

FACULTY OF SCIENCES

SYLLABUS

FOR

M. Sc. (HONS.) MATHEMATICS

(SEMESTER: I – IV)

(Under Credit Based Continuous Evaluation Grading System)

Examinations: 2012- 13



GURU NANAK DEV UNIVERSITY
AMRITSAR

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M.Sc. (Hons.) Mathematics (Semester System)

Eligibility for Admission (Any one of the following):

- a. B.A./B.Sc. with Honours in Mathematics or B.A. / B.Sc. (Pass Course) with Mathematics as one of the elective subjects having atleast 50% marks in aggregate and atleast 55% marks in Mathematics subject.

NOTE: DETAILED ORDINANCES RELATING TO EXAMINATIONS FOR THIS CLASS ARE CONTAINED IN THE GURU NANAK DEV UNIVERSITY CALENDAR VOL. II. READ WITH SYNDICATE DECISIONS / AMENDMENTS MADE FROM TIME TO TIME.

Programme Code: MTB

Master of Science (Honours) in Mathematics

Total minimum credits required for M. Sc. (Honours) Mathematics are 96.

*Out of 96 credits, student will choose minimum 8 credits interdisciplinary courses from other departments by choosing at least three credits course in each of the third and fourth semester.

Programme Code: MTB

Total minimum credits required for M. Sc. (Honours) Mathematics are 96.

Semester – I:

| Course No. | C/E/I | Course Title | L | T | P | Total Credits |
|-----------------------|-------|------------------------|-----------|----------|----------|---------------|
| Core Courses | | | | | | |
| MTL 401 | C | Real Analysis-I | 4 | 0 | 0 | 4 |
| MTL 402 | C | Algebra-I | 4 | 0 | 0 | 4 |
| MTL 403 | C | Linear Algebra | 4 | 0 | 0 | 4 |
| MTL 404 | C | Number Theory | 4 | 0 | 0 | 4 |
| MTL 405 | C | Complex Analysis | 4 | 0 | 0 | 4 |
| MTL 406 | C | Differential Equations | 4 | 0 | 0 | 4 |
| Total Credits: | | | 24 | 0 | 0 | 24 |

Semester – II:

| Course No. | C/E/I | Course Title | L | T | P | Total Credits |
|-----------------------|-------|--|-----------|----------|----------|---------------|
| Core Courses | | | | | | |
| MTL 451 | C | Real Analysis-II | 4 | 0 | 0 | 4 |
| MTL 452 | C | Algebra-II | 4 | 0 | 0 | 4 |
| MTL 453 | C | Probability Theory | 4 | 0 | 0 | 4 |
| MTL 454 | C | Classical Mechanics and Calculus of Variations | 4 | 0 | 0 | 4 |
| MTL 455 | C | Differential Geometry | 4 | 0 | 0 | 4 |
| MTL 456 | C | Mathematical Methods | 4 | 0 | 0 | 4 |
| Total Credits: | | | 24 | 0 | 0 | 24 |

Scheme of Courses for M. Sc. (Hons.) III Semester in Mathematics

| Course No. | C/E/I | Course Title | L | T | P | Total Credits |
|---|-------|------------------------------------|---|---|---|---------------|
| Core Courses | | | | | | |
| MTL 501 | C | Measure Theory | 4 | 0 | 0 | 4 |
| MTL 502 | C | Functional analysis-I | 4 | 0 | 0 | 4 |
| MTL 503 | C | Probability Theory | 4 | 0 | 0 | 4 |
| Elective/Optional Courses (Choose any Two courses) | | | | | | |
| MTL 531 | E | Operations Research-I | 4 | 0 | 0 | 4 |
| MTL 532 | E | Discrete Mathematics-I | 4 | 0 | 0 | 4 |
| MTL 533 | E | Fluid Dynamics | 4 | 0 | 0 | 4 |
| MTL 534 | E | Advanced Numerical Analysis | 4 | 0 | 0 | 4 |
| MTL 535 | E | Stochastic Process | 4 | 0 | 0 | 4 |
| MTL 536 | E | Banach Algebra and Operator Theory | 4 | 0 | 0 | 4 |
| *Interdisciplinary Courses | | | | | | |
| Total Credits | | | | | | |

Scheme of Courses for M. Sc. (Hons.) IV Semester in Mathematics

| Course No. | C/E/I | Course Title | L | T | P | Total Credits |
|--|-------|-----------------------------|---|---|---|---------------|
| Core Courses | | | | | | |
| MTL 551 | C | Topology | 4 | 0 | 0 | 4 |
| MTL 552 | C | Functional Analysis-II | 4 | 0 | 0 | 4 |
| MTL 553 | C | Statistical Inference | 3 | 0 | 1 | 4 |
| Elective/Optional Courses (Choose any Two courses) | | | | | | |
| MTL 581 | E | Topological Vector Spaces | 4 | 0 | 0 | 4 |
| MTL 582 | E | Computer Programming with C | 3 | 0 | 1 | 4 |
| MTL 583 | E | Operations Research-II | 4 | 0 | 0 | 4 |
| MTL 584 | E | Discrete Mathematics-II | 4 | 0 | 0 | 4 |
| MTL 585 | E | Advanced Fluid Dynamics | 4 | 0 | 0 | 4 |
| MTL 586 | E | Special Functions | 4 | 0 | 0 | 4 |
| *Interdisciplinary Courses | | | | | | |
| Total Credits | | | | | | |

MTL 401

REAL ANALYSIS-I

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Countable and uncountable sets. Metric spaces: Definition and examples, open sets, closed sets, compact sets, elementary properties of compact sets.

Unit-II

Compactness of k - cells, Compact subsets of Euclidean space \mathbb{R}^k . Heine Borel theorem, Perfect sets, The Cantor set, Separated sets, connected sets in a metric space, connected subsets of real line, Components, Functions of Bounded Variation.

Unit-III

Sequences in Metric Spaces: Convergent sequences (in Metric Spaces), subsequences, Cauchy sequences, Complete metric spaces, Cantor's Intersection Theorem, Baire's theorem, Banach contraction principle.

Continuity: Limits of functions (in metric spaces) Continuous functions, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic functions, Uniform Continuity.

BOOKS RECOMMENDED:

1. Walter Rudin: Principles of Mathematical Analysis (3rd Edition)
McGraw-Hill Ltd Ch.2, Ch.3.
2. Simmons, G.F.: Introduction to Topology and Modern Analysis, McGraw-Hill Ltd. (App.1)
3. Shanti Narayan: A course of Mathematical Analysis.
4. S.C. Malik & Savita Arora: Mathematical Analysis, Wiley Eastern Ltd

MTL 402
ALGEBRA-I

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Groups, Subgroups, Equivalence relations and partitions, Homomorphisms, Isomorphism Theorems, Cyclic Groups, Symmetric groups, Alternating groups, Cosets, Normal subgroups, Quotient groups, Group actions, Lagrange's theorem, Cauchy's theorem, Cayley's theorem.

Unit-II

Conjugate elements, Class equation, Sylow's theorems, Commutator subgroup, Solvable groups, Composition series, Zassenhaus lemma, Jordan Holder theorem, p-groups, Nilpotent groups, Simplicity of A_n , $n \geq 5$, Groups of automorphisms, Inner automorphisms, Sequences of subgroups.

Unit-III

Direct product and semi direct product of groups, Fundamental theorem of finitely generated Abelian groups, generators and relations, Free groups, groups of symmetries, Groups of small order.

BOOKS RECOMMENDED:

1. Artin, M. : Algebra, Prentice-Hall, 1991
2. Herstein, I.N. : Topics in Algebra, 2nd edition, Wiley India Pvt. Ltd.
3. Dummit, D.S. & Foote. : Abstract-Algebra, John-Wiley & Sons, Students Edition-1999
4. Fraleigh, J. B. : An Introduction to Abstract Algebra.
5. Bhattacharya, P.B., Jain, S.K. : Basic Abstract Algebra, Cambridge & Nagpaul, S.R. University Press, 1997.
6. Surjit Singh : Modern Algebra.

MTL 403

LINEAR ALGEBRA

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit – I

Vector Spaces, Subspaces, Basis and Dimension Theorems, Direct sum decomposition, The Algebra of linear transformations, Matrices associated with linear transformations, change of ordered bases, Elementary matrix operations and Elementary matrices, Row rank, Column rank and their equality, Proof of consistency of system of Linear Equations.

Unit-II

Eigen values and Eigen Vectors of Linear Operators, Characteristic and minimal polynomials, companion matrix, subspaces invariant under linear operators, triangulation, Diagonalization, Linear functionals, Dual Spaces and dual basis, the double dual, Inner Product Spaces, The Gram-Schmidt Orthogonalization, orthogonal complements.

Unit-III

The Adjoint of a Linear operator on an inner product space, Normal and self-Adjoint Operators, Unitary and Normal Operators, Spectral Theorem, Bilinear and Quadratic forms, Generalized Eigen Vectors, Rational and Jordan Canonical forms.

Recommended Texts:

1. Hoffman, K. and Kunze, R. : Linear algebra, Second Edition, Prentice Hall.
2. Axler, S. : Linear Algebra Done right, Second Edition, Springer-Verlag.
3. Friedberg, S.H., Insel, A.J., Spence, L.E. : Lawrence, Linear Algebra, Second Edition Prentice Hall, 1989.
4. Lang, S. Linear Algebra, Springer-Verlag, 2000.

MTL 404

NUMBER THEORY

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Number theoretic functions and ϕ , Multiplicative functions, The Mobius Inversion formula, Euler's Phi-function and its properties, Euler's theorem, Fermat's Theorem, Lagrange's Theorem, Primitive roots, m indices and their applications.

Unit-II

Euler's criterion, The Legendre symbol and its properties, Gauss Lemma, Quadratic reciprocity law, Jacobi's symbol and its Properties, Pythagorean triples, the famous "Last Theorem"

Unit-III

Representation of an integer as a sum of two squares and sum of four squares, finite and infinite simple continued fractions, Convergents, The fundamental solution of Pell's Equations, Applications to Pell's equations.

BOOKS RECOMMENDED:

1. David M. Burton: Elementary Number Theory, Mc Graw Hill 2002.
2. Hardy and Wright: Theory of Numbers.

MTL 405

COMPLEX ANALYSIS

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Functions of complex variables, continuity and differentiability, Analytic functions, Conjugate function, Harmonic function. Cauchy Riemann equations (Cartesian and Polar form). Construction of analytic functions.

Unit-II

Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form. Cauchy's inequality. Poisson's integral formula, Morera's theorem. Liouville's theorem. Power series, Taylor's theorem, Laurent's theorem. Fundamental theorem of Algebra and Rouché's theorem.

Unit-III

Zeros, Singularities, Residue at a pole and at infinity. Cauchy's Residue theorem, Jordan's lemma. Integration round Unit circle. Evaluation of integrals. Conformal transformations, Bilinear transformations, critical points, fixed points, cross ratio, Problems on cross-ratio and bilinear transformation.

BOOKS RECOMMENDED:

1. Copson, E.T.: Theory of functions of complex variables.
2. Ahlfors, D. V.: Complex analysis.
3. Titchmarsh, E.C. Theory of functions of a complex variable.
4. Conway, J.B. Functions of one complex variable

MTL 406

DIFFERENTIAL EQUATIONS

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Existence and uniqueness theorem for solution of the equation $\frac{dy}{dx} = f(x, y)$, the method of successive approximation, general properties of solution of linear differential equation of order n, adjoint and self-adjoint equations. Total differential equations. Simultaneous differential equations. Sturm Liouville's boundary value problems. Sturm comparison and Separation theorems.

Unit-II

First order PDE's., Integral surface through a given curve. Surface orthogonal to given system of surfaces. Non linear PDE's of first order, Cauchy's characteristics. Charpit's method and Jacobi's method.

Unit-III

PDE's of the 2nd order. Linear PDE's with constant coefficients. Second order PDE's with variable coefficients and their classification. Non-linear PDE's of second order, Monge's Method. Solution of linear hyperbolic equation, Solution of Laplace, wave and diffusion equations by method of separation of variables.

BOOKS RECOMMENDED:

1. Piaggio: Differential equations.
2. Ross, S.L.: Differential equations.
3. Sneddon, I.N.: Elements of partial differential equations.

MTL 451**REAL ANALYSIS-II**

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit I

The Riemann Stieltje's Integral: Definition and existence of Riemann Stieltje's integral, Properties of integral. Integration and Differentiation. Fundamental Theorem of Calculus, Ist and 2nd Mean Value Theorems of Riemann Stieltje's integral. Integration of vector valued functions, Rectifiable curves.

Unit II

Sequence and Series of functions: Uniform Convergence, Uniform Convergence and continuity, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Equicontinuous families of functions, Arzela's Theorem, Weierstrass Approximation theorem. The Stone-Weierstrass theorem.

Unit III

Power series : Radius of convergence, properties, Abel's Theorem, Taylor's Theorem
 Fourier series :Convergence, Riemann Lebesgue Lemma, Bessel's inequality, Parseval's Equality. Gamma function. Linear Transformations (in \mathbb{R}^n).

BOOK RECOMMENDED:

1. Walter Rudin : Principles of Mathematical Analysis (3rd edition)
 McGraw Hill Ltd.Ch. 6, Ch.7, Ch. 8, Ch. 9 (9.1-9.8).
2. S.C. Malik & Savita Arora. : Mathematical Analysis, Wiley Eastern Ltd.
3. Shanti Narayan :A course of Mathematical Analysis.
4. Apostol, T.M. : Mathematical Analysis 2nd Edition (7.18 Th. 7.30 & 7.31)

MTL 452
ALGEBRA-II

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit I

Rings, Subrings, Ideals, Factor Rings, Homomorphisms, Integral Domains. Maximal and prime ideals. The field of quotients of an integral domain, Chinese remainder theorem, Simple rings, Ideals of Matrix rings.

Unit-II

Principal Ideal domains, Euclidean Rings. The ring of Gaussian Integers, Unique factorization domains, Gauss lemma, Polynomial rings, Division algorithm, factorization in polynomial rings over unique factorization domains, Rings with chain conditions.

Unit-III

Modules, Submodules, free modules, quotient modules, Homomorphism theorems, Direct sums, Finitely generated modules, Simple modules, Cyclic modules, Differences between modules and vector spaces, Structure theorem for finitely generated modules over principal ideal domains, submodules of a finitely generated free module over a P.I.D., Artinian and Noetherian modules.

BOOKS RECOMMENDED:

1. Fraleigh, J. B.: A first course in Abstract Algebra 7th edition, Narosa Publishing House, New Delhi.
2. Singh, S. and Zameeruddin, Q.: Modern Algebra, Vikas Publishing House, New Delhi.
3. Dummit, D.S. & Foote, R.M. : Abstract-Algebra, John-Wiley & Sons, Students Edition-1999
4. Bhattacharya, P.B., Jain, S.K., Nagpal, S.R. : Basic Abstract Algebra, Cambridge University Press, 1997.
5. Musili, C.: Rings and Modules, Narosa Publishing House, New Delhi, 1994.

MTL 453

PROBABILITY THEORY

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Classical and axiomatic approach to the theory of probability, additive and multiplicative law of probability, conditional probability and Bayes theorem. Random variable, function of random variable, and their distributions, probability mass function, probability density function, cumulative distribution function,

Unit-II

Two and higher dimensional random variables and their functions, joint distribution, marginal and conditional distributions, Stochastic independence. Mathematical expectations, moments, moment generating function, probability generating function, Chebyshev's, Markov, Jensen inequalities, Stochastic convergence, central limit theorem (Laplace theorem Linder berg, Levy's Theorem).

Unit-III

Discrete Distribution: Uniform, Binomial, Poisson, Geometric, Hyper geometric, Multinomial. Continuous Distributions: Uniform, Exponential, Normal distributions, Gamma distribution, Beta distribution, Bivariate normal distribution.

BOOKS RECOMMENDED:

1. Hogg, R.V., Mckean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics.
2. Mukhopadhyay, P : Mathematical Statistics.
3. Casella, G. and Berger, R. L. : Statistical inference

MTL 454
CLASSICAL MECHANICS AND CALCULUS OF VARIATIONS

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Principle of virtual work, D'Alembert's Principle, Constraints and their types, Generalized coordinates and velocities, virtual work, generalized forces, Lagrange's equations for a holonomic dynamical system, conservative system, holonomic dynamical system for impulsive forces and their applications, kinetic energy as a quadratic function of velocities, theory of small oscillations.

Unit-II

Functional, variation of functional and its properties, fundamental lemma of calculus of variation, Euler's equations, necessary and sufficient conditions for extremum, The Brachistochrone problem, Functionals dependent on higher order derivatives and several dependent variables, Variational problems with moving boundaries, Transversality conditions, Orthogonality conditions, problems with moving boundary in implicit form.

Unit-III

Sturm-Liouville's theorem on extremals, one sided variations, Hamilton's principle, Hamilton's canonical equation of motion, The principle of least action, Lagrange's equations from Hamilton's principle. Variational Methods (Direct Methods, Euler's finite difference method, The Ritz method, Kantorovich Method), for Boundary value problems in ODE's & PDE's, Isoperimetric Problems.

BOOKS RECOMMENDED:

1. Chorlton, F.: Text Book of Dynamics.
2. Elsgolts, L: Differential equations and the Calculus of Variations.
3. Gelfand, I.M. and Fomin, S.V.: Calculus of variations.

MTL 455

DIFFERENTIAL GEOMETRY

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit – I

Curves in R^3 : Parametric curves, Curvature and torsion, Serret-Frenet Formulas, Helices, Evolute and involute of a parametric curve, Spherical curves.

Unit-II

Tensor Analysis: Einstein's summation convention, Transformation laws for vectors, Addition, multiplication, contraction and quotient law of tensors, Differentiation of Cartesian tensors, metric tensor, contra-variant, covariant and mixed tensors, Christoffel symbols, Covariant differentiation w. r. t. metric tensor.

Unit-III

Surfaces in R^3 : Simple sheet of a surface, Envelopes, Developable surfaces, The Two Fundamental forms of a surface, The Gaussian curvature, Formulas of Gauss and Codazzi, Geodesic curvature and geodesic torsion, Geodesics, Parallel transport along a closed contour, The Gauss-Bonnet theorem, Euler-Poincaré characteristic, integral curvature.

Reference Books:

1. L. P. Eisenhart, Riemannian Geometry, Princeton University Press, 1949. (**Scope in Ch. 1 for tensor analysis**)
2. A. Goetz, Introduction to Differential Geometry, Addison-Wesley, 1970.
3. A. Pressley, Elementary Differential Geometry, Springer, 2005.

MTL 456**MATHEMATICAL METHODS**

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Laplace Transform: Definition, existence, and basic properties of the Laplace transform, Inverse Laplace transform, Convolution theorem, Laplace transform solution of linear differential equations and simultaneous linear differential equations with constant coefficients, Complex Inversion formula.

Unit-II

Fourier Transform: Definition, existence, and basic properties, Convolution theorem, Fourier transform of derivatives and Integrals, Fourier sine and cosine transform, Inverse Fourier transform, solution of linear ordinary differential equations and partial differential equations.

Unit-III

Volterra Equations : Integral equations and algebraic system of linear equations. Volterra equation L_2 Kernels and functions. Volterra equations of first & second kind. Volterra integral equations and linear differential equations. Fredholm equations, solutions by the method of successive approximations. Neumann's series, Fredholm's equations with Pincherte-Goursat Kernel's.

BOOKS RECOMMENDED:

1. Tricomi, F.G.: Integral equation (Ch.I and II)
2. Kanwal R, P: Linear integral equations
3. Mikhlin: Integral Equations
4. Pinckus, A. and Zafrany, S.: Fourier Series and Integral transforms

MTL 501

MEASURE THEORY

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Measurable Sets: Outer Measure, Lebesgue Measure, Properties of Measurable Sets, Non Measurable Sets. Measurable Functions: Definition & Properties of Measurable functions.

Unit-II

Littlewood's three Principles. Lebesgue Integral: Lebesgue Integral of simple function and bounded function. Comparison of Riemann and Lebesgue Integral. Bounded convergence Theorem, Integral of a non negative function, Fatou's Lemma, Monotone Convergence Theorem.

Unit-III

General Lebesgue Integral, Lebesgue Convergence Theorem, Convergence in measure. Differentiation and Integration: Differentiation of monotone functions, Differentiation of an integral.

BOOKS RECOMMENDED:

1. Royden, H.L: Real Analysis, Macmillan Co. (Ch. 3, 4, 5 excluding sections 4&5)
2. Jain, P.K. and Gupta, V.P.: Lebesgue Measure and Integration.
3. Barra, G De. : Introduction to Measure Theory, Van Nostrand and Reinhold Company

MTL 502
FUNCTIONAL ANALYSIS – I

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Normed linear spaces, Banach spaces, subspaces, quotient spaces. Continuous linear transformations, equivalent norms.

Unit-II

Finite dimensional normed linear spaces and compactness, Riesz Lemma, The conjugate space N^* . The Hahn-Banach theorem and its consequences. The natural imbedding of N into N^{**} , reflexivity of normed spaces.

Unit-III

Open mapping theorem, projections on a Banach space, closed graph theorem, uniform boundedness principle, conjugate operators. L^p -spaces: Holder's and Minkowski's Inequalities, completeness of L^p -spaces.

BOOKS RECOMMENDED:

1. G.F. Simmons: Introduction to Topology and Modern Analysis, Ch. 9, Ch.10 (Sections 52-55), Mc.Graw-Hill International Book Company, 1963.
2. Royden, H. L.: Real Analysis, Ch 6 (Sections 6.1 -6.3), Macmillan Co. 1988.
3. Erwin Kreyszig: Introduction to Functional Analysis with Applications, John Wiley & Sons, 1978.
4. Balmohan V. Limaye: Functional Analysis, New Age International Limited.
5. P.K.Jain and O.P Ahuja: Functional Analysis, New Age International (P) Ltd. Publishers, 2010.
6. K. Chanrashekhra Rao: Functional Analysis, Narosa, 2002
7. D. Somasundram: A First Course in Functional Analysis, Narosa, 2006.

MTL 503
PROBABILITY THEORY

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Classical and axiomatic approach to the theory of probability, additive and multiplicative law of probability, conditional probability and Bayes theorem. Random variable, function of random variable, and their distributions, probability mass function, probability density function, cumulative distribution function,

Unit-II

Two and higher dimensional random variables and their functions, joint distribution, marginal and conditional distributions, Stochastic independence. Mathematical expectations, moments, moment generating function, probability generating function, Chebyshev's, Markov, Jensen inequalities, Stochastic convergence, central limit theorem (Laplace theorem Linder berg, Levy's Theorem).

Unit-III

Discrete Distribution: Uniform, Binomial, Poisson, Geometric, Hyper geometric, Multinomial.
Continuous Distributions: Uniform, Exponential, Normal distributions, Gamma distribution, Beta distribution, Bivariate normal distribution.

Books Recommended:

1. Hogg, R.V., Mckean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics.
2. Mukhopadhyay, P : Mathematical Statistics.
3. Casella, G. and Berger, R. L. : Statistical Inference

MTL 531

OPERATIONS RESEARCH-I

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Mathematical formulation of linear programming problem, properties of a solution to the linear programming problem, generating extreme point solution, simplex computational procedure, development of minimum feasible solution, the artificial basis techniques, a first feasible solution using slack variables, two phase and Big-M method with artificial variables.

Unit-II

General Primal-Dual pair, formulating a dual problem, primal-dual pair in matrix form, Duality theorems, complementary slackness theorem, duality and simplex method, economic interpretation of primal-dual problems. The General transportation problem, transportation table, duality in transportation problem, loops in transportation tables, linear programming formulation, solution of transportation problem, test for optimality, degeneracy, transportation algorithm (MODI method), time minimization transportation problem.

Unit-III

Assignment Problems: Mathematical formulation of assignment problem, the assignment method, typical assignment problem, the traveling salesman problem. Game Theory: Two-person zero sum games, maximin-minimax principle, games without saddle points (Mixed strategies), graphical solution of $2 \times n$ and $m \times 2$ games, dominance property, arithmetic method of $n \times n$ games, general solution of $m \times n$ rectangular games.

BOOKS RECOMMENDED:

1. Gass, S. L.: Linear Programming
2. Hadley, G.: Mathematical Programming
3. Kambo, N. S.: Mathematical Programming
4. Kanti Swarup, Gupta, P.K. & Man Mohan: Operations Research
5. R.Panneerselvam: Operations Research
6. Taha, H.A.: Operations Research

MTL 532
DISCRETE MATHEMATICS-I

| | | |
|----------|----------|----------|
| L | T | P |
| 4 | 0 | 0 |

Unit-I

Mathematical Logic: Introduction to Binary relations, equivalence relations and partitions, partial order relations, Hasse diagram. Inclusion and exclusion principle, Pigeonhole principle. Basic logical operations, conditional and biconditional statements, tautologies, contradiction, quantifiers, propositional calculus.

Unit-II

Grammar and Languages: Phrase structure grammars, derivation sentential forms, language generated by grammar, regular, context free and context sensitive grammar and languages, finite state machines.

Unit-III

Recurrence Relations and Generating Functions: Polynomial expressions, telescopic form, recursion theorem, closed form expression, generating function, solution of recurrence relation using generating function.

BOOKS RECOMMENDED:

1. Trambley, J.P. and Manohar,R: Discrete Mathematical Structures with Applications to Computer Science.
2. Liu C.L.: Elements of Discrete Mathematics.
3. Alan Doerr and Kenneth Levasseur: Applied Discrete Structures for Computer Science

MTL 533**FLUID DYNAMICS**

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Inviscid flows: Introduction to fluid flows, equation of continuity, Euler's equation of motion, Bernoulli's equation, steady motion under conservative body forces, potential theorems.

Unit-II

Viscous flows: Newtonian fluids, convective momentum transport, shell momentum balances and boundary conditions, use of shell momentum balance to solve laminar flow problems: flow of a falling film, flow through a circular tube (Hagen-Poiseuille flow), flow through an annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

Unit-III

The Navier-Stokes equation: The Navier-Stokes equation, use of the Navier-Stokes equation in solving the following flow problems: Steady flow in a long circular cylinder, falling film with variable viscosity, The Taylor-Couette flow, Plane Couette flow; Shape of the surface of a rotating liquid, Flow near a slowly rotating sphere, Steady viscous flow in tubes of uniform cross sections, viscous flow past a fixed sphere, Dimensional analysis of fluid motion, Prandtl boundary layer, Time dependent flows of Newtonian fluids.

Reference Books:

1. F. Charlton, Textbook of Fluid Dynamics 1st Edition. (Scope in **Ch.2-5, 8**)
2. R. B. Bird, W. E. Stewart, E. Lightfoot, Transport Phenomena, 2nd Edition. (Scope in **Ch. 1-4**)
3. L. D. Landau and E. M. Lifshitz, Fluid Mechanics, 3rd Edition. (Scope in **Ch. I-II**)

MTL 534

ADVANCED NUMERICAL ANALYSIS

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Finite difference approximation to partial derivatives, parabolic equations: An explicit method, crank Nicolson Implicit method, solution of implicit equations by Gauss Elimination, derivative boundary conditions, local truncation error, Convergence and stability.

Unit-II

Hyperbolic equations: Implicit difference methods for wave equation solution of advection equation by finite difference method and Maccormack method, stability analysis, Lax, Wendroff explicit method on rectangular mesh for 1st order equations, Iterative methods for elliptic equations.

Unit-III

Finite element methods: Rayleigh Ritz Method, the collocation and Galerkin's Method, finite element methods for ODE's., finite element methods for one dimensional and two dimensional problems, Introduction to F. E. M. for partial differential equations.

BOOKS RECOMMENDED:

1. G. D. Smith: Numerical solution of Partial Differential Equations.
2. B. Bradie: A friendly introduction to Numerical Analysis.
3. J. N. Reddy: An introduction to Finite Element Methods.

MTL 535

STOCHASTIC PROCESS

| L | T | P |
|----------|----------|----------|
| 4 | 0 | 0 |

Unit-I

Introduction to stochastic processes, classification of stochastic processes according to state space and time domain. Countable state Markov Chains, Chapman-Kolmogorov equations, calculations of n-step transition probability and its limit. Stationary distribution, classification of states.

Unit-II

Random walk model, gambler's ruin problem. Discrete state space continuous time Markov Chains: Kolmogorov-Feller differential equations, Poisson process, Simple birth process, Simple death process.

Unit-III

Recurrent events, recurrence time distribution, necessary and sufficient condition for persistent and transient events and their illustrations, delayed recurrent event. Discrete branching process, mean and variance of the n-th generation, probability of extinction.

Books Recommended:

1. Feller, W.: Introduction to Probability Theory and Its Applications, Vol. 1.
2. Hoel, P.G., Port, S.C. and Stone, C.J.: Introduction to Stochastic Processes.
3. Karlin, S. and Taylor, H.M.: A First Course in Stochastic Processes, Vol. 1.
4. Medhi, J.: Stochastic Processes.
5. Bailey, N.T.J.: The elements of Stochastic Processes.
6. Adke, S.R. and Manjunath, S.M.: An Introduction to Finite Markov Processes.

MTL 536

BANACH ALGEBRA AND OPERATOR THEORY

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Unit-I

Banach algebras: definitions and simple examples. Regular and singular elements. Topological divisors of zero, Spectrum of an element of a Banach Algebra, formula for spectral radius.

Unit-II

Compact and bounded operators: spectral properties of compact linear operators, spectral properties of bounded linear operators, operator equations involving compact linear operators, Spectral radius of a bounded linear operator.

Unit-III

Spectral properties of bounded self adjoint linear operators on a complex Hilbert space. Positive operators. Monotone sequence theorem for bounded self adjoint operators on a complex Hilbert space. Square roots of a positive operator. Projection operators, Properties of projection operators.

BOOKS RECOMMENDED:

1. Simmons, G.F.: Introduction to Topology and Modern Analysis (Section 6.4-6.8),
Mc Graw- Hill (1963)International Book Company.
2. Kreyszig,E. Introductory Functional Analysis with applications,
(Sections 8.1-8.5, 9.1-9.6)
John Wiley & Sons, New York 1978.

MTL 551**TOPOLOGY**

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Unit-I

Topological spaces, Continuous functions, Homeomorphisms, Product spaces, Quotient spaces, Topological groups.

Unit-II

Connectedness, Intermediate value theorem and uniform limit theorem, Local connectedness, Compactness, Finite intersection property (F.I.P.), Cantor's intersection theorem, Uniform continuity, Bolzano-Weierstrass Property, Local compactness.

Unit-III

Countability and separation axioms, Hausdorff spaces, Regular Spaces, Normal spaces, Urysohn's Lemma, Completely regular spaces, Metrizable topological spaces, Urysohn's Metrization Theorem, The Tietze extension theorem, Completely normal spaces, The Tychonoff Theorem.

Books Recommended:

1. J. R. Munkres : Topology, Prentice Hall of India, 2007 (Indian reprint)
2. J. L. Kelley : General Topology, 2008 (Indian reprint).
3. K. Janich, Topology, Springer-Verlag, 2004.

MTL 552
FUNCTIONAL ANALYSIS – II

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Unit-I

Inner product spaces, Hilbert spaces, orthogonal complements, orthonormal sets, the conjugate space H^* .

Unit-II

Strong and weak convergence in finite and infinite dimensional normed linear spaces. Weak convergences in Hilbert spaces, weakly compact set in Hilbert spaces, The adjoint of an operator, self adjoint operators, positive operators, normal operators, Unitary operators.

Unit-III

Projections on a Hilbert space, Spectral Theorem for normal operators, Compact linear operators on normed spaces, properties of Compact linear operators.

BOOKS RECOMMENDED:

1. Simmons, G.F.: Introduction to Topology and Modern Analysis
Ch. X (Sections 56-59), Ch. XI (Sections 61-62), Mc
Graw- Hill (1963) International Book Company.
2. Erwin Kreyszig: Introduction to Functional Analysis with Applications,
John Wiley & Sons (1978).
3. Limaye, Balmohan V.: Functional Analysis, New Age International Limited, 1996.
4. Jain, P.K. & Ahuja, O.P.: Functional Analysis, New Age International (P)
Ltd. Publishers, 2010.
5. Chandrasekhra Rao, K.: Functional Analysis, Narosa, 2002.
6. Somasundram, D.: A First Course in Functional Analysis, Narosa, 2006.

MTL 553
STATISTICAL INFERENCE

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Unit-I

Point Estimation: Criteria of estimation, unbiasedness, consistency, efficiency, sufficiency, Neyman factorization theorem. Minimum variance unbiased estimators, Rao Blackwell Theorem, completeness, Lehmann-Scheffe theorem, necessary and sufficient conditions for MVUE, Cramer- Rao lower bound. Efficiency of an estimator, Methods of estimation: maximum likelihood method and method of moments.

Unit-II

Tests of Hypotheses, critical region, test functions, two types of errors, power function, level, Neyman-Pearson theory, M.P. test, UMP test, Likelihood tests (excluding properties of Likelihood Ratio Tests).

Unit-III

Chi-square, t and F distributions and their applications in testing of hypothesis. Sampling distribution of mean and variance of sample from normal distribution. Large sample tests.

Books Recommended:

1. Hogg, R.V., Mckean, J.W. and Craig, A.T.: Introduction to Mathematical Statistics.
2. Mukhopadhyay, P : Mathematical Statistics.
3. Casella, G. and Berger, R. L. : Statistical inference

MTL 581**TOPOLOGICAL VECTOR SPACES**

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Unit-I

Definition and examples of topological vector spaces. Convex, balanced and absorbing sets and their properties. Minkowski's functionals.

Unit-II

Subspace, product space and quotient space of a topological vector space. Locally convex topological vector spaces.

Unit-III

Normable and metrizable topological vector spaces. Complete topological vector spaces and Frechet space. Linear transformations and linear functionals and their continuity.

Books Recommended:

1. Walter Rudin : Functional Analysis, TMH Edition, 1974.
2. Schaefer, H.H.: Topological Vector Spaces, Springer, N.Y., 1971.

MTL 582**COMPUTER PROGRAMMING WITH C**

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Unit-I

Programming Basics: Basic Structure of C-Program, Constants, variables, Data types, Assignments, console I/O statements, Arithmetical, Relational and logical operators, Control statements: if, switch, while, do while, for, continue, goto and break.

Unit-II

Functions, Arrays and Pointers: Function definition and declaration, Arguments, return values and their types, Recursion. One and two-dimensional arrays, Initialization, Accessing array elements, Functions with arrays. Address and pointer variables, declaration and initialization, pointers and arrays, pointers and functions.

Unit-III

Structure, Union and File Handling: Definition, structure initialization, structure processing, nested structure, Array of structures, structure and functions. Union. Defining and opening a file, closing a file, Input/Output operations on files.

Practical: Based on implementation of Numerical and Statistical techniques using C language.

Solution to non linear equations, a system of linear equations; Numerical integration, Solution to ordinary differential equations. Measures of central tendency, Correlation and Regression.

BOOKS RECOMMENDED:

1. Byron S. Gottfried: Programming with C (Schaum's outline series).
2. Stan Kelly-Bootle: Mastering Turbo C.
3. Brain Kernighan & Dennis Ritchi: The C Programming Language.
4. Yashavant Kanetkar: Let us C.
5. E Balagurusamy: Programming in ANSI C.
6. R.S. Salaria: Application Programming in C.

MTL 583

OPERATIONS RESEARCH-II

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Unit-I

Queueing Theory: Introduction, Queueing System, elements of queueing system, distributions of arrivals, inter arrivals, departure service times and waiting times. Classification of queueing models, Queueing Models: (M/M/1): (∞ /FIFO), (M/M/1): (N/FIFO), Generalized Model: Birth-Death Process, (M/M/C): (∞ /FIFO), (M/M/C) (N/FIFO).

Unit-II

Inventory Control: The inventory decisions, costs associated with inventories, factors affecting Inventory control, Significance of Inventory control, economic order quantity (EOQ), Deterministic inventory problems with out shortage and with shortages, EOQ problems with price breaks, Multi item deterministic problems.

Unit-III

Replacement Problems: Replacement of equipment/Asset that deteriorates gradually, replacement of equipment that fails suddenly, Mortality Theorem, recruitment and promotion problem, equipment renewal problem. Simulation: Need of simulation, methodology of simulation. Simulation models, event- type simulation, generation of random numbers, Monte Carlo simulation.

BOOKS RECOMMENDED:

1. R.Panneerselvam: Operations Research
2. Taha, H.A.: Operations Research
3. Chaddrasekhara, Rao & Shanti Lata Mishra: Operations Research
4. Kanti Swarup, Gupta, P.K. & Man Mohan: Operations Research
5. Mustafi, C.K.: Operations Research

MTL 584

DISCRETE MATHEMATICS-II

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Unit-I

Lattices and Boolean algebra: Lattices as partially ordered sets, properties, lattices as algebraic systems, sublattices, direct products, Homomorphism, some special lattices (complete, complemented, distributive lattices). Boolean algebra as lattices, Boolean identities, sub-algebra, Boolean forms and their equivalence, sum of product, product of some canonical forms.

Unit-II

Graph Theory: Definition, undirected graphs, paths, circuits, cycles, subgraphs, induced subgraphs, degree of vertex, connectivity, planner graph, complete, bipartite complete graph, matrix representation of graph, adjacency and incidence matrix for graph, Euler's theorem on the existence of Eulerian paths and circuits,

Unit-III

Trees and Colouring of the graph: Rooted tree, search tree, tree traversals, spanning trees, minimal spanning trees, Kruskal's algorithm. Chromatic number, four-colour problem, chromatic polynomials.

Books Recommended:

1. Trambley, J.P. and Manohar, R: Discrete Mathematical Structures with Applications to Computer Science.
2. Liu C.L.: Elements of Discrete Mathematics.
3. Alan Doerr and Kenneth Levasseur: Applied Discrete Structures for Computer Science.
4. Narsingh Deo: Graph Theory with Applications to Engineering and Computer Sciences.

MTL 585

ADVANCED FLUID DYNAMICS

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Unit-I

Turbulent Flows: Fundamentals of turbulent flow, mean motion and fluctuations, Reynolds stress tensor, Reynolds averaged Navier-Stokes equations (RANS), velocity profile near the wall, logarithmic and power law velocity profiles.

Unit-II

Boundary Layer Theory: Eddy viscosity, boundary-layer equations for turbulent flows, Prandtl's mixing length theory, Von Karman's similarity hypothesis, turbulent flow in jets and pipes, axial turbulent flow in an annulus, turbulent flow in a rectangular channel, Universal velocity-distribution laws for very large Reynolds numbers.

Unit-III

Hydrodynamic Instability: Fundamental concepts of hydrodynamic instability, stability instability and neutral stability in Liapunov sense, the linear instability analysis, the linear instabilities of the Taylor-Couette flow, and the Rayleigh-Bénard convection.

Reference Books:

1. R. B. Bird, W. E. Stewart, E. Lightfoot, Transport Phenomena, 2nd Edition. (Scope in **Ch.5**)
2. Hermann Schlichting, Boundary Layer Theory, 7th Edition. (Translated by J. Kestin) (Relevant parts in **Ch. XVIII, XIX, XX.**)
3. P. G. Drazin and W. H. Reid, Hydrodynamic Stability, 2nd Edition (Scope in **Ch.1-2**)
4. L. D. Landau and E. M. Lifshitz, Fluid Mechanics, 3rd Edition. (Scope in **Ch. III-V**)

MTL 586**SPECIAL FUNCTIONS**

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Unit-I

Bessel's functions of first and second kind, Recurrence relations, Generating functions, Trigonometric expansions, Asymptotic expansion, Neumann Expansion theory.

Unit-II

Legendre's functions, Laplace integral for the Legendre Polynomials, Generating functions, Recurrence relations, Orthogonality, solution of Legendre's equations, Hermite Polynomials, Recurrence relations, Rodrigue formula.

Unit-III

Hypergeometric function, solution of hypergeometric equation, Kummer function and its asymptotic expansion, Barnes Contour Integral, Integral representation, Gauss Theorem, Kummer's theorem, Vandermonde's theorem.

Books Recommended:

1. Luke, Y.P.: The Special Functions and Their Approximation
2. Rainville, F.D.: Special Functions
3. Titchmarsh, E.C.: The Theory of Functions.