**Department of Mathematics & Statistics**

Evaluation Scheme of Post Graduate Program as per NEP-2020

**w.e.f. Session 2025-26**

**M.Sc. (MATHEMATICS)** **Year: First / Semester: First (Odd Semester)**

| S. N. | Course Code | Course Title | Theory / Practical | Course Type | Periods/ Per week | | | Continuous Assessment | | | End Semester Examination (ESE) | Subject Total | Total Credit Points | Attributes | | | | | | | United Nations Sustainable Development Goals (SDGs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lecture (L) | Tutorial (T) | Practical (P) | Class Test (CT) | Teacher Assessment (TA) | Total | | | | Employability | Entrepreneurship | Skill Development | Gender Equality | nvironment & Sustainability | Human Value | Professional Ethics | |
| 1 | B030701T/MT434 | Real & Complex Analysis | Theory | Core Major (Compulsory) | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | |  |
| 2 | B030702T/MT435 | Advanced Modern Algebra | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | | | | | | |
| 3 | B030703T/MT436 | Ordinary&Partial Differential Equations | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | |  |
| 4 | B030704T/MT437 | Discrete Structures | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | |  |
| 5 | B030705T/MT438 | Mathematical Modeling & Computing through C | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | | |
| | | | | TOTAL | **25** | **5** | **0** | **75** | **50** | **125** | **375** | **500** | **20** | | | | | | | | |

**Integral University, Lucknow**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Effective from Session:** 2025-26 | | | | | | | | |
| **Course Code** | B030701T/MT434 | **Title of the Course** | Real & Complex Analysis | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII & PG: I | 5 | 1 | 0 | **4** |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | The purpose of this undergraduate course is to impart details and key knowledge of Real & Complex Analysis. After successfully completion of course, the student will able to explore subject into their respective dimensions. | | | | | | |

**Course Outcomes**

| | |
|---|---|
| **CO1** | Understand Fundamental Theorems in Complex Analysis. |
| **CO2** | Master Measure Theory and Convergence of Functions. |
| **CO3** | Analyze Functions of Several Variables. |
| **CO4** | Analyze Singularities and Residues. |
| **CO5** | Apply Transformations in Complex Analysis. |

| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| 1 | **Real Numbers & measurable sets** | Countability of sets, Lebesgue measure on the real line, length of intervals, Cantor set. outer and inner Lebesgue measure, Lebesgue measurable sets, properties of measurable sets. | 7 | 1 |
| 2 | **convergence & uniform convergence** | Sequence and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M test, Abel's and Dirichlet's test for uniform convergence, properties of uniformly convergent series of functions. | 8 | 1 |
| 3 | **Power Series** | Power series, radius of convergence and interval of convergence. uniqueness theorem of power series, Abel's, Taylor's theorem and Riemann's theorem. | 7 | 2 |
| 4 | **Partial and Total differentiations** | Functions of several variables, properties of Jacobians, partial derivatives, total derivative, Jacobian, chain rule, interchange of the order of differentiation, higher derivatives, inverse function theorem, implicit function theorem. | 8 | 3 |
| 5 | **Singularities and Residues** | Classification of singularities, residues, poles and zeros, behaviour of functions at infinity, meromorphic functions, the open mapping theorem, partial fraction expansions, analytic continuation. | 8 | 4 |
| 6 | **Evaluation of Certain Integrals** | Cauchy residue theorem, evaluation of real definite integration when function has no pole on real axis and pole lies on real axis, Integral involving many valued function, rectangular contours. | 7 | 4 |
| 7 | **Conformal Mappings and Mobius transformations** | Conformal, bilinear, exponential and trigonometric transformations, special bilinear and Schwarz, -Christoffel transformations. | 7 | 5 |
| 8 | **Special Theorems** | Weierstrass's theorem, principle of maximum modulus, Schwarz's lemma, Picard's theorem, Jensen inequality and formula, Hadamard's three circle theorem and as a convexity. | 8 | 5 |

**Reference Books:**


1. L. V. Alforse, Complex Analysis, McGraw-Hill Book Company.

2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publication.

3. S.C.Malik, Mathematical Analysis, Wiley Eastern, India.

4 W. Rudin: Principle of Mathematics Analysis, Mcgraw-Hill Inc.

5. Jain,P.K. & Gupta V.P., Lebesgue measure and Integration,Willey Eastern Ltd., New Age Int. Ltd., New Delhi,(1994).

6. Shanti Narayan, Theory of Functions of a complex variable, S. Chand & Coompany.


**e-Learning Source:**

https://www.youtube.com/watch?v=YORGYJKDDN0

https://www.youtube.com/watch?v=Xx7ULr79fy0&list=PLbMVogVj5nJSxFihV-ec4A3z_FOGPRCo-&index=4

https://www.youtube.com/watch?v=AqHxSRul-Ck

**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| **PO-PSO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | - | - | - | - | - | 2 | 3 | 3 | 2 | 3 | 3 |
| **CO2** | 3 | - | - | - | - | - | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 2 | 2 | 3 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 2 | 3 | 2 | 2 | 2 | 3 |

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| Name & Sign of Program Coordinator | Sign & Seal of HoD |
|---|---|

INTEGRAL UNIVERSITY

**Integral University, Lucknow**

| **Effective from Session:** 2025–26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | B030702T/MT435 | **Title of the Course** | Advanced Modern Algebra | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII & PG: I | **5** | **1** | **0** | **4** |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | **None** | | | | |
| **Course Objectives** | The objective of this course is to gain a deeper understanding of how algebraic structures can be broken down, built up, and connected. These concepts work together to provide a more complete picture of how to break down complex structures of groups into simpler components, how group symmetries can be understood, and how field extensions play a critical role in algebra. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Understand the concepts of generators of a subgroup, derived subgroups, normal series, and solvable groups, and will apply the Jordan-Hölder theorem to analyze the structure of finite groups and their composition series. |
| **CO2** | Understand the structure and properties of direct products of finite Abelian groups, including their classification, decomposition into cyclic groups, and applications in group theory and related fields. |
| **CO3** | Develop a deep understanding of group actions, kernels, orbits, stabilizers, and conjugacy, and will apply these concepts to analyze the structure of groups, especially in the context of symmetric groups and their conjugacy classes. |
| **CO4** | Understand the concept of an ideal in a ring. They will learn how ideals function as subsets of rings that interact with the ring's operations in specific ways. |
| **CO5** | Develop a strong understanding of the fundamental concepts in field theory and extension theory. They will learn the theory and applications of field extensions. |

| **Part A<br>Advanced Group Theory** | | | | |
|---|---|---|---|---|
| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
| 1 | **Solvable Group and Jordan Holder Theorem** | Generator of a subgroup, derived subgroups, normal series, solvable groups, composition series, Jordan Holder Theorem. | 8 | 1 |
| 2 | **External Direct Product** | External direct product, properties of external direct product, the group of unit modulo $n$ as an external direct product, Applications. | 7 | 2 |
| 3 | **Finite Abelian groups** | Internal direct product, finite abelian groups, fundamental theorem of finite abelian groups, Invariants of finite abelian groups, uniqueness of invariants. | 7 | 2 |
| 4 | **Group Acting on a Set** | Group Actions, kernel, orbit, stabilizer, group acting on themselves by conjugation, conjugacy in $S_n$. | 8 | 3 |
| **Part B<br>Advanced Ring Theory** | | | | |
| 5 | **Theory of Ideals** | Theory of Ideals, principal ideals, direct and discrete direct sum of rings, Ideals generated by subsets and their characterizations in terms of elements of the ring under different conditions, sums and direct sums of ideals, ideal products and nilpotent ideals, minimal and maximal ideals. | 8 | 4 |
| 6 | **Extension Fields** | Extension fields, the fundamental theorem of fields theory, splitting fields, zero of irreducible polynomial. | 8 | 5 |
| 7 | **Algebraic Extensions** | Characterization of extensions, finite extensions, degree of extension, properties of algebraic extensions. | 7 | 5 |
| 8 | **Cyclotomic Extensions & Finite Fields** | Cyclotomic polynomials, cyclotomic extensions, finite fields, classification of finite fields, structure of finite fields, subfield of a finite field. | 7 | 5 |
| **Reference Books:** | | | | |
| Topics in Algebra: I. N. Herstein, Wiley India Pvt. Ltd. | | | | |
| Contemporary Abstract Algebra: Joseph A. Gallian, CRC Press. | | | | |
| Group Theory: Dinesh Khattar, Neha Agrawal, Springer | | | | |
| A Course in Abstract Algebra: V. K. Khanna and S. K. Bhambri, Vikas Publishing House, New Delhi. | | | | |
| **e-Learning Source:** | | | | |
| http://elearn.psgcas.ac.in/nptel/courses/video/111108413/111108413.html | | | | |
| https://archive.nptel.ac.in/courses/111/101/111101117/ | | | | |
| | | | | |

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO** / **CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |
|---|---|
| | |

# Integral University, Lucknow

| Effective from Session: 2025-26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | B030703T/MT436 | **Title of the Course** | Ordinary & Partial Differential Equations | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII & PG: I | **5** | **1** | **0** | **4** |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • To develop understanding of differential equations.<br>• To enhance problem-solving skills.<br>• To analyze partial differential equations (PDEs) and to study boundary value problems (BVPs).<br>• To apply theoretical concepts to real-world problems. | | | | | | |

| Course Outcomes | |
|---|---|
| **CO1** | Formulate and solve homogeneous linear differential equations, analyze fundamental solutions using Wronskian and Abel's identity, and construct Green's function for boundary conditions. |
| **CO2** | Apply methods such as undetermined coefficients and variation of parameters to obtain solutions, understand the significance of adjoint operators in solving differential equations and boundary value problems (BVPs). |
| **CO3** | Formulate and solve BVPs using appropriate analytical methods, understand the formulation of Sturm-Liouville problems and their significance in mathematical physics, compare stability conditions between autonomous and non-autonomous systems. |
| **CO4** | Classify and solve second-order linear PDEs, derive and solve heat and wave equations using separation of variables and transform methods in various coordinate systems. |
| **CO5** | Solve Laplace and heat equations in cartesian, cylindrical, and spherical coordinates using separation of variables and transform methods for various boundary conditions. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| I | **Homogeneous linear differential equation** | Homogeneous linear differential equation of $n^{th}$ order, fundamental sets of solutions, Wronskian, Abel's identity, theorems on linear dependence of solutions, adjoint linear operator, self-adjoint linear operator, Green's function. | 7 | 1 |
| II | **Non-homogeneous linear differential equation** | Non-homogeneous linear differential equation of $n^{th}$ order, adjoint equations, method of variation of parameters, zeros of solutions, comparison and separation theorem, construction of Green's function for homogeneous and non-homogeneous BVPs. | 7 | 2 |
| III | **Existence and uniqueness of solutions** | Existence and uniqueness of solutions, Lipschitz condition, successive approximation, Picard's theorem for initial value problems, homogeneous and non-homogeneous boundary value problems, Sturm-Liouville problems, non-existence of solutions, Picard's theorem for boundary value problems. | 8 | 3 |
| IV | **Stability of linear systems** | Stability of linear systems, stability of quasi-linear systems, stability of autonomous and non-autonomous systems, Lyapunov functions. | 7 | 3 |
| V | **Classification of second-order linear PDE** | Classification of second-order linear PDEs, Riemann's method, derivation of heat and wave equations in one- and two-dimensional Cartesian coordinate systems, solution of BVPs using transform methods and the method of separation of variables. | 8 | 4 |
| VI | **Wave equation** | Wave equation with boundary and initial conditions, solution of the wave equation by the method of separation of variables, solution of the wave equation in cylindrical and spherical polar coordinate systems, solution of the wave equation using transform methods. | 8 | 4 |
| VII | **Laplace equation** | Laplace equation in two- and three-dimensional cartesian coordinate systems, solution by the method of separation of variables and transform methods, Dirichlet's problem, Neumann's problem, and Churchill's problem, Dirichlet's problem for a rectangle, half-plane, and circle, solution of the Laplace equation in cylindrical and spherical polar coordinate systems. | 8 | 5 |
| VIII | **Heat equation** | Heat equation in one- and two-dimensional cartesian coordinate systems, solution of the heat equation by the method of separation of variables, heat equation with Dirichlet and Neumann boundary conditions (both ends insulated or temperature prescribed), solution of the heat equation using transform methods. | 7 | 5 |

