**CENTRAL UNIVERSITY OF RAJASTHAN**  
Semester-Wise Scheme and Syllabus of  
**M.Sc. B.Ed. Mathematics (3 Year) 2018-2019 to Onward**

### Semester – I

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Type of Course (C/E)</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>MBM411</td>
<td>Abstract Algebra</td>
<td>C</td>
<td>3</td>
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<tr>
<td>2</td>
<td>MBM412</td>
<td>Real Analysis</td>
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<td>MBM413</td>
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<td>4</td>
<td>MBM414</td>
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<td>C</td>
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<tr>
<td>6</td>
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<td>Senior Secondary Education in India: Status, Challenges &amp; Strategies</td>
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**Total** 18 4 0 22

### Semester – II

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<td>MBM422</td>
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**Total** 18 4 0 22

### Semester – III

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<td>MBM534</td>
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<th>S. No.</th>
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<th>S. No.</th>
<th>Course Code</th>
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<th>Type of Course (C/E)</th>
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**Total Grand- 109 Credits**

*Note*- MSM: M.Sc. in Mathematics; Numeric (xyz) in paper/course code: x-Level of Course, y- Semester, z- Paper/Course Number; C- Compulsory/Core Course; E- Elective, O/OE- Open Elective; 15L- 15 Lectures; LTP: Lecture-Tutorial-Practical
### List of Elective/Open Electives Papers of M.Sc. B.Ed. Mathematics (3 Year)
(Semester Wise: 2018-2019 to Onward)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Elective Course Title</th>
<th>Credits</th>
<th>Semester &amp; Course Code</th>
<th>Remarks</th>
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<tr>
<td>1</td>
<td>Mathematical Software Tools</td>
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<td>Semester-III (MBM534)</td>
<td>Out of these two elective papers, any one may be taken for course code MBM534</td>
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<td>Programming in C</td>
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<td>3</td>
<td>Celestial Mechanics</td>
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<td>Semester-IV (MBM543)</td>
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<td>Computational ODE</td>
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<td>Game Theory</td>
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<td>Graph Theory</td>
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<td>7</td>
<td>Integral Equations and Calculus of Variations</td>
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<td>Number Theory-I</td>
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<td>Advanced Numerical Methods</td>
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<td>Automata Theory and Formal Languages</td>
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<td>Fractional Calculus and Geometric Function Theory</td>
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<td>23</td>
<td>Fuzzy Logics and Its Applications</td>
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<td>24</td>
<td>Module Theory</td>
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<td>25</td>
<td>Nonlinear Dynamics and its application to Information Technology</td>
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<td>26</td>
<td>Number Theory-II</td>
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Detail Revised Syllabus for M. Sc. B.Ed. Mathematics (3 Year)

(2018-2019 to Onward)

SEMESTER-I

1. **MBM411: ABSTRACT ALGEBRA**  
   LTL: 3+1+0

   **Unit I:** Review of groups, subgroups, normal subgroups, quotient groups, homomorphism, isomorphism theorems, conjugacy relation, Group Action, Stabilizer and orbits, Class equation, Sylow theorems, Normal and subnormal series, composition series, Jordan holder theorem. Solvable groups, Simple groups, simplicity of An. (15 L)

   **Unit II:** Rings, homomorphisms, ideals, Quotient rings, prime ideals, maximal ideals, field of quotients of an integral domain, Euclidean rings, unique factorization domains, principal ideal domain. Prime and Irreducible elements, GCD, Polynomial rings. Chinese remainder theorem for rings and PID’s, Eisensteinin’s criterion of irreducibility. (15 L)

   **Unit III:** Extension fields, algebraic element and transcendental elements, Simple extension, Primitive elements, Algebraic extension, Roots of a polynomial and splitting of a polynomial over fields. (15 L)

   **Recommended Reading:**
   5. Algebra by S.Mclane and G.Birkhoff, 2nd Edition,

2. **MBM412: REAL ANALYSIS**  
   LTP: 3+1+0

   **Unit-I: Euclidian space \( \mathbb{R}^n \):** Open ball and open sets, closed sets, adherent points, accumulation points, closure of sets, derived sets, Bolzano Weierstrass theorem. Cantor intersection theorem. Lindeloff covering theorem, Heine Borel theorem, Compactness in \( \mathbb{R}^n \). **Metric spaces:** open sets, closed sets, compact subsets of a metric space. (15L)

   **Unit-II: Functions of bounded variations:** Monotonic functions and its properties, types of discontinuity functions of bounded variations and its properties, total variations. Functions of several variables: continuity, partial derivatives, differentiability, derivatives of functions in an open set of \( \mathbb{R}^n \) into \( \mathbb{R}^n \) as a linear transformations, chain rule, Taylor’s theorem, inverse function theorem, implicit function theorem and explicit function theorem, Jacobians. (15L)

   **Unit-III: Riemann-Stieltjes integral:** Definition and existence of R-S integration, conditions of R-S integrability, properties of R-S integrals, integration and differentiation. **Sequence and series of functions:** Pointwise and uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Uniform convergence and R-S integration. (15L)
Recommended Reading:


3. MBM413: MATHEMATICAL PROGRAMMING  LTP: 3+1+0

UNIT-I: Linear Programming, Theoretical foundation of Simplex Method, Revised Simplex Method, Duality in linear programming problem, Primal-dual solution relationship, Duality theorems. Dual simplex method; Post optimality analysis. (15 L)


UNIT-III: Nonlinear programming, Solution of nonlinear programming problem with equality constraints and with not all equality constraints, Kuhn-Tucker necessary and sufficient conditions for optimality of the objective function in NLPP. Quadratic programming, Wolfe’s method and Beale’s Method (15 L)

Recommended Reading:

4. MBM414: QUALITATIVE THEORY OF ORDINARY DIFFERENTIAL EQUATIONS  LTP:3+1+0

UNIT-I: Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations: separation and comparison theorems, system of equations existence theorems, Homogeneous linear systems, Non homogeneous linear systems, and linear systems with constant coefficients, Singular solutions of first order ODEs. (15 L)

UNIT-II: Cauchy-Euler equation, Two-point boundary-value problem, variation of parameters, Green's functions, Construction of Green's functions, Non homogeneous boundary conditions, Orthogonal sets of function, Strum-Liouville boundary value problem, Eigen values and Eigen functions, Eigen function expansions convergence in the mean. (15L)

UNIT-III: Autonomous system of differential equations, Critical points and Stability for Linear systems with constant coefficients, linear plane autonomous systems, perturbed systems, Method of Lyapunov for nonlinear systems. Limit cycles of Poincare-Bendixson Theorem. (15 L)

Recommended Reading:
5. **ED101: BASICS OF EDUCATION**

   LTP: 3+0+0

6. **ED101: SENIOR SECONDARY EDUCATION IN INDIA: STATUS, CHALLENGES AND STRATEGIES**

   LTP: 3+0+0

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**SEMESTER-II**

7. **MBM421: LINEAR ALGEBRA**

   LTP: 3+1+0

   Unit I: Review of Vector Spaces, The algebra of linear transformations, Isomorphism, Linear functional, dual and double dual, Eigen values and Eigen vectors, Annihilating polynomials, diagonalization, Tringularization. (15 L)

   Unit II: Determinants and its geometric properties, Laplace expansion, Rational and Jordan canonical form, primary decomposition theorem, nilpotent matrices, canonical form for nilpotent matrix, computation of invariant factors, non-negatives matrices, generalized inverse of a matrix (15 L)

   Unit III: Symmetric and Skew-symmetric Bilinear Forms, Diagonalization of symmetric bilinear forms. Inner Product Space, The adjoint of Linear Transformation, Unitary operators, Self adjoints and Normal Operators. (15 L)

**Recommended Reading:**

1. Algebra by S. Mclane and G. Birkhoff
2. Linear algebra by S. Lang, Springer
3. Linear Algebra by Bisht and Sahai
4. Linear Algebra by Hoffman and Kunze, P.H.I
5. Matrix Analysis and Applied linear Algebra, by Carl D. Meyer
7. Linear Algebra: a geometric approach by S. Kumaresan

8. **MBM422: COMPLEX ANALYSIS**

   LTP: 3+1+0

   Unit-I: Functions of a complex Variable, Differentiability and analyticity, Cauchy Riemann Equations, Power series as an analytic function, properties of line integrals, Goursat Theorem, Cauchy theorem, consequence of simply connectivity, index of a closed curve (15 L)

   Unit -II: Cauchy’s integral formula, Morera’s theorem, Liouville’s theorem, Fundamental theorem of Algebra, Harmonic functions, Existence of Harmonic conjugate, Taylor’s theorem, Zeros of Analytic functions, Laurent series, singularities, classification of singularities (15 L)

   Unit -III: Maximum modulus theorem, Minimum modulus theorem, Hadamard three circle theorem, Schwarz’s Lemma, Rouche’s theorem, Calculation of residues, Residue theorem, Evaluation of integrals of the form \( \int_{\alpha}^{\alpha+2\pi} R(\cos \theta, \sin \theta) \, d\theta \), \( \int_{-\infty}^{\infty} f(x) \, dx \), Conformal mappings. (15 L)

**Recommended Reading:**

9. **MBM423: TOPOLOGY**


UNIT -II: Continuous functions, open & closed functions, homeomorphism, Lindelof’s, Separable spaces, Connected Spaces, locally connectedness, Connectedness on the real line, Components, Compact Spaces, one point compactification, compact sets, properties of Compactness and Connectedness under a continuous functions, Compactness and finite intersection property, Equivalence of Compactness. (15 L)

UNIT -III: Separation Axioms: T₀, T₁, and T₂ spaces, examples and basic properties, First and Second Countable Spaces, Regular, normal, T₃ & T₄ spaces, Tychonoff spaces, Urysohn’s Lemma, Tietze Extension Theorem, finite product topological spaces and some properties. (15 L)

**Recommended Reading:**
2. W. J. Pervin, Foundations of General Topology
4. Vicker , Topology via logic (School of Computing, Imperial College, London)

10. **MBM424: PARTIAL DIFFERENTIAL EQUATION**

UNIT-I: Formation of PDEs: First order PDE in two and more independent variables, Derivation of PDE by elimination method of arbitrary constants and arbitrary functions. Lagrange’s first order linear PDEs, Charpit’s method for non-linear PDE of first order, Monge’s method, Jacobi’s method and Cauchy problem for first order PDEs. (15L)

UNIT-II: PDEs of second order with variable coefficients: Classification of second order PDEs, Canonical form, Parabolic, Elliptic and Hyperbolic PDEs, Method of separation of variables for Laplace, Heat and Wave equations, Eigen values and Eigen functions of BVP, Orthogonality of Eigen function, , D’Almbert’s solutions to wave equations. (15L)

UNIT-III: General solution of higher order PDEs, Fundamental solution of Laplace Equation, Green’s function for Laplace Equation, Wave equation, Diffusion Equation, Solution of BVP in spherical and cylindrical coordinates, Variational formulation of boundary value problem. (15L)

**Recommended Reading:**

11. **ED201: PHILOSOPHY OF MATHEMATICS**

12. **ED202: LEARNER AND LEARNING**
SEMESTER-III

13. MBM531: FUNCTIONAL ANALYSIS  LTP: 3+1+0

UNIT-I: Inner product spaces, Normed linear spaces, Banach spaces, Quotient norm spaces, continuous linear transformations, equivalent norms, the Hahn-Banach theorem and its consequences. Conjugate space and separability, second conjugate space, Weak *topology on the conjugate space (15 L)

UNIT-II: The natural embedding of the normed linear space in its second conjugate space, The open mapping Theorem, The closed graph theorem, The conjugate of an operator, The uniform boundedness principle, Definition and examples of a Hilbert space and simple properties, orthogonal sets and complements (15 L)

UNIT-III: The projection theorem, separable Hilbert spaces. Bessel's inequality, the conjugate space, Riesz's theorem, The adjoint of an operator, self adjoint operators, Normal and unitary operators, Projections, Eigen values and eigenvectors of on operator on a Hilbert space, Spectral theorem on a finite dimensional Hilbert space. (15 L)

Recommended Reading:

14. MBM532. NUMERICAL ANALYSIS  LTP: 3+1+0


UNIT-II: Hermite interpolation, piecewise and spline interpolation, cubic spline interpolation, numerical differentiation-methods based on interpolation and methods based on finite difference operators, methods based on undetermined coefficients, errors in numerical differentiation, numerical integration-methods based on interpolation and methods based on undetermined coefficients, composite integration methods, double integration.(15 L)


Recommended Reading:
UNIT-I: Countable and uncountable sets, cardinality and cardinal arithmetic, Schröder–Bernstein theorem, $a < 2^a$, $2^{N_0} = c$, the Cantor’s ternary set, semi-algebras, algebras, monotone class, $\sigma$ – algebras, measure and outer measures, Caratheodory extension process of extending a measure on a semi-algebra to generated $\sigma$ – algebras, Borel sets (15 L)

Unit-II: Lebesgue outer measure and Lebesgue measure on R, translation invariance of Lebesgue measure, existence of a non-measurable set, characterizations of Lebesgue measurable sets, the Cantor-Lebesgue function, measurable functions on a measure space and their properties, Borel and Lebesgue measurable functions, Simple functions and their integrals, Littlewood’s three principle (statement only) (15 L)


Recommended Reading:

16. MBM534: ELECTIVE LTP: 3+1+0
17. ED301: TEACHING APPROACHES AND STRATEGIES LTP: 3+0+0
18. ED301: PEDAGOGY OF MATHEMATICS LTP: 3+1+0

SEMESTER-IV

19. MBM541: MATHEMATICAL MODELING LTP: 3+1+0

UNIT-I: Introduction to modeling. Definition of System, classification of systems, classification and limitations of mathematical models, Methodology of model building, Modeling through ordinary differential equation: linear growth and decay models, non-linear growth and decay models, Compartment models. (15 L)

UNIT-II: Checking model validity, verification of models, Stability analysis, Basic model relevant to population dynamics, Epidemics modeling, Ecology, Environment Biology through ordinary differential equation, Partial diff.equation. (15 L)

UNIT-III: Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in population dynamics, genetics, Markov chains model, Gambler’s ruin model, Stochastic models, Monte Carlo methods. (15 L)

Recommended Reading:
UNIT-I: Moments and products of inertia, moment of inertia of a body about a line through the origin, Momental ellipsoid, rotation of co-ordinate axes, principal axes and principal moments. K.E. of rigid body rotating about a fixed points, angular momentum of a rigid body, Eulerian angle, angular velocity, K.E. and angular momentum in terms of Eulerian angle. Euler’s equations of motion for a rigid body, rotating about a fixed point, torque free motion of a symmetrical rigid body (rotational motion of Earth). (15L)

UNIT-II: Classification of dynamical systems, Generalized co-ordinates systems, geometrical equations, Lagrange’s equation for a simple system using D’Alembert principle, Deduction of equation of energy, deduction of Euler’s dynamical equations from Lagrange’s equations, Hamilton’s equations, Ignorable co-ordinates, Routhian Function. (15L)

UNIT-III: Hamiltonian’s principle for a conservative system, principle of least action, Hamilton-Jacobi equation, Phase space and Liouville’s Theorem, Canonical transformation and its properties, Lagrange Brackets, and passion brackets, Poisson-Jacobi identity. (15L)

Recommended Reading:


21. MBM543: ELECTIVE
22. ED401: LEARNING ASSESSMENT
23. ED402: PEDAGOGICAL ANALYSIS OF SENIOR SECONDARY SCHOOL: MATHEMATICS
24. ED403: CLASSROOM ORGANIZATION AND MANAGEMENT

SEMESTER-V

25. ED501: INTERNSHIP-I
26. ED502: INTERNSHIP-II

SEMESTER-VI

27. MBM561: PROJECT DISSERTAION IN MATHEMATICS
28. ED601: PROJECT DISSERTAION IN EDUCATION
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<tr>
<th>Sr. No.</th>
<th>Elective Course Title</th>
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<tbody>
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<td>1.</td>
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<td>2.</td>
<td>Advance Real Analysis</td>
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<td>Computational PDE</td>
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<td>Fractional Calculus and Geometric Function Theory</td>
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<td>Game Theory</td>
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<td>17.</td>
<td>Graph Theory</td>
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<td>Integral Equations and Calculus of Variations</td>
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<td>Mathematical Tools and Software</td>
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Detail Revised Syllabus of Elective Papers

1. ADVANCED COMPLEX ANALYSIS  

UNIT-I: Analytic Continuation, Analytic Continuation along Paths via Power Series, Monodromy Theorem, Picard theorem, Poisson integral, Mean value theorem, Schwarz reflection principle, Analytic continuation via reflexion. (15 L)

UNIT-II: Infinite sums and infinite product of complex numbers, Infinite product of analytic functions, Factorization of entire functions, The Gamma functions, The Zeta functions. (15 L)

UNIT-III: The Riemann mapping theorem (Statement only), Area Theorem, Bieberbach Theorem and conjecture, Distortion theorem, Koebe ¼ theorem, Starlike and convex functions. Coefficient estimates and distortion theorem. (15 L)

Recommended Reading:

2. L. R. Ahlfors, Complex Analysis, McGraw Hill

2. ADVANCED REAL ANALYSIS  

UNIT-I: Metric spaces revisited; Baire Category theorem, completion of Metric spaces, Banach contraction principle and some of its applications. Compactness, Total boundedness, characterization of compactness for arbitrary Metric spaces; Arzella-Ascoli theorem, Stone Weierstrass theorem. (15L)

UNIT-II: Integrations: Lebesgue’s criterion of Riemann integrability over a bounded closed interval [a, b] and its consequence, length of a rectifiable curve in a plane, Riemann-Stieltjes integral over [a, b] and its properties, Integrators of bounded variation, Integration by parts, Stieltjes integral as a Riemann integral, Step function as integrator, Riesz theorem. (15L)

UNIT-III: Cesaro’s Method of Summability and Fourier Series: Cesaro’s method of summability of order 1 and order 2, Some specific examples, Regularity of Cesaro’s method, Definition of Fourier series and some examples, Dirichlet’s Kernel, Fejer’s Kernel, Fejer’s theorem, Dini’s and Jordan’s tests for point wise convergence of Fourier series. (15L)

Recommended Reading:

3. ADVANCED NUMERICAL METHODS  


UNIT-II: Polynomial Interpolation: introduction- finite difference formulas, divided difference interpolation, Aitken’s formula, Hermite’s interpolation, double interpolation, Spline interpolation (linear, quadratic and cubic spline), Error in cubic Spline. Numerical differentiation, Errors in numerical differentiation, cubic spline method; Numerical Integration: introduction to trapezoidal, Simpson’s rules and error estimates, use of cubic splines, numerical double integration. (15L)


Recommended Reading:


4. AUTOMATA THEORY AND FORMAL LANGUAGES  

Unit-I: Theory of Computation: Finite automata, Deterministic and non-deterministic finite automata, equivalence of deterministic and non-deterministic automata, Moore and Mealy machines, Regular expressions, Grammars and Languages, Derivations, Language generated by a grammar. (15L)

Unit-II: Regular Language and regular grammar, Regular and Context free grammar, Context sensitive grammars and Languages, Pumping Lemma, Kleene’s theorem. (15L)

Unit-III: Turing Machines: Basic definitions, Turing machines as language acceptors, Universal Turing machines, decidability, undecidability, Turing Machine halting problem. (15L)

Recommended Reading:

2) J. E. Hopcroft, R. Motwani, and J. D. Ullman, Introduction to Automata, Languages, and Computation
5. BIO-MATHEMATICS

Unit 1: Introduction: Goals and Challenges of mathematical modeling in biology and ecology. Idealization and general principle of model building, deterministic and stochastic models, different types of mathematical models and differential and difference equations as relevant mathematical techniques, complex network dynamics, biological and ecological examples. (15 L)

Unit 2: Continuous growth models for single species: The linear model, Logistic population model, Stability of equilibrium states and bifurcation analysis, Constant Harvesting and bifurcations, Delay models, Linear analysis of delay models: periodic solutions. (15 L)


Recommended Reading:


6. CELESTIAL MECHANICS

UNIT-I: Orbital Motion Introduction, Kepler’s Laws of Planetary Motion, Newton’s law of gravitation, Central force motion, Integral of energy, Differential equation of orbit, Inverse square force, Geometry of orbits, Two body problem, Motion of center of mass, Relative motion, Solution of two-body problem, Earth bound satellite circular orbit, Classical orbital elements, Kepler’s equation, Position in elliptic orbit, Position in parabolic orbit and Position in hyperbolic orbit. (15 L)


Recommended Reading:


7. COMPLEX DYNAMICS LTP: 3+1+0

UNIT –I: Iteration of a Mobius transformation, attracting, repelling and indifferent fixed points. Iterations of $R(z) = z^2, z^2+c, z + \frac{1}{z}$. The extended complex plane, chordal metric, spherical metric, rational maps, Lipschitz condition, conjugacy classes of rational maps, valency of a function, fixed points, Critical points, Riemann Hurwitz relation. (15 L)

UNIT –II: Equicontinuous functions, normality sets , Fatou sets and Julia sets, completely invariant sets, Normal families and equicontinuity, Properties of Julia sets, exceptional points Backward orbit, minimal property of Julia sets. (15 L)

UNIT -III: Julia sets of commuting rational functions, structure of Fatou set, Topology of the Sphere, Completely invariant components of the Fatou set, The Euler characteristic, Riemann Hurwitz formula for covering maps, maps between components of the Fatou sets, the number of components of Fatou sets, components of Julia sets. (15L)

Recommended Reading:

8. COMPUTATIONAL ODE LTP: 3+1+0

UNIT-I: Numerical solutions of system of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta (IV order) explicit methods, Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method. (15L)

UNIT-II: Types Finite difference schemes of second order BVP based on difference operators (solutions of tri-diagonal system of equations), Solutions of such BVP by Newton-Cotes and Gaussian integration rules, Convergence and stability of finite difference schemes. (15L)

UNIT-III: Variational principle, approximate solutions of second order BVP of first kind by Reyleigh-Ritz, Galerkin, Collocation and finite difference methods, Finite Element methods for BVP-line segment, triangular and rectangular elements, Ritz and Galerkin approximation over an element, assembly of element equations and imposition of boundary conditions. (15L)

Recommended Reading:
3. S. S. Sastry, Introductory Methods of Numerical Analysis,

9. COMPUTATIONAL PDE

UNIT-I: Numerical solutions of parabolic equations of second order in one space variable with constant coefficients:- two and three levels explicit and implicit difference schemes, truncation errors and stability, Difference schemes for diffusion convection equation, Numerical solution of parabolic equations of second order in two space variable with constant coefficients-improved explicit schemes, Implicit methods, alternating direction implicit (ADI) methods. (15L)

UNIT-II: Numerical solution of hyperbolic equations of second order in one and two space variables with constant and variable coefficients-explicit and implicit methods, alternating direction implicit (ADI) methods. (15L)


Recommended Reading:

10. DIFFERENTIAL GEOMETRY

UNIT-I : Differential Calculus, Tangent space. Vector fields, Cotangent space and differentials on $\mathbb{R}^n$. Charts and atlases. Differential manifolds, Induced topology on manifolds, functions and maps, some special functions of class $C^\infty$. Para compact manifolds and partition of unity. Pullback functions, local coordinates systems and partial derivatives. (15 L)

UNIT-II : Tangent vectors and Tangent space, differential of a map, the tangent bundle, pullback vector fields, Lie bracket, the cotangent space, the cotangent bundle, the dual of the differential map. One parameter group and vector fields. (15 L)
UNIT-III: Lie derivatives, tensors, tensor fields, connections, parallel translation, covariant differentiation of
tensor fields, torsion tensor, curvature tensor, Bianchi and Ricci identities, Geodesics, Riemannian manifolds. (15 L)

Recommended Reading:


11. DYNAMICAL SYSTEMS LTP: 3+1+0

Unit-I: Linear Systems: Exponentials of operators, Linear systems in $\mathbb{R}^2$, Complex eigenvalues, Multiple
eigenvalues, Jordon forms, Stability theory, generalized eigenvectors and invariant subspaces, Non-homogeneous
linear systems. (15L)

Unit-II: Non-linear Systems: local analysis: the fundamental existence-uniqueness theorem, The flow defined by a
differential equation, Linearization, The stable manifold theorem, The Hartman-Grobman theorem, Stability and
Liapunov functions, Saddles, Nodes, Foci, and Centers. (15L)

Unit-III: Non-linear Systems: global analysis: Dynamical systems and global existence theorem, Limit sets and
Attractors, Periodic orbits, Limit Cycles, and Separatrix cycles, the Poincare map, the stable manifold theorem for
periodic orbits, the Poincare-Bendixon theory in $\mathbb{R}^2$, Linear Systems, Bendixon’s Criteria. (15L)

Recommended Reading:

2. Differential Equations, Dynamical Systems and an Introduction to Chaos by Morris W. Hirsch, Stephen
3. Dynamical Systems and Numerical Analysis by A.M. Stuart and A.R. Humphries, Cambridge University
5. Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry and Engineering, by
Steven H. Strogatz, Westview Press.

12. FLUID DYNAMICS LTP: 3+1+0

UNIT-I: Physical Properties of fluids. Concept of fluids, Continuum Hypothesis, density, specific weight, specific
volume, Kinematics of Fluids: Eulerian and Lagrangian methods of description of fluids, Equivalence of Eulerian
and Lagrangian method, General motion of fluid element, integrability and compatibility conditions, strain rate
tensor, stream line, path line, streak lines, stream function, vortex lines, circulation. (15L)

UNIT-II: Stresses in Fluids: Stress tensor, symmetry of stress tensor, transformation of stress components from
one co-ordinate system to another, principle axes and principle values of stress tensor Conservation Laws:
Equation of conservation of mass, equation of conservation of momentum, Navier Stokes equation, equation of
moments of momentum, Equation of energy, Basic equations in different co-ordinate systems, boundary conditions. (15L)

UNIT-III: Irrotational and Rotational Flows: Bernoulli’s equation, Bernoulli’s equation for irrotational flows, Two dimensional irrotational incompressible flows, Blasius theorem, Circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows, methods of images. (15L)

**Recommended Reading:**

### 13. FINANCIAL MATHEMATICS

**LTP:** 3+1+0

UNIT-I: Introduction to options and markets: types of options, interest rates and present values, Black Scholes model: arbitrage, option values, pay offs and strategies, putcall parity, Black Scholes equation, similarity solution and exact formulae for European options, American option, call and put options, free boundary problem. (15L)

UNIT-II: Binomial methods: option valuation, dividend paying stock, general formulation and implementation, Monte Carlo simulation: valuation by simulation, Lab component: implementation of the option pricing algorithms and evaluations for Indian companies. (15L)

UNIT-III: Finite difference methods: explicit and implicit methods with stability and conversions analysis methods for American options- constrained matrix problem, projected SOR, time stepping algorithms with convergence and numerical examples. (15L)

**Recommended Reading:**

### 14. FRACTIONAL CALCULUS AND GEOMETRIC FUNCTION THEORY

**LTP:** 3+1+0

UNIT-I: Fractional derivatives and Integrals, application of fractional calculus, Laplace transforms of fractional integrals and fractional derivatives, fractional ordinary differential equations, fractional integral equations, Initial value problem of fractional differential equations. (15 L)


**Recommended Reading:**
2. I. Graham and G. Kohr, Geometric function theory in one and higher dimensions, Marcel Dekker, 2003.

### 15. FUZZY LOGIC AND ITS APPLICATIONS

**LTP:** 3+1+0

18


**Recommended Reading:**
4. J. Yen and R. Langari., Fuzzy Logic, Intelligence, Control and Information, Pearson Education.

### 16. GAME THEORY LTP: 3+1+0

UNIT-I: A General Introduction to Game Theory-its Origin, Representation of Games, Types of Game, Static Games with Complete and Incomplete Information, Strategic Form Game with Illustrations, Solution Concept- Pure and Mixed Strategies, Dominance and Best Response, Pareto Optimality, Maxmin and Minmax Strategies, Pure and Mixed Strategies Nash Equilibrium, Correlated Equilibrium, Bayesian Games, Market Equilibrium and Pricing: Cournot and Bertrand Game. (15L)

UNIT-II: Existence and Properties of Nash Equilibrium, Two-person Zero-Sum Games-its Solution; Dynamic Games of Perfect Information, Extensive Form Game, Nash Equilibrium, Sub-game Perfection, Backward Induction (looking forward), Stackelberg Model of Duopoly. (15L)

UNIT-III: Bargaining Problem, Dynamic Games with Imperfect Information, Finitely and Infinitely Repeated Games, The Folk Theorem, Illustrations, Stochastic Games, Coalition Games, Core and Shapley Value, Illustrations. (15L)

**Recommended Reading:**

### 17. GRAPH THEORY LTP: 3+1+0
UNIT-I: Graphs and simple graphs, Vertex Degrees, Subgraphs, Graph Isomorphism, The Incidence and Adjacency Matrices, Paths and Circuits, Trees, Cut Edges and Cut Vertices, Euler and Hamilton circuits, Bipartite and Complete graphs. Spanning trees, Minimal spanning trees, Kruskal’s Algorithm, Directed graphs, Weighted undirected graphs, Dijkstra’s algorithm, Warshal’s Algorithm. (15L)

UNIT-II: Connectivity: Connectivity of graphs, Cut-sets, Edge Connectivity and Vertex Connectivity, Planarity: Planar Graphs, Testing of Planarity, Euler’s formula for connected planar graphs, Kuratowski Theorem for Planar graphs, Random Graphs. (15L)

UNIT-III: Coloring of graphs: Chromatic number and chromatic polynomial of graphs, Brook’s Theorem, Five Color Theorem and Four Color Theorem. (15L)

Recommended Reading:
1) F. Harary, Graph Theory, Narosa Publ.
3) Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India.

18. INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS LTP: 3+1+0

UNIT-I: The variation of a functional and its properties, Euler’s equations and application, Geodesics, Variational problems for functional involving several dependent variables, Hamilton principle, Variational problems with moving (or free) boundaries, Approximate solution of boundary value problem by Rayleigh-Ritz method. (15 L)

UNIT-II: Linear integral equation and classification of conditions, Volterra integral equation, Relationship between linear differential equation and Volterra integral equation, Resolvent kernel of Volterra integral equation, solution of integral equation by Resolvent kernel, The method of successive approximation, Convolution type equation. (15 L)

UNIT-III: Fredholm integral equation, Fredholm equation of the second kind, Fundamentals-iterated kernels, constructing the resolvent kernel with the aid of iterated kernels, Integral equation with degenerated kernels, solutions of homogeneous integral equation with degenerated kernel. (15 L)

Recommended Reading:
2. Introduction to Mathematical Physics by Charlie Harper, P.H.I ., New Delhi
5. Mathematical Methods by Potter and Goldberg (Prentice Hall of India)
6. Calculus of Variations by IM Gelfand, SV Fomin, and Richard A Silverman
7. Introduction to the Calculus of Variations by Bernard Dacorogna, World Scientific

19. MATHEMATICAL TOOLS AND SOFTWARE LTP: 3+0+1

UNIT-I: MATLAB: Basic Introduction: Simple arithmetic calculations, Creating and working with arrays, numbers and matrices, Creating and printing simple plots, Function files, Applications to Ordinary differential equations: A first order ODE, A 2nd order ODE, ode23, ode45, Basic 2-D plots and 3-D plots. (10 L)
UNIT-II: Mathematica: Basic introduction: Arithmetic operations, functions, Graphics: 2-D plots, 3-D plots, Plotting the graphs of different functions, Matrix operations, Finding roots of an equation, Finding roots of a system of equations, Solving differential equations. (10 L)

UNIT-III: LaTeX: Basic Introduction: Mathematical symbols and commands, Arrays, Formulas, and Equations, Spacing, Borders and Colors, Using date and time option in LaTeX, To create applications and Letters, PPT in LaTeX, Writing an article, Pictures and Graphics in LaTeX. (10L)

(Note- Lab for 1 credits = 30 hrs.)

Recommended Reading:

20. MODULE THEORY LTP: 3+1+0

UNIT-I: Modules over a ring, submodules, Quotient Modules, module homomorphism and isomorphism theorems for modules, cyclic modules, simple modules and semisimple modules and rings, Schur’s lemma. (15L)

UNIT-II: Exact sequences, Products, Coproducts and their universal property, External and internal direct sums, Free modules, Left exactness of Hom sequences and counter-examples for non-right exactness. (15L)

UNIT-III: Noetherian and Artinian modules and rings. Hilbert basis theorem, Projective and injective modules, Divisible groups, Example of injective modules. (15L)

Recommended Reading:

21. NONLINEAR DYNAMICS AND ITS APPS. TO INFORMATION TECHNOLOGY LTP: 3+1+0


UNIT-II: Existence of chaos in Logistic and Base Models in Discrete forms. Effects of variable externals and internal influence in Bass Model (in both continuous and discrete forms, conditions for chaos). (15 L)

Recommended Reading:

22. NUMBER THEORY-I
LTP: 3+1+0

UNIT-I: Primes, Divisibility, Greatest common divisor, Euclidean algorithm, Fundamental theorem of arithmetic, Perfect numbers, Mersenne primes and Fermat numbers, Farey sequences. (15L)

UNIT-II: Congruence and modular arithmetic, Residue classes and reduced residue classes, Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Euler's theorem and its application to cryptography, Arithmetic functions \( \varphi(n), \mu(n), \tau(n), \sigma(n) \), Möbius inversion formula, Greatest integer function. (15L)

UNIT-III: Primitive roots and indices, quadratic residues, Legendre symbol, Euler's criterion, Gauss's lemma, Quadratic reciprocity law, Jacobi symbol, Representation of an integer as a sum of two and four squares, Diophantine equations \( ax+by=c \), \( x^2+y^2=z^2 \), \( x^4+y^4=z^4 \). Binary quadratic forms and Equivalence of quadratic forms. (15L)

Recommended Reading:

23. NUMBER THEORY – II
LTP: 3+1+0

UNIT-I: Continued fractions, Approximation of real numbers by rational numbers, Pell's equations, Partitions, Ferrers graphs, Jacobi's triple product identity. (15L)

UNIT-II: Congruence properties of \( \varphi(n) \), Rogers-Ramanujan identities, Minkowski's theorem in geometry of numbers and its applications to Diophantine inequalities, Order of magnitude and average order of arithmetic functions. (15L)

UNIT-III: Euler's summation formula, Abel's identity, Elementary results on distribution of primes, Characters of finite Abelian groups, Dirichlet's theorem on primes in arithmetical progression. (15L)

Recommended Reading:
UNIT-I: Nonlinear Programming: Unconstrained algorithms; direct search method, gradient method. Constrained methods; Separable programming, quadratic programming. General Inventory models, role of demand in the development of inventory; Static Economic-Order-Quantity (EOQ) models; Dynamic EOQ models. Continuous review model, single period models, multi period models. (15 L)

UNIT-II: Elements of Queuing models, role of exponential, pure birth and death models. Generalized Poisson Queuing models, Specialized Poisson Queues: Steady state measures of performance, single server model multi server models, machine servicing models-(M/M/R); (GD/K/K), R<K. Replacement and maintenance models; gradual failure, sudden failure, replacement due to efficiency deteriorate with time, staffing problems, equipment renewal problems. (15 L)


Recommended Reading:
5. Operations Research, - Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons

25. PROGRAMMING IN C

UNIT-I: Basic concepts of programming languages: Programming domains, language evaluation criterion and language categories, Describing Syntax and Semantics, formal methods of describing syntax, recursive descent parsing, attribute grammars, Dynamic semantics (operational semantics, denotational semantics, axiomatic semantics) (10 L)

UNIT-II: Names, Variables, Binding, Type checking, Scope and lifetime data types, array types, record types, union types, set types and pointer types, arithmetic expressions, type conversions, relational and Boolean expressions, assignment statements, mixed mode assignment. Statement level control structures, compound statements, selection statement, iterative statements, unconditional branching. (10 L)

UNIT-III: Programming in C: Character set, variables and constants, keywords, Instructions, assignment statements, arithmetic expression, comment statements, simple input and output, Boolean expressions, Relational operators, logical operators, control structures, decision control structure, loop control structure, case control structure, functions, subroutines, scope and lifetime of identifiers, parameter passing mechanism, arrays and strings, Pointers, Pointers to Function, Function returning Pointers. (10 L)

Note: (Lab for remaining 1 Credits=30 Hrs.)

Recommended Reading:
2. How to Program C by Deitel and Deitel, Addison Wesley, Pearson Education Asia.
5. C Programming a Modern Approach by KN King, WW Norton & Co.

26. SPECIAL FUNCTIONS

UNIT-I: Beta and Gamma Functions, Euler Reflection Formula, Stirling’s Asymptotic Formula, Gauss’s Multiplication Formula, Ratio of two gamma functions, Integral Representations for Logarithm of Gamma function and Beta functions. (15L)

UNIT-II. Hypergeometric Differential Equations, Gauss Hypergeometric Function, Elementary Properties, Conditions of convergence, Integral Representation, Gauss Theorem, Vandermonde’s theorem, Kummer’s theorem, Linear transformation, Generalized Hypergeometric Functions, Elementary Properties, Integral Representation. (15L)

UNIT-III: Legendre polynomials and functions, Solution of Legendre’s differential equations, Generating Functions, Rodrigue’s Formula, Orthogonality of Legendre polynomials, Recurrence relations. Bessel functions, Bessel differential equation and it’s solution, Recurrence relation, Generating functions, Integral representation. (15L)

Recommended Reading: