DEPARTMENT OF MATHEMATICS, OSMANIA UNIVERSITY

(w.e.f. the academic year 2018-19)

M. Sc. MATHEMATICS

SEMESTER – III

Subject	Code	Paper	Hours/ Week	Theory	T*	Max. Marks	Credits
Core	M 301	**Functional Analysis**	6	5	1	100	5
Core	M 302	**General Measure & Integration**	6	5	1	100	5
Core	M 303	**Linear Algebra**	6	5	1	100	5
Elective	M 304(A)	**Operations Research**	6	5	1	100	5
	M 304(B)	**Mathematical Statistics**					
	M 304(C)	**Advanced Complex Analysis**					
Elective	M 305(A)	**Mechanics**	5	4	1	100	4
	M 305(B)	**Numerical Analysis**					
	M 305(C)	**Differential Geometry**					
		Seminar	2	2		25	1
			31				25

T* - Tutorial Class for Problems Solving Session.

SEMESTER – IV

Subject	Code	Paper	Hours/ Week	Theory	T*	Max. Marks	Credits
Core	M 401	**Integral Equations & Calculus of Variations**	6	5	1	100	5
Core	M 402	**Elementary Operator Theory**	6	5	1	100	5
Core	M 403	**Analytic Number Theory**	6	5	1	100	5
Elective	M 404(A)	**Integral Transforms**	6	5	1	100	5
	M 404(B)	**Graph Theory**					
	M 404(C)	**Cryptography**					
Elective	M 405(A)	**Fluid Mechanics**	5	4	1	100	4
	M 405(B)	**Advanced Operations Research**					
	M 405(C)	**Finite Difference Methods**					
		Seminar	2	2			1
			31				25

T* - Tutorial Class for Problems Solving Session.

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M 301 **Semester III**

Paper-I: **Functional Analysis**

Unit I
Normed Spaces - Banach Spaces - Further properties of normed spaces - Finite dimensional normed spaces and sub spaces - compactness and finite dimension - linear operators - Bounded and continuous linear operators. [2.2, 2.3,2.4,2.5,2.6, 2.7].

Unit II
Linear Functionals - normed spaces of operators - Dual space - Inner product space - Hilbert Space - Further Properties of Inner product Spaces - Orthogonal complements and direct sums - Orthogonal sets and sequences. [2.8,2.10,3.1,3.2,3.3 and 3.4]

Unit III
Series related to Orthonormal Sequences and sets - Total Orthonormal sets and sequences - Representation of Functions on Hilbert spaces - Hilbert-Adjoint Operator - Self-Adjoint, unitary and normal operators. [3.5,3.6,3.8,3.9 and 3.10]

Unit-IV
Hahn-Banach Theorem - Hahn-Banach Theorem for Complex Vector Spaces and Normed Spaces - Adjoint Operator- Category Theorem - Uniform Boundedness Theorem - Open Mapping Theorem - Closed Linear Operators - Closed Graph Theorem. [4.2,4.3,4.5,4.7,4.12 and 4.13]

Text Book:

Introductory Functional Analysis with Applications by Erwin Kreyszig, John Wiley and sons, New York..

References:

[1] Functional Analysis by B.V. Limaye $2^n d$ Edition.

[2] Introduction to Topology and Modern Analysis by G.F.Sinmmons. Mc.Graw-Hill International Edition.

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M 302 **Semester III**

Paper-II: **General Measure & Integration**

Unit I
Measure spaces - Measurable functions - Integration - General Convergence theorem.

Unit II
Signed measures - The Radon - Nikodym theorem.

Unit III
Outer measure and measurability - The Extension theorem - The Product measure.

Unit-IV
Inner measure - Extension by sets of measure zero - Caratheodory outer measure

Text Book:

Real Analysis (Chapters 11, 12) By H.L. Royden, Wiley.

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M/AM 303 **Semester III**

Paper-III : **Linear Algebra**

Unit I
Elementary Canonical forms Introduction, Characteristic Values, Annihilating Polynomials, Invariant Subspaces, Simultaneous Triangulation and Simultaneous Diagonalization (Ch6, Sec 6.1 - 6.5).

Unit II
Direct sum Decomposition, Invariant Direct sums, The Primary Decomposition Theorem (Ch6, Sec6.6 - 6.8). The Rational and Jordan Forms: Cyclic Subspaces and Annihilators(Ch7, Sec 7.1)

Unit III
Cyclic Decompositions and the Rational Form, The Jordan Form, Computation of Invariant Factors, Semi Simple Operators (Ch7, Sec 7.2 - 7.5)

Unit-IV
Bilinear Forms:Bilinear Forms, Symmetric Bilinear Forms, Skew - Symmetric Bilinear Forms, Groups Preserving Bilinear Forms (Ch10, Sec 10.1 - 10.4)

Text Book:

Linear Algebra by Kenneth Hoffman and Ray Kunze (2e) PHI

References:

[1] Advanced Linear Algebra by Steven Roman (3e)

[2] Linear Algebra by David C Lay

[3] Linear Algebra by Kuldeep Singh

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M/AM 304(A) **Semester III**

Paper-IV: **Operations Research**

Unit I
Formulation of Linear Programming problems, Graphical solution of Linear Programming problem, General formulation of Linear Programming problems, Standard and Matrix forms of Linear Programming problems, Simplex Method, Two-phase method, Big-M method, Method to resolve degeneracy in Linear Programming problem, Alternative optimal solutions. Solution of simultaneous equations by simplex Method, Inverse of a Matrix by simplex Method, Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal.

Unit II
Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Formulation of Travelling Salesman problem as an Assignment problem, Solution procedure.
Mathematical formulation of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, North West corner rule, Lowest cost entry method, Vogel's approximation methods, Optimality test, Method of finding optimal solution, Degeneracy in transportation problem, Method to resolve degeneracy, Unbalanced transportation problem.

Unit III
Concept of Dynamic programming, Bellman's principle of optimality, characteristics of Dynamic programming problem, Backward and Forward recursive approach, Minimum path problem, Single Additive constraint and Multiplicatively separable return, Single Additive constraint and Additively separable return, Single Multiplicatively constraint and Additively separable return.

Unit-IV
Historical development of CPM/PERT Techniques - Basic steps - Network diagram representation - Rules for drawing networks - Forward pass and Backward pass computations - Determination of floats - Determination of critical path - Project evaluation and review techniques.

Text Books:

[1] S. D. Sharma, Operations Research.

[2] Kanti Swarup, P. K. Gupta and Manmohan, Operations Research.

[3] H. A. Taha, Operations Research – An Introduction.

[4] G. I. Gauss, Linear Programming.

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M/MCS 304(B) **Semester III**

Paper-IV: **Mathematical Statistics**

Unit I

Probability: Sample space and events of an experiment, Properties of Probability experiments Equally likely outcomes, Conditional probability and independence, Bayes' Theorem.

Discrete Random Variables: Random variables, Expected value, Properties of expected values, variance of random variables, Properties of variances, Binomial random variables and its Expected value and variance, Hyper-geometric random variables, Poisson random variables.[ch 4, 5]

Unit II

Normal Random Variables: Continuous random variables, Normal random variables, Probabilities associated with a standard Normal random variable, Finding Normal probabilities. Problems on related.

Distributions of Sampling Statistics: Sample Mean, Central Limit Theorem, Distribution of the sample mean, Sample size needed, Sampling proportions from a finite population; Probabilities associated with sample proportions.

Estimation: Point estimator of a population mean, population proportion, Estimating a population variance,. (Ch. 6, 7, 8)

Unit III

Testing Statistical Hypotheses: Hypothesis tests and Significance levels, Tests concerning the mean of a Normal population: Case of known variance, One-sided tests; the t-test for the mean of a Normal population: Case of unknown variance, Hypothesis Tests Concerning Population Proportions. Two-Sided Tests of p.

Hypothesis Tests Concerning Two Populations: Testing equality of means of two Normal populations: Case of known and unknown variances and large Sample sizes, Testing equality of means: Small-sample tests when the unknown population variances are equal, Paired-sample t-test, Testing equality of population proportions. Problems on related. (Ch. 9, 10)

Unit-IV

Chi-Squared Goodness-of-Fit Tests: Chi-Squared Goodness-of-fit Tests, Testing for independence in Populations classified according to two characteristics, Testing for independence in contingency tables with fixed marginal totals.

Analysis of Variance: Introduction, One-factor and two factor Analysis of Variances, Parameter estimation, Degrees of freedom, Testing hypotheses. [ch11, 12]

Text Book:

Sheldon M. Ross (2010): Introductory Statistics, Academic Press, Elsevier, 3rd Edition. (chapters 4 to 12).

Reference:

Sheldon M. Ross (2010): Introduction to Probability Models, Academic Press, Elsevier, 10th Edition. (chapters 4 to 13).

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M 304(C) **Semester III**

Paper-IV: **Advanced Complex Analysis**

Unit I
Entire Functions: Jensen's formula - Functions of finite order - Infinite products Generalities - Example: the product formula for the sine function - Weierstrass infinite products - Hadamard's factorization theorem

Unit II
The Gamma and Zeta Functions: The gamma function - Analytic continuation-Further properties of Γ - The zeta function - Functional equation and analytic continuation.

Unit III
The Zeta Function and Prime Number Theorem: Zeros of the zeta function - Estimates for $1/\zeta(s)$ - Reduction to the functions ψ and ψ_1 - Proof of the asymptotics for ψ_1 - Note on interchanging double sums.

Unit-IV
Conformal Mappings: Conformal equivalence and examples - The disc and upper half-plane - Further examples - The Dirichlet problem in a strip - The Schwarz lemma; automorphisms of the disc and upper half-plane - Automorphisms of the disc - Automorphisms of the upper half plane

Text Book:

Elias M Stein, Rami Shakarchi, Complex Analysis

References:

[1] Lars V Ahlfors, Complex Analysis.

[2] R P Boas, Entire Functions.

[3] Lars V Ahlfors, Conformal Invariants.

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M 305(A) **Semester III**

Paper-V: **Mechanics**

Unit I

Newton's Law of Motion: Historical Introduction, Rectilinear Motion: Uniform Acceleration Under a Constant Force, Forces that Depend on Position: The Concepts of Kinetic and Potential Energy, Dynamics of systems of Particles:- Introduction - Centre of Mass and Linear Momentum of a system - Angular momentum and Kinetic Energy of a system, Mechanics of Rigid bodies - Planar motion:- Centre of mass of Rigid body.

Unit II

Rotation of a Rigid body about a fixed axis, Moment of Inertia: calculation of moment of Inertia Perpendicular and Parallel axis theorem- Physical pendulum-A general theorem concerning Angular momentum-Laminar Motion of a Rigid body-Body rolling down an inclined plane (with and without slipping).

Unit III

Motion of Rigid bodies in three dimension: Angular momentum of Rigid body products of Inertia, Principles axes-Determination of principles axes - Rotational Kinetic Energy of Rigid body - Momentum of Inertia of a Rigid body about an arbitrary axis - The momental ellipsoid - Euler's equation of motion of a Rigid body.

Unit-IV

Lagrange Mechanics: Generalized Coordinates-Generalized forces - Lagrange's Equations and their applications - Generalized momentum - Ignorable coordinates - Hamilton's variational principle - Hamilton function-Hamilton's Equations - Problems - Theorems.

Text Book:

G.R.Fowles, Analytical Mechanics, CBS Publishing, 1986.

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M/AM 305(B) **Semester III**

Paper-V: **Numerical Analysis**

Unit I
Transcendental and Polynomial Equations: Introduction, Bisection Method - Iteration Methods Based on First Degree Equation: Secant Method, Regula Falsi Method, Newton-Raphson Method - Iteration Methods Based on Second Degree Equation: Muller's Method, Chebyshev Method, Multipoint Iteration Methods. Rate of convergence - Iteration Methods.

Unit II
System of Linear Algebraic Equations: Introduction - Direct Methods: Gauss Elimination Method, Gauss Jordan Elimination Method, Triangularization Method, Cholesky Method, Partition Method - Iteration Methods: Jacobi Iteration Method, Gauss Seidel Iteration Method, SOR Method.

Unit III
Interpolation and Approximation: Interpolation: Introductio - Lagrange and Newton Interpolations, Finite Difference Operators - Interpolating Polynomials using Finite Differences - Hermite Interpolations - Piecewise and Spline Interpolation. **Approximation:** Least Squares Approximation.

Unit-IV
Numerical Integration: Methods Based on Interpolation: Newton Cotes Methods - Methods Based on Undetermined Coefficients: Guass Legendre Integration Methods - Composite Integration Methods.
Numerical Solution of ODE's: Introduction - Numerical Methods: Euler Methods-Mid point Method - Single Step Methods: Taylor series method, Runge-Kutta Method (2^{nd} and 4^{th} order). Multistep Methods: Adam Bashforth Method - Adams Moulton Method, Milne-Simpson Method - Predictor Corrector Methods.

Text Books:

[1] Numerical Methods for Scientific and Engineering Computation by M.K. Jain, S.R.K. Iyengar, R.K. Jain, New Age Int. Ltd., New Delhi.

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M 305(C) **Semester III**

Paper-V: **Differential Geometry**

Unit I
Space Curves, Tangent Line, Contact of order of a curve and a surface, Osculating Plane, Principal normal, Binormal, Torsion - Curvature - Serret - Frenet formulae - Examples thereon, The Osculating Circle - Osculating Sphere - Helices Involutes and Evolutes - Examples thereon.

Unit II
Curves on Surfaces tangent plane - Normal, Parametric curves, First order magnitudes - Second order magnitudes - Direction coefficients - Double family of curves, Curvature of normal section - Meunier's theorem - Examples thereon.

Unit III
Principal directions and curvatures - First curvatures Gaussian curvatures, Euler's theorem. The surface $z = f(x, y)$, Surface of revolution - Examples thereon, Geodesics, Normal property of Geodesics - Geodesics curvature, Torsion - Joachimsthal Theorem.

Unit-IV
Envelops characteristics - Edge of regression - Developable surfaces - Osculating developable - Polar developable - Rectifying developable, Envelopes - Characteristic points - Examples thereon.

Text Book:

C.E. Wedderburn, Differential Geometry of three dimensions, (E.L.B.S.Edition,1964).

References:

[1] T.J. Willmore, An Introduction to differential geometry(Oxford University press), 11th Edition, New Delhi,1993.

[2] Mittal and Agarwal, Differential Geometry(Krishna Prakashan Media (P) Ltd.) 12th Edition.

[3] Bansi Lal, Three dimensional differential geometry, Atma Ram Publisher.

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M/AM/MCS 401 **Semester IV**

Paper-I: **Integral Equations & Calculus of Variations**

INTEGRAL EQUATIONS:

Unit I Volterra Integral Equations: Basic concepts - Relationship between Linear differential equations and Volterra Integral equations - Resolvent Kernel of Volterra Integral equation. Differentiation of some resolvent kernels - Solution of Integral equation by Resolvent Kernel - The method of successive approximations - Convolution type equations - Solution of Integro-differential equations with the aid of the Laplace Transformation – Volterra integral equation of the first kind - Euler integrals - Abel's problem - Abel's integral equation and its generalizations.

Unit II

Fredholm Integral Equations: Fredholm integral equations of the second kind – Fundamentals – The Method of Fredholm Determinants - Iterated Kernels constructing the Resolvent Kernel with the aid of Iterated Kernels - Integral equations with Degenerated Kernels. Hammerstein type equation - Characteristic numbers and Eigen functions and its properties.

Green's function: Construction of Green's function for ordinary differential equations - Special case of Green's function - Using Green's function in the solution of boundary value problem.

CALCULS OF VARIATIONS:

Unit III

Introduction - **The Method of Variations in Problems with fixed Boundaries:** Definitions of Functionals – Variation and Its properties - Euler's' equation - Fundamental Lemma of Calculus of Variation-The problem of minimum surface of revolution - Minimum Energy Problem Brachistochrone Problem - Variational problems involving Several functions - Functional dependent on higher order derivatives - Euler Poisson equation.

Unit-IV

Functional dependent on the functions of several independent variables - Euler's equations in two dependent variables - Variational problems in parametric form - Applications of Calculus of Variation - Hamilton's principle - Lagrange's Equation, Hamilton's equations.

Text Books:

[1] M. KRASNOV, A. KISELEV, G. MAKARENKO, Problems and Exercises in Integral Equations (1971).

[2] S. Swarup, Integral Equations, (2008).

[3] L.ELSGOLTS, Differential Equations and The Calculus of Variations, MIR Publishers, MOSCOW.

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M 402 **Semester IV**

Paper-II: **Elementary Operator Theory**

Unit I
Spectral theory in finite dimensional normed spaces - Basic concepts of spectrum - Spectral properties of bounded linear operators - Further properties of resolvent and spectrum. (Sections 7.1, 7.2, 7.3 & 7.4 of [1]).

Unit II
Compact linear operators on normed spaces - Further properties of compact linear operators - Spectral properties of compact linear operators on normed spaces - Operator equations involving compact linear operators. (Sections 8.1, 8.2, 8.3 and 8.5 of [1]).

Unit III
Spectral properties of bounded self adjoint linear operators - Further spectral properties of bounded linear operators - Positive operators - Square root of a positive operator. (Sections 9.1, 9.2, 9.3 and 9.4 of [1])

Unit-IV
Projection operators - Properties of projection operators - Spectral family - Spectral family of a bounded self adjoint linear operator. (Sections 9.5, 9.6, 9.7 and 9.8 of [1])

Text Book:

Introductory Functional Analysis by E. Kreyszig , John Wiley and Sons, New York, 1978.

References:

[1] Elements of Functional Analysis by Brown and Page, D.V.N. Comp.

[2] Functional Analysis by B.V. Limaye, Wiley Eastern Limited, (2nd Edition).

[3] A Hilbert Space Problem Book by P.R.Halmos, D.Van Nostrand Company, Inc. 1967.

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M 403 **Semester IV**

Paper-III: **Analytic Number Theory**

Unit I
Averages of arithmetical function: The big oh notation- Asymptotic equality of functions- Euler summation formula- Some asymptotic formulas- The average order of $d(n)$- The average order of the divisor functions $\sigma(n)$- The average order of $\phi(n)$- An application to the distribution of lattice points visible trona the origin- The average order of $\mu(n)$ and $\Lambda(n)$- The partial sums of dirichlet product- Applications to $\mu(n)$ and $\Lambda(n)$- Another identity for the partial sums of a dirichlet product. (Sections3.1 to 3.12).

Unit II
Some elementary theorems on the distribution of prime numbers- Introduction chebyshev's functions- $\psi(x)$ and $\theta(x)$- Relation connecting $\theta(n)$ and $\pi(n)$- Some equivalent forms of the prime number theorem- Inequalities for $\pi(n)$ and p_n. (Sections4.1 to 4.5)

Unit III
Shapiro's Tauberian theorem- Applications of shapiro's theorem An asymptotic formula for the partial sums $\sum_{p \leq x} 1/p$ - The partial sums of the mobins function- Selberg Asymptotic formula. (Sections4.6 to 4.11 except 4.10)

Unit-IV
Finite Abelian groups and their character: Construction of sub groups- Characters of finite abelian group- The character group- The orthogonality relations for characters Dirichlet characters- Sums involving dirichelt characters the non vanishing of $L(1, \chi)$ for real non principal χ . (Sections 6.4 to 6.10)

Text Book:

Tom M. Apostol- An Introduction to Analytic Number Theory, Springer.

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M 404(A) **Semester IV**

Paper-IV: **Integral Transforms**

Unit I

FOURIER TRANSFORM: Introduction - Classes of functions - Fourier Series and Fourier Integral Formula - Fourier Transforms - Fourier sine and cosine Transforms - Linearity property - Change of Scale property - Shifting property - The Modulation theorem - Evaluation of integrals by means of inversion theorems - Fourier Transform of some particular functions - Convolution or Faltung of two integrable functions - Convolution or Falting or Faltung Theorem for FT – Parseval's relations - Fourier Transform of the derivative of a function - Fourier Transform of some more useful functions - Fourier Transforms of Rational Functions - Other important examples concerning derivative of FT - The solution of Integral Equations of Convolution Type - Fourier Transform of Functions of several variables - Application of Fourier Transform to Boundary Value Problems.

Unit II

THE LAPLACE TRANSFORM: Introduction - Definitions - Sufficient conditions for existence of Laplace Transform - Linearity property of Laplace Transform - Laplace transforms of some elementary functions - First shift theorem - Second shift theorem - The change of scale property - Examples - Laplace Transform of derivatives of a function - Laplace Transform of Integral of a function - Laplace Transform of t_nf(t)- Laplace Transform of f(t)/t - Laplace Transform of a periodic function - The Initial-Value Theorem and the Final-Value Theorem of Laplace Transform - Examples - Laplace Transform of some special functions - The Convolution of two functions - Applications.

Unit III

THE INVERSE LAPLACE TRANSFORM AND APPLICATION: Introduction - Calculation of Laplace inversion of some elementary functions - Method of expansion into partial fractions of the ratio of two - The general evaluation technique of inverse Laplace transform - Application of Laplace Transforms. **Finite Laplace Transforms:** Introduction - Definition of Finite Laplace Transform - Finite Laplace Transform of elementary functions - Operational Properties - The Initial Value and the Final Value Theorem - Applications.

Unit-IV

The Mellin Transform: Introduction - Definition of Mellin Transform - Mellin Transform of derivative of a function - Mellin Transform of Integral of a function - Mellin Inversion theorem - Convolution theorem of Mellin Transform - Illustrative solved Examples - Solution of Integral equations - Application to Summation of Series - The Generalised Mellin Transform - Convolution of generalised Mellin Transform - Finite Mellin Transform. **The Z-Transform:** Introduction - Transform: Definition - Some Operational Properties of Z-Transform - Application of Z-Transforms.

Text Book:

[1] An Introduction to Integral Transforms by Baidyanath Patra, CRC Press, Taylor Francis Group.

References:

[1] Integral Transforms by A.R.Vasishta and R.K.Guptha.

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M 404(B) **Semester IV**

Paper-IV: **Graph Theory**

Unit I
Basics of Graph Theory: Graphs, isomorphism, subgraphs, matrix representations, degree, operations on graphs, degree sequences.
Connected graphs and shortest paths: Walks, trails, paths, connected graphs, distance, cut-vertices, cut-edges, blocks, connectivity, weighted graphs, shortest path algorithms.

Unit II
Trees: Characterizations, number of trees, minimum spanning trees.
Special classes of graphs: Bipartite graphs, line graphs, chordal graphs.
Eulerian graphs: Characterization, Fleury's algorithm, chinese-postman-problem.
Hamilton graphs: Necessary conditions and sufficient conditions

Unit III
Independent sets, coverings, matchings: Basic equations, matchings in bipartite graphs, perfect matchings, greedy and approximation algorithms.
Vertex colorings: Chromatic number and cliques, greedy coloring algorithm, coloring of chordal graphs, Brook's theorem.
Edge colorings: Gupta-Vizing theorem, Class-1 graphs and class-2 graphs, equitable edge-coloring.

Unit-IV
Planar graphs: Basic concepts, Eulers formula, polyhedrons and planar graphs, characterizations, planarity testing, 5-color-theorem.
Directed graphs: Out-degree, in-degree, connectivity, orientation, Eulerian directed graphs, Hamilton directed graphs, tournaments

Text Books:

[1] J.A. Bondy and U.S.R. Murty: Graph Theory with Applications (Freely downloadable from Bondy's website; Google-Bondy).

[2] D.B. West: Introduction to Graph Theory, Prentice-Hall of India/Pearson, 2009 (latest impression).

References:

[1] J.A. Bondy and U.S.R. Murty: Graph Theory, Springer, 2008.

[2] R.Diestel: Graph Theory, Springer(low price edition) 2000.

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M 404(C) **Semester IV**

Paper-IV: **Cryptography**

Unit I
Simple substitution ciphers; Divisibility and greatest common divisors Modular arithmetic; Prime numbers, unique factorisation, and finite fields; Powers and primitive roots in finite fields; Cryptography before the computer age; Symmetric and asymmetric ciphers.

Unit II
The birth of public key cryptography,The discrete logarithm problem Diffie–Hellman key exchange,The El-Gamal public key cryptosystem, An overview of the theory of groups, How hard is the discrete logarithm problem?, A collision algorithm for the DLP.

Unit III
The Chinese remainder theorem, The Pohlig-Hellman algorithm, Rings, quotients, polynomials, and finite fields, Euler's formula and roots modulo pq, Primality testing.

Unit-IV
Pollard's $(p-1)$ factorisation algorithm, Factorisation via difference of squares, Smooth numbers and sieves, Elliptic curves, Elliptic curves over finite fields, The elliptic curve discrete logarithm problem, Elliptic curve cryptography.

Text Book:

Mathematical Cryptography by Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman.

References:

[1] Everyday Cryptography: Fundamental Principles and Applications by Keith Martin.

[2] Cryptography: An Introduction by N. P. Smart.

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M 405(A) **Semester IV**

Paper-V: **Fluid Mechanics**

Unit I
General Orthogonal Curvilinear Coordinates: Definition - **Kinematics of fluids in motion:** Real fluids and ideal fluids - velocity of a fluid at a point - Lagrangian and Eulerian Methods - Stream lines, Path lines and Streak lines - Steady and Unsteady flows - The velocity potential - the vorticity vector - Local and particle rates of change - Acceleration of fluid - The Equation of Continuity (Vector and Cartesian form) - Conditions at a Rigid Boundary.

Unit II
Equations of Motion of Fluid: Euler's equations of motion (Vector and Cartesian form) - Lagrange's equations of Motion - Equation in one dimensional flow problems: Bernoulli's Theorem - Applications of the Bernoulli Theorem - Kelvins circulation theorem.

Unit III
Some Two Dimensional Flows: The complex potential - Irrotational motion - Velocity potential - Stream function - physical meaning of Stream function - Source, Sinks and Doublets and their Images - Milne Thomson Circle Theorem - The Theorem of Blasius.

Unit-IV
Irrotational Motion in Two Dimensions: Two-dimensional Irrotational motion produced by motion of circular cylinder, two coaxial cylinders. Equations of motion of a circular cylinder.

Text Books:

[1] FRANK CHORLTON, **Textbook of Fluid Dynamics**, CBS-Publishers, New Delhi, India.

[2] W.H.BESANT and A.S.RAMSEY, **A Treatise on Hydro-Mechanics (Part-II)**, CBS-Publishers, New Delhi, India.

[3] M.D.RAISINGHANIA, **Fluid Dynamics** S.Chand & Company, New Delhi.

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M/AM 405(B) **Semester IV**

Paper-V: **Advanced Operations Research**

Unit I
Characteristics of Game theory – Minimax(Maxmin) criterion and optimal strategy- Saddle points - Solution of Games with saddle points- Rectangular Games without saddle points - Minimax(Maxmin) principle for Mixed strategy Games - Equivalence of Rectangular Game and Linear programming problem - Solution of $(m \times n)$ Games by Simplex method-Arithmetic method for (2×2) Games - concept of Dominance - Graphical method for (3×3)Games without saddle point.

Unit II
Inventory Problems: Analytical structure of inventory Problem, ABC analysis, EOQ Problems with and without shortage, with (a) Production is instantaneous (b) finite constant rate (c) shortage permitted random models where the demand follows uniform distribution.

Unit III
Non - Linear programming-unconstrained problems of Maxima and Minima - constrained problems of Maxima and Minima - Constraints in the form of Equations – Lagrangian Method-Sufficient conditions for Max(Min) of Objective function with single equality constraint – With more than one equality constraints - Constraints in the form of Inequalities - Formulation of Non - Linear programming problems - General Nonlinear programming problem - Canonical form - Graphical Solution

Unit-IV
Quadratic programming - Kuhn-Tucker Conditions - Non-negative constraints, General quadratic programming problem - Wolfe's modified simplex method-Beales's Method - Simplex method for quadratic Programming.

Text Books:

[1] S.D. Sharma, Operations Research.

[2] Kanti Swarup, P. K. Gupta and Manmohan, Operations Research.

[3] O.L. Mangasarian, Non-Linear Programming, McGraw Hill, New Delhi.

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M 405(C) **Semester IV**

Paper-V: **Finite Difference Methods**

Unit I
Partial differential Equations – Introduction - Difference Method - Routh Hurwitz criterion - Domain of Dependence of Hyperbolic Equations. (1.1 to 1.4)

Unit II
Difference Methods for Parabolic Partial Differential Equations - Introduction – One space dimension - Two space dimensions.(2.1, 2.2 2.3 & 2.5).

Unit III
Difference Methods for Hyperbolic Partial Differential Equations Introduction - One space dimensions - Two space dimensions - First order equations.(3.1 to 3.4).

Unit-IV
Numerical Methods for Elliptic Partial Differential Equations – Introduction - Difference Methods for Linear Boundary Value Problems - General second order linear equation - Equation in polar coordinates.(4.1 to 4.4).

Text Book:

M. K.Jain, S. R.K. Iyengar, R. K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern Limited, New Age International Limited, New Delhi.