| **Reference Books:** |
|---|
| 1. Advanced Differential Equations, M.D. Rai Singhania-S. Chand, 1995. |
| 2. Ordinary Differential Equations, M.D. Rai Singhania-S. Chand, 1995. |
| 3. Ordinary Differential Equations, P. Haitman, Wiley New York, 1964. |

| **PO-PSO** / **CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | - | - | 1 | 1 | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | - | - | 1 | 1 | - | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO3** | 3 | - | - | 1 | 1 | - | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO4** | 3 | - | - | 1 | 1 | - | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO5** | 3 | - | - | 1 | 1 | - | 3 | 3 | 3 | 2 | 3 | 2 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

**Integral University, Lucknow**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Effective from Session:** 2025-26 | | | | | | | |
| **Course Code** | B030704T/MT437 | **Title of the Course** | Discrete Structures | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII & PG: I | 5 | 1 | 0 | 4 |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • To impart detailed knowledge of problem-solving and logical skills.<br>• Have a deeper understanding of mathematical theory.<br>• Able to communicate mathematical/logical ideas in writing.<br>• After successfully completing the course, the student can explore the subject into their respective dimensions. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Learn to explain propositional calculus and predicate calculus and to analyze logical propositions via truth tables. |
| **CO2** | Learn to evaluate problems based counting, will be able to discuss and apply permutation and combination to real life problems. Get knowledge of Recurrence relation and able to solve them using characteristic roots and generating function. |
| **CO3** | Understand the terminology of graphs and trees & explore different operations on them. Learn to develop minimal spanning tree and to formulate tree traversal through different techniques. |
| **CO4** | Able to describe relations on a set and learn to create graphs and matrices from them. Discuss poset and get skill in designing Hasse diagram on them. |
| **CO5** | Able to illustrate boolean identities with different boolean forms and learn to create gate circuits. Explore language, operations on language and grammar and learn to design finite state machine. |

| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| 1 | **Mathematical logic** | Statement calculus: propositional logic, connectives, truth tables, tautologies & contradictions. equivalences & implications. proving validity by truth table, normal forms, inference theory of statement calculus, predicate calculus: predicates, quantifier. | 8 | 1 |
| 2 | **Counting Theory** | Fundamental principles, permutations & combinations, combinatorial identities, pigeon hole principle, binomial theorem, Pascal's identity, multimonial coefficients, derangements. | 7 | 2 |
| 3 | **Recurrence relation and Generating function** | Recurrence relation, Solution of linear recurrence relation with constant coefficients, generating function, shifting property of generating function, solution of linear recurrence relation using generating function, application of generating functions in counting problems. | 8 | 2 |
| 4 | **Graph Theory** | Basic terminology, directed and undirected graph, types of graph, path and connectivity, subgraph, planar graph, cut set and cut vertex, Eulerian & Hamiltonian graphs, matrix representation of graphs, graph coloring, vertex coloring and edge coloring, shortest path algorithm. | 7 | 3 |
| 5 | **Trees** | Properties, Rooted trees, Binary tree, Binary search tree, Trees of an Algebraic expression, Spanning tree, minimal spanning tree, Kruskal's algorithm, Prim's algorithm, Tree reversal, evaluation of prefix and postfix form of an expression. | 7 | 3 |
| 6 | **Relation, Poset & Lattices** | Properties, types of relation, partial order relation, matrix & digraph representation of relation, composition of relations. posets, Hasse diagram, lattice, lattice as algebraic system, sub-lattice, some special lattices. | 8 | 4 |
| 7 | **Boolean Algebra** | Boolean identities, the switching algebra, sub-algebra, direct product & homomorphism, boolean forms & their equivalences, logic gates, sum of products & product of sums form, normal form, canonical form, boolean expression & boolean functions, Karnaugh map method. | 8 | 5 |
| 8 | **Language, Grammar and Machine** | Stings, operations on string, languages, operations on languages, regular expressions, regular languages, grammar, language of a grammar, types of grammar, finite state machine, state table and state design of a finite state machine. | 7 | 5 |

