POSTGRADUATE DEPARTMENT OF MATHEMATICS

SYLLABUS
MASTER'S DEGREE IN MATHEMATICS
2009

CHRIST UNIVERSITY

POSTGRADUATE DEPARTMENT OF MATHEMATICS

Masters Programme in Mathematics

Course Objective:

The M.Sc. course in Mathematics aims at developing mathematical ability in students with acute and abstract reasoning. The course will enable students to cultivate a mathematician's habit of thought and reasoning and will enlighten students with mathematical ideas relevant for oneself and for the course itself.

Course Design:

Masters in Mathematics is a two years programme spreading over four semesters. In the first two semesters focus is on the basic papers in mathematics like Algebra and Analysis along with the basic applied papers such as ordinary and partial differential equations, and discrete mathematics and combinatorics. In the third and fourth semester focus is on the special papers and skill-based papers including operations research, number theory and graph theory. In order to meet the needs of the industry and research, special importance is given to computer programming, which is taken care of by courses such as programming in C and introduction to Mathematica.

Methodology:

We offer this course through Lectures, Seminars, Workshops, Group Discussion and talks by experts.

Admission procedure:

Candidates who have secured at least 50% of marks in Mathematics in their bachelor degree examination are eligible to apply. The candidates will then appear for written test and selected candidates for the interview.

Modular Objectives:

MTH 131: ADVANCED ALGEBRA
This paper enables students to understand the intricacies of advanced areas in algebra. This includes a study of advanced group theory, polynomial rings, Galois theory and linear transformation.

MTH 132: REAL ANALYSIS
This paper will help students understand the basics of real analysis. This paper includes such concepts as basic topology, Riemann-Stieltjes integral, sequences and series of functions.

MTH 133: DIFFERENTIAL GEOMETRY
This paper helps students understand the geometrical aspects of curves and surfaces. This paper includes parametric representation of curves and surfaces, fundamental theorems on curves and surfaces, mapping of surfaces and geodesics curvature.

MTH 134: ORDINARY DIFFERENTIAL EQUATIONS
This helps students understand the beauty of the important branch of mathematics, namely, differential equations. This paper includes a study of second order linear differential equations, adjoint and self-adjoint equations, Eigen values and Eigen vectors of the equations, power series method for solving differential equations and nonlinear differential equations.

MTH 135: DISCRETE MATHEMATICS AND COMBINATORICS
Discrete mathematics in recent days has emerged as one of the major areas of research in mathematics. This paper includes foundation topics such as advanced counting principles, relations , finite fields and an introduction to coding and Polya's enumeration method.

MTH 231: MEASURE THEORY AND INTEGRATION
This paper deals with various aspects of measure theory and integration by means of the standard approach. More advanced concepts such as Lebesgue measure, Borel measure, L^P spaces, signed and product measures have been included in this paper.

MTH 232: COMPLEX ANALYSIS
This paper will help students learn about the essentials of complex analysis. This paper includes important concepts such as power series, analytic functions, linear transformations, Laurent's series, Cauchy's theorem, Cauchy's integral formula, Cauchy's residue theorem, argument principle, Schwarz lemma , Rouche's theorem and Hadamard's 3-circles theorem.

MTH 233: PROGRAMMING IN C
The purpose of this paper is to help students learn various aspects of C programming and make them skilled in C programming.

MTH 234: PARTIAL DIFFERENTIAL EQUATIONS
This paper aims at enabling students to learn various aspects of parabolic, elliptic and hyperbolic partial differential equations. This paper consists of several effective methods for solving second order linear partial differential equations.

MTH 235: CONTINUUM MECHANICS
This paper is an introductory course to the basic concepts of continuum mechanics. This includes Cartesian tensors, stress–strain tensor, conservation laws and constitutive relations for linear elastic solid.

MTH 331: GENERAL TOPOLOGY
This paper deals with the essentials of topological spaces and their properties in terms of continuity, connectedness, compactness etc.

MTH 332: NUMERICAL ANALYSIS
This paper helps students to have an in-depth knowledge of various advanced methods in numerical analysis. This includes solution of algebraic and transcendental equations, and ordinary and partial differential equations.

MTH 333: NUMBER THEORY
This paper is concerned with the basics of analytical number theory. Topics such as divisibility, congruence's, quadratic residues and functions of number theory are covered in this paper. Some of the applications of the said concepts are also included.

MTH 334: FLUID MECHANICS
This paper aims at studying the fundamentals of fluid mechanics such as kinematics of fluid, incompressible flow and boundary layer flows.

MTH 335: OPERATIONS RESEARCH
This skill-based paper aims at imparting theoretical knowledge of optimization techniques. These techniques are widely used in the industry to optimize available resources.

MTH 431: GRAPH THEORY
Major graph-theoretical concepts like planarity, colorability and tournament are dealt with in detail in this paper.

MTH 432: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS
This paper concerns the analysis and applications of calculus of variations and integral equations. Applications include areas such as classical mechanics and differential equations.

MTH 433: FUNCTIONAL ANALYSIS
This abstract paper imparts an in-depth analysis of Banach spaces, Hilbert spaces, conjugate spaces, etc. This paper also includes a few important applications of functional analysis to other branches of both pure and applied mathematics.

MTH 441(A): MAGNETOHYDRODYNAMICS
This paper provides the fundamentals of Magnetohydrodynamics, which include theory of Maxwell's equations, basic equations, exact solutions and applications of classical MHD.

MTH 441(B): MATHEMATICAL MODELLING
This paper is concerned with the fundamentals of mathematical modeling. The coverage includes mathematical modeling through differential and difference equations and graphs.

MTH 441(C): ATMOSPHERIC SCIENCE

This paper provides an introduction to the dynamic meteorology, which includes the essentials of fluid dynamics, atmospheric dynamics and atmosphere waves and instabilities.

MTH 442(A): ALGORITHMS AND THEORY OF COMPUTER SCIENCE

This paper introduces students to many of the basic techniques on analysis and design of algorithms. Automata theory and Turing machines have been given special attention.

MTH 442(B): ADVANCED LINEAR PROGRAMMING

This paper concerns analysis and applications of transportation and assignment models, game theory, CPM and PERT methods and dynamic programming.

MTH 442(C): CRYPTOGRAPHY

This paper introduces basics of number theory and some crypto systems.

COURSE STRUCTURE FOR M.Sc. (MATHEMATICS)

I Semester

Paper Code	Title	Hrs./week	Marks	Credit
MTH 131	**Advanced Algebra**	4	100	4
MTH 132	**Real Analysis**	4	100	4
MTH 133	**Differential Geometry**	4	100	4
MTH 134	**Ordinary Differential Equations**	4	100	4
MTH 135	**Discrete Mathematics and Combinatorics**	4	100	4
	Total	**20**	**500**	**20**

II Semester

Paper Code	Title	Hrs./week	Marks	Credit
MTH 231	**Measure Theory and Integration**	4	100	4
MTH 232	**Complex Analysis**	4	100	4
MTH 233	**Programming in C**	4	100	4
MTH 234	**Partial Differential Equations**	4	100	4
MTH 235	**Continuum Mechanics**	4	100	4
	Total	**20**	**500**	**20**

III Semester

Paper Code	Title	Hrs./week	Marks	Credit
MTH 331	**General Topology**	4	100	4
MTH 332	**Numerical Analysis**	4	100	4
MTH 333	**Number Theory**	4	100	4
MTH 334	**Fluid Mechanics**	4	100	4
MTH 335	**Operations Research**	4	100	4
	Total	**20**	**500**	**20**

IV Semester

Paper Code	Title	Hrs./week	Marks	Credit
MTH 431	**Graph Theory**	4	100	4
MTH 432	**Calculus of Variations and Integral Equations**	4	100	4
MTH 433	**Functional Analysis**	4	100	4
	Elective I:	4	100	4
MTH 441 (A)	**Magnetohydrodynamics**			
MTH 441 (B)	**Mathematical Modelling**			
MTH 441 (C)	**Atmospheric Science**			
	Elective II:	4	100	4
MTH 442 (A)	**Algorithms and Theory of Computer Science**			
MTH 442 (B)	**Advanced Linear Programming**			
MTH 442 (C)	**Cryptography**			
	Total	**20**	**500**	**20**

CERTIFICATE COURSES

II Semester

Paper Code	Title	Total No. of Hours	Credit
MTH 201	**Statistics**	45	2

III Semester

Paper Code	Title	Total No. of Hours	Credit
MTH 301	**Introduction to Mathematica**	45	2

SYLLABUS (M.Sc. MATHEMATICS)

I SEMESTER:

MTH 131 : ADVANCED ALGEBRA

Unit I (15 hours)

Advanced Group Theory: Automorphisms, Cayley's theorem, permutation groups, symmetric groups, alternating groups, simple groups, conjugate elements and class equations of finite groups, Sylow theorems, direct products, finite abelian groups, solvable groups.

Unit II (15 hours)

Polynomial Rings and Fields: Polynomial rings, polynomials rings over the rational field, polynomial rings over commutative rings, extension fields, roots of polynomials, construction with straightedge and compass, more about roots.

Unit III (15 hours)

Galois theory: The elements of Galois theory, solvability by radicals, Galois group over the rationals, finite fields.

Unit IV (15 hours)

Linear transformation: Algebra of linear transformations, characteristic roots, canonical forms - triangular, nilpotent and Jordan forms, Hermitian, unitary and normal transformations, real quadratic forms.

Text Book :

I. N. Herstein, "Topics in algebra", 2nd Edition, John Wiley and Sons, 2006.

Reference Books :_

1. S. Lang, "Algebra", Springer, 2002.
2. S. Warner, "Classical modern algebra", Prentice Hall, 1971.
3. G. Birkhoff and S. Maclane, "Algebra", Macmillan, 1979.
4. J. R. Durbin, "Modern algebra", John Wiley, 1979.
5. N. Jacobson, "Basic algebra – I", Hemisphere Publishing Corporation, 1984.
6. Surjeet Singh & Qazi Zameeruddin, "Modern algebra", Vikas, 1990.
7. M. Artin, "Algebra", Prentice Hall, 1991.
8. J. B. Fraleigh, "A first course in abstract algebra", Addison-Wesley, 2002.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2 3 and 4

UNITS III & IV	Questions 5, 6 and 7

MTH 132: REAL ANALYSIS

Unit I (18 hours)

Basic Topology and sequences and series: Finite, countable and uncountable sets, metric spaces, compact sets, perfect sets, connected sets, convergent sequences, subsequences, Cauchy sequences, upper and lower limits, some special sequences, series, series of nonnegative terms, absolute convergence.

Unit II (12 hours)

Continuity and Differentiability: Limits of functions, continuous functions, continuity and compactness, continuity and connectedness, discontinuities, monotonic functions, derivative of a real function, mean value theorems, continuity of derivatives.

Unit III (15 hours)

The Riemann-Stieltjes Integral: Definition, existence and linearity properties, the integral as the limit of sums, integration and differentiation, integration by parts, mean value theorems on Riemann-Stieltjes integrals, change of variable.

Unit IV (15 hours)

Sequences and Series of Functions: Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, uniform convergence and continuity, uniform convergence and Riemann-Stieltjes integration, uniform convergence and differentiation.

Text Book :

Walter Rudin, "Principles of mathematical analysis", 3rd **Edition**, McGraw-Hill, 1976.

Reference Books :

1. A.J. White, "Real analysis: An introduction", Addison Wesley, 1968.
2. S. Lang, "Real analysis", Addison Wesley, 1969.
3. R.R. Goldberg, "Methods of real analysis", John Wiley & Sons, 1976.
4. T. M. Apostol, "Mathematical analysis", Narosa, 2004.
5. H.L. Royden, "Real analysis", MacMillan, 1988.
6. G.B. Folland, "Real analysis", Brooks/Cole, 1992.
7. S.C. Malik and S. Arora, "Mathematical analysis", New Age, 1992.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from units I and II.

UNITS I and II	Questions 1, 2 and 3
UNIT III	Questions 4 and 5
UNIT IV	Question 6 and 7

MTH 133: DIFFERENTIAL GEOMETRY

Unit I (15 hours)

Space Curves: Regular parametric representation, regular curves (of class C^M), orthogonal projections, implicit representations of curves, arc-length parametrization, tangent vectors, curvature, principle normal, binormal, torsion, spherical indicatrices.

Unit II (15 hours)

Theory of Curves: Serret-Frenet equations, intrinsic equations, the fundamental existence and uniqueness theorem, canonical representation of a curve, involutes, evolutes, theory of contact, oscillating curves and surfaces.

Unit III (15 hours)

Surfaces: Regular parametric representation, coordinate patches, simple surface, tangent plane and normal line, topological properties of simple surfaces, first fundamental form, second fundamental form, normal curvature, principal curvatures and directions, Gaussian and mean curvature.

Unit IV (15 hours)

Theory of Surfaces: The fundamental theorem of surfaces, tensors, applications of tensors to the equations of surface theory, mappings of surfaces, isometric mappings, geodesic curvature, geodesic coordinates, surfaces with constant Gaussian curvature.

Text Book :

M. Lipschultz Martin, "Differential geometry", Schaum's Series, Tata McGraw-Hill, New Delhi, 2005.

Reference Books:

1. Thorpe, "Elementary topics in differential geometry", Springer (India), 2004.
2. Andrew Pressley, "Elementary differential geometry", Springer (India), 2004.
3. Mittal & Agarwal, "Differential Geometry", Krishna Prakashan Media (P) Ltd., Meerut, 2005.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2, 3 & 4
UNITS III & IV	Questions 5, 6, & 7

MTH 134: ORDINARY DIFFERENTIAL EQUATIONS

Unit I (20 hours)

Linear differential equations, fundamental sets of solutions, Wronskian, Liouville's theorem, adjoint and self-adjoint equations, Lagrange identity, Green's formula, zeros of solutions, comparison and separation theorems.

Unit II (10 hours)

Eigen values and Eigen functions, related examples.

Unit III (20 hours)

Power series solutions, solution near an ordinary point and a regular singular point by Frobenius method, hypergeometric equations, Laguerre, Hermite and Chebyshev equations and their polynomial solutions, standard properties, generating functions.

Unit IV (10 hours)

Nonlinear equations, autonomous systems, phase plane, critical points, stability.

Text Books:

1. **E. A. Coddington,** "Introduction to ordinary differential equations", McGraw Hill, 1989.
2. **G. F. Simmons,** "Differential equations with applications and historical notes", Tata McGraw Hill, 2003.

Reference Books:

1. **M.S.P. Eastham,** "Theory of ordinary differential equations", Van Nostrand, London, 1970.
2. **E. D. Rainville and P. E. Bedient**, "Elementary differential equations", McGraw-Hill, New York, 1969.
3. **Boyce W.E. and DiPrima R.C.,** "Elementary differential equations and boundary value problems", 4th Ed., Wiley, New York, 1986.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2
UNIT II	Question 3
UNIT III	Questions 4, 5 and 6
UNIT IV	Question 7

MTH 135: DISCRETE MATHEMATICS AND COMBINATORICS

Unit I (20 hours)

Counting: Basic counting principles, simple arrangements and selections, arrangements and selections with repetitions, distributions, Binomial identities, the inclusion–exclusion principle, the Pigeonhole principle, advanced counting techniques – recurrence relations, modeling with recurrence relations, generating function, calculating coefficients of generating functions, partitions, exponential generating functions.

Unit II (10 hours)

Relations: Types of relations, representing relations using matrices and digraphs, closures of relations, paths in digraphs, transitive closures, Warshall's algorithm, equivalence relations, partial orderings, Hasse diagrams, maximal and minimal elements, lattices.

Unit III (20 hours)

Coding Theory and Polya's method of Enumeration: Elements of coding theory, the Hamming metric, the parity-check and generator metrics, group codes, decoding with coset leaders, Equivalence and symmetric groups, Burnside theorem, the cycle index, pattern inventory - Polya's method.

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Unit IV (10 hours)

Finite Fields and Combinatorial Designs: Polynomial rings, irreducible polynomials, finite fields, Latin squares, finite geometries and affine planes, block designs and projective planes.

Text Books:

1. **Kenneth H. Rosen**, "Discrete mathematics and its applications", McGraw-Hill, 2008.
2. **R.P. Grimaldi**, "Discrete and combinatorial mathematics: An applied introduction", Pearson Education Inc., 2008.

Reference Books:

1. F. Harary, "Graph theory", Addison Wesley, 1969.
2. J.P. Tremblay and R.P. Manohar, "Discrete mathematical structures with applications to computer science", McGraw-Hill, 1975.
3. C. L. Liu, "Elements of discrete mathematics", Tata McGraw-Hill, 2000.
4. V.K. Balakrishnan, "Combinatorics", Schaum's ouline series, 2001.
5. D.B. West, "Introduction to graph theory", 2nd Ed., Pearson Education Asia, 2002.
6. Alan Tucker, "Applied combinatorics", John Wiley and Sons, 2005.
7. D.S. Chandrasekharaiah, "Graph theory and combinatorics", Prism Books, 2005.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1, 2 & 3
UNIT II	Question 4
UNIT III	Question 5 and 6

UNIT IV	Question 7

II SEMESTER:

MTH 231 : MEASURE THEORY AND INTEGRATION

Unit - I (18 hours)

Introduction: Lebesgue outer measure, extension of measures, measurable sets and functions, characteristic functions, simple functions, Borel and Lebesgue measurability.

Unit – II (15 hours)

Integration: Monotone convergence theorem, Fatou's lemma, dominated convergence theorem. Differentiation: Functions of bounded variation, differentiation and integration, absolute continuity.

Unit – III (10 hours)

L^P spaces: Definitions and examples, Holder and Minkowski inequalities, convergence and completeness, Riesz-Fischer theorem.

Unit – IV (17 hours)

Signed measures: Definitions, the Jordan and Hahn decomposition, the Radon-Nikodym theorem, bounded linear functionals, Riesz representation theorem. Product measures: Definition, Fubini's theorem.

Text Books:

1. **M.E. Munroe**, "Introduction to measure and integration" Addison Wesley, 1959.
2. **G. de Barra**, "Measure theory and integration", New Age, 1981.
3. **Frank Burk**, "Lebesgue measure and integration: An introduction", Wiley, 1997.

Reference Books:

1. Paul Halmos, "Measure theory", Van Nostrand, 1950.
2. H.L. Royden, "Real analysis", Macmillan, 1968.
3. G.E. Shilov and B.L. Gurevich, "Integral, measure and derivative: A unified approach", Dover, 1978.
4. D.H. Fremlin, "Measure theory", Torres Fremlin, 2000.
5. M.M. Rao, "Measure theory and integration", Second Edition, Marcel Dekker, 2004.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2

UNIT II	Questions 3 and 4
UNIT III	Question 5
UNIT IV	Questions 6 and 7

MTH 232: COMPLEX ANALYSIS

Unit I (18 hours)

Power series, radius and circle of convergence, power series and analytic functions, Line and contour integration, Cauchy's theorem, Cauchy integral formula, Cauchy integral formula for derivatives, Cauchy integral formula for multiply connected domains, Morera's theorem, Gauss mean value theorem, Cauchy inequality for derivatives, Liouville's theorem, fundamental theorem of algebra, maximum and minimum modulus principles.

Unit II (12 hours)

Taylor's series, Laurent's series, zeros of analytical functions, singularities, classification of singularities, characterization of removable singularities and poles.

Unit III (15 hours)

Rational functions, behavior of functions in the neighborhood of an essential singularity, Cauchy's residue theorem, contour integration problems, mobius transformations, conformal mappings.

Unit IV (15 hours)

Meromorphic functions and argument principle, Schwarz lemma, Rouche's theorem, convex functions and their properties, Hadamard 3-circles theorem.

Text Books:

1. **L.V. Ahlfors**, "Complex analysis", 3rd Ed., McGraw-Hill, New York, 1979.
2. **J.B. Conwey**, "Functions of one complex variable", Narosa, 1987.

Reference Books:

1. E. Hille, "Analytic function theory", Vol. 1, Ginn, 1959.
2. R. Nevanlinna, "Analytic functions", Springer, 1970.
3. M.R. Spiegel, "Theory and problems of complex variables", Schaum's Outline Series, McGraw-Hill, New York, 1985.
4. R.V. Churchill, J.W. Brown and R.F. Verkey, "Complex variables and applications", 5th Ed., McGraw-Hill, New York, 1989.
5. R. Remmert, "Theory of complex functions", Springer, New York, 1991.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNIT I & II	Questions 1, 2, 3 and 4
UNIT III & IV	Questions 5, 6 & 7

MTH 233: PROGRAMMING IN C

Unit I (10 hours)

Basics: Algorithm and Flow chart. Introduction to C: Development of C, Features, constants and variables, data types, operators and expressions, library functions. I/O statements: Formatted and Unformatted I / O, Scanf(), Print(), getchar() and putchar() functions. **Control Structures**: Conditional and Unconditional, if, for, while and do… while, switch, break and continue, goto statement. Lab Programs on the topics.

Unit II (16 hours)

Arrays: one and Multi dimensional arrays, Strings and String functions. Linear and binary search. **Functions**: Definition, different types, advantages, calling a function, passing parameters, call by reference and call by value, local and global variables, recursive functions. Lab Programs on the topics.

Unit III (17 hours)

Structure and Unions: Defining a structure, classification, union, user-defined data types, pointers to a structure, structure as an argument to a function. **Pointers**: Declaration, operation on pointers, relationship. Lab Programs on the topics.

Unit IV (17 hours)

Files: Sequential files, file pointers random files, processing a data file, unformatted data file, file error handling, implementation of copy and merge commands. Object Oriented Programming (OOP), Introduction to C++, OOP Concepts, Structure of C++ Program, Data types, Classes and Methods, Simple C++ Programs with Classes. Lab Programs on the topics.

Text Books:

1. **Kanetkar, Yashavant**: "Let Us C", 4th Edition. BPB Publications.
2. **Gottfried, Byron S**: "Programming with C", 1996. Tata McGraw-Hill.

Reference Books:

1. Balagurusamy, E: "Programming in ANSI C" 2nd Edition. Tata McGraw-Hill
2. Deitel, H M and Deitel P J: "C How to Program", 2nd Edition. Prentice-Hall.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Question 1
UNIT II	Questions 2 and 3
UNIT III	Questions 4 and 5
UNIT IV	Questions 6 and 7

MTH 234: PARTIAL DIFFERENTIAL EQUATIONS

Unit I (16 Hours)

Basic concepts and definitions, mathematical models representing stretched string, vibrating membrane, heat conduction in solids and the gravitational potentials, second-order equations in two independent variables, canonical forms and general solution.

Unit II (17 Hours)

The Cauchy problem for homogeneous wave equation, D'Alembert's solution, domain of influence and domain of dependence, the Cauchy problem for non-homogeneous wave equation, existence and uniqueness of solution of the one-dimensional vibrating string problem, Laplace and Fourier transform method of solution to one-dimensional wave equation, the method of separation of variables for the one-dimensional wave equation with time-independent non-homogeneous term, solution by the method of eigenfunctions.

Unit III (17 Hours)

Existence and uniqueness of solution of the one-dimensional heat conduction equation, Laplace and Fourier transform method of solution to one-dimensional heat conduction equation, method of separation of variables, solution by the method of eigenfunctions, Green's function method of solution.

Unit IV (10 Hours)

Boundary value problems, Dirichlet and Neumann problems in Cartesian coordinates, maximum and minimum principles, uniqueness and stability theorem, solution by the method of separation of variables.

Text Books :

1. **Tyn Myint**, "Partial differential equations of mathematical physics", Elsevier, 1973.
2. **Christian Constanda**, "Solution techniques for elementary partial differential equations", Chapman & Hall, 2002.

Reference Books :

1. I. N. Sneddon, "Elements of partial differential equations", Mc-Graw Hill, 1957.
2. P. Garbedian, "Partial differential equations", John Wiley & Sons, 1964.
3. P. Berg & J. McGregor, "Elementary partial differential equations", Holden-Day, 1966.
4. R. L. Street, "Analysis and solution of partial differential equations", Brooks/Cole, 1973.
5. E.C. Zachmanoglou & D.W. Thoe, "Introduction to partial differential equations with applications", Williams & Wilkins, 1976.
6. F. John, "Partial differential equations", Springer, 1982.
7. S.J. Farlow, "Partial differential equations for scientists and engineers", John Wiley, 1982.
8. J. David Logan, "Partial differential equations", Springer, 2000.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)

Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2
UNIT II	Questions 3 and 4
UNIT III	Questions 5 and 6
UNIT IV	Question 7

MTH 235 – CONTINUUM MECHANICS

Unit I (15 Hours)

Co-ordinate transformations, Cartesian tensors, basic properties, transpose, symmetric and skew symmetric tensors, isotropic tensors, gradient, divergence and curl in tensor calculus, integral theorems.

Unit II (20 Hours)

Continuum hypothesis, deformation gradient, strain tensors, infinitesimal strain, compatibility relations, principal strains, material and local time derivatives, strain-rate tensor, transpose formulas, stream lines, path lines, vorticity and circulation, stress components and stress tensor, normal and shear stresses, principal stresses.

Unit III (15 Hours)

Law of conservation of mass, principles of linear and angular momentum, balance of energy.

Unit IV (10 Hours)

Constitutive relations for a linear elastic solid, generalized Hooke's law, governing equations, Navier's equation, stress formulation, Beltrami-Michell equation.

Text Book:

D. S. Chandrasekharaiah and L. Debnath, "Continuum mechanics", Academic Press, 1994.

Reference Books:

1. **P. Chadwick,** "Continuum mechanics", Allen and Unwin, 1976.
2. **A. J. M. Spencer,** "Continuum mechanics", Longman, 1980.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from units I and II.

UNITS I & II	Questions 1, 2 & 3
UNIT III	Questions 4 & 5

UNIT IV	Questions 6 & 7

III SEMESTER:

MTH 331: GENERAL TOPOLOGY

Unit I (**15 hours**)

Topological Spaces: Elements of topological spaces, basis for a topology, the order topology, the product topology on X x ***Y,*** the subspace topology, Closed sets and limit points.

Unit II (**15 hours**)

Continuous Functions: Continuous functions, the product topology, metric topology.

Unit III (**15 hours**)

Connectedness and Compactness: Connected spaces, connected subspaces of the Real Line, components and local connectedness, compact spaces, Compact Subspaces of the Real Line, limit point compactness, local compactness.

Unit IV (**15 hours**)

Countability and Separation Axioms: The countability axioms, the separation axioms, normal spaces, the Urysohn lemma, the Urysohn metrization theorem, Tietze extension theorem.

Text Book:

J.R. Munkres, "Topology", 2nd Edition, Prentice Hall of India, 2007.

Reference Books:

1. Simmons,G.F. "Introduction to topology and modern analysis," Tata McGraw Hill, 1963.
2. Dugundji,J. "Topology", Prentice Hall of India, 1966.
3. Willard, "General topology", Addison-Wesley, 1970.
4. Crump, W. Baker, "Introduction to topology", Krieger Publishing Company, 1997.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I and II	Questions 1, 2 and 3
UNIT III and IV	Questions 4, 5, 6 and 7

MTH 332 : NUMERICAL ANALYSIS

Unit I (20 Hours)

Solution of algebraic and transcendental equations: Fixed point iterative method, convergence criterion, Aitken's Δ^2-process, Sturm sequence method to identify the number of real roots, Newton-Raphson methods (includes the convergence criterion for simple roots), Bairstow's method, Graeffe's root squaring method, Birge-Vieta method, Muller's method. **Solution of Linear System of Algebraic Equations**: LU-decomposition methods (Crout's, Choleky and Delittle methods), consistency and ill-conditioned system of equations, Tri-diagonal system of equations, Thomas algorithm.

Unit II (15 Hours)

Numerical solution of ordinary differential equations: Initial value problems, Runge-Kutta methods of second and fourth order, multistep method, Adams-Moulton method, stability (convergence and truncation error for the above methods), boundary value problems, second order finite difference method, linear shooting method.

Unit III (10 Hours)

Numerical solution of elliptic partial differential equations: Difference methods for elliptic partial differential equations, difference schemes for Laplace and Poisson's equations, iterative methods of solution by Jacobi and Gauss-Siedel, solution techniques for rectangular and quadrilateral regions.

Unit IV (15 Hours)

Numerical solution of parabolic and hyperbolic partial differential equations: Difference methods for parabolic equations in one-dimension, methods of Schmidt, Laasonen, Crank-Nicolson and Dufort-Frankel, stability and convergence analysis for Schmidt and Crank-Nicolson methods, ADI method for two-dimensional parabolic equation, explicit finite difference schemes for hyperbolic equations, wave equation in one dimension.

Text Books:

1. **M.K. Jain,** “Numerical solution of differential equations”, Wiley Eastern Ltd., 1979.
2. **S.S. Sastry,** “Introductory methods of numerical analysis”, Prentice-Hall of India, 2005.

Reference Books:

1. R.L. Burden and J. Douglas Faires, “Numerical Analysis”, 4th Ed., P.W.S. Kent Publishing Company, Boston, 1989.
2. S.C. Chopra and P.C. Raymond, “Numerical methods for engineers”, Tata McGraw-Hill, New Delhi, 2000.
3. C.F. Gerald and P.O. Wheatley, “Applied numerical methods”, Pearson Education, 2002.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 & 2
UNIT II	Questions 3 & 4
UNIT III	Questions 5 & 6
UNIT IV	Question 7

MTH 333: NUMBER THEORY

Unit I (10 hours)

Divisibility: The division algorithm, the Euclidean algorithm, the unique factorization theorem, Euclid’s theorem, linear Diophantine equations.

Unit II (20 hours)

Congruences: Definitions and properties, complete residue system modulo m, reduced residue system modulo m, Euler’s ϕ function, Fermat’s theorem, Euler’s generalization of Fermat’s theorem, Wilson’s theorem, solutions of linear congruences, the Chinese remainder theorem, solutions of polynomial congruences, prime power moduli, power residues, number theory from algebraic point of view, groups, rings and fields.

Unit III (18 hours)

Quadratic residues: Legendre symbol, Gauss’s lemma, quadratic reciprocity, the Jacobi symbol, binary quadratic forms, equivalence and reduction of binary quadratic forms, sums of two squares, positive definite binary quadratic forms.

Unit IV (12 hours)

Some functions of number theory: Greatest integer function, arithmetic functions, the Mobius inversion formula.

Text Book:

IVAN NIVEN, HERBERT S. ZUCKERMAN AND HUGH L. MONTGOMERY, “AN INTRODUCTION TO THE THEORY OF NUMBERS”, JOHN WILEY, 2004.

REFERENCE BOOKS:

1. Kenneth Ireland and Michael Rosen, A classical introduction to modern number theory, Springer, 1990.
2. Neal Koblitz, A course in number theory and cryptography, Springer, 1994.
3. Gareth A. Jones and J. Mary Jones, Elementary number theory, Springer, 1998.
4. Joseph H. Silverman, A friendly introduction to number theory, Pearson Prentice Hall, 2006.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Question 1
UNIT II	Questions 2, 3 & 4
UNIT III	Questions 5 & 6
UNIT IV	Question 7

MTH 334: FLUID MECHANICS

Unit I (10 Hours)

Introduction: General description of fluid mechanics, continuum mechanics. Fluid properties: Pressure, density, specific weight, specific volume, specific gravity, viscosity, temperature, thermal conductivity, specific heat, surface tension. Regimes in the mechanics of fluids, ideal fluids, viscous incompressible fluids, non-Newtonian fluids. Kinematics of fluids: Methods of describing fluid motion - Lagrangian and Eulerian methods, translation, rotation and rate of deformation, stream lines, path lines and streak lines, material derivative and acceleration, vorticity, vorticity in polar coordinates and orthogononal curvilinear coordinates. Stress and rate of strain: Nature of stressess, transfomation of stress components, nature of strain, transformation of the rate of strain, relation between stress and rate of strain.

Unit II (10 Hours)

Fundamental Equations of the Flow of Compressible and Incompressible Fluids: The equation of continuity, conservation of mass, equation of motion (Navier-Stokes equations), conservation of momentum, the energy equation, conservation of energy.

Unit III (20 Hours)

One, Two and Three Dimensional, Inviscid Incompressible Flow: Equation of continuity, stream tube flow, equation of motion, Euler's equation, the Bernoulli equation, applications of Bernoulli equation, basic equations and concepts of flow, equation of continuity, Eulerian equation of motion, circulation theorems, circulation concept, Stoke's theorem, Kelvin's theorem, constancy of circulation, velocity potential, irrotational flow, integration of the equations of motion, Bernoulli's equation, steady motion, irrotational flow, the momentum theorem, the moment of momentum theorem, Laplace equations, stream functions in two and three dimensional motion. Two dimensional flow: Rectilinear flow, source and sink, radial flow, the Milne-Thomson circle theorem and applications, the theorem of Blasius. Three dimensional axially symmetric flow: Uniform flow, radial flow, source or sink.

Unit IV (20 Hours)

The Laminar Flow of Viscous Incompressible Fluids and the Laminar Boundary Layer: Similarity of flows, the Reynolds number, viscosity from the point of view of the kinetic theory, flow between parallel flat plates, Couette flow, plane Poiseuille flow, steady flow in pipes, flow through a pipe, the Hagen-Poiseuille flow, flow between two concentric rotating cylinders, properties of Navier-Stokes equations, boundary layer concept, the boundary layer equations in two-dimensional flow, the boundary layer along a flat plate, the Blasius solution.

Text Book:

S. W. Yuan, "Foundations of fluid mechanics", Prentice Hall of India, 1976.

Reference Books:

1. R.K. Rathy, "An introduction to fluid dynamics", Oxford and IBH Publishing Company, New Delhi, 1976.
2. G.K. Batchelor, "An introduction to fluid mechanics", Foundation Books, New Delhi, 1984.
3. F. Chorlton, "Text book of fluid dynamics", CBS Publishers & Distributors, New Delhi, 1985.
4. J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick, "Computational fluid dynamics: An introduction", Springer-Verlag, 1996.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from units I & II.

UNITS I & II	Questions 1, 2 & 3
UNIT III	Questions 4 & 5
UNIT IV	Questions 6 & 7

MTH 335: OPERATIONS RESEARCH

Unit I **(16 hours)**

Introduction to simplex algorithm – Integer programming using Branch and Bound algorithm and Cutting plane algorithm – Special cases in the Simplex Method – Sensitivity analysis (both graphical and algebraic) – Revised simplex method.

Unit II **(16 hours)**

Definition of the Dual Problem – Primal Dual relationships – Dual simplex methods – Post optimal analysis – Matrix definition of the Dual problem – Optimal dual solution – Parametric Linear Programming – Unconstrained problems , Necessary and sufficient conditions – Constrained Problems, equality constraints and inequality constraints (Karush-Kuhn-Tucker conditions).

Unit III **(16 hours)**

Deterministic Inventory Models: Classic EOQ model – EOQ with Price Breaks – Multi item EOQ with storage limitation – Dynamic EOQ Models - Probabilistic Inventory Models: Continuous Review models – Single period models (Newsvendor Model and s-S Policy).

Unit IV **(12 hours)**

Elements of a queuing Model – Pure Birth Model – Pure Death Model – Specialized Poisson Queues – Steady state Models: $(M/M/1):(GD/\infty/\infty)$ – $(M/M/1):(FCFS/\infty/\infty)$ - $(M/M/1):(GD/N/\infty)$ – $(M/M/c):(GD/\infty/\infty)$ – $(M/M/\infty):(GD/\infty/\infty)$.

Text Book:

A.H. Taha, “Operations research”, (7th Ed), Pearson Education, 2003.

Reference Books:

1. **R. Ravindran**, **D.T. Philips and J.J. Solberg**, “Operations Research: Principles and Practice”, 2nd Ed., John Wiley & Sons, 1976.
2. **R. Bronson**, “Operations research”, Shaum’s Outline Series, McGraw Hill, 1997.
3. **F.S. Hillier and G.J. Lieberman**, “Introduction to operations research”, 7th Ed., McGraw-Hill, 2001.
4. **Chandrasekhara Rao & Shanthi Lata Mishra**, “Operations research”, Narosa, 2005.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2
UNIT II	Questions 3 and 4
UNIT III	Questions 5 and 6
UNIT IV	Question 7

Note: Problems involving more than 5 iterations may be avoided.

IV SEMESTER:

MTH 431: GRAPH THEORY

Unit I (15 hours)

Introduction to graphs: Introduction to graph theory, types of graphs, basic terminology, subgraphs, representing graphs as incidence matrix and adjacency matrix, graph isomorphism, connectedness in simple graphs, paths and cycles in graphs and digraphs, Euler and Hamiltonian paths, necessary and sufficient conditions for Euler circuits and paths in simple, undirected graphs. Distance in graphs, Eccentricity, radius, diameter, center. Trees, rooted trees, binary trees, spanning trees and properties on trees. Connectivity: Vertex connectivity, edge connectivity.

Unit II (15 hours)

Planar and Non-planar Graphs: Planarity in graphs, Eulers formula for polyhedron, maximal planar graphs, Subdivision graph, homeomorphic graphs, inner vertex set, outerplanar graphs, maximal outerplanar graphs, minimally non-outerplanar graphs, detection of planarity, non-planar graphs with crossing number, geometric dual, underlying graph.

Unit III (15 hours)

Colorability: Coloring, color class, n-coloring, chromatic index of a graph, Bichromatic graphs, vertex coloring algorithm, simple-sequential algorithm, largest-first sequential algorithm, smallest-last sequential algorithm, edge coloring, coloring of a plane map, four color conjecture, five color theorem, uniquely colorable graph.

Unit IV (15 hours)

Tournaments and Graph valued functions: Digraphs – directed trees - arborescence – Tournament: spanning path in a tournament, tournaments with a Hamiltonian path, strongly connected tournament, transitive tournaments, Graph valued functions: Line graphs, some properties of line graphs, total graphs.

Text Books:

1. **F. Harary**, "Graph theory", Addison-Wesley, 1969.
2. **K.R. Parthasarathy**, "Basic graph Theory, Tata McGraw-Hill, 1994.

Reference Books:

1. M. Behzad and G. Chartrand, "Introduction to graph theory", Allyn and Bacon, 1972.
2. J. R. J. Wilson, "Introduction to graph theory", Oliver and Boyd, Edinburgh, 1979.
3. Clark and D.A. Holton, "A first look at graph theory", World Scientific, Singapore, 1995.
4. T.W. Haynes, S.T. Hedetneimi and P.J. Slater, "Fundamentals of domination in graphs", Marcel Dekker, New York, 1998.
5. D.B. West, "Introduction to graph theory", Prentice-Hall of India, New Delhi, 1999.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2, 3,4
UNITS III & IV	Questions 5, 6 & 7

MTH 432: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

Unit I (18 hours)

Maxima and minima, method of Lagrange multipliers, the simplest case, Euler equation, extremals, stationary function, geodesics, Brachistochrone problem, natural boundary conditions and transition conditions, variational notation, the more general case.

Unit II (16 hours)

Constraints and Lagrange multipliers, variable end points, Sturm-Liouville problems, Hamilton's principle, Lagrange's equation, the Rayleigh-Ritz method.

Unit III (12 hours)

Definitions, integral equation, Fredholm and Volterra equations, kernel of the integral equation, integral equations of different kinds, relations between differential and integral equations, symmetric kernels, the Green's function.

Unit IV (14 hours)

Fredholm equations with separable kernels, homogeneous integral equations, characteristic values and characteristic functions of integral equations, Hilbert-Schmidt theory, iterative methods for solving integral equations of the second kind, the Neumann series.

Text book :

F.B. Hildebrand, "Methods of applied mathematics", Dover, 1992.

Reference Books :

1. J.A. Cochran, "The analysis of linear integral equations", McGraw Hill, 1972.
2. Robert Weinstock, "Calculus of variations", Dover, 1974.
3. C. Fox, "An introduction to the calculus of variations", Dover, 1987.
4. C. Corduneanu, "Integral equations and applications", Cambridge University Press, 1991.
5. F. Wan, "Introduction to the calculus of variations and its applications", Chapman/Hall, 1995.
6. R.P. Kanwal, "Linear integral equations", Birkhäuser, 1997.
7. J. Jost and X. Li-Jost, "Calculus of variations", Cambridge University Press, 1998.
8. A.J. Jerry, "Introduction to integral equations with applications", Wiley, 1999.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2, 3 and 4
UNITS III & IV	Questions 5, 6 and 7

MTH 433: FUNCTIONAL ANALYSIS

Unit I (15 hours)

Normed linear spaces, Banach spaces, continuous linear transformations, isometric isomorphisms, functionals and the Hahn-Banach theorem, the natural embedding of a normed linear space in its second dual.

Unit II (12 hours)

The open mapping theorem and the closed graph theorem, the uniform boundedness theorem, the conjugate of an operator.

Unit III (15 hours)

Inner products, Hilbert spaces, Schwarz inequality, parallelogram law, orthogonal complements, orthonormal sets, Bessel's inequality, complete orthonormal sets.

Unit IV (18 hours)

The conjugate space, the adjoint of an operator, self-adjoint, normal and unitary operators, projections, finite dimensional spectral theory.

Text Book:

G.F. Simmons, "Introduction to topology and modern Analysis", McGraw Hill, 1963.

Reference Books :

1. Kosaku Yoshida, "Functional analysis", Springer, 1974.
2. E. Kreyszig, "Introductory functional analysis with applications", John Wiley, 1978.

3. B.V. Limaye, "Functional analysis", Wiley Eastern, 1981.
4. Walter Rudin, "Functional analysis", McGraw Hill, 1991.
5. Karen Saxe, "Beginning functional analysis", Springer, 2002.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2 and 3
UNITS III & IV	Questions 4, 5, 6 and 7

ELECTIVE PAPER – I

MTH 441 (A): MAGNETOHYDRODYNAMICS

Unit I (12 Hours)

Electrodynamics: Outline of electromagnetic units and electrostatics, derivation of Gauss law, Faraday's law, Ampere's law and solenoidal property, dielectric material, conservation of charges, electromagnetic boundary conditions.

Unit II (13 Hours)

Basic Equations: Outline of basic equations of MHD, magnetic induction equation, Lorentz force, MHD approximations, non-dimensional numbers, velocity, temperature and magnetic field boundary conditions.

Unit III (20 Hours)

Exact Solutions: Hartmann flow, generalized Hartmann flow, velocity distribution, expression for induced current and magnetic field, temperature discribution, Hartmann couette flow, magnetostatic-force free magnetic field, abnormality parameter, Chandrashekar theorem, application of magnetostatic-Bennett pinch.

Unit IV (15 Hours)

Applications: Classical MHD and Alfven waves, Alfven theorem, Frozen-in-phenomena, Application of Alfven waves, heating of solar corana, earth's magnetic field, Alfven wave equation in an incompressible conducting fluid in the presence of an vertical magnetic field, solution of Alfven wave equation, Alfven wave equation in a compressible conducting non-viscous fluid, Helmholtz vorticity equation, Kelvin's circulation theorem, Bernoulli's equation.

Text Books:

1. **V.C.A. Ferraro and Plumpton**, "An introduction to magnetofluid mechanics", Clarendon Press, 1966.
2. **P.H. Roberts,** "An introduction to magnetohydrodynamics", Longman, 1967.
3. **Allen Jeffrey,** "Magnetohydrodynamics", Oliver Boyds, 1970.

Reference Books:

1. Sutton and Sherman, "Engineering magnetohydrodynamics", McGraw-Hill, 1965.
2. H.K. Moffat, "Magnetic generation in electrically conducting fluids", Cambridge University Press, 1978.
3. David J. Griffiths, "Introduction to electrodynamics", Prentice Hall of India, 1997.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from units I & II.

UNITS I & II	Questions 1, 2 & 3
UNIT III	Questions 4 & 5
UNIT IV	Question 6 & 7

ELECTIVE PAPER - I

MTH 441(B) : MATHEMATICAL MODELLING

Unit I (15 hours)

Concept of mathematical modeling: Definition, classification, characteristics and limitations. **Mathematical modelling through ordinary differential equations of first order**: Linear and nonlinear growth, decay models, compartment models, dynamics problems, geometrical problems

Unit II (12 hours)

Mathematical modelling through systems of ordinary differential equations of first order: Population dynamics, epidemics, compartment models, economics, medicine, arms race, battles and international trade, dynamics.

Unit III (13 hours)

Mathematical modelling through ordinary differential equations of second order: Modelling of planetary motions – Circular motion and motion of satellites, mathematical modelling through linear differential equations of second order, miscellaneous mathematical models.

Unit IV (20 hours)

Mathematical modeling through difference equations and graphs: Simple models, basic theory of linear difference equations with constant coefficients, economics and finance, population dynamics and genetics, probability theory, solutions that can be modeled through graphs, mathematical modeling in terms of directed graphs, signed graphs, weighted graphs and unoriented graphs.

Text Books:

1. **M. Braun, C.S. Coleman and D.A. Drew**, " Differential equation models", 1994.
2. **J.N. Kapoor**, "Mathematical modeling", Wiley Eastern Limited, 1988.
3. **J.N. Kapoor**, "Mathematical models in biology and medicine", East-West Press, New Delhi, 1981.

Reference Books:

1. W. F. Lucas, F S Roberts and R.M. Thrall, "Discrete and system models", Springer, 1983.
2. H.M. Roberts & Thompson,"Life science models", Springer, 1983.
3. A.C. Fowler, "Mathematical Models in Applied Sciences", Cambridge University Press, 1997.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2
UNIT II	Question 3
UNIT III	Questions 4 and 5
UNIT IV	Questions 6 and 7

ELECTIVE PAPER – I

MTH 441 (C) : ATMOSPHERIC SCIENCE

Unit I (15 Hours)

Essential Fluid Dynamics: Thermal wind, geostrophic motion, hydrostatic approximation, consequences, Taylor-Proudman theorem, Geostrophic degeneracy, dimensional analysis and non-dimensional numbers. Physical Meteorology**:** Atmospheric composition, laws of thermodynamics of the atmosphere, adiabatic process, potential temperature, the Classius-Clapyeron equation, laws of black body radiation, solar and terrestrial radiation, solar constant, Albedo, greenhouse effect, heat balance of earth-atmosphere system.

Unit II (15 Hours)

Atmosphere Dynamics: Geostrophic approximation, pressure as a vertical coordinate, modified continuity equation, balance of forces, non-dimensional numbers (Rossby, Richardson, Froude, Ekman etc.), scale analysis for tropics and extra-tropics, vorticity and divergence equations, conservation of potential vorticity, atmospheric turbulence and equations for planetary boundary layer.

Unit III (15 Hours)

General Circulation of the Atmosphere: Definition of general circulation, various components of general circulation, zonal and eddy angular momentum balance of the atmosphere, meridional circulation, Hadley-Ferrel and polar cells in summer and winter, North-South and East-West (Walker) monsoon circulation, forces meridional circulation due to heating and momentum transport, available potential energy, zonal and eddy energy equations.

Unit IV (15 hours)

Atmospheric Waves and Instability: Wave motion in general, concept of wave packet, phase velocity and group velocity, momentum and energy transports by waves in the horizontal and vertical, equatorial, Kelvin and mixed Rossby gravity waves, stationary planetary waves, filtering of sound and gravity waves, linear barotropic and baroclinic instability.

Text Books:

1. **Joseph Pedlosky,** "Geophysical fluid dynamics", Springer-Verlag, 1979.
2. **J.R. Holton,** "An introduction to dynamic meteorology", 3rd Ed., Academic Press, 1992.

Reference Books:

1. F.F. Grossard and W.H. Hooke, "Waves in the atmosphere", Elsevier, 1975.
2. Ghil and Chidress, "Topics in geophysical fluid dynamics", Applied Mathematical Science, Springer Verlag, 1987.
3. S. Friedlander, "Geophysical fluid dynamics", Lecture Notes, Springer, 1998.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from units I & II.

UNITS I & II	Questions 1, 2 & 3
UNIT III	Questions 4 & 5
UNIT IV	Question 6 & 7

ELECTIVE PAPER – II

MTH 442 (A) : ALGORITHMS AND THEORY OF COMPUTER SCIENCE

Unit I (15 hours)
Fundamentals of Algorithms
Algorithms: Algorithms, Pseudocode, Searching Algorithms (Linear Search, Binary Search), Sorting (Bubble Sort, Insertion Sort), Greedy Algorithms, The Halting Problem; The Growth of Functions: Asymptotic Notations; Complexity of Algorithms.

Unit II (15 hours)

Recursive and Divide and Conquer Algorithms
Recursive Algorithms: Introduction, Examples, Mergesort; Program Correctness: Programme Verification, Rules of Inference, Conditional Statements, Loop Invariants; Divide and Conquer Algorithms: D&C Recurrence Relations, Examples.

Unit III (15 hours)
Automata Theory
Languages and Grammars: Phrase-Structure Grammars, Types of Phrase-Structure Grammars, Derivation Trees, Backus-Naur Form; Finite-State Machines with Output; Finite-State Machines with No Output: Set of Strings, Finite-State Automata, Language Recognition by FSM, Nondeterministic FSA.

Unit IV (15 hours)
Turing Machines
Language Recognition: Regular Sets, Kleen's Theorem, Regular Sets and Regular Grammars, A Set Not Recognized by a Finite-State Automation; Turing Machines: Definition, Using TM to Recognize Sets, Computing Functions with TM, Different Types of TM, Church-Turing Thesis, Computational Complexity, Computability, and Decidability.

Text Book:
Rosen, Kenneth H., Discrete Mathematics and Its Applications (6th Ed), Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.

Reference Books:

1. Brassand, Gilles and Bratley, Paul, "Fundamentals of Algorithms," Prentice-Hall of India Private Ltd, New Delhi, 2004
2. Venkataraman, M.K. et.al, Discrete Mathematics, The National Publishing Company, Chennai, 2006.
3. Chandraseikaran, N., et.al, Theory of Computer Science, Prentice-Hall of India Private Ltd., New Delhi, 2007
4. Baase S and Gelder, A.V., "Computer Algorithmics", Addition-Wesley/Langman, 2000.
5. Sedgewick, R. "Algorithms in C++", Addison-Wesley, 1992.
6. Garey M.R. and Johnson D.S., "Computers and intractability: A guide to the theory of NP-completeness", Freeman, San Francisco, 1976.
7. T. Cormen, C. Leiserson, R. Rivest and C. Stein, "Introduction to algorithms", MIT Press, 2001
8. David Harel, "Algorithms: The spirit of computing", Addison-Wesley/Langman, 2000.
9. Horowitz, Ellis, Sahni, Sartaj and Rajasekaran, Sanguthevar, "Fundamentals of Computer Algorithms," Galgotia Publications Pvt. Ltd, New Delhi, 2007
10. Knuth, Donlad E., "The Art of Computer Programming," Vol I-V, Pearson Education, Delhi, 2002
11. Ullman, Jeffrey D., Aho, Alfred V. and Hopcroft, John E., "The Design and Analysis of Computer Algorithms,"Addison-Wesley Publishing Company

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I and II	Questions 1, 2 and 3
UNITS III and IV	Questions 4, 5, 6 and 7

ELECTIVE PAPER – II

MTH 442 (B) : ADVANCED LINEAR PROGRAMMING

Unit I (16 hours)

Transportation Model: Determination of the Starting Solution – Iterative computations of the transportation algorithm. Assignment Model: - The Hungarian Method – Simplex explanation of the Hungarian Method – The trans-shipment Model.

Unit II (16 hours)

Game Theory: Optimal solution of two person zero – sum games – Solution of Mixed strategy Games (both graphical and Linear programming solution) – Goal Programming: - Formulation – Tax Planning Problem – Goal programming algorithms – The weights method – preemptive method.

Unit III (16 hours)
Network Models: Linear programming formulation of the shortest-route Problem. Maximal Flow model:- Enumeration of cuts – Maximal Flow Algorithm – Linear Programming Formulation of Maximal Flow Model. CPM and PERT:- Network Representation – Critical path computations – Construction of the Time Schedule – Linear Programming formulation of CPM – PERT calculations.

Unit IV (12 hours)
Dynamic Programming: Recursive nature of computations in DP – Forward and Backward Recursion – Knapsack / Fly Away / Cargo-Loading Model - Equipment Replacement Model .
Text Book:
A.H. Taha, "Operations research", (7th Ed), Pearson Education, 2003.

Reference Books:
1. R. Ravindran, D.T. Philips and J.J. Solberg, "Operations Research: Principles and Practice", 2nd Ed., John Wiley & Sons, 1976.
2. R. Bronson, "Operations research", Shaum's Outline Series, McGraw Hill, 1997.
3. F.S. Hillier and G.J. Lieberman, "Introduction to operations research", 7th Ed., McGraw-Hill, 2001.
4. Chandrasekhara Rao & Shanthi Lata Mishra, "Operations research", Narosa, 2005.

FORMAT: Part A: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

UNIT I	Questions 1 and 2
UNIT II	Questions 3 and 4
UNIT III	Questions 5 and 6
UNIT IV	Question 7

Note: Problems involving more than 5 iterations may be avoided.

ELECTIVE PAPER – II

MTH 442 (C): CRYPTOGRAPHY

Unit I (15 hours)
Some Topics in Elementary Number Theory: Elementary concepts of number theory, time estimates for doing arithmetic, divisibility and the Euclidian algorithm, congruences, some applications to factoring. Finite fields and quadratic residues: Finite fields, quadratic residues and reciprocity.

Unit II (15 hours)

Cryptography: Some simple cryptosystems, enciphering matrices.

Unit III (15 hours)

Public Key: The idea of public key cryptography, RSA, discrete log., knapsack, zero-knowledge protocols and oblivious transfer.

Unit IV (15 hours)

Elliptic Curves: Basic facts, elliptic curve cryptosystems, elliptic curve primality test, elliptic curve factorization.

Text Book:

N. Koblitz, "A course in number theory and cryptography", Graduate Texts in Mathematics, No.114, Springer-Verlag, New York, 1987.

Reference Books:

1. A. Baker, "A concise introduction to the theory of numbers", Cambridge University Press, 1990.
2. A.N. Parshin and I.R. Shafarevich (Eds.), "Number theory, encyclopedia of mathematics sciences", Vol. 49, Springer-Verlag, 1995.
3. D.R. Stinson, " Cryptography: Theory and Practice", CRC Press, 1995
4. H.C.A. van Tilborg, "An introduction to cryptography", Kluwer Academic Publishers, 1998.
5. Wade Trappe and Lawrence C. Washington, " Introduction to Cryptography with Coding Theory", Prentice hall, 2005.

FORMAT: **Part A**: Questions 1, 2 and 3 (answer any two; 20 marks each)
Part B: Questions 4, 5, 6 and 7 (answer any three; 20 marks each)

There must at least be **ONE FULL** question from each unit.

UNITS I & II	Questions 1, 2, 3
UNITS III & IV	Questions 4, 5, 6 & 7

CERTIFICATE COURSE

II Semester

MTH 201: MATHEMATICAL STATISTICS

(45 Hours)

Unit I

Probability: Sample spaces, events, probability of an event, theorems on probability, conditional probability, independent events, Bayes theorem. Boole's inequality.

Unit II

Random Variables and Expectation: Discrete and continuous random variables, distribution functions, probability mass and density functions, bivariate distributions, marginal and conditional distributions, expected value of a random variable, independence of random variables, conditional expectations, covariance matrix, correlation coefficients and regression, Chebyshev's inequality, moments, moment generating functions, characteristic functions.

Unit III

Discrete Probability Distribution: Introduction, uniform, Bernoulli, Binomial, negative Binomial, geometric, Hypergeometric and Poisson distribution. **Continuous Probability Distributions**: Introduction, uniform, gamma, exponential, beta and normal distributions.

Unit IV

Sampling distributions: t, F and chi-square distributions, standard errors and large sample distributions.

__Text Books__:

1. E. Freund John, "Mathematical Statistics", 5th Ed., Prentice Hall of India, 2000.
2. Gupta S.C. and Kapoor V.K., "Fundamentals of mathematical Statistics", Sultan Chand and Sons, New Delhi, 2001.

__Reference Books:__

1. Paul G. Hoel, "Introduction to mathematical Statistics", Wiley, 1984.
2. M. Spiegel, "Probability and statistics", Schaum's Outline Series, 2000.
3. Neil Weiss, "Introductory Statistics", Addison-Wesley, 2002.
4. Sheldon M. Ross, "A first course in probability", Pearson Prentice Hall, 2005.
5. Ronald E. Walpole, Raymond H. Myers and Sharon L. Myers, "Probability and Statistics for Engineers and Scientists", Pearson Prentice Hall, 2006.
6. Dennis Wackerly, William Mendenhall and Richard L. Scheaffer, "Mathematical Statistics with Applications", Duxburry Press, 2007.

__CERTIFICATE COURSE__

__III Semester__

__MTH 301: INTRODUCTION TO MATHEMATICA__

(45 Hours)

Algebraic Computation: Simplification of algebraic expression, simplification of expressions involving special functions, built-in functions for transformations on trigonometric expressions, definite and indefinite symbolic integration, symbolic sums and products, symbolic solution of ordinary and partial differential equations, symbolic linear algebra, matrix operations.

Mathematical Functions: Special functions, inverse error function, gamma and beta function, hypergeometric function, elliptic function, Mathieu function.

Numerical Computation: Numerical solution of differential equations, numerical solution of initial and boundary value problems, numerical integration, numerical differentiation, matrix manipulations, optimization techniques.

Graphics: Two- and three-dimensional plots, parametric plots, typesetting capabilities for labels and text in plots, direct control of final graphics size, resolution etc.

Packages: Linear algebra, calculus, discrete math, geometry, graphics, number theory, vector analysis, statistics.

Text Book:

1. **Stephen Wolfram**, "The mathematica book", Wolfram Research Inc., 2008.

Reference Books:

1. Michael Trott, "The Mathematica guide book for programming", Springer, 2004.
2. P. Wellin, R. Gaylord and S. Kamin, "An introduction to programming with Mathematica", Cambridge, 2005.