Faculty of Science

Jananayak Chandrashekhar University, Ballia

Semester Based Syllabus (w.e.f. 2020-21)

M.A./M.Sc. MATHEMATICS

Scheme of Examination

Semester	Paper	Marks
First	I -MAT 101 – Algebra-I II - MAT 102 - Real Analysis III - MAT 103 – Topology-I IV - MAT 104 - Complex Analysis V - MAT 105 – Hydrodynamics	80 80 80 80 80
Second	I -MAT 201 –Algebra-II II - MAT 202 – Functional Analysis-I III - MAT 203 – Measure & integration-I IV - MAT 204 – Classical Mechanics V - MAT 205 – Special Theory of Relativity	80 80 80 80 80
Third	I -MAT 301 – Topology-II II - MAT 302 – Differential & Integral Equations III - MAT 303 – Differential Geometry of Manifolds IV - MAT 304 – Operations Research V - MAT 305 – General Relativity and Cosmology	80 80 80 80 80
Fourth	I -MAT 401 – Functional Analysis-II II - MAT 402 – Measure & Integration-II III - MAT 403 – Complex manifolds & Contact manifolds IV - MAT 404 – Fluid Mechanics V -Viva Voce + Seminar + Project (Based on Theory Papers)	80 80 80 80 60+10+10

SEMESTER – I

MAT 101 **ALGEBRA – I**

UNIT I: Action of a group G on a set S, Equivalent formulation as a homomorphism of G to T(S), Examples, Stabilizer (Isotropy) subgroups and Orbit decomposition, Class equation of an action, Its particular cases (left multiplication and conjugation), Conjugacy class equation, Core of a subgroup. Sylow's Theorem I, II and III.

UNIT II: Subnormal and normal series, Zassenhaus's lemma (Statement only), Schreier's refinement theorem, composition series, Jordan – Holder theorem, Chain conditions, Examples, Internal and External direct products and their relationship, Indecomposability. p–groups, Examples and applications, Groups of order pq.

UNIT III: Commutators, Solvable groups, Solvability of subgroups, factor groups and of finite p–groups, Examples, Lower and upper central series, Nilpotent groups and their equivalent characterizations.

UNIT IV: Canonical forms, Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, Index of nilpotency, Invariants of nilpotent transformations, The primary decomposition theorem, Jordon blocks and Jordan forms.

Books Recommended:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley, N.Y, 2003.

2. N.S. Gopalakrishnan, University Algebra, Wiley Eastern, New Delhi, 1986.

3. N. Jacobson, Basic Algebra, Vol. I, Hindustan Publishing Co, New Delhi, 1984.

4. Ramji Lal, Algebra, Vols. I & II, Shail Publications, Allahabad, 2002.

5. K. Hoffman and R. Kunze, Linear Algebra, Pearson,2015

MAT 102 **REAL ANALYSIS**

UNIT I: Definition and existence of Riemann – Stieltjes integral, Conditions for R–S integrability. Properties of the R-S integral, R-S integrability of functions of a function Integration and differentiation, Fundamental theorem of Calculus.

Unit II: Series of arbitrary terms. Convergence, divergence and oscillation, Absolute Convergence, Abel's and Dirichilet's tests. Multiplication of series. Rearrangements of terms of a series, Riemann's theorem and sum of series, Sequences and series of functions.

Unit III: Pointwise and uniform convergence, Cauchy's criterion for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjies integration, Uniform convergence and differentiation, Weierstrass approximation theorem, Power series. Uniqueness theorem for power series, Abel's and Tauber's theorems.

Unit IV: Functions of Several Variables, Linear transformations, Derivatives in an open subset of R^n Jacobian matrix and Jacobians, Chain rule and its matrix form, Interchange of order of differentiation, Derivatives of higher orders Taylor's theorem, Inverse function theorem, Implicit function theorem, Extremum problems with constraints, Lagranges multiplier method.

Books Recommended:

1- Walter Rudin, Principle of Mathematical Analysis (3rd edition) McGraw- Hill Kogakusha, 1976 International Student Edition.

2- T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

3- S Lang, Analysis I and II, Addision-Wesley Pub. Co. 1969

MAT 103 **TOPOLOGY-I**

UNIT I: Definition and examples of topological spaces, open sets, closed sets, closure, interior, dense subsets, nowhere dense subsets, neighborhoods, interior, exterior, boundary, accumulation points and derived sets.

UNIT II: Bases and subbases, subspaces and relative topology, alternate methods of deriving topology in terms of Kuratowski closure operator and neighborhood systems, First and second countable spaces, Separable spaces, Lindelof theorem.

Unit III: Continuous map and its characterizations via closure, interior, basic open sets and sub-basic open sets, open map, closed map, homeomorphism, topological invariants, pasting lemma.

Unit IV: Separation axioms, T_0 , T_1, T_2, T_3, $T_{3\frac{1}{2}}$, T_4 spaces and their characterization and basic properties, their preservation under homeomorphism, Urysohn's Lemma, Tietz's extension theorem.

Books Recommended:

1. J.L. Kelley, General Topology, Van Nostrand 1995.

2. K.D. Joshi, Introduction to General Topology, Wiley Eastern,1983.

3. James R. Munkres, Topology, 2nd Edition, Pearson Internationl, 2000.

4. J. Dugundji, Topology, Prentice-Hall of India, 1966.

MAT 104 **COMPLEX ANALYSIS**

UNIT I: Analytic continuation, uniqueness of analytic continuation, Natural Boundary, complete analytic functions , Power series method of Analytic continuation, Schwarz's Lemma, Inverse function theorem, Schwarz's reflection principle, Reflection across analytic arcs.

UNIT II: Residue at infinity, Cauchy's Residue theorem, Contour integration: Integral of the type $\int_{\alpha}^{2\pi+\alpha} f(cos\theta, sin\,\theta)d\theta$, Integral of the $type \int_{-\infty}^{+\infty} f(x)dx$, Integral of the $type \int_{-\infty}^{+\infty} g(x)\ cosmxdx$, Singularities on the real axis, Integrals involving branch points, Jordan's Lemma.

UNIT III: The Riemann mapping theorem, Behavior at the boundary, Picard' theorem, Borel theorem, Infinite Products, Jensen's formula, Poission –Jenson formula, Borel Cartheodory theorem.

UNIT IV: Entire Functions with Rational Values, The Phragmen-Lindelof and Hadamard Theorems, Meromorphic Functions, Mittag-Leffler Theorem, Weierstrass factorization theorem, Gama functions.

Books Recommended:

1. Serge lang, Complex Analysis, Fourth edition, Springer. (Chapters vii, ix-xii).

2. J. Bak and D.J. Newman, Complex Analysis, Springer.

3. J.B. Conway, Complex Analysis, Springer.

MAT 105 **HYDRODYNAMICS**

UNIT I: Equation of continuity, Boundary surfaces, streamlines, Velocity potential, Irrotational and rotational motions, Vortex lines, Euler's Equation of motion, Bernoulli's theorem, Impulsive actions.

UNIT II: Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, Conformal mapping, Circle Theorem.

UNIT III: Two- dimensional irrotational motion produced by the motion of circular cylinder in an infinite mass of liquid, theorem of Blasius, Motion of Eliptic Cylinder.

UNIT IV: Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere, Equation of motion of a sphere. Concentric Spheres.

Books Recommended:

1. W.H. Besant and A.S. Ramsey, A Treatise on Hydrodynamics, CBS Pub. Delhi, 1988.

2. S.W. Yuan, foundations of Fluid Dynamics, Prentice-Hall of India, 1988.

SEMESTER – II

MAT 201 **ALGEBRA – II**

UNIT I: Modules over a ring Endomorphism ring of an abelian group. R-Module structure on an abelian group M as a ring homomorphism form R to End M, Submodules, Direct summands, Homomorphism, Factor modules, Correspondence theorem, Isomorphism theorems, Exact sequences, Five lemma, Products, External and internal direct sums.

UNIT II: Free modules, Homomorphism extension property, Equivalent characterization as a direct sum of copies of the underlying ring, Split exact sequences and their characterizations, Left exactness of Hom sequences and counter-examples for non-right exactness, Projective modules, Injective modules, Baer's characterization,

UNIT III: Noetherian modules and rings, Equivalent characterizations, Submodules and factors of noetherian modules, Characteristic of a field, Prime subfields, Field extension, Finite extensions, Algebraic and transcendental extensions. Factorization of polynomials in extension fields, Splitting fields and their uniqueness.

UNIT IV: Separable field extensions, Perfect fields, Separability over fields of prime characteristic, Transitivity of separability, Automorphisms of fields, Dedekind's theorem, Fixed fields, Normal extensions, Splitting fields and normality, Normal closures, Galois extensions, extensions, Fundamental theorem of Galois theory.

Books Recommended:

1. D.S Dummit and R.M. Foote, Abstract Algebra, john Wiley, N.Y., 2003.

2. F.W. Anderson and K.R. Fuller, Rings and Categories of Modules, Springer, N.Y., 1974

3. I.A. Adamson, An Introduction to Field Theory. Oliver & Boyd, Edinburgh, 1964.

4. N.S. Gopalakrishnan, University Algebra, Wiley Eastern Ltd., New Delhi, 1986.

5. T.W. Hungerford, Algebra, Springer (India) Pvt. Ltd., New Delhi, 2004.

6. Ramji Lal, Algebra, Vol. 2, Shail Publishing House, Allahabad, 2002.

MAT: 202 **FUNCTIONAL ANALYSIS I**

UNIT I: Normed linear spaces, Banach spaces, their examples including R^n , C^n ,l_p^n , l_p, C[a,b] and topological properties, Holder's and Minkowski's inqualities, Subspaces, Quotient spaces of normed linear spaces and its completeness.

UNIT II: Continuous linear transformations, Spaces of bounded transformations, Continuous linear functional, Hahn Banach theorems(separation and extension), strict convexity and uniqueness of Hahn Banach extension , Banach Steinhous theorem, Uniform boundedness principle.

UNIT III: Closed graph theorem, Projection, Open mapping theorem, Bounded inverse theorem, Finite dimensional normed lnear spaces, Compactness, Equivalent norms.

UNIT IV: Duals of R^n , C^n ,l_p^n , l_p, C[a,b], weak and $weak^*$ convergence, Embedding and reflexivity, Uniform convexity and Milman theorem.

Books Recommended:

1.G.F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963

2.S.Ponnusamy, Foundation of Functional Analysis, Narosa Publishing House, New Delhi, 2002.

3.B.V.Limaye,Functional Analysis,New Age Int. Publisher ,Third Edition.

MAT 203 MEASURE AND INTEGRATION – I

UNIT I: Lebesgue outer and inner measure, Lebesgue measure on R, translation invariance of Lebesgue measure, existence of a non-measuable set, characterizations of Lebesgue measurable sets, Borel sets, Cantor-Lebesgure function.

UNIT II: Measurable functions on a measure space and their properties, Borel measurable functions, simple functions and their integrals, Lebesgue integral on R and its properties, Riemann and Lebesgue integrals.

UNIT III: Integral of non negative measureable function and of unbounded functions, Bounded convergence theorem, Fatou's lemma, Monotone convergence theorem, Lebesgue dominated convergence theorem.

UNIT IV: Uniform integrability, Vitali convergence theorem, Convergence in measure, The L^p-space, Holder and Minkowski inequalities, Completeness of L^p, Convergence in L^p, Approximation and separability of L^p.

Books Recommended:

1- H.L. Royden and P.M. Fitzpatrick, Real Analysis, (Fourth edition), P.H.I, 2010.

2- P.R. Halmos, Measure Theory, Grand Text Mathematics, 14, Springer, 1994.

3- I.K. Rana, An Introduction to Measure and Integration, Narosa Publ. House, New Delhi, 2005.

4- E. Hewit and K. Stromberg, Real and Abstract Analysis, Springer, 1975.

5- H.L. Royden, Real Analysis, Macmillan, 4th Edition, 1993.

MAT 204 CLASSICAL MECHANICS

UNIT I: The linear momentum and the angular momentum of a rigid body in terms of inertia constants, kinetic energy of a rigid body, equations of motion, examples on the motion of a sphere on horizontal and on inclined planes. Euler's equations of motion, motion under no forces, Eulerian angles and the geometrical equations of Euler.

UNIT II: Generalized co-ordinates, geometrical equations, holonomic and non-holonomic systems, configuration space, Lagrange's equations using D' Alembet's Principle for a holonomic conservative system, deduction of equation of energy when the geometrical equations do not contain time explicitly, Lagrange's multipliers case, deduction of Euler's dynamical equations from Lagrange's equations.

UNIT III: Theory of small oscillations, Lagrange's method, normal (principal) co-ordinates and the normal modes of oscillation, small oscillations under holonomic constraints,stationary property of normal modes, Lagrange equations for impulsive motion.

UNIT IV: Generalized momentum and the Hamiltonian for a dynamical system, Hamilton's canonical equations of motion, Hamiltonian as a sum of kinetic and potential energies, phase space and Hamilton's Variational principle, the principle of least action, canonical transformations, Hamilton-Jacobi theory, Integrals of Hamilton's equations and Poisson-Brackets, Poisson- Jacobi identity.

Books Recommended:

1. A.S. Ramsey, Dynamics, Part II, CBS Publishers & Distributors, Delhi, 1985.

2. H. Goldstein, Classical Mechanics, Addison-Wesley Publishing Company, London, 1969.

3. K. C. Rana and P. C. Joag, Classical Mechanics, Narosa. Pub.

MAT 205 **SPECIAL THEORY OF RELATIVITY**

UNIT I: Review of Newtonian Mechanics, Inertial frame, Speed of light and Galilean relativity, Michelson-Morley experiment, Lorentz-Fitzerold contraction hypothesis, relative character of space and time, postulates of special theory of relativity, Lorentz transformation equations and geometrical interpretation, Group properties of Lorentz transformations.

UNIT II: Relativistic kinematics, composition of parallel velocities, length contraction, time dialation, transformation equations, equations for components of velocity and acceleration of a particle and contraction factor.

UNIT III: Geometrical representation of space time, four dimensional minkowskian space of special relativity, time-like intervals, light-like and space-like intervals, Null cone, proper time, world line of a particle, four vectors and tensors in Minkowskian space time.

UNIT IV: Relativistic mechanics-Varriations of mass with velocity, equivalence of mass energy, transformation equation for mass, momentum and energy, Energy momentum for light vector, relativistic force and transformation equation for its components, relativistic Lagrangian and Hamiltonian, relativistic equations of motion of a particle, energy momentum tensor of a continuous material distribution.

Books Recommended:

1. C. Mollar, Theory of relativity, Clarendon press, 1952.

2. R. Resnick, Introduction to special relativity, Wiley Eastern Pvt. Ltd. 1972.

3. J.L. Anderson, Principles of relativity, Academic Press.

SEMESTER – III

MAT 301 **TOPOLOGY-II**

Unit I: Compactness, Continuous functions and compact sets, Basic properties of compactness, Compact hausdorff spaces, finite intersection properties, Sequential, countable and B-W compactness, Local compactness.

Unit II: Connectedness, Connected spaces, Continuous functions and connected sets, Connectedness in real line, Components, Local connectedness, Path connectedness.

Unit III: Tychonoff product topology in terms of standard sub-basis and its characterization, Product topology and separation axioms, connectedness and compactness (including the Tychonoff's theorem), Product spaces.

Unit IV: Homotopy between continuous maps and paths, Contractible spaces, Fundamental groups (its examples and basic properties), Null homotopic spaces, Induced homomorphism and its functional properties.

Books Recommended:

1. J.K. Kelley, General Topology, Van Nostrand, 1995

2. K.D. Joshi, Introduction to General Topology, Wiley Eastern, 1983.

3. James R. Munkres, Topology, 2nd Edition, Pearson International, 2000.

4. J. Dugundji, Topology, Prentice-Hall of India, 1966.

MAT 302 DIFFERENTIAL AND INTEGRAL EQUATIONS

UNIT I: Solution of differential equations in ascending and descending power series, Frobenius metod, Hpergeometric Differential equations, Pochhammer symbol, Hypergeometric Function, Solution of Gauss's Hypergeometric differential equation, Differentiation of Hypergeometric functions, Solution of Legendre's and Bessel's differential equation, Legendre's and Bessel's function.

UNIT II: Generating function for P_n (x), Laplace definite integrals for P_n (x), Orthogonal properties of Legendre's polynomials, Recurrence formulae, Beltrami result, Christoffel's expansion and summation formulae, Rodrigue's formula for P_n (x), Generating function for J_n (x) Recurrence formulae for J_n (x), Orthogonality of Bessel's function.

UNIT III: Method of separation of variables: Laplace, Diffusion and Wave equations in Cartesian, cylindrical and spherical polar coordinates, Boundary value problems for transverse vibrations in a string of finite length and heat diffusion in a finite rod, Classification of linear integral equations, Relation between differential and integral equations.

UNIT IV: Fredholm equations of second kind with separable kernels, Fredholm alternative theorem, Eigen values and eigen functions, Method of successive approximation for Fredholm and Volterra equations, Resolvent kernel.

Books Recommended:

1. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957.

2. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Pub. New Delhi.

3. R.P. Kanwal, Linear Integral Equations, Birkhäuser,Inc., Boston, 1997.

4. V.S. Verma,Series solution and special functions, Neelkamal Publication.

MAT 303 DIFFERENTIAL GEOMETRY OF MANIFOLDS

UNIT I: Definition and examples of differentiable manifolds. Tangent spaces. Vector fields, Jacobian map Lie derivatives. Exterior algebra. Exterior derivative, Lie groups and Lie algebras.

UNIT II: Riemannian manifolds, Riemannian connections, Curvature tensors, Sectional curvature, Shur's theorem, Projective curvature tensor , Conformal curvature tensor, Conharmonic curvature tensor and Concircular curvature tensor.

UNIT III: Homomorphism and isomorphism. Lie transformation groups, Principle fibre bundle, Linear fame bundle, Associated fibre bundle, Vector bandle, Tangent bundle, Induced bundle, Bundle homomorphism.

UNIT IV: Submanifolds and Hypersurfaces, Normals, Induced connection, Gauss formulas, Weingarten formulae, Lines of curvature, Mean curvature, Generalized Gauss and Minardi-Codazzi's equations.

Books Recommended:

1. R.S. Mishra, A course in tensors with applications to Riemannian Geometry Pothishala (Pvt.) Ltd. 1965.

2. R.S. Mishra, Structures on a differentiable manifold and their applications. Chandrama Prakashan, Allahabad, 1984.

3. B.B. Sinha, An introduction to modern differentrial geometry, Kalyani Publishes, New Delhi, 1982.

MAT 304 **OPERATONS RESEARCH**

UNIT I: Operations Research and its Scope. Linear Programming- Simplex Method, Dual simplex method, Parametric linear programming, Upper bound technique.

UNIT II: Transformation and Assignment problems, Integer programming,Dynamic Programming.

UNIT III: Network Analysis- Shortest path problem, Minimum squaring problems, Maximum Flow problem, Minimum cost flow problem, Network simplex method ,Game theorem-Two Person, Zero-sum Games. Games with mixed strategies. Graphic solution.

UNIT IV: Non linear programming-one and multi variable unconstrained optimization, Conditions for constrained optimization, Separable programming, Convex programming, Non-convex programming, Linear Goal programming.

Books Recommended:

1. H.A. Taha. Operations Research- An Introduction, Macmillan Publishing Co., Inc., New York.

2. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.

MAT 305: GENERAL RELATIVITY AND COSMOLOGY

UNIT I: Review of special theory of relativity and the Newtonian Theory of Gravitation. Principle of equivalence and general covariance. Geodesic Principle. Newtonian approximation.

UNIT II: Schwarzchild external solution and its isotropic form. Planetary orbits and analogues of Kepler's law in general relativity. Advance or perihelion of a planet. Bending of light rays in gravitational field. Gravitational redshift of spectral lines.

UNIT III: Energy momentum tensor of a perfect fluid. Schwarzchild internal solution. Boundary conditions. Energy momentum tensor of an electromagnetic field. Einstein-Maxwell equations. Reissner-Nordstrom solution.

UNIT IV: Mach's Principle. Einstein modified field equations with cosmological term. Static Cosmological models of Einstein and De-Sitter, their derivation, properties and comparison with the actual universe. Hubble's law. Cosmological principle's Wey' is postulate. Derivation of Robertson-Walke metric.

References:

1. C.E. Weatherburn An Introduction To Reimanian Geometry and the tensor Calculus, Cambridge University Press, 1950.

2. J.V. Narlikar, General Relativity and Cosmology, The Macmillan Company of India Ltd., 1978.

SEMESTER- IV

MAT 401 FUNCTIONAL ANALYSIS-II

UNIT I: Inner product spaces with example, Polarization identity, Scwartz inequality, Parallelogram law, Uniform convexity of norm induced by inner product,Orthonarmal sets, Gram-Schmidt Orthogonalisation.

UNIT II: Hilbert spaces, Bessel's inequality, Riesz-Fisher theorem, orthonormal basis, characterization of orthonormal basis, Fourier series representation and Parsevell's relation, Separable Hilbert paces, Continuity of linear mappings, Projection theorem, Riesz-representation theorem, reflexivity of a Hilbert's space, Unique Hahn extension theorem, weak convergence and weak boundedness.

UNIT III: Unitary operators on a Hilbert spaces, Adjoint of an operator, Self adjoint and normal operators with examples, Characterization and results pertaining to these operators, Positive operator, Shift operator, Projection on a Hilbert's space.

UNIT IV: Finite dimensional spectral theory, Determinant and spectrum of an operator, Spectral theorem, spectral resolution.

Books Recommended:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

2. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, New Delhi, 2002.

3.B.V.Limaye, Functional Analysis, New Age Int. Publication.

MAT 402: MEASURE & INTEGRATION-II

UNIT I: Semi algebras, algebras, monotone class, σ- algebras, measure and outer measures, Caratheodory extension process of extending a measure on a semi-algebra to generated σ – algebra, completion of measure space.

UNIT II: Signed measure, Hahn and Jordan decomposition theorems, Absolutely continuous and singular measures, Radon Nikodyn theorem, Lebesgue decomposition, Riesz Representation theorem, Extension theorem (carathedory).

UNIT III: Product measures, Fubini's theorem, Tonelli's theorem, Baire sets, Baire measure, Continuous functions with compact support.

UNIT IV: Regularity of measures on locally compact spaces. Integration of continuous functions with compact support. Reisz-Markoff theorem.

Books Recommended:

1. H.L. Royden, Real Analysis, Macmillan, 4th Edition, 1993.

2. P.R. Halmos, Measure Theory, Van Nostrand, 1950.

3. S.K. Berberian, Measure and Integration, Wiley Eastern, 1981

4. A.E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.

5. G. de Barra, Measure Theory and Integration, Wiley Eastern, 1981.

6. R.G. Bartle, The Elements of Integration, John Wiley, 1966.

7. Inder K. Rana, An Introduction to measure and Integration, narosa Publishing House, 1997.

MAT 403 COMPLEX MANIFOLDS AND CONTACT MANIFOLDS

UNIT I: Almost complex manifolds: Elementary notions ,Nijenuis tensor, Eigen values of F, Integrability conditions, Contravariant and covariant almost analytic vectors fields, F connection.

UNIT II: Almost Hermite manifolds: Definition, Curvature tensor, Linear connection

Kaehler manifolds: Definition, Curvature tensor, Properties of Projective, Conformal, Conharmonic and concircular curvature tensor.

UNIT III: Almost contact manifolds: Definition, Eigen values of F, Lie derivative, Normal contact structure, Particular affine connection, Almost Sasakian manifold.

UNIT IV: Sasakian manifolds: K- contact Riemannian manifold and its properties , Sasakian manifolds and its properties, Properties of Projective, Conformal, Conharmonic and concircular curvature tensor in Sasakian manifolds, Cosymplectic structure.

Books Recommended:

1. R.S. Mishra, A course in tensors with applications to Riemannian Geometry Pothishala (P.vt.) Ltd., 1965.

2. R.S. Mishra, Structures on a differentiable manifold and their applications. Chandrama Prakashan, Allahabad, 1984.

3. B.B. Sinha, An introduction to modern differential geometry, Kalyani Publishers, New Delhi, 1982.

MAT 404 **FLUID MECHANICS**

UNIT I: Elementary notions of fluid motion: Body forces and surface, Forces nature of stresses, Transformation of stress components, Stress invariants, Principal stresses, Nature of strains, Rates of strain components, Relation between stress and rate of strain components, General displacement of a fluid element, Newton's law of viscosity, Navier-Stokes equation (sketch of proof).

UNIT II: Equation of motion for inviscid fluid, Energy equation, Vortex motion-Helmholtz's vorticity theorem and vorticity equation, Kelvin's circulation Theorem, Mean Potential over a spherical surface, Kelvin's Minimum kinetic energy Theorem, Acyclic irrotational motion.

UNIT III: Wave motion in a gas. Speed of Sound. Equation of motion of a gas. Subsonic, Sonic and Supersonic flows of a gas. Isentropic gas flows.

UNIT IV: Normal and oblique shocks. Plane Poiseuille and Couette flows between two parallel plates. Unsteady flow over a flat plate. Reynold's number.

Books Recommended:

1. L.D. Landau and E.M. Lifshitz, Fluid Mechanics, Butterworth-Heinemann, 2nd Edition, 1987.

2. N. Curle and H.J. Davies, Modern Fluid Dynamics, Vol. I, D. Van Nost. Comp London, 1968.

3. S.W. Yuan, Foundation of Fluid Mechanics, Prentice-Hall, Englewood Cliffs, N.J, 1967.

4. A.S. Ramsey, A. Treatise on Hydrodynamics, Part I, G. Bell and Sons Ltd. 1960.

5. F. Chalton. A text book of fluid dynamics. CBS Publication, New Delhi.