| **Reference Books:** |
|---|
| 1. Elements of Discrete Mathematics, C.L.Liu, Tata McGraw-Hill Publishing Company Ltd, New Delhi. |
| 2. Discrete Mathematical Structures, Kolman, Busby & Ross, 4e, Prentice Hall of India. |
| 3. Discrete Mathematics with Graph theory, Goodaire & Parmenter, 2e, Pearson. |
| 4. Discrete Mathematical Structures, J.P.Tremblay & R.Manohar, McGraw-Hill Book. |
| 5. Discrete Mathematics and its applications, K. H. Rosen, MGH 1999. |
| **e-Learning Source:** |
| 1. Suggestive digital platforms web link/platform: NPTEL/SWAYAM/MOOCS |
| 2. https://www.cis.upenn.edu/~jean/discmath-root-b.pdf |

| | **Course Articulation Matrix: (Mapping of COs with POs and PSOs)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO**<br>**CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 3 | - | - | - | - | - | 3 | 1 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | - | - | - | - | - | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | - | - | - | - | - | 3 | 1 | 2 | 2 | 3 | 1 |
| **CO5** | 3 | - | - | - | - | - | 3 | 2 | 2 | 2 | 3 | 2 |

**Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |
|---|---|
| | |

# Integral University, Lucknow

| Effective from Session: 2025-26 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | B030705T/MT438 | **Title of the Course** | Mathematical Modeling and Computing with C | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII & PG: I | 5 | 1 | 0 | 4 |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • The course is aimed to develop the skills in mathematics specially in calculus which is necessary for grooming them into successful science graduate. The topics introduced will serve as basic tools for specialized studies in science field.<br>• To explore the concept of C programming and its application to solve mathematical problems. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Construct a Mathematical model of a given physical system and analyze it. |
| **CO2** | Make predictions of the behavior of a given physical system based on the analysis of its Mathematical Model. |
| **CO3** | Demonstrate understanding of powerful mathematical tools such as calculus of several variables, differential equations and elementary dynamical systems theory |
| **CO4** | To understand the concept of problem solving technique and basics of C programming and apply it to write the C programs. |
| **CO5** | To understand arrays, functions, strings and pointers and apply these to solve the problems. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Basics of Mathematical Modeling** | Simple situations requiring mathematical modeling, techniques of mathematical modeling, classifications of mathematical modeling, characteristics of mathematical models. Mathematical modeling through geometry, algebra, trigonometry and calculus, limitations of methodical modeling. | 9 | 1 |
| 2 | **Mathematical Modeling through ODE** | Mathematical modeling through ordinary differential equations first order linear growth and decay models, compartment models, mathematical modeling in dynamics through first order ODE, mathematical modeling through systems of ODE of first order. | 7 | 2 |
| 3 | **Mathematical Modeling through System of ODE** | Mathematical modeling in population dynamics, mathematical modeling of epidemic, Compartment model through system of ODE, mathematical modeling of circular motion, planetary motions and motions of satellite. | 7 | 2 |
| 4 | **Mathematical Modeling through Higher Order ODE** | Mathematics modeling in economics, in medicine, arms race, battles, international trade in terms of system of ODE and dynamic through ordinary differential equations, mathematical modeling through ODE of second order. | 7 | 3 |
| 5 | **Problem Solving Strategy** | Problem identification, problem definition, goal and objective, program design and implementation issue: algorithm, algorithm generalization, algorithm representation, flow chart, program writing: sequence, iterative and selection logic. type of programming language: machine level, assembly level, high level and scripting languages, programming language tools: compiler, interpreter, linker, editor. | 9 | 4 |
| 6 | **Operators, Expressions & Statements** | C fundamentals: character set, constants, identifiers, keywords, basic data types, variables, operators, expressions, statements, input and output statements – structure of a C program – simple programs., control statements: if, if-else, nested if, switch, while, do-while, for, break & continue, nested loops. | 7 | 4 |
| 7 | **Arrays & Functions** | Single dimensional arrays: defining an array, array initialization, accessing array elements, programs for sequential search, binary search and bubble sort, multidimensional arrays: defining a two-dimensional array, array initialization, accessing elements, programs for matrix additions and multiplications, functions: function definition, function call, function prototype, parameter passing, void function recursion of function. | 7 | 5 |

| | | | | |
|---|---|---|---|---|
| 8 | **Strings & Pointers** | Storage class associated with variables: automatic, static, and external and register, strings: declaring a string variable, reading and displaying strings, programs for string matching and sorting, pointers: declaration, operations on pointers, accessing array elements using pointers, processing strings using pointers, pointer to pointer. | 7 | 5 |

**Reference Books:**


1. 1. Programming in C (5e) – E. Balaguruswamy , Mc Graw Hill.
2. 2. How to Programme C Deitel & Deitel, Addison Wesley, Pearson Education Asia.
3. 3. Programming with C - Byron S. Gottfried, Tata McGraw Hill.
4. J.N. Kapur: Mathematical modeling Wiley Eastern limited, 1990.
5. Principles of Mathematical Modeling, 2nd Edition, Clyve L. Dym, Elsevier Academic Press.


