

HIMACHAL PRADESH UNIVERSITY
DETAILS OF SYLLABI
M.Sc. (Mathematics)
w.e.f. Academic Session (2019-2020)

Duration: Two Years (Four Semesters)

Semester – I		Semester - III	
M-101	Real Analysis-I	M-301	Complex Analysis-I
M-102	Advanced Algebra-I	M-302	Topology
M-103	Ordinary Differential Equations	M-303	Analytic Number Theory
M-104	Operations Research-I	M-304	Operations Research-II
M-105	Fluid Dynamics	M-305	Mathematical Statistics
Semester – II		Semester – IV	
M-201	Real Analysis-II	M-401 or M-406	Complex Analysis-II or Linear Algebra and Matrix Analysis
M-202	Advanced Algebra-II	M-402	Functional Analysis
M-203	Partial Differential Equations	M-403	Advanced Discrete Mathematics
M-204	Classical Mechanics	M-404	Differential Geometry
M-205	Solid Mechanics	M-405	Magneto Fluid Dynamics

Note:

1. M.A/M.Sc. (Mathematics) is a Two Years Post-Graduate degree course divided into Four Semesters. Maximum Marks for each paper will be of 100 marks (written examination 80 marks plus internal assessment 20 marks).
2. Each paper will be divided into three sections. Nine questions will be set in all. Each section will contain three questions. The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

M.Sc. (Mathematics) First Semester
Course Code: M-101
Real Analysis-I

Section –I

Numerical Sequences and Series

Convergent Sequences. Sub-sequences. Cauchy Sequences (in metric spaces). Absolute Convergence. Addition and Multiplication of Series. Rearrangements of Series of Real Number.

Power series

Uniqueness Theorem for Power Series. Abel's and Taylor's Theorems.

Continuity

Limits of Functions (in Metric Spaces). Continuous Functions, Continuity, Uniform Continuity and Compactness. Limit Inferior and Limit Superior. Integral Test. Comparison Test.

Section – II

The Riemann-Stieltjes Integral

Definition and Existence of Riemann-Stieltjes Integral. Properties of The Integral. Integration and Differentiation. The Fundamental Theorem of Calculus. Change of Variable. Rectifiable Curves.

Section-III

Sequences and Series of Functions

Problem of Interchange of Limit Processes for Sequences of Functions, Pointwise and Uniform Convergence, Cauchy Criterion for Uniform Convergence. Weierstrass M-Test. Abel's and Dirichlet's Tests for Uniform Convergence. Uniform Convergence and Continuity. Uniform Convergence and Riemann – Stieltjes Integration. Uniform Convergence and Differentiation. The Weierstrass Approximation Theorem.

Text Book

1. Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition, (Chapter 6: §§ 6.1 to 6.27, Chapter 7: §§ 7.1 to 7.18, 7.26 – 7.32, Chapter 3 § 3.1-3.25, 3.45-3.55 Chapter 4§ 4.1-4.20, Chapter 8§§8.1-8.5

Reference Books

1. T.M. Apostol, "Mathematical Analysis", Narosa publishing House, New Delhi, 1985.
2. S. Lang, Analysis-I, Addison – Wesley Publishing Company, Inc. 1969
3. Robert G. Bartle, Donald R. Sherbest, "Introduction to Real Analysis (Fourth Edition- (2015)", John Wiley & Sons, Inc.
4. S.C. Malik, Savita Arora, "Mathematical Analysis (Third edition-2008)", New Age International (P) Ltd., New Delhi.

M.Sc. (Mathematics) First Semester
Course Code: M-102
Advanced Algebra-I

Section – I

Conjugacy and G-Sets. Normal Series, Solvable Groups, Nilpotent Groups, Direct Products, Finitely Generated Abelian Groups, Invariants of a Finite abelian Groups, Sylow Theorems, Groups of Orders p^2 , pq .

Section – II

Definition and Examples of Rings, Some Special Classes of Rings, Homomorphisms, Ideals and Quotient Rings, More Ideals and Quotient Rings and The Field of Quotients of an Integral Domain.

Euclidean Rings, a Particular Euclidean Ring, Polynomial Rings, Polynomials over the Rational Field, Polynomial Rings over Commutative Rings.

Section – III

Definition and examples, Submodules and direct sums, homomorphisms and quotient modules, Completely reducible modules, Free modules.

Text Books

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpal, Basic Abstract Algebra, 2nd Edition, Cambridge University Press (§§107-152).
2. I.N. Herstein, 'Topics in Algebra', Second Edition), John Wiley & Sons, New York (§§ 3.1 to 3.11).
3. Kenneth Hoffman & Ray Kunze, 'Linear Algebra', Second Edition, Prentice-Hall of India Private Limited, New Delhi (§§ 8.4, 8.5, 9.1 to 9.5).

