Shivaji University Kolhapur

Department of Mathematics

Revised Syllabus for M.A. / M. Sc. Mathematics (Part-II)
Choice Based Credit System

Syllabus to be implemented from June 2014 onwards
M. A. / M. Sc. Mathematics (Part II) (Semester III)
(Choice Based Credit System)
(Introduced from June 2014 onwards)

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M. A. / M. Sc. Mathematics (Part II) (Semester III)  
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Paper: 301  
Title of Paper: Functional Analysis

Unit I: Normed linear spaces, Banach spaces, Quotient spaces, Continuous linear transformations, Equivalent norms, Finite dimensional normed spaces and properties, Conjugate space and separability, The Hahn-Banach theorem and its consequences.  
15 Lectures

Unit II: Second conjugate space, the natural embedding of the normed linear space in its second conjugate space, Reflexivity of normed spaces, Weak * topology on the conjugate space. The open mapping theorem, Projection on Banach space, the closed graph theorem, the conjugate of an operator, the uniform boundedness principle.  
15 Lectures

15 Lectures

Unit IV: Self adjoint operators, Normal and Unitary operators, Projections, Eigen values and eigenvectors of an operator on a Hilbert space, The determinants and spectrum of an operator, The spectral theorem on a finite dimensional Hilbert space.  
15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  
15 Lectures

Recommended Book(s):  

Reference Books:  
M. A. / M. Sc. Mathematics (Part II) (Semester III)
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(Introduced from June 2014 onwards)

Paper: 302
Title of Paper: Advanced Discrete Mathematics

Unit I: Graph Theory: Definition, examples and properties, Simple graph, Graph isomorphism, Bipartite graphs, Complete Bipartite graph, regular graph, sub-graphs spanning sub-graph, Edge deleted sub-graph, Vertex deleted sub-graph, Union and intersection of two graphs, complements of a graph, self complementary graph, paths and cycles in a graph, Eccentricity, radius and diameter of a connected graph, Peterson graph, Wheel graph. Isomorphism of Graphs. First theorem of graph theory. 15 Lectures

Unit II: The Matrix representation of a graph, Adjacency matrix and Incidence matrix of a graph, Definition and simple properties of a tree, bridges, spanning trees, Inclusion exclusion principle. Simple examples on Inclusion exclusion principle Pigeonhole principle, examples on Pigeonhole principle. 15 Lectures

Unit III: Discrete numeric functions and sum and product of two numeric functions, generating functions, Linear recurrence relations with constant coefficients Particular solutions of linear recurrence relations, Total solutions. 15 Lectures

Unit IV: Ordered sets and lattices Hasse diagrams of posets ,Supremum and infimum ,Isomorphic ordered sets, well-ordered sets,Lattices, Bounded lattices , Distributive lattices, Complements complemented lattices , Boolean algebra, Basic definitions, Basic theorems, duality, Boolean algebras as lattices 15 Lectures

Unit V: Examples, seminars, group discussions on above four units. 15 Lectures

Recommended Books:

3. C. T. Liu : Discrete Mathematics

Reference Books:-

1. Gorrett Birkhoff : Lattice Theory
2. Rich and Brualdi : Combinatorics
Paper: 303  
Title of Paper: Number Theory

15 Lectures

Unit II: Congruences: Properties of Congruences, Linear congruences, Special divisibility tests. Fermats theorem: Fermats factorization method, Little theorem, Wilsons theorem Number theoretic functions: The functions \( \tau \) and \( \sigma \). The Mobius Inversion formula, The greatest integer function.  
15 Lectures

Unit III: Euler’s Generalization of Fermat’s theorem: Euler's phi function, Euler's theorem, properties of phi function, An application to Cryptography. Primitive roots: The order of an integer modulo \( n \).  
15 Lectures

Unit IV: Primitive roots for primes, composite numbers having primitive roots, The theory of Indices. The Quadratic reciprocity law: Eulerian criteria, the Legendre symbol and its properties, quadratic reciprocity, quadratic reciprocity with composite moduli.  
15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  
15 Lectures

Recommended Book:  

Reference Books  
1. S.B.Malik : Baise Number theory Vikas publishing House.  
UNIT– I Classification of linear integral equations, Conversion of initial value problem to Volterra integral equation, Conversion of boundary value problem to Fredholm integral equation, Separable kernel, Fredholm integral equation with separable kernel, Fredholm alternative. Homogeneous Fredholm equations and eigenfunctions.  