**e-Learning Source:**

1. Suggestive digital platforms web link/platform: 1. NPTEL/SWAYAM/MOOCS
2. http://www.vssut.ac.in/lecture_notes/lecture1424354156.pdf
3. http://www2.cs.uregina.ca/~hilder/cs833/Other%20Reference%20Materials/The%20C%20Programming%20Language.pdf
4. https://www.youtube.com/watch?v=-uCwgZUz51o
5. https://study.com/academy/lesson/types-of-mathematical-models.html

**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| PO-PSO / CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO2** | **2** | - | - | - | - | - | 2 | 2 | 3 | 3 | 3 | 2 |
| **CO3** | **2** | - | - | - | - | - | 2 | 2 | 3 | 2 | 3 | 2 |
| **CO4** | **3** | - | - | - | - | - | **3** | **1** | **2** | **2** | **1** | - |
| **CO5** | **3** | - | - | - | - | - | **3** | **2** | **2** | **2** | **2** | - |

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |
|---|---|
| | |

**Department of Mathematics & Statistics**

Evaluation Scheme of Post Graduate Program as per NEP-2020

**w.e.f. Session 2025-26**

**M.Sc. (MATHEMATICS)** **Year: First / Semester: Second (Even Semester)**

| S. N. | Course Code | Course Title | Theory / Practical | Course Type | Periods/ Per week | | | Continuous Assessment | | | End Semester Examination (ESE) | Subject Total | Total Credit Points | Attributes | | | | | | | United Nations Sustainable Development Goals (SDGs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lecture (L) | Tutorial (T) | Practical (P) | Class Test (CT) | Teacher Assessment (TA) | Total | | | | Employability | Entrepreneurship | Skill Development | Gender Equality | nvironment & Sustainabilit | Human Value | Professional Ethics | |
| 1 | B030801T/MT439 | Special Functions | Theory | Core Major (Compulsory) | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | |  |
| 2 | B030802T/MT440 | Geometry of Manifolds-I | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | | | | | | |
| 3 | B030803T/MT441 | Numerical Analysis and applications | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | | |
| 4 | B030804T/MT442 | Module Theory and Advanced Linear Algebra | Theory | | 5 | 1 | 0 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | | |
| 5 | B030805P/MT443 | Advanced Numerical Analysis Lab | Practical | | 0 | 0 | 8 | 15 | 10 | 25 | 75 | 100 | 04 | ✓ | | ✓ | | | | | |
| | | | | **TOTAL** | **20** | **4** | **8** | **75** | **50** | **125** | **375** | **500** | **20** | | | | | | | | |

**Integral University, Lucknow**

| **Effective from Session:** 2025-26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | B030801T/MT439 | **Title of the Course** | Special Functions | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VII& PG: I | **5** | **1** | **0** | **4** |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • To develop understanding of differential equations.<br>• To enhance problem-solving skills.<br>• To analyze partial differential equations (PDEs) and to study boundary value problems (BVPs).<br>• To apply theoretical concepts to real-world problems. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Solve, expand and interpret solutions of many types of important differential equations by making use of special functions and orthogonal polynomials. |
| **CO2** | Derive the formulas and results of certain classical special functions and orthogonal polynomials by different methods. |
| **CO3** | Derive the generating relations involving special functions. |
| **CO4** | Understand purpose and functions of the gamma and beta functions, and Transformation. |
| **CO5** | Achieve the knowledge to analyse the problems using the methods of special functions and orthogonal polynomials, which helps in exploring the role of special functions and orthogonal polynomials in other areas of mathematics. |

| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| **I** | **Gamma and Beta functions** | A series for gamma function, difference equation Gamma(Z+1) = ZGamma(Z), Euler's Integral for Gamma(z), beta function, value of Gamma(z) Gamma(1-z), factorial function, Legender duplication formula, Gauss multiplication Theorem. | 7 | 1 |
| **II** | **Power Series and Power Series Solutions** | Theorems on power series, introduction of power series solutions of ordinary differential equation, ordinary and singular points, regular and irregular singular points, power series solution about the ordinary points. | 7 | 2 |
| **III** | **Gauss Hyper geometric Functions** | Definition and its properties, condition of convergence, representation, Gauss theorem, Vandermonde's theorem, Kummer's theorem, linear transformation. | 8 | 3 |
| **IV** | **Gauss's Hypergeometric Differential Equation** | Gauss's hypergeometric differential equation solution, relation between the solutions of hypergeometric equation, two summation theorems, Kummer's confluent hypergeometric function: Definition and differential equation, integral representation | 7 | 3 |
| **V** | **Bessel Functions** | Bessel's equation and its solution, recurrence relations, generating function, integral representations of Bessel function, integrals involving Bessel's functions | 8 | 4 |
| **VI** | **Legendre Polynomials** | Rodrigue's formula, recurrence relations and hypergeometric form of Legendre polynomials, first and second kind integral transforms, orthogonally. | 8 | 4 |
| **VII** | **Hermite Polynomials** | Definition of Hermite polynomials $H_n(x)$, pure and recurrence relations, Rodrigue's formula, other generating functions, orthogonally, expansion polynomials. | 8 | 5 |
| **VIII** | **Laguerre Polynomials** | The Laguerre Polynomials $L_n(x)$, generating function, pure and differential recurrence relations, Rodrigues formula, orthogonally, expansion of polynomials. | 7 | 5 |

**Reference Books:**


1. R.K Saxena, D.C.Gokhroo, Special Functions ,Jaipur Publishing House, 2014.

2. E. D. Rainville: Special Functions, Chelsea Publishing Co., Bronx, New York, Reprint, 1971.

3. Saran, N., Sharma S.D., and Trivedi: Special functions with applications, PragatiPrakashan, 1986.

4.. Lebdev, N.N: Special functions and Their Applications, Prentice Hall, Englewood Cliffs, New Jersey, USA, 1995

| PO-PSO / CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 2 | 2 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 2 | 3 | 2 | 3 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

**INTEGRAL UNIVERSITY**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Effective from Session: 2025-2026** | | | | | | | |
| **Course Code** | B030802T/MT440 | **Title of the Course** | Geometry of Manifolds- I | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VIII& PG: II | 5 | 1 | 0 | 4 |
| **Pre-Requisite** | B. Sc. with Mathematics | **Co-requisite** | Geometry of Curves, Spaces and Tensor Analysis | | | | |
| **Course Objectives** | **The objective of the course is to provide knowledge of differentiable manifolds, which enable students to:**<br>• Understand the fundamental concepts of differentiable manifolds.<br>• Develop proficiency with advanced geometrical structures.<br>• Explore Riemannian geometry and geodesics.<br>• Analyze curvature and its role in Riemannian geometry.<br>• Investigate complex geometrical structures in advanced manifold theory. | | | | | | |

| | |
|---|---|
| **Course Outcomes** | |
| **Students after successful completion of the course would be able to:** | |
| **CO1** | Define and understand differentiable manifolds and related geometric terms, analyze the properties of immersions and submersions, which describe the behavior of smooth maps between manifolds. |
| **CO2** | **C**alculate length and distance in Riemannian manifolds, apply metric to find geodesics in Riemannian manifolds, and analyze the Bianchi identities and curvatures. |
| **CO3** | Apply Gauss & Weingarten formulae to analyze the inerrability of distributions on Riemannian manifolds, and develop the geometric results on Hyper surface & submanifolds of Riemannian manifolds. |
| **CO4** | Define an almost complex structure, explain the Nijenhuis tensor and its role in the integrability of the almost complex structure, apply the concept of an almost Kaehler structure and its curvature identities, analyze the Ricci curvature in almost Kaehler manifolds and evaluate the projective correspondence in almost Kaehler structures to create new geometric insights into their interactions. |
| **CO5** | Define an almost Hermitian structure and almost Hermite manifold, explain the role of the Nijenhuis tensor in an almost Hermite manifold, apply conformal transformations to these manifolds, analyze the geometry of submanifolds in almost Hermitian manifolds and evaluate the effects of these transformations on the curvature and structure of the submanifolds. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Differentiable Manifolds** | Definition of Differentiable manifolds, Examples of Differentiable manifolds, Tangent vectors, Tangent space, vector fields and their examples, Jacobean map. | 6 | CO1 |
| 2 | **Differentiable Manifolds (continued)** | Cotangent space, Differential forms, Tensor fields, immersions and submersion, Integral curves and their examples. | 6 | |
| 3 | **Riemannian manifolds** | Length and an distance in Riemannian manifolds, Riemannian connections, Riemannian metric, geodesics in Riemannian manifolds. | 8 | CO2 |
| 4 | **Curvatures in Riemannian manifolds** | Bianchi identities, Riemannian curvature, Sectional curvature, Ricci curvature and scalar curvature. | 8 | |
| 5 | **Submanifolds of Riemannian manifolds** | Distributions on Riemannian manifolds, Gauss & Weingarten formulae, Hypersurface & submanifolds of Riemannian manifolds. | 8 | CO3 |
| 6 | **Almost complex manifolds** | Almost complex structure, Nijenhuis tensor, Integrability of almost complex structure. | 8 | |
| 7 | **Almost Kaehler manifold** | Almost Kaehler structure, curvature identities, Ricci curvature in Almost Kaehler manifolds, Projective correspondence in almost Kaehler structures. | 8 | CO4 |
| 8 | **Almost Hermitian Manifolds** | Almost Hermitian structure, Almost Hermite manifold, Nijenhuis tensor in almost Hermite manifold, Conformal transformation, Submanifolds of almost Hermitian manifold. | 8 | CO5 |

**Reference Books:**


1. David E. Blair, *Contact manifolds in Riemannian Geometry*, Springer-Verlag. Structures of manifolds,

2. S. Kumaresan, *A Course in Differential Geometry and Lie Groups*, Hindustan Book Agency, 2002.

3. S.I. Hussain. *Lecture notes on differentiable manifolds*, Marcel Dekker, New York.

4. B.B. Sinha, *An Introduction to Modern Geometry*, Kalyani publishers.

5. B.Y. Chen, Geometry of Submanifolds, Marcel Dekker, New York.


**e-Learning Source:**

1. https://www.youtube.com/watch?v=klks723on3k
2. https://www.youtube.com/watch?v=klks723on3k
3. https://www.youtube.com/watch?v=KwHfz5BegoU

**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| PO/ PSO<br>CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | - | - | - | - | 3 | 2 | 3 | - | 2 | - |
| **CO2** | 3 | 2 | - | - | - | - | 3 | 2 | 3 | 2 | 2 | - |
| **CO3** | 3 | 2 | - | - | - | - | 3 | 2 | 3 | 3 | 2 | 3 |
| **CO4** | 3 | 2 | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO5** | 3 | 2 | - | - | - | - | 2 | 3 | 3 | 2 | 2 | 3 |

