometry by A First Course by D. Somasundaram, Narosa Publishing House, Reprint 2008. |



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| **Course code** | | **ELECTIVE 3: NEURAL NETWORKS** |  | |
| **Pre-requisite** | | Self-explanatory |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. To know the main fundamental principles and techniques of neural network systems and investigate the principal neural network models and applications. 2. Acquire in-depth knowledge in Non-linear dynamics 3. Apply neural network to classification and generalization problems. | | | | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Understand and analyze different neutron network models | | | |
| Understand the basic ideas behind most common learning algorithms for multilayer perceptions, radial-basis function networks. | | | |
| Describe Hebb rule and analyze back propagation algorithm with examples. | | | |
| Study convergence and generalization and implement common learning algorithm, | | | |
| Study directional derivatives and necessary conditions for optimality and to evaluate quadratic functions. | | | |
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| **Unit:1** | **Neuron Model and Network Architectures** | | | |
| Mathematical Neuron Model- Network Architectures- Perceptron-Hamming Network- Hopfield Network-Learning Rules. | | | | |
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| **Unit:2** | **Perceptron Architectures** | | | |
| Perceptron Architectures and Learning Rule with Proof of Convergence. Supervised Hebbian Learning -Linear Associator. | | | | |
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| **Unit:3** | **Supervised Hebbian Learning** | | | |
| The Hebb Rule-Pseudo inverse Rule-Variations of Hebbian Learning-Back Propagation - Multilayer Perceptrons. | | | | |
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| **Unit:4** | **Back Propagation** | | | |
| Back propagation Algorithm-Convergence and Generalization - Performances Surfaces and Optimum Points-Taylor series. | | | | |
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| **Unit:5** | **Performance Surfaces and Performance Optimizations** | | | |
| Directional Derivatives - Minima-Necessary Conditions for Optimality-Quadratic Functions- Performance Optimizations-Steepest Descent-Newton’s Method-Conjugate Gradient. | | | | |
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| **Text Book(s)** | |
| 1 | Martin T. Hagan, Howard B. Demuth and Mark Beale, Neural Network Design, Vikas Publishing House, New Delhi,2002. |
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| **Reference Books** | |
| 1 | James A. Freeman, David M. Skapura, Neural Networks Algorithms, Applications and Programming Techniques, Pearson Education, 2003. |
| 2 | Robert J. Schalkoff, Artificial Neural Network, McGraw-Hill International Edition, 1997. |



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| **Course code** | | **ELECTIVE 4: MAGNETOHYDRODYNAMICS** | **Elective** |
| **Pre-requisite** | | Knowledge of fluid dynamics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand the concepts of electromagnetism, electrostatic energy and magnetostatic energy. 2. Gain knowledge about boundary conditions of electric and magnetic fields. 3. Develop flexibility and creativity of the students in applying mathematical ideas and techniques to unfamiliar problems arising in everyday life. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand the basic concepts of Electromagnetism, Fundamental Laws and fluid motion in magnetic field. | | | |
| Solve and analyze the Naiver-Stokes equations and velocity Magneto fluid dynamic equations with examples. | | | |
| Understand the MHD approximation and gain ability to analyze Magnetic Reynolds number. | | | |
| Gain knowledge about the Magneto hydrostatics and Alfven waves in incompressible MHD. | | | |
| Understand and develop the Hartmann Flow in the presence of magnetic field. | | | |
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| **Unit:1** | **Title of the Unit (Capitalize each Word)** | | |
| Electromagnetism – Fundamental Laws – Electrostatic Energy – Electrodynamics Ampere’s Law – Lorentz force on a moving charge – Magnetostatic Energy – Faraday’s Law of Induction  – Poynting stresses. | | | |
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| **Unit:2** | **Title of the Unit (Capitalize each Word)** | | |
| Electromagnetic Equations with respect to moving axes – boundary conditions of electric and magnetic fields. Kinematics of fluid motion – equation of continuity – Stress tensor – Navier-  stokes equations – boundary condition – Velocity Magneto fluid dynamic equations. | | | |
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| **Unit:3** | **Title of the Unit (Capitalize each Word)** | | |
| MHD approximation – equation of Magnetic diffusion in a moving conducting medium – Magnetic Reynolds number. | | | |
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| **Unit:4** | **Title of the Unit (Capitalize each Word)** | | |
| Alfven’s theorem Law of isorotation - Magneto hydrostatics – Force-free field – Alfven waves in incompressible MHD. | | | |
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| **Unit:5** | **Title of the Unit (Capitalize each Word)** | | |
| Incompressible viscous flows in the presence of magnetic field – Hartmann Flow – unsteady Hartmann flow – Magneto fluid dynamic pipe flow. | | | |
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| **Text Book(s)** | |
| 1 | Crammer K.R. and Pai S.I, Magneto Fluid Dynamics for Engineers and Applied Physicists, McGraw Hill, 1973. |
| 2 | Ferraro, VCA and Plumpton, Introduction to Magneto Fluid Dynamics, Oxford, 1966. |
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| **Reference Books** | |
| 1 | P. A. Davidson, An Introduction to Magnetohydrodynamics, Cambridge University press, 2001. |
| 2 | R. V. Polovin, V. P. Demutskii, Fundamentals of Magnetohydrodynamics, Springer US, 1990. |



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| **Course code** | | **ELECTIVE 5:**  **FUZZY LOGIC AND FUZZY SETS** | **Elective** |
| **Pre-requisite** | | Self-explanatory |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. identify fuzzy sets and perform set operations on fuzzy sets. 2. apply fuzzy logic in various real-life situations such as decision making and inventory control. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Gain knowledge about the basic types of fuzzy sets and the difference between crisp sets and fuzzy sets and the concept of operations on fuzzy sets | | | |
| Analyze and apply the knowledge of fuzzy relations. | | | |
| Develop the basic concepts of fuzzy measures. | | | |
| Explore the concept of uncertainity. . | | | |
| Understand the types of uncertainity measures and principles | | | |
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| **Unit:1** | **Crisp Sets and Fuzzy Sets** | | |
| Introduction-Crisp sets: An over view-The Notion of Fuzzy Sets-basic concepts of Fuzzy Sets – Classical Logic: complement-Fuzzy Union-Fuzzy intersection – Combination of operations – General aggregation of operations. | | | |
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| **Unit:2** | **Fuzzy Relations** | | |
| Crisp and Fuzzy relations – Binary relations – Binary relations on a single set – Equivalence and similarity relations – Compatibility on Tolerance Relations-Orderings – Morphism – Fuzzy relations Equations. | | | |
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| **Unit:3** | **Fuzzy Measures** | | |
| General discussion – Belief and plausibility Measures –Probability measures – Possibility and Necessity measures. | | | |
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| **Unit:4** | **Fuzzy Measures, Uncertainty** | | |
| Relationship among classes of fuzzy measures - Types of Uncertainty – Measures of Fuzziness- Classical Measures of Uncertainty. | | | |
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| **Unit:5** | **Uncertainty and Information** | | |
| Measures of Dissonance-Measures of Confusion – Measures of Non-Specificity – Uncertainty and Information – Information and Complexity – Principles of Uncertainty and information. | | | |
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| **Text Book(s)** | |
| 1 | George J. Klir and Tina A. Folger, Fuzzy Sets, Uncertainty and Information, Fourth printing, Prentice Hall of India Private Limited, 1995.  Unit-I: 1.1 – 1.5, 2.2 - 2.6  Unit-II: 3.1 – 3.8  Unit-III: 4.1 – 4.4  Unit-IV: 4.5, 5.1 – 5.3  Unit-V: 5.4 – 5.9. |
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| **Reference Books** | |
| 1 | George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic - Theory and Applications, Prentice-Hall of India Private Limited |
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| **Course code** | | **ELECTIVE 6: CONTROL THEORY** | **Elective** |
| **Pre-requisite** | | Basic knowledge in differential equations at Undergraduate level. |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand the concepts of Observability, Controllability and Stability. 2. Gain knowledge about linear time varying systems. 3. Develop the ability of solving linear feedback control. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Explain observability and estimate the observability of constant coefficient system, linear, nonlinear system, and discuss reconstruction kernel. | | | |
| Apply controllability criteria to constant coefficient system, linear, nonlinear system, and explain steering function. | | | |
| Analyze the stability of linear system, linear time varying system, perturbed linear system and nonlinear system. | | | |
| Evaluate stabilizabilization via linear feedback control, Bass method. | | | |
| Analyze controllable subspace, and stabilization with restricted feedback. | | | |
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| **Unit:1** | **Observability** | | |
| Linear Systems – Observability Grammian – Constant coefficient systems – Reconstruction kernel – Nonlinear Systems. | | | |
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| **Unit:2** | **Controllability** | | |
| Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems – steering function – Nonlinear systems. | | | |
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| **Unit:3** | **Stability** | | |
| Stability – Uniform Stability – Asymptotic Stability of Linear Systems. | | | |
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| **Unit:4** | **Perturbed Linear Systems** | | |
| Linear time varying systems – Perturbed linear systems – Nonlinear systems. | | | |
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| **Unit:5** | **Stabilizability** | | |
| Stabilization via linear feedback control – Bass method – Controllable subspace – Stabilization with restricted feedback. | | | |
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| **Text Book(s)** | |
| 1 | K. Balachandran and J. P. Dauer, Elements of Control Theory, Narosa, New Delhi, 1999. |
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| **Reference Books** | |
| 1 | R. Conti, Linear Differential Equations and Control, Academic Press, London, 1976. |
| 2 | R. F. Curtain and A. J. Pritchard, Functional Analysis and Modern Applied Mathematics, Academic Press, New York, 1977. |
| 3 | J. Klamka, Controllability of Dynamical Systems, Kluwer Academic Publisher, Dordrecht, 1991. |
| 4 | D. L. Russell, Mathematics of Finite Dimensional Control Systems, Marcel Dekker, New York, 1979. |
| 5 | E. B. Lee and L. Markus, Foundations of optimal Control Theory, John Wiley, New York, 1967. |



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| **Course code** | | **ELECTIVE 7: CRYPTOGRAPHY** | **Elective** |
| **Pre-requisite** | | Basic knowledge in Modular arithmetic and  finite field. **Ve** |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Provide the deeper understanding in cryptography and its application to network security. 2. Able to know the applications of number theory in cryptography. 3. Know the methods of public key cryptography and its usefulness. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand the basic concepts and objective of cryptography and recall the concept of modular arithmetic. | | | |
| Understand mathematical foundations required for various cryptographic algorithms. | | | |
| Apply the concept and properties of modular arithmetic in various algorithms to find the solution. | | | |
| Describe and Analyze existing authentication protocols for two party communications. | | | |
| Evaluate security mechanisms in the theory of networks and apply the appropriate algorithms. | | | |
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| **Unit:1** | **Title of the Unit (Capitalize each Word)** | | |
| Introduction – Encryption and Secrecy – The objective of Cryptography - Number Theory – Introduction – Modular Arithmetic. | | | |
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| **Unit:2** | **Title of the Unit (Capitalize each Word)** | | |
| Integer factorization problem – Pollard’s rho factoring – Elliptic curve factoring – Discrete logarithm problem. | | | |
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| **Unit:3** | **Title of the Unit (Capitalize each Word)** | | |
| Finite fields – Basic properties – Arithmetic of polynomials –Factoring polynomials over finite fields – Square free factorization. | | | |
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| **Unit:4** | **Title of the Unit (Capitalize each Word)** | | |
| Symmetric key encryption – Stream ciphers – Block Ciphers – DES. | | | |
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| **Unit:5** | **Title of the Unit (Capitalize each Word)** | | |
| Public key cryptography – Concepts of public key cryptography – Modular arithmetic – RSA – Discrete logarithm – Elliptic curve cryptography. | | | |
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| **Text Book(s)** | |
| 1 | Hans Delfs, Helmut Knebl, Introduction to Cryptography, Springer Verlag, 2002. |
| 2 | Alfred J. Menezes, Paul C. Van Oorschot, Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press, 2000. |
| 3 | William Stallings, Cryptography and Network Security, Prentice Hall of India, 2000. |
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| **Reference Books** | |
| 1 | Cryptography and Information Security, Pachghare V.K., PHI Learning Pvt. Ltd., New Delhi, 2009 |
| 2 | Cryptography and Network Security, Behrouz A. Forouzan and Debdeep Mukhopathyey, 2013, second edition, Mc Graw Hill Education Pvt. Ltd., New Delhi. |



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| **Course code** | | **ELECTIVE 8: MATLAB** | **Elective** |
| **Pre-requisite** | | Self-explanatory |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand the Matlab Desktop, Command window and the Graph Window. 2. Be able to carry out numerical computations and analyses. 3. Understand the mathematical concepts upon which numerical methods rely. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand the basic concepts of starting windows and solve the MATLAB applications. | | | | |
| Create arrays and solve them in MATLAB. | | | | |
| Solve problems using M files and apply the same for advanced data objects in MATLAB. | | | | |
| Understand the importance of MATLAB in differential equations and assess it for plotting graphs using layouts. | | | | |
| Diagnose various applications of MATLAB in curve fitting, statistics and integration. | | | | |
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| **Unit:1** | **Starting with Matlab and Creating Arrays** | | |
| Starting with Matlab: Starting MATLAB, MATLAB Windows - Working in the Command Window - Arithmetic Operations with Scalars - Display Formats - Elementary Math Built-In Functions - Defining Scalar Variables - Useful Commands for Managing Variables - Script Files  - Examples of MATLAB Applications.  Creating Arrays: Creating a One-Dimensional Array (Vector) - Creating a Two-Dimensional Array (Matrix) - Notes about Variables n MATLAB - The Transpose Operator - Array Addressing - Using a Colon: In Addressing Arrays - Adding Elements to Existing Variables - Deleting Elements - Built-In Functions for Handling Arrays - Strings and Strings as Variables. | | | |
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| **Unit:2** | **Mathematical Operations with Arrays, Using Script Files and Managing Data** | | |
| Mathematical Operations with Arrays: Addition and Subtraction - Array Multiplication - Array Division - Element-By-Element Operations - Using Arrays in MATLAB Built-in Math Functions - Built-in Functions for Analyzing Arrays - Generation of Random Numbers - Examples of MATLAB Applications.  Using Script Files and Managing Data: The MATLAB Workspace and the Workspace Window  - Input to A Script File - Output Commands - The Save And Load Commands - Importing And Exporting Data - Examples of MATLAB Applications. | | | |
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| **Unit:3** | **Two-Dimensional Plots and Three-Dimensional Plots** | | |
| Two-Dimensional Plots: The plot Command - The fplot Command - Plotting Multiple Graphs in the Same Plot - Formatting a Plot - Plots with Logarithmic Axes - Plots with Error Bars - Plots With Special Graphics - Histograms - Polar Plots - Putting Multiple Plots on the Same Page - | | | |



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| Multiple Figure Windows - Examples of MATLAB Applications.  Three-Dimensional Plots: Line Plots - Mesh and Surface Plots - Plots with Special Graphics - The View Command - Examples of Matlab Applications. | | |
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| **Unit:4** | | **Programming In Matlab, User-Defined Functions and Function Files** |
| Programming In Matlab: Relational and Logical Operators - Conditional Statements - The Switch-Case Statement - Loops - Nested Loops and Nested Conditional Statements - The Break and Continue Commands - Examples of MATLAB Applications.  User-Defined Functions and Function Files: Creating A Function File - Structure of a Function File - Local And Global Variables - Saving A Function File - Using A User-Defined Function - Examples of Simple User-Defined Functions - Comparison Between Script Files and Function Files - Anonymous And Inline Functions - Function Functions - Subfunctions - Nested  Functions - Examples Of MATLAB Applications. | | |
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| **Unit:5** | | **Polynomials, Curve Fitting, Interpolation and Applications in Numerical Analysis** |
| Polynomials, Curve Fitting, and Interpolation: Polynomials - Curve Fitting - Interpolation - The Basic Fitting Interface - Examples of MATLAB Applications.  Applications in Numerical Analysis: Solving an Equation with One Variable - Finding a Minimum or a Maximum of a Function - Numerical Integration - Ordinary Differential Equations - Examples of MATLAB Applications. | | |
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| **Text Book(s)** | | |
| 1 | Amos Gilat, MATLAB An Introduction with Applications, John Wiley & Sons, Inc., 2011. | |
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| **Reference Books** | | |
| 1 | Rudra Pratap, Getting Started with MATLAB– A Quick Introduction for Scientists and Engineers, Oxford University Press. | |
| 2 | William John Palm, Introduction to MATLAB 7 for Engineers, McGraw-Hill Professional, 2005. | |
| 3 | Dolores M. Etter and David C. Kuncicky, Introduction to MATLAB 7, Printice Hall, 2004. | |



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| **Course code** | | **ELECTIVE 9: LaTex** | **Elective** |
| **Pre-requisite** | | Self-explanatory |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand richness of Latex rather than using M.S word for documentation. 2. Proficient in documentation using mathematical symbols, graphs and tables. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Understand basic concepts of Text formatting and LaTex file | | | |
| Demonstrating command names and arguments, Special characters. | | | |
| Apply the commands to create document layout and displayed output | | | |
| Create Table, Printing Text, Foot notes and marginal notes | | | |
| Apply LaTex commands to mathematical formulae | | | |
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| **Unit:1** | **Introduction** | | |
| Text formatting, TEX and its offspring, What’s different in LATEX 2є, Distinguishing LaTex 2є, Basics of a LaTex file. | | | |
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| **Unit:2** | **Commands and Environments** | | |
| Command names and arguments, Environments, Declarations, Lengths, Special Characters – Spaces and carriage returns, Quotation marks, Hyphens and dashes, Printing command characters, The date, Exercises. | | | |
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| **Unit:3** | **Document Layout and Organization, Displayed Text** | | |
| Document class, Page style, Parts of the document, Table of contents – Automatic entries, Printing the table of contents, Fine-Tuning text – Line breaking, Page breaking. Displayed Text – Changing font – Emphasis, Choice of font size, Font attributes, Centering and indenting, Lists. | | | |
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| **Unit:4** | **Displayed Text (Continued)** | | |
| Tables, Printing literal text, Footnotes and marginal notes. | | | |
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| **Unit:5** | **Mathematical Formulae** | | |
| Mathematical environments, Main elements of math mode,  Mathematical symbols – Greek letters, function names, Additional elements, Fine–tuning mathematics – Horizontal spacing, Selecting font size in formulas. | | | |
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| **Text Book(s)** | |
| 1 | Helmut Kopka and Patrick W. Daly, A Guide to LATEX, Third Edition, Addison – Wesley, London,1999.  Unit I : Chapter 1 : Sections : 1.1-1.3, 1.4.1, 1.5.  Unit II : Chapter 2 : Sections : 2.1-2.4, 2.5.1-2.5.4, 2.5.9, 2.7.  Unit III : Chapter 3 : Sections : 3.1-3.3, 3.4.1, 3.4.2, 3.5.2, 3.5.5,  Chapter 4 : 4.1.1-4.1.3, 4.2, 4.3  Unit IV : Chapter 4 : Sections : 4.8-4.10.  Unit V : Chapter 5: Sections : 5.1, 5.2, 5.31, 5.3.8, 5.4, 5.4.1 – 5.4.8, 5.5.1, 5.5.2. |



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| **Course code** | | **10 - ELEMENTS OF STOCHASTIC PROCESSES** | **Elective** |
| **Pre-requisite** | | Basic concepts of Statistics and Operation Research at Undergraduate level |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Acquire knowledge about the concept of Markov Chain and Queueing System. 2. Understand the methods of Birth and Death queues with Finite and Infinite Capacity. 3. Develop the ability of Standard Brownian Motion. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Acquire adequate knowledge about Continuous Time Markov Chain and Queueing Systems. | | | |
| Gain understanding on the Renewal Process, Cumulative Process and Semi- Markov Process. | | | |
| Apply different methods and solve Birth and Death queues. | | | |
| Examine the computations of M/G/1 and G/M/1 Queues and Network of Queues. | | | |
| Conclude the idea of Brownian Motion and First Passage Times. | | | |
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| **Unit:1** | **Continuous-Time Markov Models** | | |
| Continuous Time Markov Chain, Examples, Transient Analysis, Occupancy Times, Limiting Behavior. | | | |
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| **Unit:2** | **Generalized Markov Models** | | |
| Renewal Process, Cumulative Process, Semi-Markov Process, Examples and Long term Analysis. | | | |
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| **Unit:3** | **Queueing Models** | | |
| Queueing Systems, Single-Station Queues, Birth and Death queues with Finite and Infinite Capacity. | | | |
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| **Unit:4** | **Queueing Models (Contd)** | | |
| M/G/1 and G/M/1 Queues and Network of Queues. | | | |
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| **Unit:5** | **Brownian Motion** | | |
| Standard Brownian Motion, Brownian Motion and First Passage Times. | | | |
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| **Text Book(s)** | |
| 1 | V. G. Kulkarni, Introduction to Modelling and Analysis of Stochastic Systems, Second Edition, Springer, 2011. |
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| **Reference Books** | |
| 1 | J. Medhi, Stochastic Processes, New Age, 2009. |
| 2 | S. M. Ross, Stochastic Processes, Wiley Series in Probability and Statistics, 1996. |
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