Unit V: Examples, seminars, group discussions on above four units.
M. A. / M. Sc. Mathematics (Part II) (Semester III)
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Paper: 305
Title of Paper: Riemannian geometry -I

Unit I: Space of N-dimensions, curves, subspaces and hypersurfaces, transformation of co-
ordinates, summation convention, contravariant vectors, covariant vectors, scalar product of two
vectors, symmetric and skew symmetric tensors, contraction, composition of tensors, Quotient
law, reciprocal symmetric tensor of the second rank, Quadratic forms, real quadratic forms,
Quadratic differential forms. 

15 lectures

Unit II: Riemannian metric, Riemannian space, length of a curve, magnitude of a vector,
inclination of two vectors, orthogonal vectors, co-ordinate hypersurfaces, co-ordinate curves,
field of normals to the hypersurface, n-ply orthogonal system of hypersurfaces, congruences of
curves, orthogonal enuples, Principal directions for a symmetric covariant tensor of the second
rank, Euclidean space of n- dimensions, simple properties.

15 lectures

Unit III: Three index symbols, second derivatives of the x s' with respect to x s', covariant
derivative of a covariant and contravariant vectors, curl of a vector, derived vector in a given
direction, covariant differentiation of tensors, divergence of a vector, Laplacian of a scalar
invariants.

15 lectures

Unit IV: Curvature of a curve, Principal normal, Euler’s conditions, Differential equations of
geodesic, Geodesic co-ordinates, Riemannian co-ordinates, Geodesic form of the linear element.
Parallel displacement of a vector of constant magnitude, parallelism for a vector of variable
magnitude, subspaces of a Riemannian manifold, parallelism in a subspace. Tendency and
divergence of vectors with respect to subspaces or enveloping space.

15 lectures

Unit V: Examples, seminars, group discussions on above four units.

15 Lectures

Recommended Book(s):
1. C. E. Weatherburn: An Introduction to Riemannian Geometry and Tensor Calculus,
   Cambridge University Press, (1963)

Reference Books:
1. J.A. Schouten: Ricci Calculus, Springer Verlag, Berlin
   New York
Paper: 306
Title of Paper: General Relativity I


15 Lectures


15 Lectures

Unit III: Riemannian metric. Generalized Kronecker delta, alternating symbol and Levi-Civita tensor, Dual tensor. Parallel transport and Lie derivative. Geodesic: i) geodesic as a curve of unchanging direction ii) geodesic as the curve of shortest distance and iii) geodesic through variational principle. The first integral of geodesic and types of geodesics. Geodesic deviation and geodesic deviation equation.  

15 Lectures


15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  

15 Lectures

Recommended Book(s):

Reference Books:

15 Lectures

Unit II: Revised simplex method in standard form I, Duality in linear programming duality theorems, Integer linear programming, Gomory’s cutting plane method, Branch and Bound method.  

15 Lectures

Unit III: Dynamic programming. Bellman’s principle of Optimality, solution of problems with a finite number of stages. Application of dynamic programming in production, inventory control and linear programming.  

15 Lectures

Unit IV: Non linear programming unconstrained problems of maximum and minimum Lagrangian method Kuhn Tucker necessary and sufficient conditions, Wolfe’s method, Beale’s method

Unit V: Examples, seminars, group discussions on above four units.  

15 Lectures

Recommended Books:  
1. S.D.Sharma : Operations Research, Kedar Nath Ram Noth and co

Reference Books:-  
4. S.D.Sharma : Nonlinear and Dynamic programming Kedar Nath Ram Nath and Co. Meerut  
Paper: 308
Title of Paper: Lattice Theory –I

Unit I: Basic concepts
1. Posets, Definition and examples of posets.
2. Two definitions of lattices and their equivalence, examples of lattices.
3. Description of Lattices, some algebraic concepts.
5. Homomorphism, Isomorphism and isotone maps.

Unit II: Special types of Lattices
1. Distributive lattices – Properties and characterizations.
3. Congruence relations.

Unit III: Ideal theory
1. Ideals and filters in lattices.
2. Lattice of all ideals I(L).
3. Properties and characterizations of I(L).

Unit IV: Stone algebra
1. Pseudo complemented lattices.
2. S(L) and D(L) – special subsets of pseudo complemented lattices.
3. Distributive pseudo complemented lattice.

Unit V: Examples, seminars, group discussions on above four units.

Recommended Book(s):

Reference Books: ---
M. A. / M. Sc. Mathematics (Part II) (Semester III)
(Choice Based Credit System)
(Introduced from June 2014 onwards)

Paper: 309
Title of Paper: Approximation Theory

Unit – I: Uniform Approximation: Uniform Approximation by Polynomials; The Weierstrass Theorem and Bernstein Polynomial Approximation, Jackson’s Theorems; Characterization of Best Approximations. 15 Lectures

Unit – II: Interpolation: Algebraic Formulation of Finite Interpolation; Lagrange Form; Extended Haar Subspaces and Hermite Interpolation; Hermite-Fejer Interpolation; Divided Differences and the Newton Form. 15 Lectures

Unit–III: Fourier Series: Introduction, Preliminaries, Convergence of Fourier Series, Summability, Convergence of Trigonometric Series, Convergence in Mean. 15 Lectures


Unit V: Examples, seminars, group discussions on above four units. 15 Lectures

Recommended Books:


References Books:

1. Stoponet: Uniform approximation by trigonometric polynomials, VSP, Lriden
Paper: 310
Title of Paper: Dynamical Systems- I

Unit 1: First order systems- Qualitative Analysis:
Introduction; First order linear systems, equilibrium points- classification, stability, bifurcation, phase portraits. Scalar autonomous non-linear systems, Stability (linearization, equilibrium points), phase portraits- slope fields, Examples, two-parameter family.  

Unit 2: Planer systems- Qualitative Analysis:
Second order linear ODE as a system of first order ODEs, preliminaries from algebra, eigen-values and eigen-vectors, solution of planar linear systems. Phase portraits for planar systems: Real distinct eigen-values, complex eigen-values, repeated eigen-values; changing co-ordinates. Classification of planar systems: the trace-determinant plane. 

Unit 3: Higher order systems:
Preliminaries from linear algebra; Higher order ODEs as a vector differential equation; real distinct, complex and repeated eigen-values. Yet another elegant way to find solution: The Exponential of a Matrix (Definition, properties of exponential of a matrix, application to the solution of a system). Non-autonomous systems of the form X’(t)=AX(t) + G(t), Variation of parameters. 

Unit 4: Discrete dynamical systems:
Introduction to the discrete maps (iterative maps), orbit, periodic points, cobweb plots. Fixed points of a map, stability analysis of a fixed point (sink, source, saddle). Bifurcation and chaos; Standard examples (Logistic map, tent map, doubling map). 

Unit 5: Examples, seminars, group discussion on above four units. 

Recommended Book:

Reference Books:
Paper: 311  
Title of Paper: Fluid Dynamics

Unit I: Physical properties of fluids and kinematics of fluids: Concepts of fluids, continuum hypothesis, density, specific weight, specific volume, pressure, viscosity, surface tension, Eulerian & Lagrangian methods of description of fluids, Equivalence Eulerian and Lagrangian method, General motion of a fluid element, Integramility and compatibility conditions, stream lines, path lines, streak lines, stream function, vortex lines, circulation.  
15 Lectures

Unit II. Stresses in fluids: Strain rate tensor, stress tensor, normal stress, shearing stress, symmetry of stress tensor, Transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor. Newtonian fluids, non Newtonian fluids, purely viscous fluids, Constitutive equations.  
15 Lectures

Unit III. Conservation laws: Equation of conservation of mass, equation of conservation of momentum, Navier-Stokes equation, equation of moment of momentum, Equation of energy, Basic equations in different co-ordinate systems: Cartesian co-ordinate system, Cylindrical co-ordinate system, Spherical co-ordinate system, general orthogonal curvilinear co-ordinate system, boundary conditions.  
15 Lectures

Unit IV. Rotational and irrotational flows, Dynamic Similarity: Theorems about rotational and irrotational flows: Kelvins minimum energy theorem, Gauss theorem, Kinetic energy of an infinite fluid, uniqueness of irrotational flows Bernoullis’s equation, Bernoullis equation for irrotational flows, Two dimensional irrotational incompressible flows, Blasius theorem, circle theorem, Sources and sinks, sources, sinks and doublets in two dimensional flows, Methods of images. Dimensional analysis, Non dimensional numbers, some applications of non-dimensional analysis.  
15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  
15 Lectures

Recommended Books:

Reference Books:
2. Fluid Mechanics’ Kundu & Cohen, Elsevier pub 2004
M. A. / M. Sc. Mathematics (Part II) (Semester III)
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Paper: 312
Title of Paper: Graph Theory-I


15 Lectures


15 Lectures


15 Lectures


15 Lectures

Unit V: Examples, seminars, group discussions on above four units.

15 Lectures

Recommended Book(s):

Reference Books:
1. Douglas B.West : Introduction to Graph Theory Pearson Education Asia.
Title of Paper: Fuzzy Mathematics

Unit I: Fuzzy sets and crisp sets, Examples of fuzzy sets, Basic types and basic concepts, Standard operations, cardinality, degree of subsethood, Level cuts. 15 Lectures

Unit II: Representation of Fuzzy sets, Properties of level cuts, Decomposition theorems, Extension principle, Direct and inverse image of a fuzzy set. Properties of direct and inverse images. 15 Lectures

Unit III: Operations on fuzzy sets, Types of operations, Fuzzy complement, Equilibrium and dual point, Increasing and decreasing generators, Fuzzy intersection: t-norms, Fuzzy union: t-conorms, Combination of operators, Aggregation operations. 15 Lectures

Unit IV: Fuzzy numbers, Characterization theorem, Linguistic variables, Arithmetic operations on intervals, arithmetic operations on fuzzy numbers, Lattice of fuzzy numbers, Fuzzy equations. 15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:

Reference Books:-
5. Bojadiev and M. Bojadiev, Fuzzy Logic and Application
Paper: 314  
Title of Paper: Algebraic Topology

Unit I: Homotopy of paths, The fundamental group, covering spaces, the fundamental group of the circle, retractions and fixed points, deformation retracts and homotopy type,  
15 Lectures

Unit II: The fundamental group of $S^n$, fundamental groups of some surfaces, the Jordan separation theorem, the Jordan curve theorem, direct sums of Abelian groups.  
15 Lectures

Unit III: Free products of groups, free groups, the Seifert-van Kampen theorem, the fundamental group of a wedge of circles.  
15 Lectures

Unit VI: Equivalence of covering spaces, the universal covering space, covering transformations, covering spaces of a graph, the fundamental group of a graph.  
15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Book:  

Reference Book:  
Paper: 315
Title of Paper: Measure and Integration

Unit I: Measure and Integration: Measurable space, Measure space and its properties, finite, sigma finite and semi finite measures, complete measure space, Locally measurable sets, saturated measure. Signed measure: Definition, Positive, negative and null sets and their properties, Hahn Decomposition, mutually singular measures, Jordan Decomposition theorem.  
15 Lectures

Unit II: The Caratheodory measure induced by an outer measure. The construction of outer measure. Measurable functions. Integration of a non negative measurable function, Fatou’s lemma, Monotone convergence Theorem, Integrable functions and their properties, Lebesgue convergence Theorem. Integration of general measurable function.  
15 Lectures

Unit III: Absolute or total variation of a signed measure, The Radon Nikodym theorem, Radon – Nikodym derivative, Lebesgue decomposition theorem Product measure, measurable rectangles, Cross sections and their measurabilities, Fubini’s and Tonelli’s theorems.  
15 Lectures

Unit IV: Lp spaces. The completeness of Lp(µ,X). Riesz representation Theorem. Inner measure and its properties  
15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units.  
15 Lectures

Recommended Books:

Reference Books:-
M. A. / M. Sc. Mathematics (Part II) (Semester III)
(Choice Based Credit System)
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Paper: 316
Title of Paper: Topological Vector Spaces

Unit I: Preliminary concepts, linear spaces, topological spaces, mappings, metric spaces, topological vector spaces, separation properties, linear mappings. 15 Lectures

Unit II: Finite dimensional spaces, metrization, boundedness and continuity, seminorm and local convexity, quotient spaces 15 Lectures

Unit III: Completeness, Baire category, The Banach Steinhaus theorem, The open mapping theorem. The closed graph theorem, bilinear mapping. 15 Lectures

Unit IV: Convexity, Hahn Banach theorem, weak topologies, compact convex sets, duality in Banach spaces, compact operators. 15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:
1. Functional analysis by Walter Rudin, Tata McGraw Hill publishing company 1986

Reference Books:
1. Introductory theory of topological vector spaces, Yau-Chuen Wong, Marcel Dekker, Inc, New York 1992
Paper: 317  
Title of Paper: Commutative Algebra I

15 Lectures

Unit II: Modules and module homomorphisms, Submodules and quotient modules, Operations on submodules, Direct sum and product, Finitely generated modules, Exact sequences.  
15 Lectures

Unit III: Tensor product of modules, Restriction and extension of scalars, Exactness properties of the tensor product, Algebras. Tensor product of algebras.  
15 Lectures

Unit IV: Rings and modules of Fractions, Local properties, Extended and contracted ideals in rings of fractions, primary decomposition.  
15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units.  
15 Lectures

Recommended Books:  
1. M. F. Atiyah and I. G. MacDonald – Introduction to Commutative Algebra, Addison Wesley publishing company

Reference Books:  
2. D. G. Northcot, Ideal theory, Cambridge University, press, 1953  
M. A. / M. Sc. Mathematics (Part II) (Semester IV)  
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**Compulsory Papers**

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**Note:**

1. Student from Department of Mathematics, Shivaji University Kolhapur, who has passed Algebra-II at M.Sc. Part-I (AF/Credit System) must opt for Differential Geometry in the place of Field Theory.
2. Student from Sangli centre and Distance mode students, who has passed Algebra - II at M.Sc. Part-I (Regular) must opt for Linear Algebra in the place of Field Theory.
Paper: 401
Title of Paper: Field Theory

Unit I: Field Extensions
Extension of a field, Algebraic extensions, Algebraically closed fields, Derivatives and multiple roots, Finite Fields. 15 Lectures

Unit II: Galois Theory
Separable and normal extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory. 15 Lectures

Unit III: Finite Fields
Prime fields, Fundamental theorem of algebra, Cyclic extensions, Cyclotomic extensions. 15 Lectures

Unit IV: Applications of Galois theory
Constructions by ruler and compass, Solvable groups, Polynomials solvable by radicals. 15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:

Reference Books:
2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
4. A first course in Abstract Algebra by John Fraleigh (3rd edition) Narosa publishing house, New Delhi
M. A. / M. Sc. Mathematics (Part II) (Semester IV)
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Paper: 402
Title of Paper: Partial Differential Equations


15 Lectures

Unit II: Charpits method, Jacobi method of solving partial differential equations, Cauchy Problem, Integral surfaces through a given curve for a linear partial differential equations, for a non-linear partial differential equations, Method of characteristics to find the integral surface of a quasi linear partial differential equations and nonlinear first order partial differential equations.

15 Lectures


15 Lectures


15 Lectures

Unit V: Examples, seminars, group discussions on above four units.

15 Lectures

Recommended Book(s):

Reference Books:
Paper: 403
Title of Paper: Algebraic Number Theory

Unit I: Revision of basic module theory, Fundamental concepts and results, Free modules and matrices, Direct sums of modules, Finitely generated modules over a P.I.D., Equivalence of matrices with entries in a P.I.D., Structure theorem for finitely generated modules over a P.I.D., Applications to abelian groups, Algebraic Numbers, Quadratic and cyclotomic fields. 15 Lectures

Unit II: Factorization into irreducibles, Euclidean quadratic fields. 15 Lectures

Unit III: Prime factorization of ideals, Lattices, Minkowski's theorem. 15 Lectures

Unit IV: Geometric Representation of algebraic numbers, class groups and class numbers, computational methods. 15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:
1. N.Jacobson, Basic Algebra - I, Hindustan Publishing Corporation (India), Delhi (Unit-I)
2. Algebraic Number Theory by I.N. Stewart & D.O. Tall, Academic press. (Chapters 2 to 10) (Unit-II to Unit-IV)

Reference Books:
1. Algebraic Number Theory : Mathematical Pamphlet, TIFR, Bombay.
Paper: 404  
Title of Paper: Fractional Differential Equations

**Unit I:** Brief review of Special Functions of the Fractional Calculus: Gamma Function, Mittag-Leffler Function, Wright Function, Fractional Derivative and Integrals: Grünwald-Letnikov (GL) Fractional Derivatives-Unification of integer order derivatives and integrals, GL Derivatives of arbitrary order, GL fractional derivative of \((t-a)^{\beta}\), Composition of GL derivative with integer order derivatives, Composition of two GL derivatives of different orders. Riemann-Liouville (RL) fractional derivatives- Unification of integer order derivatives and integrals, Integrals of arbitrary order, RL derivatives of arbitrary order, RL fractional derivative of \((t-a)^{\beta}\).

15 Lectures

**Unit II:** Composition of RL derivative with integer order derivatives and fractional derivatives, Link of RL derivative to Grünwald-Letnikov approach, Caputo’s fractional derivative, generalized functions approach, Left and right fractional derivatives. Properties of fractional derivatives: Linearity, The Leibnitz rule for fractional derivatives, Fractional derivative for composite function, Riemann-Liouville fractional differentiation of an integral depending on a parameter, Behaviour near the lower terminal, Behaviour far from the lower terminal.

15 Lectures


15 Lectures


15 Lectures

**Unit V:** Examples, seminars, group discussions on above four units.

15 Lectures

**Recommended Book(s):**

**Reference Books:**
M. A. / M. Sc. Mathematics (Part II) (Semester IV)
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Paper: 405
Title of Paper: Riemannian Geometry -II

Unit I: Ricci’s coefficients of rotation, Curvature of congruence, Geodesic congruences, commutation formula for second derivatives along the arcs of the enuple. Coefficients of rotation, condition for normal congruence, curl of a congruence, congruences canonical with respect to a given congruence.

15 Lectures

Unit II: Curvature of a Riemannian Space: Curvature Tensor and Ricci tensor, covariant curvature tensor, The identity of Bianchi. Riemannian Curvature of a $V_n$ Formula for Riemannian curvature. Theorem of Schur, Mean Curvature of a space for a given direction. Einstein space.

15 Lectures


15 Lectures

Unit IV: Totally geodesic hypersurfaces. Tensor derivative of the unit normal. The equations of Gauss and Codazzi for a Hypersurface, Gauss and Codazzi equations for a hypersurface of a Euclidean space and a space of constant curvature. Hypersurface in Euclidean space. Riemannian curvature of a hypersphere in a Euclidean space. Hyperplanes and hypersphere in a Euclidean space. Geodesics in a space of positive constant curvature. Gauss formulae for subspace $V_n$ of $V_m$, curvature of a curve in a subspace.

15 Lectures

Unit V: Examples, seminars, group discussions on above four units.

15 Lectures

Recommended Book(s):

Reference Books:
1. J. A. Schouten: Ricci Calculus, Springer Verlag, Berlin
2. T. Y. Thomas: Concepts from Tensor Analysis and differential Geometry,
Paper: 406
Title of Paper: General Relativity II

Unit I: The action principle, Einstein’s field equations from action principle and its Newtonian approximation. Poisson’s Equation as an approximation of Einstein’s Field equations. Flat space-time and empty space-time. Local conservation laws associated with perfect fluid distribution, the energy momentum tensor. The stress-energy momentum tensor for perfect fluid, electromagnetic field. Schwarzschild space-time. Spherical symmetry. Einstein field equations under spherical symmetry. Schwarzschild exterior solution. 15 Lectures


Unit IV: Frame components of Riemannian Curvature tensor. Covariant differentiation. Ricci’s rotation coefficients. Cartan’s first equation of structure, Cartan’s second equation of structure. Curvature 2-forms. Bianchi identities in tetrad form, Calculation of tetrad components of Riemann tensor and Ricci tensor of spherically and axially symmetric metrics. 15 Lectures

Unit V: Examples, seminars, group discussions on above four units. 15 Lectures

Recommended Book(s):

Reference Books:
4. Flander: Defferential forms in General Relativity (1963)
M. A. / M. Sc. Mathematics (Part II) (Semester IV)
(Choice Based Credit System)
(Introduced from June 2014 onwards)

Paper: 407
Title of Paper: Operations Research –II

Unit I: Replacement Problems, Failure mechanism of items, Replacement policy for items whose maintenance cost increases with time and money values is constant, Group replacement of items that fail completely.

Unit II: Inventory – Cost involved in inventory problems, variables in inventory problem, symbols in inventory concept of EOQ, Methods with calculus method, Model I (a) The economic lot size system with uniform demand, Model I (b) Economic lot size with different rates of demand in different cycles, Model I (c) Economic lot size with finite Rate of Replenishment, Model II(a) The EOQ with constant rate of demand, scheduling, time constant, Model II (c) The production lot size model with shortages, Probabilistic inventory Models, Instantaneous demand, no set up cost model, Model VI(a) Discrete case, Model VI(b) continuous case.

Unit III: Queuing Theory, Queuing systems, Queuing Problems: transient and steady states, traffic intensity, Probability distributions in Queuing systems Poisson process, Exponential process, Classification of Queuing Models, Model I: (M/M/I) : (∞ /FCFS), Model II (a): General Erlang queuing model.

Unit IV: Information Theory: Communication process, Quantitative measure of information, A binary unit of information, measure of uncertainty of entropy, basic properties of entropy function (H) Joint and conditional entropies, Uniqueness theorem, Chanel capacity, efficiency and redundancy Encoding, Shannon Fano encoding procedure, PERT / CPM: Applications of PERT / CPM techniques, Network diagram, representations. Rules for constructing the Network diagram, determination of the critical path.

Unit V: Examples, Seminars and group discussion on the above four units.

Recommended Books:

Reference Books:
4. S.D. Sharma: Nonlinear and Dynamic programming Kedar Nath Ram Nath and Co. Meerut
M. A. / M. Sc. Mathematics (Part II) (Semester IV)
(Choice Based Credit System)
(Introduced from June 2014 onwards)

Paper: 408  
Title of Paper: Lattice Theory –II

**Unit I:** Congruences and Ideals: Week projective and congruences, Distributive, Standard and Neutral elements, Distributive, Standard and Neutral Ideals, Structure Theorems. 15 Lectures

**Unit II:** Modular and Semimodular Lattices: Modular lattices, Semimodular Lattices, Geometric lattices, Partition of Lattices, Complemented modular Lattices, Direct decompositions, Jordon – Holder theorem, Kurosh – Ore theorem, Ore’s theorem, sub group lattices. 15 Lectures

**Unit III:** Semimodular Lattices with Finite Length: Rank and covering Inequalities, Embeddings, Geometric closure operators, Semimodular Lattices and selectors, consistent semimodular lattices, Pseudomodular lattices 15 Lectures

**Unit IV:** Local Distributivity and Modularity: The characterization of Dilworth and Crawley, Avann’s characterization Theorem, Meet-distributive lattices and Convexity, The Kurosh-Ore Replacement property Dually consistent semimodular lattices, Lattices of subnormal subgroups. 15 Lectures

**Unit V:** Examples, seminars, group discussions on above four units. 15 Lectures

**Recommended Book(s):**

**Reference Books:**
Paper: 409
Title of Paper: Wavelet Analysis

15 Lectures

Unit II: The continuous wavelet transform: Wavelet transform, Definitions and examples, A Plancherel formula, Inversion formulas, The kernel function, Decay of the wavelet transform  
15 Lectures

Unit III: Frames: Geometrical considerations, The general notion of a frame, The discrete wavelet transform  
15 Lectures

Unit IV: Multiresolution analysis: Axiomatic description, The scaling function, Constructions in the Fourier domain, Orthonormal wavelets with compact support.  
15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units.  
15 Lectures

Recommended Book(s):

Reference Books:
1. Mark A. Pinsky : Introduction To Fourier Analysis and Wavelets
Paper: 410  
Title of Paper: Dynamical Systems- II

Unit I: Basic concepts of nonlinear dynamics:  
Introduction, Historical developments; Autonomous system of nonlinear ODEs: fundamental existence and uniqueness of solution; dependence of solution on initial conditions and parameters; The maximal interval of existence.  
15 Lectures

Unit II: Stability analysis:  
The flow defined by a differential equation; Linearization; Stable manifold theorem; Hartman-Grobman theorem; Stability and Lyapunov functions; Bifurcation.  
15 Lectures

Unit II: Chaos:  
Concept, properties; Limit sets and attractors; Poincare-Bendixson theorem, The Poincare map, Lyapunov exponents in flows, Numerical computation of Lyapunov exponents, Examples: Lorenz system, Chua circuit, Rossler attractor; Forced oscillators; Chaos synchronization.  
15 Lectures

Unit IV: Applications and computer experiments:  
Application of chaos to secure communication; Introduction to fractals; Use of computer softwares to solve problems in Dynamical Systems: Solving linear and nonlinear systems; data visualization-2D and 3D plots, vector field plots, chaotic phase portraits; solving discrete systems- cobweb plots.  
15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  
15 Lectures

Recommended Book(s):  

Reference Books:  
Paper: 411  
Title of Paper: Computational Fluid Dynamics

Unit I. Comparison of experimental, Theoretical and numerical approaches, Governing equations, continuity equation, momentum equation (in inviscid, viscous flows) energy equation, incompressible viscous flow, laminar boundary layer flow.  


Unit III: Stability, Convergence & consistency at finite difference scheme, Explicit, Implicit and Crank-Nicolson methods for heat equation, Von Neumann analysis, Euler’s explicit method, Upstream differencing method, Lax method, Euler implicit method for wave equation. Finite difference representation of Laplace equation, five point method.

Unit IV: Burgers equation (inviscid) Lax method, implicit methods, Burgers equation (viscous) FTCS method, Briley – McDonald method, Convergence and stability, Grid generation, orthogonal grid generation, order of magnitude analysis, flow in a straight rectangular duct, flow in a curved rectangular duct. Introduction to Finite Element Methods (FEM)

Unit V: Examples, Seminars and group discussion on the above four units.

Recommended Book(s):
1. Computational Fluid Dynamics’ Chung 2002 Cambridge University, Press.

Reference Books:
Paper: 412
Title of Paper: Graph Theory-II

Unit – I Preliminaries, Incidence Matrix: Rank, Minors, Path Matrix, Integer generalized inverse, Moore-Perose inverse, 0-1 incidence matrix, Matchings in bipartite graphs.

Unit – II Adjacency Matrix, Eigenvalues of some graphs, Determinant, Bounds, Energy of graph, Antiadjacency matrix of directed graph, nonsingular trees.


Unit V: Examples, seminars, group discussions on above four units.

Recommended Book(s):

Reference Books:
1. Douglas B. West : Introduction to Graph Theory Pearson Education Asia.
M. A. / M. Sc. Mathematics (Part II) (Semester IV)
(Choice Based Credit System)
(Introduced from June 2014 onwards)

Paper: 413
Title of Paper: Fuzzy Relations and Logic

Unit-I: Projections and cylindrical Extensions Binary Fuzzy Relations on single set, Fuzzy equivalence relations, Fuzzy Compatibility Relations, Fuzzy ordering Relations Fuzzy morphisms Sup-i compositions and inf-w; compositions 15 Lectures

Unit – II: Fuzzy Relation Equation, Problem Partitioning, solution methods, Fuzzy relational equations based on sup-I and inf-wi compositions, Approximate solutions 15 Lectures

Unit – III: Fuzzy propositions. Fuzzy Quantifiers, Linguistic Hedges, Inference from conditional fuzzy propositions, Qualified and quantified propositions 15 Lectures


Unit – V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:

Reference Books:-
Paper: 414
Title of Paper: Analysis on Manifolds

Unit I: Change of variables theorem: Diffeomorphisms in $\mathbb{R}^n$, proof of the change of variables theorem, Application.  

Unit II: Manifolds: the Volume of a parallelepiped, volume of a parametrized manifold, manifold in $\mathbb{R}^n$, the boundary of a manifold, integration on a manifold.  

Unit III: Differential forms: Multilinear algebra, alternating tensors, wedge product, tangent vectors and differential forms, the differential operator, action of differential map.  

Unit IV: Stokes theorem: Integrating forms over parametrized manifolds, orientable manifolds, integrals over orientable manifolds, Stokes theorem.  

Unit V: Examples, seminars, group discussion on above four units.  

Recommended Book:

1. Analysis on Manifolds by J.R. Munkers (Addision Wesely) Section 18-37  

Reference Book:

M. A. / M. Sc. Mathematics (Part II) (Semester IV)  
(Choice Based Credit System)  
(Introduced from June 2014 onwards)  

Paper: 415  
Title of Paper: Combinatorics  

Unit I: The sum Rule and the product Rule, Permutations and combinations, The Pigeonhole Principle, Ramsey Numbers, Catalan Numbers, Stirling Numbers.  

Unit II: Generalized Permutations and combinations, Multinomial Theorem, The Inclusion – Exclusion principle, Sieve’s formula, Derangements, System of Distinct Representatives (SDR), Combinatorial Number theory.  

Unit III: Rook-Polynomial, Ordinary and Exponential generating functions, Partitions of a positive integer, Recurrence Relations, Fibonacci sequence.  


Unit V: Examples, Seminars and group discussion on the above four units.  

Recommended Book(s):  
1. V.K. Balakrishnan Schum’s Outline of Theory and problems of combinatorics. Schum’s Outline Series Mc. Grew Hill INC  

Reference Books:  
1. Alan Tucker – Applied Combinatorics. – John Willey Sons.  
2. Sharad Sane- Combinatorial Techniques-Hindustan Book Agency
Paper: 416
Title of Paper: Theory of Distributions

Unit I: Locally convex spaces, topological vector spaces, seminorms, locally convex spaces, examples of locally convex spaces.  15 Lectures

Unit II: Test functions and distributions: space of test functions, distributions, Differentiation of distributions, convergence of distributions, Multiplication by smooth functions.  15 Lectures

Unit III: Local properties of distributions, Distributions of finite order, distributions defined by powers of x, dual spaces of $C^\infty(\Omega)$, tensor product.  15 Lectures

Unit IV: Distribution with compact support, convolution, regularization of distributions, local structure of distributions, Applications to differential equations.  15 Lectures

Unit V: Examples, seminars, group discussions on above four units.  15 Lectures

Recommended Book(s):

Reference Book(s):
1. Functional analysis, Walter Rudin, Tata McGraw Hill publishing company 1986
2. Distribution Theory and transform analysis, A.H. Zemanian, Dover publication 1987
Paper: 417
Title of Paper: Commutative Algebra – II

Unit I: Integral dependence, The going-up theorem. Integrally closed integral domains. The going-down theorem. Valuation rings. 15 Lectures

Unit II: Chain Conditions and theorems. 15 Lectures

Unit III: Noetherian Rings, Primary decomposition in Noetherian ring, Artin Rings. 15 Lectures

Unit IV: Discrete valuation rings, Dedekind domains, Fractional ideals. 15 Lectures

Unit V: Examples, Seminars and group discussion on the above four units. 15 Lectures

Recommended Books:
1. M. F. Atiyah and I. G. MacDonald – Introduction to Commutative Algebra, Addison Wesley publishing company

Reference Books:
2. D. G. Northcot, Ideal theory, Cambridge University, press, 1953