1. **Low Correlation; 2. Moderate Correlation; 3.Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

| Effective from Session:2025-26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | B030803T/MT441 | **Title of the Course** | Numerical Analysis and Applications. | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VIII& PG: II | 5 | 1 | 0 | 4 |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • The course is aimed to develop the skills in numerical analysis which is necessary for grooming them into successful science graduate.<br>• The topics introduced will serve as basic tools for specialized studies in science field. | | | | | | |

| Course Outcomes | |
|---|---|
| **CO1** | Apply root-finding methods and analyze numerical errors and convergence. |
| **CO2** | Apply and analyze interpolation and spline techniques for function approximation. |
| **CO3** | Apply and understand iterative methods to compute eigenvalues and eigenvectors. |
| **CO4** | Apply numerical differentiation and integration techniques with error estimation. |
| **CO5** | Solve ODEs, PDEs, and difference equations using numerical methods and analyze their accuracy. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Error** | Definition and sources of errors, accuracy of numbers, Error analysis, , error in numerical computations, Floating-point arithmetic and rounding errors, Machine computation | 7 | 1 |
| 2 | **Algebraic and Transcendental Equations** | Solution of algebraic and transcendental equations by Newton-Raphson's method, Stephenson method, Muller's method, Chebyshev method, Rate of convergence of Newton-Raphson's and Stephenson method. | 8 | 1 |
| 3 | **Interpolation** | Various polynomial forms for approximating a given function by Newton's, Gauss's and Sterling's Interpolation formula, Lagrange and Newton's divided difference interpolation, Hermite interpolation, quadratic spline, piecewise, cubic spline | 8 | 2 |
| 4 | **Eigen Value Problems** | Power method, Inverse Power method, Rutishauser method, Jacobi's method, Given's method, Householder's method. | 7 | 3 |
| 5 | **Numerical Differentiation and Integration** | Numerical differentiation using different interpolation formula, Euler Maclaurin's formula, Newton's Cote formula, Simpson's ,Gauss' , Gaussian and Romberg formula for numerical integration and their error estimation, double integrals using trapezoidal and Simpson's rule. | 7 | 4 |
| 6 | **Ordinary differential** | Solution of initial value problems of first and second order by Range Kutta method, Solution of initial value problems by finite difference equations and Adam's interpolation method. Two points boundary value problems for second order linear and non-homogeneous differential equations, Shooting method with least square convergence criterion, finite element method | 9 | 5 |
| 7 | **Partial Differential Equation** | Classification of partial differential equations, solution of Laplace and Poisson's equations by Liebmann's method. Solution of one dimensional heat equation by Bender-Schmidt method, solution of one dimensional wave equation by Crank-Nicholson's method. | 8 | 5 |
| 8 | **Difference equation** | Order and degree of difference equation, Linear difference equation ,solution of homogeneous linear equation | 6 | 5 |

**Reference Books:**


1. Numerical Methods for Scientific and Engineering computation by M.K.
2. Jain, S.R.K. Iyengar, R.K. Jain, New Age Int. Ltd., New Delhi.
3. Numerical Methods by P. Kandasamy, S. Chand Publ. New Delhi.
4. Introduction to Numerical Analysis, by S.S. Sastry Prentice Hall Flied


**e-Learning Source:**

1. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/111107105/lec6.pdf
2. https://nptel.ac.in/content/storage2/courses/122104018/node114.html
3. https://nptel.ac.in/courses/111107062/
4. https://www.yumpu.com/en/document/view/8662778/derivation-of-runge-kutta-method-nptel

**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| PO/ PSO<br>CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | - | 1 | - | - | - | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | - | 1 | - | - | - | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | - | 1 | - | - | - | 3 | 3 | 2 | 3 | 2 | 2 |
| **CO4** | 3 | - | 1 | - | - | - | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO5** | 3 | - | 1 | - | - | - | 3 | 3 | 3 | 3 | 2 | 3 |

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

**INTEGRAL UNIVERSITY**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Effective from Session:** 2025–26 | | | | | | | |
| **Course Code** | B030804T/MT442 | **Title of the Course** | Module Theory & Advanced Linear Algebra | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VIII & PG: II | **5** | **1** | **0** | **4** |
| **Pre-Requisite** | B.Sc. With Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | Students will develop a comprehensive understanding of module theory, including simple modules, homomorphisms, quotient modules, and invariant factors, alongside the application of linear algebra concepts such as invariant subspaces, diagonalization, and bilinear forms. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Understand the fundamental concepts of modules, including simple modules, submodules, and homomorphisms, and learn to apply these concepts in quotient modules, torsion-free modules, and direct sums and also understand proficiency in exact sequences, short exact sequences, split exact sequences, and the five lemma. |
| **CO2** | Develop an understanding of free modules and their properties over division rings and PIDs, including the invariant rank property and the invariant factor theorem and also learn about finitely generated modules over a PID and the fundamental structure theorem, along with the chain of invariant ideals. |
| **CO3** | Understand annihilating polynomials, invariant subspaces, simultaneous diagonalization, and direct sum decompositions, with a focus on their applications in the theory of linear operators and vector spaces. |
| **CO4** | Understand cyclic subspaces, annihilators, cyclic decomposition, rational form, and the computation of invariant factors to analyze the structure of linear operators. |
| **CO5** | Understand symmetric and skew-symmetric bilinear forms, and groups preserving bilinear forms in the context of inner product spaces. |

| **Part A<br>Module Theory** | | | | |
|---|---|---|---|---|
| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
| 1 | **Modules and Submodules** | Modules-Definition and examples, simple modules, submodules, Module Homomorphisms, Quotient modules, torsion free and torsion modules. | 8 | 1 |
| 2 | **Exact Sequence** | Direct sum of modules, Exact sequences, Short exact sequence, split exact sequences. Five lemma | 7 | 1 |
| 3 | **Free Modules** | Free modules, modules over division rings are free modules, invariant rank property. | 7 | 2 |
| 4 | **Free Module over Principal Ideal Domain** | Free modules over PID's, Invariant factor theorem for submodules, finitely generated modules over PID, Chain of invariant ideals, Fundamental structure theorem for finitely generated module over a PID | 8 | 2 |
| **Part B<br>Advanced Linear Algebra** | | | | |
| 5 | **Elementary Canonical Form** | Annihilating Polynomials, Invariant Subspaces, Simultaneous Diagonalization, Direct Sum decomposition, Invariant direct Sum | 8 | 3 |
| 6 | **The Rational and Jordan Form** | Cyclic Subspaces and Annihilators, cyclic Decomposition and Rational Form, Computation of Invariant Factors | 8 | 3 |
| 7 | **Operators on Inner Product Spaces** | Forms on Inner Product Spaces: Sesqui linear forms, Positive linear theorem, positive forms, Spectral Theorem | 7 | 4 |
| 8 | **Bilinear Forms** | Bilinear Forms, Symmetric Bilinear Forms, Skew Symmetric Bilinear Forms, Groups Preserving Bilinear Forms | 7 | 4 |

| **Reference Books:** |
|---|
| 1. MODULE THEORY An approach to linear algebra |
| 2. Algebra, S. Lang, Addison Wesley |
| 3. Linear Algebra, Kenneth Hoffman, Ray Kunze, Pearson Education |
| 4. Schaum's Outline Series: Linear Algebra, McGraw Hill |
| **e-Learning Source:** |
| https://archive.nptel.ac.in/courses/111/105/111105161/ |
| https://www.nptelvideos.com/course.php?id=725 |

| | **Course Articulation Matrix: (Mapping of COs with POs and PSOs)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO/ PSO<br>CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO3 |
| **CO1** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO2** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 2 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 2 | 3 | 3 | 2 | 3 | 2 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 3 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Effective from Session:** 2025-26 | | | | | | | | |
| **Course Code** | B030805P/MT443 | **Title of the Course** | Advanced Numerical analysis Lab | **L** | **T** | **P** | **C** |
| **Year** | UG: IV & PG: I | **Semester** | UG: VIII & PG: II | **0** | **0** | **8** | **4** |
| **Pre-Requisite** | B.Sc. with Mathematics | **Co-requisite** | None | | | | |
| **Course Objectives** | • To familiarize students with numerical techniques needed in problem-solving and industrial applications by using C++.<br>• The course will develop numerical methods aided by technology to solve algebraic, transcendental, and differential equations, and to calculate derivatives and integrals by using C++.<br>• The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs.<br>• The course will further develop problem solving skills. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Apply numerical methods to find our solution of algebraic equations using different methods under different conditions, and numerical solution of system of algebraic equations. |
| **CO2** | Apply various interpolation methods and finite difference concepts |
| **CO3** | Work out numerical differentiation whenever and wherever routine methods are not applicable |
| **CO4** | Work out numerical integration whenever and wherever routine methods are not applicable |
| **CO5** | Work numerically on the ordinary differential equations using different methods through the theory of finite differences. |

| **Experiment No.** | **Title of the Experiment** | **Content of Experiment** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| **I** | Root-Finding Methods in C | 'C' Programming**:** Algebraic and transcendental equations using False Position method, Newton Raphson's method and Mullar's method, also give rate of convergence of roots in tabular form for each method. | 5 | 1 |
| **II** | Interpolation Methods in C | 'C' Programming: Interpolation by Newton's, cubic spline and Lagrange's formulae. | 5 | 1 |
| **III** | Numerical Integration in C | 'C' Programming: Numerical integration using Simpson's 1/3, Simpson's 3/8 and Romberg formulae. | 5 | 2 |
| **IV** | ODE Solving in C | 'C' Programming: Numerical solution of O.D.E. using Runge-Kutta IV order method. | 5 | 3 |
| **V** | Matrix Operations in MATLAB | 'MATLAB' Programming: Matrix addition, multiplication & inverse. | 5 | 4 |
| **VI** | Matrix Determinant in MATLAB | 'MATLAB' Programming: Determinant of matrices. | 5 | 4 |
| **VII** | Solving Equations in MATLAB | 'MATLAB' Programming: Algebraic and transcendental equations. | 5 | 5 |

**Suggested Readings(Part-A Differential Equations):**

1. Programming in C (5e) – E. Balaguruswamy
2. Computer Based Numerical Techniques by Santosh Kumar
3. CBNT by Dr. Manish Goyal

**Suggested Readings(Part-B Mechanics):**

1. https://www.youtube.com/watch?v=zT83sJ5IrEE&list=PLyqSpQzTE6M-QT7PvEBHV0iNMvZk9mocO
2. https://www.youtube.com/watch?v=IuEOMyGuuIg&list=PLRWKj4sFG7-6_Xr9yqg6SMr_F80KdFVhN
3. https://www.youtube.com/watch?v=zjyR9e-N1D4&list=PL1A70C686CB3C95FC
4. https://www.youtube.com/watch?v=7Mg0b9Gc_mc

**Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| **PO-PSO** / **CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | - | 2 | 1 | 2 | - | - | - | - | - |
| **CO2** | 3 | 1 | 1 | - | 1 | 2 | 2 | - | - | - | - | - |
| **CO3** | 3 | 1 | 1 | - | 1 | - | 2 | - | - | - | - | - |
| **CO4** | 3 | 1 | 1 | - | 1 | - | 2 | - | - | - | - | - |
| **CO5** | 3 | 1 | 1 | - | 1 | 2 | 2 | - | - | - | - | - |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |