DEPARTMENT OF MATHEMATICS, OSMANIA UNIVERSITY

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

M. Sc. APPLIED MATHEMATICS

SEMESTER – III

Subject	Code	Paper	Hours/ Week	Theory	T*	Max. Marks	Credits
Core	AM 301	**Finite Difference Methods**	6	5	1	100	5
Core	AM 302	**Viscous Flows**	6	5	1	100	5
Core	AM 303	**Linear Algebra**	6	5	1	100	5
Elective	AM 304(A)	**Operations Research**	6	5	1	100	5
	AM 304(B)	**Compressible Flows**					
	AM 304(C)	**Computational Fluid Dynamics**					
Elective	AM 305(A)	**Elementary Number Theory**	5	4	1	100	4
	AM 305(B)	**Numerical Analysis**					
	AM 305(C)	**Topology**					
		Seminar	2	2		25	1
			31				25

T* - Tutorial Class for Problem Solving Session.

SEMESTER – IV

Subject	Code	Paper	Hours/ Week	Theory	T*	Max. Marks	Credits
Core	AM 401	**Integral Equations & Calculus of Variations**	6	5	1	100	5
Core	AM 402	**Finite Element Methods**	6	5	1	100	5
Core	AM 403	**Functional Analysis**	6	5	1	100	5
Elective	AM 404(A)	**Magnetohydrodynamics**	6	5	1	100	5
	AM 404(B)	**Bio-Mechanics**					
	AM 404(C)	**Differential Geometry**					
Elective	AM 405(A)	**Discrete Mathematics**	5	4	1	100	4
	AM 405(B)	**Advanced Operations Research**					
	AM 405(C)	**Advanced Complex Analysis**					
		Seminar	2	2			1
			31				25

T* - Tutorial Class for Problem Solving Session.

DEPARTMENT OF MATHEMATICS
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M.Sc. Applied Mathematics

AM 301 **Semester III**

Paper-I: **Finite Difference Methods**

Unit I
Partial Differential Equations: Introduction - Classification of Second order PDE's - Difference Methods - 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 - Spherical and Cylindrical Coordinate System.(2.1 to 2.3, 2.5, 2.6).

Unit III
Difference Methods for Hyperbolic Partial Differential Equations: Introduction - One Space Dimensions - Two Space Dimensions - System of First order equations.(3.1 to 3.5).

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 4.5).

Text Book:

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

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AM 302 **Semester III**

Paper-II: **Viscous Flows**

Unit I

Vortex Motion: Vorticity – Vortex Line, Vortex Tube and Vortex Filament - Properties of Vortex Filament - Kelvin's Proof – Helmholtz's Vorticity Theorems – Strength of Vortex - Rectilinear Vortices – Complex Potential of a Two-Dimensional Vortex Motion - Centre of Vortices - Two Vortex Filaments – Vortex Pair – Vortex Doublet or Dipole – Image of a Vortex Filament in a Plane - Vortex inside and outside Circular Cylinder - Rectilinear Vortices - Rectilinear Vortex with Circular Section.

Unit II

General Theory of Stress and Rate of Strain: Viscosity – Measurement of Viscosity – Stress, Stress vector and Stress Tensor - Stress components in a Real Fluid – State of stress at a point - Relations between Cartesian Components of Stress – Translation motion of Fluid Element – Stress Analysis in Fluid Motion – Principal Stresses, Principal directions of Stress Tensor - The Navier-Stokes Equations of motion of a viscous fluid.

Unit III

Laminar Flow of Viscous Incompressible Fluid: Steady motion between two parallel plates: Plane Couette flow, Generalized plane Couette flow - Plane Poiseuille flow – Flow through a circular pipe – The Hagen-Poiseuille flow - Steady visous flow in Tubes of uniform cross section - Steady motion in Tube having uniform Elliptic cross section and Tube having Equilateral Triangle cross section – Unsteady flow over a flat plate.

Unit-IV

Dynamical Similarity: Dynamical similarity - Flow similarity - Dimensional Analysis – Buckingham π-Theorem - Non-dimensional parameters in fluid mechanics - Reynolds number - Significance of Reynolds number.

Boundary Layer Theory: – Prandtl's Boundary Layer Theory – Boundary Layer thickness – Displacement thickness, Momentum thickness, Energy thickness - Boundary Layer equations in two dimensions – The Boundary Layer along a flat plate (Blasius solution) – Approximate solutions of Boundary Layer Equations - Von Karman's Integral Relation - Von Karman's Integral Relation by Momentum Law.

Text Books:

[1] Frank M.White, **Viscous Fluid Flow**,McGraw-Hill, Inc.

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

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

DEPARTMENT OF MATHEMATICS
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AM/M 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.Sc. Applied Mathematics

AM/M/MCS 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.Sc. Applied Mathematics

AM 304(B) **Semester III**

Paper-IV: **Compressible Flows**

Unit I

Thermodynamics and Physical properties of Gases: Introduction to Equation of State – Perfect gas – First law of Thermodynamic – Internal Energy and Enthalpy, Specific Heats – Entropy and Second law of Thermodynamics and perfect gas mixture – Dissociation and Ionization – Real gases – Physical properties of gases.

Unit II

Fundamental Equations of the Aerodynamics of a Compressible Inviscid and non-heat conducting fluid: – Equation of State – Equation of Continuity – Equation of Motion – Equation of Energy - Maxwell's Thermodynamics Relations – Isothermal, Adiabatic and Isentropic Processes - Kelvin's Theorem – Irrotational Motion – Vortex Motion – Helmholtz's Theorem -

Unit III

One dimensional Flow of an Inviscid Compressible Fluid: Energy Equation – Velocity of sound and Mach number – Subsonic, Sonic and Supersonic - Steady flow in a Nozzle – Pressure and velocity relation in isentropic flow – Non-steady one dimensional flow – Sound wave with Finite Amplitude – Formation of a Shock.

Unit-IV

Flow of Viscous Compressible Fluids: Introduction - Basic Equations - Plane Couette Flow of a Compressible viscous fluid - Laminar flow of a Compressible viscous fluid through a circular pipe. **Boundary Layer Theory of Viscous Compressible Fluid:** Introduction - Two dimensional Boundary Layer Theory for a Compressible fluid - Two dimensional steady Boundary Layer flow of a Compressible fluid - Velocity and Temperature relation in laminar boundary layers.

Text Books:

[1] S.I,Pai, Introduction to Theory of Compressible Flow, Van Nostrand Reinhold Company.

[2] F.Chorlton, Text Book of Fluid Dynamics, CBS Publications and Distributors, New Delhi.

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M.Sc. Applied Mathematics

AM 304(C) **Semester III**

Paper-IV: **Computational Fluid Dynamics**

Unit I

INTRODUCTION: Motivation - Background - Problem Specification and Geometry Preparation - Selection of Governing Equations and Boundary Conditions. Selection of Gridding Strategy and Numerical Method - Assessment and Interpretation of Results.

Unit II

Conservation Laws and The Model Equations: Conservation Laws - The Navier Stokes and Euler Equations - The Linear Convection Equation Diferential Form - Solution in Wave Space -The Difusion Equation - Diferential Form - Linear Hyperbolic Systems.

Unit III

Finite Volume Methods: Introduction - Obtaining the Integral Form from the Differential Form - Finite Volume Meshes - Discretising the Semi-Integral Equation - Implementation of Finite Volume Schemes - The Shallow Water Equations - General FVS for the SWE - FVS for the 2D SWE on a Structured Mesh - Heuristic Time Step for a 2D SWE FVS.

Unit-IV

Inviscid Flows, Incompressible potential flows, Viscous Fluid flows : Pipe and Open channel flows, generalized Rayleigh problem, starting flow in a channel problem, Numerical solution of a bi-harmonic equations - Stokes flows.

Text Books:

[1] Chuen-Yen-Chow and Sedat Biringen, An Introduction to Computational Fluid Mechanics, Wiley, 2011.

[2] Tarit Kumar Bose, Computational Fluid Dynamics, Wiley Eastern Ltd., 1988.

[3] C.A.J. Fletcher, Computational Techniques for Fluid Dynamics, Vol.II, Springer-Verlag, Berlin, 1991.

[4] D.M. Causon, C.G. Mingham, L.Qian : Introductory Finite Volume Methods for Partial Differential Equations, Springer, 2009.

DEPARTMENT OF MATHEMATICS
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AM 305(A) **Semester III**

Paper-V: **Elementary Number Theory**

Unit I
The Fundamental Theorem of Arithmetic: Divisibility, GCD, Prime Numbers, Fundamental Theorem of Arithmetic, the series of reciprocal of the Primes, The Euclidean Algorithm.

Unit II
Arithmetic function and Dirichlet Multiplication, The functions $\phi(n), \mu(n)$ and a relation connecting them, Product formulae for $\phi(n)$, Dirichlet Product, Dirichlet inverse and Mobius inversion formula and Mangoldt function $\Lambda(n)$, Multiplication function and Dirichlet multiplication, Inverse of a completely multiplication function, Liouville's function $\lambda(n)$, the divisor function $\sigma_\alpha(n)$.

Unit III
Congruences, Properties of congruences, Residue classes and complete residue system, linear Congruences conversion, reduced residue system and Euler Fermat theorem, polynomial congruence modulo P, Lagrange's theorem, Application of Lagrange's theorem, Chinese remainder theorem and its application, polynomial congruences with prime power moduli.

Unit-IV
Quadratic residue and quadratic reciprocity law, Quadratic residues, Legendre's symbol and its properties, evaluation of $(-1/p)$ and $(2/p)$, Gauss Lemma, the quadratic reciprocity law and its applications.

Text Book:
Introduction to Analytic Number Theory by Tom M. Apostol, Spriger International, Student Edition.(Ch 1, 2, 5, 9.)

References:

[1] Number Theory by Joseph H. Silverman.

[2] Theory of Numbers by K. Ramchandra.

[3] Elementary Number Theory by James K Strayer.

[4] Elementary Number Theory by James Tattusall.

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AM/M 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: Introduction - 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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AM 305(C) **Semester III**

Paper-V: **Topology**

Unit I
Topological Spaces: The Definition and examples - Elementary concepts - Open bases and open subbases - Weak topologies.

Unit II
Compactness: Compact spaces - Products of spaces - Tychonoff's theorem and locally compact spaces - Compactness for metric spaces - Ascoli's theorem.

Unit III
Separation: T_1-spaces and Hausdorff spaces - Completely regular spaces and normal spaces - Urysohn's lemma and the Tietze extension theorem - The Urysohn imbedding theorem.

Unit-IV
Connectedness: Connected spaces - The components of a spaces - Totally disconnected spaces - Locally connected spaces.

Text Book:

Introduction to Topology and Modern Analysis By G.F. Simmons, TATA McGraw-Hill Publishing Company Ltd.(Ch 3,4,5,6)

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AM/M/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.

CALCULUS OF VARIATIONS:

Unit III

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 - Application of Calculus of Variation - Hamilton's principle - Lagrange's Equation, Hamilton's equations and Applications.

Text Books:

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

[2] S. SWARUP, Integral Equations, Krishna Prakash Mandir Pub.

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

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AM 402 **Semester IV**

Paper-II: **Finite Element Methods**

Unit I
Introduction -**Weighted Residual Methods:** - Least Square Method - Partition Method - Galerkin Method - Moment Method - Collocation Method – problems. **Variational Methods:** Ritz Method - Examples.

Unit II
Finite Elements: Line segment Element - Triangular Element - Rectangular Elements with examples - Numerical Integration over Finite Elements.

Unit III
Finite Element Methods: Ritz Finite Element Method - Least Square Finite Element Method - Galerkin Finite Element Method - Boundary Value Problems in Ordinary Differential Equations - Assembly of Element Equations - Boundary Value Problem in Partial Differential Equations(with Linear triangular element) - Mixed boundary conditions - Boundary points - Examples.

Unit-IV
Finite Element Error Analysis: Approximation Errors - Various Measures of Error - Convergence of solution - Accuracy of the solution - Examples. **Eigenvalue Problems:** Introduction - Eigenvalue problems - Formulation of a Eigenvalue problems - Examples. (5.1 to 5.4, 6.1) of [2]

Text Books:

[1] M.K.Jain, Numerical Solution of Differential Equations. New Age Int.(P).Ltd., New Delhi.(for Units I, II and III)

[2] J.N.Reddy, Finite Element Method, Mc Graw-Hill International Edition, Engineering Mechanics Series. (for Unit IV).

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AM/M 403 **Semester IV**

Paper-III: **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^{nd} Edition.

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

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AM 404(A) **Semester IV**

Paper-IV: **Magnetohydrodynamics**

Unit I
Introduction: A brief remainder of the laws of electrodynamics. **Governing equations of Electrohydrodynamics:** The electric field and Lorentz force, Ohm's law and volumetric Lorentz force, Ampere's law, Faraday's law in differential form, reduced form of Maxwell equations for MHD.

Unit II
Transport equation for imposed magnetic field (B), an important kinematic equation, the significance of Faraday's law and Faraday's law in ideal conductors. Vorticity, Angular momentum and Biot-Savart Law.

Unit III
Advection and Diffusion of Vorticity, Kelvin's Theorem, Helmholtz law and helicity, Prandtl-Batchelor theorem. Fluid flow in the presence of Lorentz force: Equations of MHD and dimensionless groups Maxwell stresses.

Unit-IV
Kinematics of MHD: Analogy to vorticity, Diffusion of a magnetic field, Advection in ideal conductors: Alfven's theorem, Magnetic helicity, Advection plus diffusion, Azimuthal field generation by differential rotation, Magnetic reconnection.

Text Book:

P.A. Davidson, "An Introduction to magnetohydrodynamics", Cambridge University Press, 2001.

References:

[1] PH Roberts, An Introduction to Magnetohydrodynamics", Longman's Publishers, 1961.

[2] HK Moffat, Magnetic field generation in electrically conducting fluids, Cambridge Universiyt Press, 1978.

[3] R Moreau, Magneto hydrodyanimcs, Kluwer Academy Publishers, 1990.

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AM 404(B) **Semester IV**

Paper-IV: **Biomechanics**

Unit I

Introduction -**Blood Flow in Heart, Lung, Arteries and Veins:** Introduction - The geometry of the circulation system - Field equations and Boundary conditions - Coupling of Left Ventricle to Aorta and Right Ventricle to Pulmonary Artery - Pulsatile Flow in Arteries - Progressive waves superposed on a Steady flow - Reflection and Transmission of Waves at Junctions - Velocity profile of a steady flow in a Tube - Steady Laminar Flow in Elastic Tube - The Velocity Profile of Pulsatile flow. (1.1, 5.1, 5.2, 5.4, 5.6 – 5.12 of [1])

Unit II

The Reynolds Number, Stokes Number, and Womersley Number - Equations of Balance of Energy and Work - Systemic Blood Pressure - Flow in a Collapsible Tubes.

Micro and Macro Circulation: Introduction - Major Feature of Microcirculation - The Rheological Properties of Blood - Pulmonary Blood Flow - Waterfall Phenomenon in Zone 2 - (5.13-5.17, 6.1, 6.3, 6.4, 6.7-6.8 of [1]).

Unit III

Respiratory Gas Flow: Introduction - Gas flow in the Airway - Interaction between Convection and Diffusion - Exchange between Alveolar Gas and Erythrocytes. (7.1 to 7.4 of [1]).

Unit-IV

Basic Transport Equations According to Thermodynamics Molecular Diffusion Mechanisms in Membranes: Introduction - The laws of Thermodynamics - The Gibbs and Gibbs-Duhem Equations - Chemical Potential - Entropy in a system with Heat and Mass transfer - Diffusion, Filtration, and Fluid movement in Interstitial Space from the point of view of Thermodynamics - Diffusion from the Molecular Point of view (8.1-8.7).

Text Book:

Y.C.Fung, **Biomechanics:** Motion,Flow,Strees and Growth Published by Springer- Verlag, New York Inc., 1990.

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AM 404(C) **Semester IV**

Paper-IV: **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's 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.

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AM 405(A) **Semester IV**

Paper-V: **Discrete Mathematics**

Unit I
Mathematical Logic: Propositional logic, Propositional equivalences, Predicates and Quantifiers, Rule of inference,direct proofs, proof by contraposition, proof by contradiction. **Boolean Algebra:** Boolean functions and its representation, logic gates, minimizations of circuits by using Boolean identities and K-map.

Unit II
Basic Structures: Sets representations, Set operations, Functions, Sequences and Summations. Division algorithm, Modular arithmetic, solving congruences, applications of congruences. **Recursion:** Proofs by mathematical induction, recursive definitions, structural induction, generalized induction, recursive algorithms.

Unit III
Counting: Basic counting principle, inclusion - exclusion for two sets, Pigeonhole principle, Permutations and Combinations, Binomial coefficient and identities, generalized permutations and combinations. **Recurrence Relations:** Introduction, solving linear recurrence relations, generating functions, principle of inclusion-exclusion, applications of inclusion-exclusion. **Relations:** Relations and their properties, representing relations, closures of relations, equivalence relations, partial orderings.

Unit-IV
Graphs: Graphs definitions, graph terminology, types of graphs, representing graphs, graph isomorphism, connectivity of graphs, Euler and Hamilton paths and circuits, Dijkstra's algorithm to find shortest path, planar graphs–Euler's formula and its applications, graph coloring and its applications. **Trees:** Trees definitions–properties of trees, applications of trees–BST, Haffman Coding, tree traversals: pre-order, in-order, post-order, prefix, infix, postfix notations, spanning tress–DFS, BFS, Prim's, Kruskal's algorithms.

Text Book:

Discrete Mathematics and its Applications (7e)by Kenneth H. Rosen.

References:

[1] **Discrete and Combinatorial Mathematics** by Ralph P. Grimaldi.

[2] **Discrete Mathematics for Computer Scientists** by Stein, Drysdale, Bogart.

[3] **Discrete Mathematical Structures with Applications to Computer Science**by J.P. Tremblay, R. Manohar.

[4] **Discrete Mathematics for Computer Scientists and Mathematicians**by Joe L. Mott, Abraham Kandel, Theoder P. Baker.

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M.Sc. Applied Mathematics

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

Paper-V: **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.