SYLLABUS FOR B.SC MATHEMATICS HONOURS

Structure of Syliabus

Note : Each paper in each semester is of 56 marks. 5 periods per week for each unit of 50 marks.

Semester 1: First Year First Semester	150
1.1 Calculus	
1.2 Geometry	
1.3 Algebra I	
Semester 2: First Year Second Semester	150
2.1 Mechanics I	
2.2 Differential Equations I	
2.3 Algebra II	
Semester 3: Second Year First Semester	150
3.1 Mechanics II	
3.2 Differential Equations II	
3.3 Analysis I	
Semester 4: Second Year Second Semester	150
4.1 Vector Analysis	
4.2 Differential Equations III	
4.3 Analysis II	
Semester 5: Third Year First Semester	300
5.1 Numerical Methods	
5.2 Numerical Methods Practical using C	
5.3 Algebra III	
5.4 Analysis III	
5.5 Optional Paper I	
5.6 Optional Paper II	
Semester 6: Third Year Second Semester	300
6.1 Probability Theory	
6.2 Linear Programming and Optimization	
6.3 Algebra rV	
6.4 Analysis IV	
6.5 Optional Paper III	
6.6 Optional Paper IV	

Detailed Syllabus

1. First Year First Semester

1.1. Calculus.

Differential and Integral Calculus. The real line and its geometrical representation. *e-S* treatment of limit and continuity. Properties of limit and classification of discontinuities. Properties of continuous functions. Differentiability and differentials. Successive differentiation and Leibnitz Theorem. Statement of Rolle's Theorem. Mean Value Theorem, Taylor and Maclaurin's Theorems, indeterminate forms. Limits and continuity of functions of two variables. Partial derivatives. Methods of Integration: Partial fractions. Definite integrals. Statement of the Fundamental Theorem.

Applications. Asymptotes. Concavity, convexity, and points of inflection. Extrema. Plane curves, tangent and normal in parametric form. Envelopes. Polar Coordinates.

Quadrature. Rectifiability and length of a curve. Arc length as a parameter. Curvature. Volumes and surface areas of solids of revolution.

References. [32], [4].

1.2. Geometry.

Analytical geometry of two dimensions. Transformation of rectangular axes. General equation of second degree and its reduction to normal form. Systems of conies. Polar equation of a conic.

Analytical geometry of three dimensions. Direction cosines. Straight line. Plane. Sphere. Cone. Cylinder.

Central conicoids, paraboloids, plane sections of conicoids. Generating lines. Reduction of second degree equations to normal form; classification of quadrics.

References. [82], [119], [11], [22], [26].

1.3. Algebra I.

Matrix Theory and Linear Algebra in R". Systems of linear equations, Gauss elimination, and consistency. Subspaces of R", linear dependence, and dimension. Matrices, elementary row operations, row-equivalence, and row space. Systems of linear equations as matrix equations, and the invariance of its solution set under row-equivalence. Row-reduced matrices, row-reduced echelon matrices, row-rank, and using these as tests for linear dependence. The dimension of the solution space of a system of independent homogeneous linear equations.

Linear transformations and matrix representation. Matrix addition and multiplication. Diagonal, permutation, triangular, and symmetric matrices. Rectangular matrices and column vectors. Non-singular transformations. Inverse of a Matrix. Rank-nullity theorem. Equivalence of row and column ranks. Elementary matrices and elementary operations. Equivalence and canonical form. Determinants. Eigenvalues, eigenvectors, and the characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Theory of Equations. Polynomials in one variable and the division algorithm. Relations between the roots and the coefficients. Transformation of equations. Descartes rule of signs. Solution of cubic and biquadratic (quartic) equations (as in [16]).

References. Mainly [16] and [75]. (Also [74], [27], [23], [35], [18].)

2. First Year Second Semester

2.1. Mechanics I.

Statics. Forces. Couples. Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Catenary. Forces in three dimensions. Reduction of a system of forces in space. Invariance of the system. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium.

References. [84], [46], [132], [107].

2.2. Differential Equations I.

Elementary Methods in Ordinary Differential Equations. Formation of a differential equation. Solutions: General, particular, and singular. First order exact equations and integrating factors. Degree and order of a differential equation. Equations of first order and first degree. Equations in which the variable are separable. Homogeneous equations. Linear equations and equations reducible to linear form. First order higher degree equations solvable for x, y, p. Clairaut's form and singular solutions. Orthogonal trajectories. Linear differential equations with constant coefficients. Homogeneous linear ordinary differential equations.

Linear differential equations of second order. Transformation of the equation by changing — the dependent variable and the independent variable. Method of variation of parameters.

Ordinary simultaneous differential equations.

References. [100], [122], [20].

2.3. Algebra II.

Modern Algebra. Commutative rings, integral domains, and their elementary properties. Ordered integral domain: The integers and the well-ordering property of positive elements. Finite induction. Divisibility, the division algorithm, primes, GCDs, and the Euclidean algorithm. The fundamental theorem of arithmetic. Congruence modulo n and residue classes. The rings Z„ and their properties. Units in Z_n, and Z_p for prime p. Subrings and ideals. Characteristic of a ring. Fields.

Sets, relations, and mappings. Bijective, injective, and surjective maps. Composition and restriction of maps. Direct and inverse images and their properties. Finite, infinite, countable, uncountable sets, and cardinality. Equivalence relations and partitions. Ordering relations.

Definition of a group, with examples and simple properties. Groups of transformations. Subgroups. Generation of groups and cyclic groups. Various subgroups of GL2(R). Coset decomposition. Lagrange's theorem and its consequences. Fermat's and Euler's theorems. Permutation groups. Even and odd permutations. The alternating groups A_n. Isomorphism and homomorphism. Normal subgroups. Quotient groups. First homomorphism theorem. Cayley's theorem.

Trigonometry. De-Moivre's theorem and applications. Direct and inverse, circular and hyperbolic, functions. Logarithm of a complex quantity. Expansion of trigonometric functions.

References. [16], [42], [79], [127], [52], [55], [75], [34].

3. SECOND YEAR FIRST SEMESTER

3.1. Mechanics II.

Dynamics. Motion of a particle in two dimensions. Velocities and accelerations in Cartesian, polar, and intrinsic coordinates. Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Motion of a particle in a plane under different laws of resistance.

Central forces. Stability of nearly circular orbits. Motion under the,inverse square law. Kepler's laws. Time of describing an arc and area of any orbit. Slightly disturbed orbits. Motion of artificial satellites. Problems of motion of varying mass such as falling raindrops and rockets.

Tangential and normal accelerations. Motion of a particle on a smooth or rough curve. Principle of conservation of energy.

Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution.

References. [81], [28], [86], [25].

3.2. Differential Equations II.

Ordinary Differential Equations. Series solutions of differential equations: Power series method, Bessel, Legendre, and Hypergeometric equations. Bessel, Legendre, and Hypergeometric functions and their properties: Convergence, recurrence, and generating relations. Orthogonality of functions. Sturra-Liouville problem. Orthogonality of eigenfunctions. Reality of eigenvalues. Orthogonality of Bessel functions and Legendre polynomials.

Laplace transforms. Introduction to infinite integrals. Linearity of Laplace transforms. Existence theorem for Laplace transforms. Laplace transforms of derivatives and integrals. Shifting theorems. Differentiation and integration of transforms. Convolution theorem. Solution of integral equations and systems of differential equations using Laplace transforms.

References. [113], [122], [60].

3.3. Analysis I. Countability of Z and Q. Order properties of Q and its order incompleteness. Construction of R from Q using Dedekind cuts. Order complete ness of R: The least upper bound property and equivalent conditions including the nested interval property. Uncountability of R Bounds, bounded sets, and their properties, sup and inf of sets. Bolzano-Weierstrass theorem.

Sequences. Bounded sequences, monotone sequences and their convergence, limsup and liminf and convergence criterion using them, subsequences, Cauchy sequences and their convergence criterion.

Interior points and limit points, open, closed, and perfect sets. Compact sets.

Limits and continuity. Basic properties of continuous functions. Operations on sequences. Uniform continuity. Bounded functions. Continuous functions defined on a compact set: Their boundedness, attainment of bounds, and uniform continuity. Intermediate Value Theorem. Discontinuities. Monotonic functions.

Infinite series and their convergence. Geometric series. The comparison test. Series of non-negative terms. The condensation test. Integral test. Ratio and root tests. Absolute and conditional convergence. Alternating series and Leibnitz's theorem.

References. [3], [115], [32], [47], [118].

4. Second Year Second Semester

4.1. Vector Analysis.

Vector Algebra. Operations with vectors. Scalar and vector product of three vectors. Product of four vectors. Reciprocal vectors.

Vector Calculus. Scalar-valued functions over the plane and the space. Vector function of a scalar variable: Curves and Paths. Vector fields.

Vector differentiation. Directional derivatives, the tangent plane, total differential, gradient, divergence, and curl.

Vector integration: Path, line, surface, and volume integrals. Line integrals of linear differential forms, integration of total differentials, conservative fields, conditions for line integrals to depend only on the endpoints, the fundamental theorem on exact differentials. Serret-Frenet Formulas.

Theorems of Green, Gauss, Stokes, and problems based on these.

References. [89], [33], [4], [73], [56].

4.2. **Differential Equations III.**

Partial differential equations. Formation of partial differential equations. Types of solutions. PDEs of the first order. Lagrange's solution. Some special types of equations which can be solved easily by methods other than the general methods. Charpit's and Jacobi's general method of solution.

Partial differential equations of second and higher order. Classification of linear partial differential equations of second order. Homogeneous and non-homogeneous equations with constant coefficients. Partial differential equations reducible to equations with constant coefficients. Monge's methods.

Calculus of variations. Variational problems with fixed boundaries - Euler's equation for functionals containing first-order derivative and one independent variable. Extremals. Functionals dependent on higher order derivatives. Functionals dependent on more than one independent variable. Variational problems in parametric form. Invariance of Euler's equation under coordinate transformation.

Variational problems with moving boundaries. Functionals dependent on one and two functions. One sided variations.

Sufficient conditions for an extremum — Jacobi and Legendre conditions. Second variation. Variational principle of least action. Applications.

References. [123], [96], [49], [19], [40].

4.3. Analysis **II.**

Differentiation. Derivatives. Rolle's theorem. Mean Value Theorem. Darboux's theorem on intermediate value property of derivatives. Taylor's theorem. Indeterminate forms.

Integration. The Riemann Integral and its properties. Integrability of continuous and monotonic functions. Functions of bounded variation, their relation with monotonic functions, and integrability.

The fundamental theorem of calculus. Mean value theorems of integral calculus.

Convergence of improper integrals. Comparison tests, Abel's and Dirichlet's tests. Beta and Gamma functions. Frullani's integral. Integral as a function of a parameter, and its continuity, differentiability, and integrability.

References. [3], [33], [32], [115], [47], [134].

5. THIRD YEAR FIRST SEMESTER

5.1. **Numerical Methods.** Representations of numbers: Roundoff error, truncation error, significant error, error in numerical computations.

Solution of transcendental and algebraic equations: Bisection, secant, Regula Falsi, fixed-point, Newton-Raphson, Graffe's methods.

Interpolation: Difference schemes, interpolation formulas using differences. Lagrange and Newton interpolation. Hermite interpolation. Divided differences.

Numerical differentiation: Methods based on interpolations. Methods based on finite differences.

Numerical integration: Trapezoidal, Simpson's, and Weddle's rules. Gauss Quadrature Formulas.

Solution of linear equations: Direct methods - Gauss elimination, Gauss-Jordan elimination, LU decomposition. Iterative methods - Jacobi, Gauss-Siedel.

The algebraic eigenvalue problem: Jacobi's method, Given's method, Householder's method, Power method.

Ordinary differential equations: Euler's method, Single-step methods, Runge-Kutta's method, multi-step methods.

Approximation: Different types of approximation, least square polynomial approximation.

References. [44], [62], [117], [6], [116], [9].

5.2. **Numerical Methods Practical (Lab) using C programming.**

Numerical Methods Lab. Programming in C of the following set of problems:

- Bisection method.
- Regula Falsi method.
- Fixed-point method.
- Newton-Raphson method.
- Graffe's methods.
- Lagrange interpolation.
- Newton's forward and backward interpolation.
- Hermite interpolation.
- Richardson extrapolation (differentiation).
- Trapezoidal and Simpson one-third rules.
- Gauss Quadrature.
- Gauss elimination method.
- LU decomposition.
- Gauss-Siedel method.
- Jacobi's method (eigenvalue).
- Power method (eigenvalue).
- Euler's method.
- Runge-Kutta's method.
- Predictor-corrector method.
- Fitting a polynomial function.

References. [70], [99], [53], [48], [38], [65], [8], [138], [110].

5.3. **Algebra** III.

Linear Algebra. Vector spaces over a field, subspaces. Sum and direct sum of subspaces. Linear span. Linear dependence and independence. Basis. Finite dimensional spaces. Existence theorem for bases in the finite dimensional case. Invariance of the number of vectors in a basis, dimension. Existence of complementary subspace of any subspace of a finite-dimensional vector space. Dimensions of sums of subspaces. Quotient space and its dimension.

Matrices and linear transformations, change of basis and similarity. Algebra of linear transformations. The rank-nullity theorem. Change of basis. Dual space. Bidual space and natural isomorphism. Adjoints of linear transformations. Eigenvalues and eigenvectors. Determinants, characteristic and minimal polynomials, Cayley-Hamilton Theorem. Annihilators. Diagonalization and triangularization of operators. Invariant subspaces and decomposition of operators. Canonical forms.

Inner product spaces. Cauchy-Schwartz inequality. Orthogonal vectors and orthogonal complements. Orthonormal sets and bases. Bessel's inequality. Gram-Schmidt orthogonalization method. Hermitian, Self-Adjoint, Unitary, and Orthogonal transformation for complex and real spaces. Bilinear and Quadratic forms. The Spectral Theorem. The structure of orthogonal transformations in real Euclidean spaces.

Applications to linear differential equations with constant coefficients.

References. [16], [55], [74], [51], [58], [85], [75], [43], [128], [76].

5.4. Analysis **III.**

Metric spaces. Definition and examples, neighbourhoods, limit points, interior, and boundary points. Open and closed sets. Closure, interior, and boundary of a set. Subspaces. Cauchy sequences and complete spaces. Cantor's intersection theorem and the contraction mapping principle. Dense and nowhere dense subsets. Baire Category Theorem. Compactness: Sequential compactness and Heine-Borel property, totally bounded spaces, finite intersection property, continuous functions on compact sets.

Sequence and series of functions. Pointwise convergence. Uniform convergence, and its relation to continuity, integration, and differentiation. Weierstrass M-test. *C[a, b]* is a complete metric space. Power series, radius of convergence. Analytic functions and examples. Fourier series: Periodic functions and Trigonometric polynomials. Definition of Fourier coefficients and series. Riemann Lebesgue lemma. Bessel's inequality. Parseval's identity. Dirichlet's conditions for convergence of Fourier series. Examples of Fourier expansions and summation results for series.

References. [72], [71], [47], [121], [115], [3], [32], [88].

5.5. **Optional Paper I.** Any one from:

- Mechanics III: Rigid Dynamics
- Computer Science I
- Computational Mathematics Lab I
- Number Theory

5.6. **Optional Paper II.** Any one from:

- Mathematical Physics and Relativity I

- Discrete Mathematics I
- Mathematical Modeling I

6. THIRD YEAR SECOND SEMESTER

6.1. **Probability Theory.** Notion of probability: Random experiment, sample space, axioms of probability, elementary properties of probability, equally likely outcome problems.

Random variables: Concept, cumulative distribution function, discrete and continuous random variables, expectation, mean, variance, moment generating function.

Discrete random variables: Bernoulli random variable, Binomial random variable, geometric random variable, Poisson random variable.

Continuous random variables: Uniform random variable, exponential random variable, Gamma random variable, Normal random variable.

Conditional probability and conditional expectations, Bayes theorem, independence, computing expectation by conditioning; some applications — a list model, a random graph, Polya's urn model.

Bivariate random variables: Joint distribution, joint and conditional distributions, the correlation coefficient. Bivariate normal distribution.

Functions of random variables: Sum of random variables, the laws of large numbers, central limit theorem, approximation of distributions.

References. [14], [103].

6.2. **Linear Programming and Optimization.** The Unear programming prob lem. Problem formulation. Types of solutions. Linear programming in matrix notation. Graphical solution of linear programming problems. Some basic proper ties of convex sets, convex functions, and concave functions. Theory and applica tion of the simplex method of solution of a linear programming problem, Charne's M-technique. The two phase method, principle of duality in linear programming problem, fundamental duality theorem, simple problems, the transportation and assignment problems.

***References.* [50], [45].**

6.3. **Algebra IV.**

Advanced Group Theory. Group automorphisms, inner automorphisms. Automorphism groups and their computations. Conjugacy relation. Normalizer. Counting principle and the class equation of a finite group. Center of a group. Free abelian groups. Structure theorem of finitely generated abelian groups.

Ring Theory. Rings and ring homomorphisms. Ideals and quotient rings. Prime and maximal ideals. The quotient field of an integral domain. Euclidean rings. Polynomial rings. Polynomials over *Q* and Eisenstein's criterion. Polynomial rings over arbitrary commutative rings. UFDs. If *A* is a UFD, then so is $A[x\backslash, x_2, \ldots, x_n]$

References. [55], [61], [42], [114], [5].

6.4. **Analysis IV.**

Several Variables. R" as a normed linear space, and 1/(1", R"^{1}) as a normed linear space. Limits and continuity of functions from W^1 to R^{171}. The derivative at a point of a function from R° to R™ as a linear transformation. The tangent space and linear approximation. The chain rule.

Partial derivatives and higher order partial derivatives; their continuity. Sufficient conditions for differentiability. Examples of discontinuous and non-differ-entiable functions whose partial-derivatives exist. C^1 maps. Euler's theorem. Sufficient condition for equality of mixed partial derivatives.

Proofs of the inverse function theorem, the implicit function theorem, and the rank theorem. Jacobians.

The Hessian and the real quadratic form associated with it. Extrema of real-valued functions of several variables. Proof of the necessity of the Lagrange multiplier condition for constrained extrema.

Complex Variables. Confonnal transformations of the plane and Cauchy Riemann equations. Continuity and differentiability of complex functions. Analytic functions. Harmonic functions. Elementary functions. Mapping by elementary functions. Mobius transformations. Fixed points. Cross ratio. Inverse points and critical mappings. Conformal maps. Gregory's series.

References. [115], [3], [89], [33], [4], [30], [2].

6.5. **Optional Paper III.** Continuation of Optional Paper I from previous semes ter corresponding to the appropriate topic:

- Mechanics IV: Hydrostatics
- Computer Science II
- Computational Mathematics Lab II
- Differential Geometry

6.6. Optional Paper IV. Continuation of Optional Paper II from previous se mester corresponding to the appropriate topic:

- Mathematical Physics and Relativity II a
Discrete Mathematics II
- Mathematical Modeling II

OPTIONAL PAPERS

Mechanics **III.**

Rigid Dynamics. Degrees of freedom. Moments and products of inertia. Momental ellipsoid. Equimomental systems. Principal axes. D'Alembert's principle.

The general equation of motion. Motion of the centre of inertia. Motion relative to the centre of inertia. Motion about a fixed axis. Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces. Conservation of momentum and energy. Lagrange's equation in generalized coordinates. Theory of small oscillations.

References. [83], [28], [25].

Mechanics IV.

Hydrostatics. Pressure of heavy fluid. Conditions of equilibrium for homogeneous, heterogeneous, and elastic fluid. Lines of force. Surfaces of equal pressure. Centre of pressure. Thrusts on plane and curved surfaces. Rotating fluid. Floating bodies. Stability. Meta-centre. Curves of buoyancy. Surface of buoyancy. Vessel containing liquid. Oscillation of floating bodies.

References. [108], [67], [13], [120], [106].

Number Theory.

Divisibility. Introduction, The Division Algorithm, Gcd and Lcm, The Euclidean Algorithm, Primes and their properties, Infinitude of primes, The Fundamental Theorem of Arithmetic, The Prime Number Theorem (statement only).

Congruences. Definition and properties, Euler's phi function, Fermat's Theorem, Euler's Theorem, Wilson's Theorem, Solutions of Congruences, The Chinese Remainder Theorem, Multiplicative property of Euler's phi function, Primitive Roots.

Quadratic Reciprocity. Quadratic Residues, The Legendre Symbol and its properties, Lemma of Gauss, The Gaussian Reciprocity Law, The Jacobi symbol.

Note. The above course is based on the first three chapters of [101].

References. [101], [54], [37]. Differential Geometry.

Curves. Introduction, Parametrized Curves and Arc Length, The Vector Product in R^3, The Local Theory of Curves Parametrized by Arc Length, Curvature, Torsion, Serret-Frenet Formulas, Fundamental Theorem of the Local Theory of Curves.

Regular Surfaces. Introduction, Regular Surfaces and Inverse Image of Regular Values, Change of Parameters and Differential Functions on Surfaces, The Tangent Plane, The Differential of a map, The First Fundamental Form, Area.

Note. The above course is based on the first two chapters of [39].

References. [39], [102], [97], [135].

Discrete Mathematics I. Mathematical induction. Principle of inclusion and exclusion. Pigeon hole principle. Finite combinatorics. Generating functions. Partitions. Recurrence relations. Linear difference equations with constant coefficients.

Partial and linear orderings. Chains and antichains. Lattices. Distributive lattices. Complementation.

Graphs and Planar graphs. Paths and circuits. Hamiltonian paths. Shortest paths. Eulerian paths. Traveling salesman problem. Trees. Spanning trees.

Truth functional logic and prepositional connectives. Switching circuits. Boolean algebras. Duality. Boolean functions. Normal forms. Karnaugh maps.

References. [80], [112], [57].

Discrete Mathematics II. Alphabets and strings. Formal languages and phrase structure grammars. BNF notation. Derivations. Language generated by a grammar. The Chomsky hierarchy: Regular, Context-free, Context-sensitive, and arbitrary grammars.

Finite state machines. Nondeterministic finite automata. Regular languages. Closure properties. Kleene's theorem. Regular expressions. Pumping lemma. Algorithms for regular grammars.

Introduction to the theory of Context-free languages, push-down automata, and parsing.

References. [109], [36], [59], [77].

Computer Science I.

Algorithms. Concept and basic techniques in the design and analysis of algorithms. Models of computation. Lower bounds. Algorithms for optimum search trees, balanced trees, and union-find algorithms. Numerical and algebraic algorithms. Combinatorial algorithms.

Theory of Computation. RAMs, Turing machines, recursive functions, string computation, and other models of computation and their equivalence. Halting problem, recursively enumerable sets, and Rice's theorem. Semi-Thue processes, grammars, and word problems. Deterministic and nondeterministic Turing machines. Exponential and polynomial-time problems. Polynomial-time equivalence of all reasonable models of computation. NP-completeness. Unsolvable and intractable problems.

References. [29], [69], [36], [59], [77].

Computer Science II.

The Unix Programming Environment. The shell as a command interpreter, using a modern version of Bourne shell such as zsh or bash. Input/Output redirection. Pipelines. Processes: Parents and children. Job control, and background processing of multiple processes simultaneously. The Unix filesystem: Permissions, inodes; regular, special, and device files. Shell metacharacters, shell variables, and control structures. Shell programming. Regular expressions and extended regular expressions. Advanced editing using regular expressions. Unix filters, including grep/egrep, sed, awk, and other text and sorting filters. Perl programming.

The kernel. Unix system calls. Signals. Systems Programming using C: System calls relating to file I/O and filesystem. The Standard I/O library. System calls relating to process control, process relationships, and signals. Interprocess communication. Networking in the Unix environment.

References. [68], [104], [125], [124], [126], [131].

Mathematical Modeling I. Introduction, basic steps of Mathematical Modeling, its needs, types of models, limitations. Elementary ideas of dynamical systems, autonomous dynamical systems in the plane-linear theory. Equilibrium point, node, saddle point, focus, centre and limit-cycle ideas with simple illustrations and figures. Linearization of non-linear plane autonomous systems.

Mathematical Modeling in the biological environment.

Blood flow and oxygen transfer. Modeling blood flow, viscousity, Poiseuille law, mathematical formulation of the problem, solution and interpretation. Oxygen transfer in red cells, diffusion, mathematical formulation, solution, interpretation, and limitations.

Single **species** population models. Basic concepts. Exponential growth model, formulation, solution, interpretation, and limitations. Compensation and depensa**tion. Logistic growth** model, formulation, solution, interpretation, and limitations. **Gompertz growth** model, formulation, solution, interpretation, and limitations.

Two species population models. Types of interaction between two species. Lotka-VolteiTa prey-predator model, formulation, solution, interpretation, arid limitations. Lotka-Volterra model of two competing species, formulation, solution, interpretation, and limitations.

Mathematical modeling of epidemics. Basic concepts. Simple epidemic model, formulation, solution, interpretation, and limitations. General epidemic model, formulation, solution, interpretation, and limitations.

References. [94], [95], [12], [66], [21], [15], [7], [93], [10].

Mathematical Modeling II. Optimization models on real life situations. One variable optimization, multi-variable optimization, sensitivity analysis and robustness, computational methods.

Models on the spread of technological innovations, atomic waste disposal, and electrical networks. Mathematical theories of war, Richardson's theory of conflict, Lancaster's combat models, limitations, and extension.

Mathematical modeling in economic environment, production and supply functions, price-elasticities, utility of consumption and consumer surplus, pure competition, competitive equilibrium, monopoly versus competition, duopoly, oligopoly, conjectural variation. Theory of production, production function, Cobb-Douglas production function and its properties, costs of production.

References. [94], [95], [12], [66], [21], [15], [7], [93], [10].

Mathematical Physics and Relativity **I.**

Group A (25 marks) Electromagnetic Theory I: Electrostatics and Magnetostatics. Field equations due to charges, potential. Conductors, condensers, and dielectrics. Boundary conditions. Surface, line, and point charges. General solution of Poisson's equation. Dipoles, boundary value problems for spherical conductors and dielectrics. Electrical images and inversion. Electrostatic stress and energy, magnetism, induced magnetism. Flow of steady electric currents in linear conductors. Steady electric currents in continuous media. Biot-Savant law of electromagnetic induction.

Group B (25 marks) Special Theory of Relativity I. Review of Newtonian mechanics - inertia! frames. Galilean transformation. Michelson Morley experiment. Concepts of simultaneity. Postulates of Special Theory of Relativity. Lorentz transformation equations and its geometrical interpretation. Group properties of Lorentz transformations.

Relativistic Kinematics - composition of parallel velocities. Length contraction. Time dilation. Transformation equations for components of velocity and acceleration of a particle. Variation of mass with velocity. Equivalence of mass and energy. Relativistic energy - momentum relation, longitudinal and transversal mass.

References. [1], [41], (31], [63] (for Group A). [105], [111], [129], *[98]*, [64], [137], [130], [133] (for Group B).

Mathematical Physics and Relativity II.

Group A (25 marks) Electromagnetic Theory II: Electrodynamics. Displacement current. Maxwell's equations in vacuo, conducting and non-conducting medium. Conditions to be satisfied at the surface of separation of two media. Electromagnetic potential and stress. Radiation of energy: Poynting's Theorem. Quasi-stationary fields - alternating fields. Electromagnetic waves in isotopic conducting and non-conducting medium. Skin effect. Wave guides. The Hertzian vectors. Electric oscillator. Lorentz force on a charged particle.

Group B (25 ***marks)*** *Special Theory of Relativity II.* Geometrical representation of space-time - four dimensional Minkowskian space-time of special relativity. Time-like, light-like, and space-like intervals. Null cone, proper time. World line of a particle. Four-vectors and tensors in Minkowskian space-time.

Relativistic mechanics - energy-momentum four-vector. Relativistic force and transformation equations for its components. Relativistic Lagrangian and Hamiltonian. Relativistic equation of motion of a particle. Energy-momentum tensor of a continuous material distribution.

Transformation equations for electric and magnetic field strengths under Lorentz transformation. Lorentz invariance of Maxwell's equations. Maxwell's equations in tensor form.

References. [1], [41], [31], [63] (for Group A). [105], [111], [129], [98], [64], [137], [130], [133] (for Group B).

Computational Mathematics Laboratory I. Introduction to popular software for numerical computation and optimization. Knowledge of numerical algorithms for linear and non-linear algebraic equations, finite difference methods, interpolation, differentiation, integration, ODEs.

Based on the knowledge of above topics and using software like Mathematica, MATLAB, MathCAD, etc, following practicals are to be done in the Computer Laboratory.

- Plotting of functions.
- Solution of linear and non-linear equations.
- Data analysis and curve fitting.
- Numerical integration.
- ODEs.

References. [136], [91], [90].

Computational Mathematics Laboratory II. Numerical algorithms for eigenvalue problems. Laplace and Fourier transforms. Linear, integer, and non-linear optimization problems. Necessary theoretical background of above subjects, and using the following software: Mathematica, MATLAB, MathCAD, LINDO, etc, following practicals are to be done in the Computer Laboratory.

- Matrix operations and eigenvalue problems.
- Laplace and Fourier transforms.
- Two and three dimensional graphics.
- Linear, integer, and quadratic programming.

References. [136], [91], [90], [78].

APPENDIX

UGC Marks Distribution by Subject (B.Sc. **Math.** Hons.)

Subject	Marks
Calculus	50
Analytical Geometry	50
Vector Analysis	50
Differential Equations (50+100)	150
Algebra	200
Analysis and Advanced Calculus	200
Mechanics	100
Numerical Analysis and C Programming	100
Probability and Optimization	100
Optional Papers	200
Total	1200

REFERENCES

1. **Abraham and Becker,** ***Electricity and Magnetism.***
2. **Ahlfors,** ***Complex Analysis.***
3. **Apoetol, T.,** ***Mathematical Analysis.***
4. **Apoetol, T.,** ***Calculus, Volumes I and II.***
5. **Artin,** ***Algebra.***
6. **Atkinson, K. E.,** ***An Introduction to Numerical Analysis,*** **John Wiley and Sons, 1978.**
7. **Bailey, N.,** ***The Mathematical Theory of Infectious Diseases,*** **Haftier Press, New York, 1975.**
8. **Balaguruswamy, E.,** ***Programming in ANSI C,*** **2nd ed., Tata McGraw Hill.**
9. **Balaguruswamy, E.,** ***Numerical Methods,*** **Tata McGraw Hill, 2000.**
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