M.Sc. (Mathematics) First Semester
Course Code: M-103
Ordinary Differential Equations

Section –I

Existence and Uniqueness Theory

Some Concepts from Real Function Theory. The Fundamental Existence and Uniqueness Theorem. Dependence of Solutions on Initial Conditions and on the Function f . Existence and Uniqueness Theorems for Systems and Higher-Order equations.

The Theory of Linear Differential Equations

Introduction. Basic Theory of the Homogeneous Linear System. Further Theory of the Homogeneous Linear System. The Nonhomogeneous Linear System. Basic Theory of the n th-Order Homogeneous Linear Differential Equation. The n th-Order Nonhomogeneous Linear equation.

Section – II

Sturm-Liouville Boundary-Value Problems

Sturm-Liouville Problems. Orthogonality of Characteristic Functions. The Expansion of a Function in a Series of Orthonormal Functions.

Strumian Theory

The separation theorem, Sturm's fundamental theorem Modification due to Picone, Conditions for Oscillatory or non-oscillatory solution, First and Second comparison theorems. Sturm's Oscillation theorems. Application to Sturm Liouville System.

Section – III

Nonlinear Differential Equations

Phase Plane, Paths, and Critical Points. Critical Points and paths of Linear Systems. Critical Points and Paths of Nonlinear Systems. Limit Cycles and Periodic Solutions. The Method of Kryloff and Bogoliuboff.

Text Books

1. S.L. Ross, Differential Equations, Third Edition, John Wiley & Sons, Inc., (Chapter 10: §§ 10.1 to 10.4; Chapter 11: §§ 11.1 to 11.8; Chapter 12: §§ 12.1 to 12.3; Chapter 13: §§ 13.1 to 13.5).
2. E.L. Ince, Ordinary Differential Equations,, Dover Publication Inc. 1956 (Chapter X: §§ 10.1 to 10.6.1)

Reference

1. W. Boyce and R. Diprima, Elementry Differential Equations and Boundary value Problems, 3rd Ed. New York, (1977).
2. E.A. Coddington, An Introduction to Ordinary Differential Equations, 2nd Ed. Prentice Hall of India Pvt. Ltd., Delhi, (1974).

M.Sc. (Mathematics) First Semester
Course Code: M-104
Operations Research-I

Section –I

Hyperplane and hyperspheres, Convex sets and their properties, convex functions. Linear Programming Problem (LPP): Formulation and examples, Feasible, Basic feasible and optimal solutions, Extreme points. Graphical Methods to solve L.P.P., Simplex Method, Charnes Big M Method, Two phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Duality theory, Dual LPP, fundamental properties of Dual problems, Complementary slackness, Dual simplex algorithm, Sensitivity analysis.

Section – II

Integer programming: Gomory's Method, Branch and Bound Method.

Transportation Problem (TP): Mathematical formulation, Basic feasible solutions of T.Ps by North – West corner method, Least cost-Method, Vogel's approximation method. Unbalanced TP, optimality test of Basic Feasible Solution (BFS) by U-V method, Stepping Stone method, degeneracy in TP.

Assignment Problem (AP): Mathematical formulation, assignment methods, Hungarian method, Unbalanced AP.

Section – III

Goal programming Problem (GPP): formulation of G.P. Graphical Goal attainment method, simplex method for GPP.

Game theory: Two-person, zero-sum games, The maximin – minimax principle, pure strategies, mixed strategies, Graphical solution of $2 \times n$ and $m \times 2$ games, Dominance property, General solution of $m \times n$ rectangular games, Linear programming problem of GP.

Network Techniques

Shortest path model, Dijkstra algorithm, Floyd's algorithm, Minimal Spanning tree, Maximal flow problem.

Text Books

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co. 14th Edition 2004 (Scope as in relevant sections of Chapters 3 to 13 and 19).
2. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons 12th Edition, 2004 (Scope as in relevant sections of Chapters 0, 02 to 08 & 10, 11 & 17).
3. R. Panneerselvam, Operations Research, Prentice Hall of India Pvt. Ltd., 2004 (Chapters 5: §§ 5.1 to 5.4).

Reference Books

1. G. Hadley, Linear Programming, Narosa Publishing House (2002).
2. H.A. Taha, Operations Research: An Introduction, Prentice Hall of India Pvt. Ltd., 7th Edition, 2004.
3. J.K. Sharma, Operations Research, Macmillan India Pvt. Ltd. 2003.

M.Sc. (Mathematics) First Semester
Course Code: M-105
Fluid Dynamics

Section-I

Type of fluids, Lagrangian and Eulerian method of describing fluid motion

Motion of the fluid element: Translation, rotation and deformation

Stream lines path lines and streak lines, Material derivative, Acceleration Components of fluid particle in Cartesian, Cylindrical and Spherical polar coordinates (without proof). Vorticity vector, Vortex Lines, rotational and irrotational motion. Velocity, Potential boundary surface, Boundary condition.

Irrational Motion in two-dimensional, Stream function, Physical significance of stream function, Complex velocity potential, Sources, sinks, doublets, and their images in two dimensional.

Section-II

Continuum hypothesis, Newton's law of viscosity, Some Cartesian tensor notations. General analysis of fluid motion, Thermal conductivity, Generalized law of heat conduction. Fundamental equations of motion of viscous fluid.

Equation of State, Equation of continuity, Navier-Stokes (N-S) equations of motion. Equation of energy, Vorticity and circulation (Kelvin's circulation theorem).

Section-III

Dynamical similarity (Reynolds law), Inspection analysis, Dimensional analysis, Buckingham π theorem and its application, π product and coefficients, non-dimensional parameter and their physical importance. Exact solution of the N-S Equations, Steady motion between the parallel plates (a) velocity distribution, (b) Temperature distribution, Plane Couette flow, Plane Poiseuille flow, Generalized plane Couette flow. Flow in a circular pipe (Hagen-Poiseuille flow), (a) Velocity distribution, (b) temperature distribution.

Text-Books:

1. J.L. Bansal, Viscous fluid dynamics, Oxford and IBH Publishing Company Pvt. Ltd., (1977).
2. F. Chorlton, Text book of fluid dynamics, CBS Publishers and distribution (2000).

Reference Books:

1. G.K. Batchelor, An introduction to fluid dynamics, Cambridge University press, (1970).
2. C.S. Yih, Fluid Mechanics, McGraw-Hill Book Company.
3. S.W. Yuan, Foundation of Fluid Mechanics, PHI Pvt Ltd. New Delhi (1969).

M.Sc. (Mathematics) Second Semester
Course Code: M-201
Real Analysis-II

Section-I

Functions of Several Variables

Linear Transformation. The Space of Linear Transformations on \mathbf{R}^n to \mathbf{R}^m as a Metric Space. Differentiation of Vector-valued Functions. Differentiation of a Vector-valued Function of Several Variables. Partial Derivatives. The Contraction Principle. The Inverse Function Theorem. The Implicit Function Theorem.

Differentiation and Integration

Introduction on Differentiation of Monotone Functions. Functions of Bounded Variation. Differentiation of an Integral. Absolute Continuity. Convex Functions.

Section –II

Lebesgue Measure

Introduction. Outer measure. Measurable sets and Lebesgue measure. A nonmeasurable set. Measurable functions. Littlewood's three principles.

Section – III

The Lebesgue Integral

The Riemann integral. The Lebesgue Integral of Simple Functions. The Lebesgue Integral of a Bounded Function Over a Set of Finite Measure. The Integral of Nonnegative Functions. The General Lebesgue Integral. Convergence in Measure.

Text Book

1. H.L. Royden, Real Analysis, Third Edition, Prentice-Hall of India, Private Limited, New Delhi – 110 001 (1995), (Chapter 3 to 5)
2. Walter Rudin, Chapter 5: § 5.16 to 5.19, Chapter 9: § 9.7, 9.8, 9.10-9.15, 9.22-9.29

Reference Books

1. S. Lang, Analysis-I, Addison-Wesley Publishing Company, Inc. 1969
2. T.M. Apostol, "Mathematical Analysis- A modern approach to Advanced Calculus, Addison- Wesley Publishing Company, Inc 1957 (Indian Edition by Narosa Publishing House New Delhi also available).
3. R.R. Goldberg, "Methods of Real Analysis", Oxford and IHB Publishing Company, New Delhi.

M.Sc. (Mathematics) Second Semester
Course Code: M-202
Advanced Algebra-II

Section – I

Field Theory

Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots.

Section – II

Finite Fields

Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotomic polynomials, Representation of Elements of Finite Fields, Order of Polynomials and Primitive Polynomials, Irreducible Polynomials.

Section – III

Galois Theory and its Applications

Separable extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra.

Text Book

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press, (Chapter 15 to Chapter 18).
2. Rudolf Lidl & Harald Niederreiter, "Finite Fields", Cambridge University Press, Chapter 2 (§ 2.2 to 2.4) Chapter 3 (§ 3.1 & 3.2)

M.Sc. (Mathematics) Second Semester

Partial Differential Equations

Course Code: M-203

Section – I

Fundamental Concepts

Classification of Second Order Partial Differential Equations. Canonical Forms: Canonical Form for Hyperbolic Equation, Canonical Form for Parabolic Equation, Canonical form for elliptic equation. Adjoint Operators.

Elliptic Differential Equations

Occurrence of the Laplace and Poisson Equations: Derivation of Laplace Equation, Derivation of Poisson Equation. Boundary Value Problems (BVPs). Some Important Mathematical Tools. Properties of Harmonic Functions. Separation of Variables.

Section – II

Parabolic Differential Equations

Occurrence of the Diffusion Equation. Boundary Conditions. Elementary Solutions of the Diffusion Equation. Dirac Delta Function. Separation of Variables Method. Solution of Diffusion Equation in Cylindrical Coordinates. Solution of Diffusion Equation in Spherical Coordinates. Maximum-Minimum Principle and its Consequences.

Section – III

Hyperbolic Differential Equations

Occurrence of the Wave Equation. Derivation of One-dimensional Wave Equation. Solution of One-dimensional Wave Equation by Canonical Reduction. The Initial Value Problem; D'Alemberts Solution. Vibrating String – Variables Separable Solution. Forced Vibrations – Solution of Nonhomogeneous Equation. Boundary and Initial Value Problem for Two-dimensional Wave Equation – Method of Eigenfunction. Periodic Solution of One-dimensional Wave Equation in Cylindrical Coordinates. Periodic Solution of One-dimensional Wave Equation in Spherical Polar Coordinates.

Text Book

1. K. Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India Private Limited, New Delhi, 1997 (Scope as in relevant sections of Chapters 1 to 4).

M.Sc. (Mathematics) Second Semester

Course Code: M-204

Classical Mechanics

Section-I

Generalized Coordinates. Constraints. Work and potential energy. Generalized forces. The Principle of virtual work. Introduction to Lagrange's equations. Lagrange's Equations for a particle in a plane. The Classification of Dynamical Systems. Lagrange's equations for any simple Dynamical system. Lagrange's equations for Non-holonomic systems with moving constraints. Lagrange's equations for impulsive motion.

Section-II

Hamilton's Principle. Stationary Values of a function. Constrained stationary values. Stationary Value of a definite integral. The Brachistochrone problem. Hamilton's equations. Derivation of Hamilton's equations. Ignorable coordinates. The Routhian function.

Section-III

The form of Hamiltonian function. Modified Hamilton's principle. Principle of least action. The Hamilton-Jacobi equation. Lagrange and Poission Brackets. Calculus of Variation. Invariance of Lagrange and Poission Brackets under canonical transformation.

Text Books

1. Principle of Mechanics, John L. Synge and Byron A. Griffith, McGraw Hill, International Edition (§§ 10.6, 10.7, 15.1 & 15.2), Third Edition.
2. Classical Dynamics, Donald. T. Green – Wood, Prentice – Hall of India, 1979, (§§ 4.2, 4.3, 5.2 & 6.3).
3. Classical Mechanics, K. Sankara Rao, Prentice-Hall of India, 2005 (§§ 6.7, 6.8, 7.5 & 7.6).

M.Sc. (Mathematics) Second Semester
Course Code: M-205
Solid Mechanics
Section-I

Analysis of Strain – Affine transformation, Infinitesimal Affine deformations, Geometrical interpretation of the components of Strain. Strain Quadric of Cauchy, Principal Strains. Invariants. General Infinitesimal Deformation. Equation of compatibility. Finite deformation.

Analysis of Stress – Stress Tensor. Equations of Equilibrium. Transformation of coordinates. Stress Quadric of Cauchy. Principal stress and Invariants. Maximum normal and shear stresses, Mohr's circle Diagram.

Section – II

Equations of Elasticity – Generalized Hooke's law. Stress – Strain relations for a medium having one plane elastic symmetry, three orthogonal planes symmetry and for homogeneous isotropic media. Elastic-moduli for isotropic media. Equilibrium and Dynamic equations for an isotropic solids. Strain energy function and its connection with Hooke's law. Unique solution of Boundary value problem. Derivation of Navier's equations and Beltrami-Michal compatibility equations.

Section – III

Statement of problem. Extension of beams by longitudinal forces. Beam stretched by its own weight. Bending of beams by terminal couples. Torsion of a circular shaft. Plane stress. Plane strain.

Text Book

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw-Hill Publishing Company Ltd, 1977, (Chapter I, II, III, IV: §§29 – 33 and Chapter V: §§ 65-67).

Reference Books

1. S. Timoshenko and N.Goodier, Theory of Elasticity, McGraw-Hill, New York 1970.
2. A.E. Love, A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, London, 1963.
3. Y.C. Fung, Foundations of Solid Mechanics, Prentice-Hall, New Delhi , 1965.
4. I.H. Shames, Introduction to Solid Mechanics, Prentice-Hall, New Delhi , 1975.
5. S.Valliappan, Continuum Mechanics, Oxford and IBH Publishing Company, New Delhi, 1981.

M.Sc. (Mathematics) Third Semester
Course Code: M-301
Complex Analysis-I

Section – I

The algebra and the geometric representation of complex numbers. Limits and continuity. Analytic functions. Polynomials and rational functions. The exponential and the trigonometric functions. The periodicity. The logarithm. Sets and elements. Arcs and closed curves, Analytic functions in region.

Conformal mapping, length and area. The linear group, the cross ratio, symmetry, oriented circles, family of circles. The use of level curves, a survey of elementary mappings, elementary Riemann surfaces.

Section- II

Line integrals, rectifiable arcs, line integral as function of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk. The index of a point with respect to a closed curve. The integral formula. Higher derivatives.

Sequences, Series, Uniform convergence, Power series and Abel's limit theorem. Weierstrass's theorem, the Taylor's series and the Laurent series.

Removable singularities. Taylor's theorem, zeros and poles. The local mapping and the maximum principle.

Section – III

Chains and cycles, simple connectivity, Homology, the general statement of Cauchy's theorem. Proof of Cauchy's theorem. Locally exact differentials and multiply connected regions. The residue theorem, the argument principle and evaluation of definite integral.

Text Books

1. Lars V. Ahlfors, Complex Analysis, McGraw Hill Int. Ed. (1979).
Section-I: Chapter-1 §§ 1.1 - 1.5 and §§ 2.1 – 2.4. Chapter-2 §§ 1.1 – 1.4, 3.1 – 3.4. Chapter-3 §§ 1.1, 2.1 – 2.4, 3.1 – 3.5 and 4.1 – 4.3.
Section-II: Chapter-4 §§ 1.1 – 1.5, 2.1 – 2.3, 3.1 – 3.4. Chapter – 2 §§ 2.1 – 2.5. Chapter – 5 §§ 1.1 – 1.3 and
Section-III: Chapter- 4 §§ 4.1 – 4.7 , 5.1 – 5.3.

Reference

1. John B. Conway, Function of One Complex Variable, (Second Edition), Narosa Publishers.

M.Sc. (Mathematics) Third Semester
Course Code: M-302
Topology

Section - I

Elementary Set Theory

Partial ordered sets and lattices.

Metric Spaces

Open sets, closed sets, convergence, completeness, Baire's category theorem, continuity.

Topological Spaces

The definition and some examples, elementary concepts, Open bases and open subbases, weak topologies, the function algebras $C(X, \mathbb{R})$ and $C(X, \mathbb{C})$.

Section - II

Compactness

Compact spaces, products of spaces, Tychonoff's theorem and locally compact spaces, compactness for metric spaces, Ascoli's theorem.

Separation

T_1 -spaces and Hausdorff spaces, completely regular spaces and normal spaces, Urysohn's lemma and Tietze's extension theorem, the Urysohn imbedding theorem, the Stone-Cech compactification.

Section - III

Connectedness

Connected spaces, the components of a space, totally disconnected spaces, locally connected spaces.

Approximation

The Weierstrass approximation theorem.

Text Book

1. G.F. Simmons, Introduction to Topology and Modern Analysis, International Student Edition, McGraw Hill Book Company, Inc. 1963, Chapter 1: §§ 8; Chapter 2: §§ 9-15; Chapter 3: §§ 16-20; Chapter 4: §§ 21-25; Chapter 5: §§ 26-30; Chapter 6: §§ 31-34 and Chapter 7: 35.

M.Sc. (Mathematics) Third Semester
Course Code: M-303
Analytic Number Theory

Section – I

Divisibility Theory in the Integers

The Division Algorithm, The Greatest Common Divisor, The Euclidean Algorithm, and The Diophantine Equation $ax + by = c$.

Primes and their Distribution

The Fundamental Theorem of Arithmetic. The Sieve of Eratosthenes and The Goldbach Conjecture.

The Theory of Congruences

Basic Properties of Congruence, Special Divisibility Tests and Linear Congruences.

Section – II

Fermat's Theorem

Fermat's Factorization Method, The Little Theorem and Wilson's Theorem.

Number – Theoretic Functions

The Functions τ and σ , The Möbius Inversion Formula, The Greatest Integer Function and An Application to the Calendar.

Euler's Generalization of Fermat's Theorem

Euler's Phi-Function, Euler's Theorem and Some properties of the Phi-Function, An Application to Cryptography.

Section – III

Primitive Roots and Indices

The Order of an Integer Modulo n , Primitive Roots for Primes, Composite Numbers Having Primitive Roots and The Theory of Indices.

The Quadratic Reciprocity Law

Euler's Criterion, The Legendre Symbol and Its Properties, Quadratic Reciprocity and Quadratic Congruences with Composite Moduli.

Text Book

1. David M. Burton, "Elementary Number Theory", (Fifth Edition) International Edition, McGraw Hill, (Chapter 2nd to 9th).

M.Sc. (Mathematics) Third Semester
Course Code: M-304
Operations Research-II

Section – I

Queueing Theory

Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems. Poisson process (pure birth process), Properties of Poisson arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models.

Dynamic Programming

Decision Tree and Bellman's principle of optimality, Concept of dynamic programming, minimum path problem, Mathematical formulation of Multistage Model, Backward & Forward Recursive approach, Application in linear programming.

Section – II

Non-Linear Programming Problems (NLPP): Formulation of a NLPP, General non-linear NLPP, Constrained optimization with equality constraint, Necessary and sufficient condition for a general NLPP (with one constraint), with $m(<n)$ constraints, constrained optimization with inequality constraints (Kuhn – Tucker conditions), Saddle point problem, saddle point and NLPP, Graphical solution of NLPP, Verification of Kuhn – Tucker conditions, Kuhn – Tucker conditions with Non-negative constraints.

Section – III

Quadratic programming

Quadratic programming; Wolfe's Modified Simplex method, Beale's Method.

Separable Programming

Separable Programming, Piecewise linear approximation, Separable programming algorithm.

Simulation

Definition, Types of simulation, Event type simulation, Generation of random numbers, Monte – Carlo Simulation.

Text Books

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co. 14th Edition 2004 (Scope as in relevant sections of Chapters 17,23, 27 to 30 and 33).
2. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons 12th Edition, 2004 (Scope as in relevant sections of Chapters 13,20,23,24 and 25).

Reference Books

1. J.K. Sharma, Operations Research, Macmillan India Pvt. Ltd. 2003.
2. M.S. Bazara, H.D. Sherali and C.M. Shetty, Non-Linear Programming, Theory and Algorithms, 2nd Ed., John Wiley & Sons, Inc.

M.Sc. (Mathematics) Third Semester
Course Code: M-305
Mathematical Statistics

Section – I

Distributions of Random Variables

The probability set Function, random variables, The probability density Function, the distribution function, Certain probability Models, Mathematical Expectation, Some special Mathematical expectations, Chebyshev's Inequality, conditional probability, Marginal and conditional distributions, the correlation coefficient, Stochastic Independence.

Section – II

Some Special Distributions

The Binomial, trinomial, and Multinomial Distributions, the Poisson Distribution, The Gamma and Chi-square Distributions, the normal distribution, and the bivariate normal distribution.

Sampling theory, Transformations of variables of the Discrete type, Transformations of the variables of the continuous type. The t and F distributions.

Section- III

Extensions of the change-of-variable Technique, Distributions of order statistics, the moment generating function Technique, The distribution of $\bar{\chi}$ and nS^2/σ^2 , Expectations of Functions of Random variables, Limiting Distributions, Stochastic Convergence, Limiting Moment Generating Functions, The Central limit Theorem, some theorems on limiting Distributions.

Test Book

1. Robert V. Hogg and Allen T. Craig, Introduction to Mathematical Statistics, Forth Edition, Macmillan Publishing Co., Inc., New York, 1989, (Chapter 1 to 5).

Reference

1. Feller, W.: Introduction to Probability and its Applications, Wiley Eastem Pvt. Ltd. Vol. 1, (1972).

M.Sc. (Mathematics) Fourth Semester
Course Code: M-401
Complex Analysis-II

Section – I

Harmonic functions

Definition and basic properties of harmonic function, The mean value property, Hadamard's three circle theorem, Poisson's formula, Schwarz's theorem, The reflection principle. A closer look at Harmonic functions, Functions with the mean value property, Harnack's principle. The Dirichlet's problem; Subharmonic functions, Solution of Dirichlet's problem.

Section – II

Partial fractions and factorization

Partial fractions, infinite products, canonical products, the Gamma functions, Stirling's formula. Entire functions; Jensen's formula, Hadamard's theorem. The Riemann zeta functions; The product development. Extension of $\zeta(s)$ to the whole plane. The functional equation. The zeros of the zeta function.

Section – III

Simply periodic functions, Representation by exponentials, The Fourier development, Functions of finite order. Doubly periodic functions, The period module, unimodular transformations, The canonical basis, General properties of elliptical functions. Analytic continuations, The Weierstrass theory, germs and sheaves, Sections and Riemann surfaces, Analytic continuations along arcs, Homotopic curves, The Monodromy theorem, Branch points. Algebraic functions, The resultant of two polynomials, Definition and properties of algebraic functions, Behaviour at the critical points. Picard's theorem.

Text Books

1. Lars V. Ahlfors, Complex Analysis, Int. Ed. McGraw-Hill Book Co. (Third Edition), (1979).
Section I: Chapter 4: §§ 6.1 - 6.5; Chapter 5: §§ 2.2 to 2.4, 3.1, 3.2, 4.1 & 4.2. **Section II:** Chapter: 6 §§ 3.1, 3.2, 4.1, 4.2, 5.1-5.3.
Section III: Chapter- 7: §§ 1.1 – 1.3, 2.1-2.4, & Chapter 8: §§ 1.1-1.7, 2.1-2.3,3.1.

Reference

1. John B. Conway, Function of One Complex Variable, (Second Edition), Narosa Publishers.

M.Sc. (Mathematics) Fourth Semester
Course Code: M-402
Functional Analysis

Section - I

Banach Spaces

The definition and some examples, continuous linear transformations. The Hahn-Banach Theorem, the Open Mapping Theorem, the Closed Graph Theorem, the Uniform Boundedness Theorem, the natural embedding of N in N^{**} , reflexivity.

Section - II

Hilbert Spaces

The definition and some simple properties, orthogonal complements, orthonormal sets, the conjugate space H^* , the adjoint of an operator, self-adjoint normal and unitary operators, projections.

Section - III

Spectral Theory of Linear Operators in Normed Spaces

Spectral Theory in Finite Dimensional Normed Spaces. Basic Concepts. Spectral Properties of Bounded Linear Operators. Further Properties of Resolvent and Spectrum. Use of Complex Analysis in Spectral Theory. Banach Algebras. Further Properties of Banach Algebras.

Text Books

1. G.F. Simmons, Introduction to Topology and Modern Analysis, International Student Edition, McGraw Hill Book Company, Inc. 1963, (Chapter 9: §§ 46-51 and Chapter 10: §§ 52-59).
2. E. Kreyszig, Introductory Functional Analysis with Applications, John, Wiley and Sons, Wiley Classics Library Edition Published, 1989 (Chapter 7).

M.Sc. (Mathematics) Fourth Semester

Course Code: M-403

Advanced Discrete Mathematics

Section – I

Boolean Algebras

Logic, Propositional Equivalences, Predicates and Quantifiers. Partial Ordered Sets, Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems defined by Lattices, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebras, Uniqueness of Finite Boolean Algebras, Boolean Functions and Boolean Expressions, Propositional Calculus, Switching Circuits.

The Pigeonhole Principle

Pigeonhole principle: Simple form, Pigeonhole principle: Strong form, A theorem of Ramsey.

Permutations and Combinations

Two basic counting principles, Permutations of sets, Combinations of Sets, Permutations of multisets, Combinations of multisets.

Section – II

Generating Permutations and Combinations

Generating permutations, Inversions in permutations, Generating combinations, Partial orders and equivalence relations. **The Binomial Coefficients** Pascal's formula, The binomial theorem, Identities, Unimodality of binomial coefficients, The multinomial theorem, Newton's binomial theorem.

The Inclusion-Exclusion Principle and Applications

The inclusion-exclusion principle, Combinations with repetition, Derangements, Permutations with forbidden positions.

Recurrence Relations and Generating Functions

Some number sequences, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Generating functions, Recurrences and generating functions, Exponential generating functions.

Section – III

Introduction to Graph Theory

Basic properties, Eulerian trails, Hamilton chains and cycles, Bipartite multigraphs, Trees, The Shannon switching game.

Digraphs and Networks

Digraphs and Networks.

More on Graph Theory

Chromatic number, Plane and planar graphs, A 5-color theorem, Independence number and clique number, Connectivity.

Text Books

1. C.L. Liu, 'Elements of Discrete Mathematics', Tata McGraw-Hill, Second Edition, (§§ 12.1 to 12.8 & 12.10)
2. Richard A. Brualdi, Introductory Combinatorics, third Edition, (Chapter 2 to 7 and Chapter 11 to 13).

Reference

1. Kenneth H. Rosen, "Discrete Mathematics and Its Applications", Tata McGraw-Hill, Fourth Edition.

M.Sc. (Mathematics) Fourth Semester
Course Code: M-404
Differential Geometry

Section – I

Tangent, Principal normal, Curvature, Binormal, Torsion, Serret Frenet formulae, Locus of center of curvature, Spherical curvature, Locus of center of spherical curvature. Theorem: Curve determined by its intrinsic equations, Helices, Involutives & Evolutes.

Section – II

Surfaces, Tangent plane, Normal, Curvilinear co-ordinates First order magnitudes, Directions on a surface, The normal, second order magnitudes, Derivatives of n , Curvature of normal section. Meunier's theorem, Principal directions and curvatures, first and second curvatures, Euler's theorem. Surface of revolution.

Section – III

Gauss's formulae for F_{11}^p , F_{12}^p , F_{22}^p , Gauss characteristic equation, Mainardi – Codazzi relations, Derivatives of angle ω , Geodesic property, Equations of geodesics, Surface of revolution, Torsion of Geodesic, Bonnet's theorem, vector curvature, Geodesic curvature, κ_g .

Text Book

1. Differential Geometry of Three Dimension, C.E. Weatherburn, Khosla Publishing House, 2003 (§§ 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 13, 14, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 34, 41, 42, 43, 46, 47, 48, 49, 50, 52, 53).

Reference

1. Introduction to Differential Geometry, T.J. Willmore, Oxford University.

M.Sc. (Mathematics) Fourth Semester
Course Code: M-405
Magneto Fluid Dynamics

Section – I

Fundamental Equations

Maxwell's electromagnetic field equations, Magnetic induction equation and magnetic Reynold's number. Alfven's Theorem and its consequences. Magnetic energy equation. Mechanical equations and effects.

Magnetohydrostatics

Magnetohydrostatic, Force Free magnetic fluids (Basic equations, boundary conditions & magnetic energy, general solution when α is constant).

Section – II

Steady States

Pressure balanced magnetohydrostatic configurations. Toroidal magnetic field. Steady laminar motion. General solution of a vector wave equation.

Magnetohydrodynamic Waves

Alfven waves, Magnetohydrodynamic waves in compressible fluid. Reflection and refraction of Alfven waves. Dissipative effects.

Section – III

Stability

Introduction. Linear Pinch. Method of small Oscillations. Energy principle. Virial Theorem. Marginal stability – Bénard problem with a magnetic field.

Turbulence

Introduction, spectral analysis. Homogeneity and Isotropy. Kolmogorff's principle. Hydromagnetic turbulence. Inhibition of turbulence by a magnetic field.

Text Book

1. An Introduction to Magneto Fluid Dynamics by V.C.A. Ferraro & C. Plumpton. Clarendon Press, Oxford 2nd Edition, 1966, (Chapter 1: §§ 1.1 to 1.7, Chapter 2: §§ 2.1, 2.1 (1,2,3), 2.3, 2.4; Chapter 4: §§ 5.1 to 5.6, Chapter 6: §§ 6.1, 6.3 to 6.7).

M.Sc. (Mathematics) Fourth Semester
Course Code: M-406
Linear Algebra and Matrix Analysis

Section-I

Inner product, Inner product spaces, Linear functional and adjoints, orthogonal projections, self-adjoint operators. Unitary operators, Normal operators, Spectral theory, functions of operators. Polar decomposition.

Section-II

Simultaneously Diagonalisable Matrices, Unitary equivalence, some implication of Schur's theorem, the eigenvalues of sum and product of commuting matrices. Normal matrices, spectral theorem for normal matrices, Simultaneously unitarily diagonalisable commuting normal matrices. Matrix norms, Examples, Operator norms, Matrix norms induced by vector norms, The spectral norm, Frobenius norm, Unitary invariant norm, The maximum column sum matrix norms, the maximum row sum matrix norm.

Section-III

Positive definite matrices, Definitions and properties, Characterizations, The positive semi-definite ordering, Loewner partial order, Inequalities for the positive definite matrices, Hadamard's inequality, Fischer's inequality, Minkowski's inequality.

Text Books

Linear Algebra, Kenneth Hoffman and Ray Kunze, Second Edition (2001), Princeton-Hall of India.

Section I, 8.1-8.5, 9.5 (Theorem 9-Theorem-14).

Matrix Analysis, Roger A. Horn and Charles R. Johnson. Second Edition (2013). Cambridge University Press.

Section II, 1.3 Definition 1.3.6, 1.3.11, Theorem 1.3.7., 1.3.9., 1.3.12., Lemma 1.3.8, 1.3.10. **2.2** Definition 2.2.1, Theorem 2.2.2, **2.3** Theorem 2.3.1-2.3.4, **2.4** 2.4.1-2.4.3, Theorem 2.4.8.1, Corollary 2.4.8.5, **2.5** Definition 2.5.1, Theorem 2.5.3-2.5.6., Lemma 2.5.2, **5.6** Examples, Definitions 5.6.1, 5.6.3, Theorem 5.6.2, 5.6.7, 5.6.9.

Section III, 7.1 Observation 7.1.2, 7.1.3, 7.1.4, 7.1.6, 7.1.8, 7.1.9, 7.1.10, 7.1.12, 7.1.14. Corollary 7.1.5, 7.1.7, 7.1.13. Lemma 7.1.11. **7.2** Theorem 7.2.1, 7.2.5, 7.2.6, 7.2.7, Corollary 7.2.2, 7.2.3, 7.2.4, 7.2.8, 7.2.9. **7.7** Definition 7.7.1, Theorem 7.7.2, 7.7.3, 7.7.4, 7.7.7. Lemma 7.7.6. **7.8** Theorem 7.8.1, 7.8.5, 7.8.21. Corollary 7.8.3.

Reference Books

1 Matrix Analysis, Rajendra Bhatia, Springer Verlag, (1997)

2 Positive Definite Matrix, Rajendra Bhatia, Hindustan Book Agency, (2007)

...