RayatShikshanSanstha's

SadguruGadageMaharajCollege,Karad

(An Autonomous College)

Proposed syllabus for Autonomy

M. Sc. Mathematics (Part II)

(Choice Based Credit System)

(Introduced from June 2020 onwards)

Scheme of the Programme

Name of the Programme : M.Sc.(MATHEMATICS)

SEMESTER-III

Course Code	**Course Type**	**Name of the course**	**Credits**
MMT 301	Core	Algebra-II	05
MMT 302	Core	Partial Differential Equations	05
Select any three courses from Electives			
MMT 303	Elective	Number Theory	05
MMT 304	Elective	Integral Equations	05
MMT 305	Elective	Operations Research I	05
MMT 306	Elective	Lattice Theory I	05
MMT 307	Elective	Graph Theory I	05
MMT 308	Elective	Fuzzy Mathematics I	05
		Total Credits	**25**

Evaluation Structure

Class M.Sc.-II (Mathematics)

SEMESTER III

	ESE	Internal Exam		Submission		Total
		ISE-I (Online Test)	ISE-II	Project-I/Seminar	Day to day performance	
CourseXI	90	10	15	15	10	
CourseXII	90	10	15			
CourseXIII	90	10	15			
Course XIV	90	10	15			
Course XV	90	10	15			
Total	**450**	**50**	**75**	**15**	**10**	**600**

SEMESTER IV

	ESE	Internal Exam		Submission		Total
		ISE-I (Online Test)	ISE-II	Project-I/Seminar	Day to day performance	
Course XVI	90	10	15	15	10	
Course XVII	90	10	15			
Course XVIII	90	10	15			
Course XIX	90	10	15			
Course XX	90	10	15			
Total	**450**	**50**	**75**	**15**	**10**	**600**

M. Sc. Mathematics (Part II) (Semester III)
(Choice Based Credit System)
(Introduced from June 2020 onwards)

Paper: MMT 301

Title of Paper: Algebra-II

Course Objectives:

1. To look in details at the theory of fields as applied to one of the earliest motivational problems of algebra, solving polynomial equation.
2. To develop one of the most beautiful gems of mathematics, the GaloisTheory of polynomial equations.
3. To the extend that we can answer and understand why is there no general formula giving the roots of general polynomial of degree five or higher.
4. Describe the structure of finite field.
5. Do computations in specific examples of finite fields.

Unit I **15 L**

Extension of a field, Algebraic extensions, Algebraically closed fields, Derivatives and multiple roots,Finite Fields.

Unit II **15 L**

Separable and normal extensions, Automorphism groups and fixed fields, Fundamental theoremof Galois Theory.

Unit III **15 L**

Prime fields, Fundamental theorem of Algebra, Cyclic extensions, Cyclotomic extensions.

Unit IV **15 L**

Constructions by ruler and compass, Solvable groups, Polynomials solvable by radicals.

Course Outcome:

Upon successful completion of this course, the student will be able to:

1. Determine the basis and degree of a field over its subfield.
2. Construct splitting field for the given polynomial over the given field.
3. Find primitive n^{th} roots of unity and n^{th} cyclotomic polynomial.
4. Make use of Fundamental Theorem of Galois Theory and Fundamental Theorem of Algebra to Solve problems in Algebra.
6. Apply Galois Theory to constructions with straight edge and compass.

Recommended Book:

1.P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, UK.(Asian edition) 2005.

Reference Books:

1. **Nathan Jacobson**, Basic Algebra I, second edition, W. H. Freeman and company, New York
2. **I. N. Herstein**, Topics in Algebra, 2nd Edition Reprint, Wiley India Pvt.Ltd,2006.
3. **U. M. Swamy, A. V. S. N. Murthy**, Algebra: Abstract and Modern, Pearson Education, 2012
4. **John B.Fraleigh**, A first course in Abstract Algebra 6th EditionNarosa Publishing House, New Delhi .
5. **I. T. Adamson**, Introduction to Field Theory, second edition, Cambridge University Press, 1982.
6. **M. Artin**, Algebra, PHI, 1996
7. **Ian Stewart**, Galois Theory,4th Edition,CRC Publication,2015

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 302

Title of Paper: Partial Differential Equations

Course Objectives :

1. To introduce students to Partial differential equations.
2. To introduce students to how to solve linear partial differential with different methods.
3. To define various methods for solving nonlinear partial differential equations.
4. Solve Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Riemann's Method of solution of Linear Hyperbolic equations.

Unit I **15 L**

Curves and surfaces, First order Partial Differential Equations, , classification of firstorder Partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian Differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible Systems of first order partial differential equations.

Unit II **15 L**

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 ofa quasi linear partial differential equations and nonlinear first order partial differential equations.

Unit III **15 L**

Second order Partial Differential Equations. Origin of Partial differential equation, wave equations,Heat equation. Classification of second order partial differential equation.
Vibration of an infinitestring (both ends are not fixed) Physical Meaning of the solution of the wave equation. Vibration ofasemi infinite string, Vibration of a string of finite length, Method of separation of variables,Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod, Cauchy problems.

Unit IV **15 L**

Families to equipotential surfaces, Laplace equation, Solution of Laplace equation, Laplace Equation in polar form, Laplace equation in spherical polar coordinates. Kelvin's inversion Theorem. Boundary Value Problems: Dirichlets problems and Neumann problems.
Maximum and Minimum principles, Stability theorem.
Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane,Riemann's Method of solution of Linear Hyperbolic equations,Harnacks theorem.

Course Outcomes:

Upon successful completion of this course, the student will be able to:
1. Determine the complete solution of Partial Differential Equations
2. Find the integral surface of a quasi linear partial differential equations.

3. Explore the use of partial differential equation as models for processes wave Equation.
4. Student will identify the types of Partial differential equation and apply the method tosolve system of equations.

Recommended Book:

1.**T. Amaranth**, An elementary course in Partial differential equations, Narosa publication, 1987.

Reference Books:

1. **Fritz John**, Partial Differential Equations 4thEdition, Springer Science & Business Media, 1991
2. **I.N. Sneddon**, Elements of Partial Differential Equations, Dover Publication 2013.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 303

Title of Paper : Number Theory

Course Objectives:

1. To expose students to this beautiful theory.
2. To understand what inspired this quote from Gauss.
3. To allow students to Number theory as a creative, empirical science.
4. To show Fundamental theorem of Arithmetic and Euler's Generalization of Fermat's theorem.

Unit I **15 L**

Review of divisibility: The division algorithm,G.C.D.
Euclidean algorithm, Diophantine equationax + by = c.
Primes and their distribution : Fundamental theorem of Arithmetic, The Goldbach Conjecture.

Unit II **15 L**

Congruence, Properties of Congruences, Linear Congruence, Special divisibility tests.
Fermat's theorem, Fermat's factorization method, Little theorem, Wilson's theorem Number Theoretic functions: The functions τ and σ. The Mobius Inversion formula,The greatest integer function.

Unit III **15 L**

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 aninteger modulo n.

Unit IV **15 L**

Primitive roots for primes, composite numbers having primitive roots, The theory ofIndices.
The Quadratic reciprocity law Eulerian criteria, the Legendre symbol and its properties,
Quadratic reciprocity, quadratic reciprocity with composite moduli.

Course Outcomes:

Successful completion of this course will enable you to.

1. Prove results involving divisibility of gcd
2. Solve the system of linear congruence's.
3. Find integral solutions to specify linear congruence's Apply Euler, Fermat's theorem to prove relations involving prime numbers.
4. Apply the Wilsons theorem to find the last digit of given number.

Recommended Book

1. **D. M. Burton**, Elementary Number Theory,7^{th} Edition ,Universal book stall, New Delhi,2015.

Reference Books

1. **S. B. Malik**, Basic Number theory 2nd Revised Edition,Vikas Publishing House,2005
2. **George E. Andrews**, Number theory, Hindusthan Pub. Corp,1972
3. **I.Niven, H. S. Zuckerman, H. L. Montgomery**, An Introduction to Theory of Numbers, 5^{th}Edition .John Wiley & Sons,1991.
4. **S. G. Telang, M. Nadkarni, J. Dani**, Number Theory, Tata McGraw-Hill Publishing Co. New Delhi, 2001.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 304

Title of Paper : Integral Equations

Course Objectives :

1. To introduce the student to a number of fundamental mathematical ideas and techniques that lie at the core of integral equation approach of problem solving.
2. To find numerical solutions of integral equations as well as on solving elliptical boundary value problems.
3. Find the solutions of Fredholm integral equations and its various methods.
4. To learn Applications of Laplace and Fourier transforms to solutions of Volterra integral equations.

Unit I **15 L**

Classification of linear integral equations, Conversion of initial value problem toVolterra integral equation, Conversion of boundary value problem to Fredholm integral equation, Separable kernel,Fredholm integral equation with separable kernel, Fredholm alternative, Homogeneous FredholmEquations and Eigen functions.

Unit II **15 L**

Solutions of Fredholm integral equations by: Successive approximations Method,Successive substitution Method, Adomain decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties, Solutions of Volterra integral Equations, Successive approximations method, Neumann series, Successive substitution Method.

Unit III **15 L**

Solution of Volterra integral equations by Adomian decomposition method, and theModified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels, Applications of Laplace and Fourier transforms to solutions ofVolterra integral equations, Symmetric Kernels**:** Fundamental properties of eigenvalues andeigenfunctions for Symmetric kernels, expansion in eigenfunctions and bilinear form.

Unit IV **15 L**

Hilbert Schmidt Theorem and its consequences, Solution of symmetric integralequations, Operator method in the theory of integral equations, Solution of Volterra and Fredholm integrodifferential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems.

Course Outcomes:

On completion of this module, the learner will be able to:

1.Solve the integrodifferential equation.

2. Convert integral equations to ordinary differential equation and vice versa.
3. Solve linear and non-linear integral equations by using different methods.
4. Fundamental Mathematical ideas and techniques that lie at thecore of integral equations are known.

Recommended Books :

1.R. P. Kanwal, Linear Integral Equation- Theory and Technique, Academic Press, 1971.

2.Abdul-MajidWazwaz, Linear and Nonlinear Integral Equations-Methods and Applications.Springer, 2011.

Reference Books:

1. **L. G. Chambers**, Integral Equations- A Short Course, International Text Book Company, 1976.
2. **M. A. Krasnov**, et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
3. **C. D. Green**, Integral Equation Methods, Thomas Nelson and sons, 1969.
4. **J. A. Cochran**, The Analysis of Linear Integral Equations, McGraw Hill Publications, 1972.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 305

Title of Paper: Operations Research I

Course Objectives :

1. To introduce the students how to use variables for formulating complex mathematical models in management science, and transportation problem.
2. To introduce the students to the advanced methods for large-scale transportation.
3. To introduce the students to the basic methodology for the solution of linear programs.
4. To introduce Kuhn Tucker, Wolfe's method and Beale's method for solving Non-linear programming.

Unit I **15 L**

Convex sets and their properties. Lines and hyper planes convex set Important Theorems, polyhedral convex set Convex combination of vectors, convex hull, Convex polyhedron, convexcone, simplex and convex function, General formulation of linear programming Matrix form of LP Problem, definitions of standard LPP, Fundamental Theorem of linear programming. Simplex method, computational procedure of simplex method, problem of degeneracy and method toResolve degeneracy.

Unit II **15 L**

Revised simplex method in standard form I, Duality in linear programming duality theorem, Integer linear programming, Gomory's cutting plane method, Branch and Bound and linear Programming.

Unit III **15 L**

Dynamic programming. Bellman's principle of optimality, solution of problems with afinite number of stages. Application of dynamic programming in production, inventory control.

Unit IV **15 L**

Non-linear programming unconstrained problems of maximum and minimumLagrangian methodKuhn Tucker necessary and sufficient conditions, Wolfe's method, Beale's method.

Course Outcomes:

Upon successful completion of this course, the student will be able to

1. To develop linear programming (LP) models for shortest path, maximum flow, minimal spanning tree, critical path.
2. Use some solution methods for solving the nonlinear and linear optimization problems.
3. Construct linear programing models and discuss the solution techniques.
4. Analyze the general nonlinear programing models.
5. Derive the Khun-Tucker optimality conditions.

Recommended Book:

1. **S.D.Sharma,Himanshu Sharma** ,Operations Research Theory ,Methods and Applications, KedarNath Ram Noth,2010.

Reference Books:

1.KantiSwarup, P.K.Gupta and Manmohan, Operations research, S.Chand & Sons, New Delhi 2001.

2. **Hamady. A.Taha**, Operations Research10th Edition, Pearson 2017.
3. **P. K. Gupta, D. S. Hira**, Operations Research 7th Edition, S.Chand Publication 1976.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 306

Title of Paper: Lattice Theory –I

Course Objectives :

1. Student will gain the knowledge of basic theories of lattices and their equivalence.
2. Apply the methods for characterizing distributive lattices.
3. Define Pseudo complemented lattices and its special subsets of pseudo complemented lattices.
4. To show ideas from lattice theory can be used in the implementation of a knowledge representation language.

Unit I **15 L**

Posets, Definition and examples of posets, definitions of lattices and their equivalence, examples of lattices, description of Lattices, some algebraic concepts, duality principle, Specialelements, homomorphism, Isomorphism and isotone maps.

Unit II **15 L**

Distributive lattices – Properties and characterizations, Modular lattices – Properties and Characterizations, Congruence relations, Boolean algebras – Properties and characterizations.

Unit III **15 L**

Ideals and filters in lattices, Lattice of all ideals I(L), Properties and characterizations of I(L), Stone's theorem and its consequences.

Unit IV **15 L**

Pseudo complemented lattices, S(L) and D(L) – special subsets of pseudo complemented lattices,Distributive pseudo complemented lattice, Stone lattices – properties and Characterizations.

Course Outcomes:

Upon successful completion of this course, the student will be able to:

1. Understand the relation between Posets and Lattice.
2. Study the basic Properties and characterizations of Lattice .
3. Understand and apply the Distributive pseudo complemented lattice.
4. Implemented computationally tractable representation of a finite distributive lattice.

Recommended Book:

1. **George Gratzer, W. H. Freeman**, First concepts and distributive lattices by and company,

San Francisco 1971.

Reference Book:

1. **G. Birkhoff, Amer**, Lattice Theory Math. Soc. Coll. Publications, 3rdEdition ,1973.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.

3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 307
Title of Paper: Graph Theory-I

Course Objectives:

1. To understand and apply fundamental concepts in Graph theory.
2. To apply graph theory based tools in solving practical problems.
3. To design and implement algorithms to solve large scale combinatorial optimization problems resulting in explosive growth in this field.
4. Understand some applications of graph theory to practical problems and other branches of Mathematics.

Unit I **15 L**

Trees and connectivity: Definitions and simple properties, Bridges, spanning trees, cut vertices and Connectivity. Euler Tours: Euler graphs, Properties of Euler graph, The Chinesepostman problem.

Unit II **15 L**

Hamiltonian Cycles, Hamiltonian graphs, The travelling salesman problem, Matching's and Augmenting path, The marriage problem, The Personal Assignmentproblem.

Unit III **15 L**

The Optimal Assignment problem, A Chinese postman Problem, Postscript, PlanerGraphs : Plane and Planar graphs, Euler's formula, Platonic bodiesKurotowskis theorem, Non Hamiltonian plane Graphs, The dual of a plane graph.

Unit IV **15 L**

Colouring: Vertex coloring, vertex coloring algorithms, critical graphs, cliques, Edgecoloring, Map coloring, Directed graphs: Definition, Indegree and outdegree, Tournaments, traffic flow. Networks : Flows and Cuts, The Ford and Fulkerson Algorithm, Separating seen.

Course Outcomes:

Upon successful completion of this course, the student will be able to:

1. Solve problems using basic graph theory.
2. Determine whether graph are Hamiltonian or planar.
3. Solve problems using vertex and edge colouring.
4. Construct models of real word problem using graph theory.

Recommended Book:

1. **John Clark and Derek Holton**, A first look at graph theory, World Scientific Publishing Co Pt Ltd, 1991.

Reference Books:

1. **Douglas B.West**, Introduction to Graph Theory,2nd Edition , Pearson Education Asia,2001.
2. **F. Harary**,Graph Theory, Narosa Publishing House 1989.
3. **K. R. Parthsarthy** , Basic Graph Theory, Tata McGraw Hill publishing Co.Ltd.New Delhi,1994.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.
3. General/specific instructions for Laboratory safety should be given whenever necessary.

Paper: MMT 308
Title of Paper: Fuzzy Mathematics -I

Course Objectives:

1. To introduce the basic structure of fuzzy sets and classical sets.
2. To Show Decomposition theorems, Extension principle of fuzzy sets.
3. To teach the students the need of fuzzy sets, fuzzy relations and its applications.
4. Construct the appropriate fuzzy theory corresponding to uncertain and imprecise collected data.

Unit I **15 L**

Fuzzy sets and crisp sets, Examples of fuzzy sets, Basic types and basic concepts, Standard operations, Cardinality, degree of subsethood, Level cuts.

Unit II **15 L**

Representation of Fuzzy sets, Properties of level cuts, Decomposition theorems, Extension principle, Direct and inverse image of a fuzzy set. Properties of direct and inverseimages.

Unit III **15 L**

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.

Unit IV **15 L**

Fuzzy numbers, Characterization theorem, Linguistic variables, Arithmetic operationson Intervals, Arithmetic operations on fuzzy numbers, Lattice of fuzzy numbers, Fuzzy equations.

Course Outcomes :

1. Gain the main subject of fuzzy sets .
2. Decide the difference between crisp sets and fuzzy sets .
3. Make calculation on fuzzy set theory.
4. Make application on fuzzy logic membership function and fuzzy inference systems.
5. Evaluate the fuzzy statistical problems.

Recommended Book:

1.**George J. Klir, Bo Yuan,** Fuzzy sets and Fuzzy Logic. Theory and Applications, PHI.Ltd.2000

Reference Books:

1. **M. Grabish, Sugeno**, Murofushi Fuzzy Measures and Integrals theory and Applications, PHI, 1999.

2. **H.J.Zimmerermann**, Fuzzy set Theory and its Applications, Kluwer, 1984.

3. **M. Hanss**, Applied Fuzzy Arithmetic, An Introduction with Engineering Aplications, Springer-Verlag Berlin Heidelberg 2005.
4. **M. Ganesh**, Introduction to Fuzzy sets & Fuzzy Logic, PHI Learning Private Limited, New Delhi 2006.
5. **Timothy J. Ross**, Fuzzy Logic with Engineering Applications, 3rd Edition, John Wiley and Sons, 2011.

Paper: MMT 401

Title of Paper : Functional Analysis

Course Objectives:

5. The Study of the main properties of bounded operators between Banach and Hilbert spaces.
6. The basic result associated to different types of converges in normed spaces.
7. They will demonstrate the knowledge of the properties of a Hilbert spaces.
8. Define and thoroughly explain Banach and Hilbert spaces and self-adjoint operators
9. Identify and independently use contractions of Banach spaces.

Note: 1. The details of field work ,seminars, Group discussions and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars.

3. General/specific instructions for Laboratory safety should be given whenever necessary.

Unit I **15 L**

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.

Unit II **15 L**

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.

Unit III **15 L**

Hilbert spaces: examples and elementary properties, Orthogonal complements, The projection theorem, Orthogonal sets, The Bessel's inequality, Fourier expansion and Perseval's equation, separable Hilbert spaces, The conjugate of Hilbert space, Riesz's theorem, The adjoint of an operator

Unit IV **15 L**

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.

Course Outcome:

Upon successful completion of this course students will

1. To learn and recognize the fundamental properties of normed spaces and transformations between them
2. To be acquainted with the statement of the Hahn-Banach theorem and its corollaries
3. To understand the notion of dot product and Hilbert spaces.
4. To apply the spectral theorem to the resolution of integral equations
5. To learn to use properly the specific techniques for bounded operators over normed spaces

Recommended Book

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

Reference Books

1. **Erwin Kreyszig**, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978
2. **G. Bachman and L. Narici**, Functional Analysis, Academic Press, 1972.
3. **A. E. Taylor**, Introduction to Functional analysis, John Wiley and sons,1958.
4. **J. B. Convey**, A course in Functional Analysis, Springer-Verlag, 1985.
5. **B. V. Limaye**, Functioned Analysis, New age international, 1996

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Paper: MMT 402

Title of Paper : Advanced Discrete Mathematics

Course Objectives:

1. Solve discrete probability problems and use set to solve problems in combinatorics and probability theory.
2. Determine if a given graph is simple or a multigraph, directed or undirected graph, cyclic or acyclic, and determine the connectivity of a graph.
3. Determine if graph has an Euler or a Hamiltonian path or circuit.
4. Define Pigeonhole principle and solve problems related to this.
5. Identify the types of Lattice and find suprimum and infimum.

Unit I **15 L**

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.

Unit II **15 L**

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.

Unit III **15 L**

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.

Unit IV **15 L**

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

Course Outcome:

Upon successful completion of this course students will able to .

1. Students will gain advanced knowledge of Advanced Discrete Mathematics.
2. Ability to engage with unfamiliar problems and identify relevant solution strategies.
3. Ability to construct and express logical arguments and to work in abstract.
4. Student will able to model and solve real-world problems using graphs and trees.
5. Demonstrate and justify relationship of various graphs.

Recommended Book

1. **Seymon Lipschutz and Mark Lipson** ,Discrete Mathematics 2nd by.Tata Mc Graw Hill

Publishing Company Ltd. New Delhi
2. **John Clark and Derek Holton** ,A first book at Graph Theory Applied Publishers Ltd

Reference Books

5. Gorrett Birkhoff : Lattice Theory
6. Rich and Brualdi : Combinatorics

Paper: MMT 403

7. S. G. Telang, M. Nadkarni, J. Dani, Number Theory, Tata McGraw-Hill Publishing Co. New Delhi, 2001.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.
2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Title of Paper : Algebraic Number Theory

Course Objectives:

1. Define algebraic numbers and algebraic integers and find its integral basis.
2. Determine the relationship between factorization of numbers and of ideals.
3. Classify the existence of factorization and norms.
4. Describe the properties of number field and its extensions.
5. Compute the class number and fitness of class group.

Unit I **15 L**

Revision of rings, polynomial rings and fields, Field extensions, Symmetric polynomials, Modules, Free Abelian groups.

Unit II **15 L**

Algebraic Numbers, Algebraic number fields, Conjugates and Discriminants, Algebraic integers, Integral Bases, Norms and Traces, Ring of integers, Quadratic fields, Cyclotomic fields.

Unit III **15 L**

Factorization into irreducible, Noetherian rings, Dedekind rings, Examples of Non- Unique factorization into irreducible, Prime factorization, Euclidean Domains, Euclidean quadratic fields.

Unit IV **15 L**

Ideals, Prime factorization of ideals, Norm of an ideal, Nonunique factorization in cyclotomic fields, Two-squares theorem, Four-squares theorem, class groups and class numbers, Finiteness of the Class groups.

Course Outcome:

Upon successful completion of this course students will able to:

1. Understand properties of number fields.
2. Student will learn about the arithmetic of algebraic number fields.
3. They will learn to prove theorem about integral bases, and about unique factorization in to ideals.
4. They will learn to calculate class numbers.
5. Find the Relationship between factorization of number and of ideals.

Recommended Book

1. **I. Stewart and D. Tall**, Algebraic Number Theory and Fermat's last theorem, 3rd Edition 2002.

Reference Books

1. **N. Jacobson**, Basic Algebra - I, Dover Publications, Second edition 2012.
2. **Murty, M. Ram, Esmonde, Jody Indigo**, Problems in Algebraic Number Theory, Springer 2008.
3. **J. Neukirch,** Algebraic Number Theory, Grundlehren der mathematischen Wissenschaften 1999th Edition

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given

Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Paper: MMT 404

Title of Paper : Fractional Differential Equations

Course Objectives:

1. Identify the types of Fractional Differential Equations and select and apply the appropriate analytical technique for finding the solution.
2. Show existence and uniqueness of solution.
3. Apply Mellin transforms of fractional derivatives-Mellin transforms of the Riemann-Liouville fractional integrals and fractional derivative.
4. Find the solution of FDE by using Laplace transform method.
5. Create and analyse mathematical models using fractional derivatives to solve application problems such as harmonic oscillators and circuits.

Unit I **15 L**

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 ofarbitrary order, RL derivatives of arbitrary order, RL fractional derivative of $(t-a)^{\beta}$

Unit II **15 L**

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.

Unit III **15 L**

Laplace transforms of fractional derivatives- Laplace transform of the Riemann-Liouville fractional derivative, Caputo derivative and Grünwald-Letnikov fractional derivative. Fourier transforms of fractional integrals and derivatives. Mellin transforms of fractional derivatives-Mellin transforms of the Riemann-Liouville fractional integrals and fractional derivative, Mellin transforms of Caputo derivative.

Unit IV **15 L**

Existence and uniqueness theorem: Linear fractional differential equations (FDE),Fractional

differential equation of a general form, Existence and uniqueness theorem as a method of solution. Dependence of a solution on initial conditions. Methods of solving FDE's: The Laplace transform method. The Mellin transform method, Power series method

Course Outcome:

Upon successful completion of this course students will able to:

1. Understand G-L and RL-fractional integral and evaluate fractional integrals of some common functions
2. RL and Caputo-fractional derivatives and evaluate fractional derivatives of some common functions
3. To Solve Linear Fractional differential Equation using the Laplace and Mellin transform.
4. The study of fractional differential

Recommended Book

1. Igor Podlubny, Fractional differential equations. San Diego, Academic Press 1999.

Reference Books

1. **A. Kilbas, H.M. Srivastava, J.J. Trujillo**, Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam, 2006.
2. **Kai Diethelm**, The Analysis of Fractional Differential Equations, Springer, 2010.
3. **L. Debnath, D. Bhatta**, Integral Transforms and Their Applications, CRC Press, 2010.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Paper: MMT 405

Title of Paper : Combinatorics

Course Objectives:

1. To introduce topics and techniques of discrete methods and combinatorial analysis.
2. To introduce a large variety of application and through some of them, Ramsey Numbers, Catalan Numbers and Stirling Numbers.
3. To develop combinatorial approach for solving the practical approach.
4. To present survey of essential topics for Group theory in combinatorics

Unit I **15 L**

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

Unit II **15 L**

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

Unit III **15 L**

Rook- Polynomial ,Ordinary and Exponential generating functions ,Partitions of a positive Integer, Recurrence Relations, Fibonacci sequence.

Unit IV **15 L**

Group Theory in Combinatories ,The Burnside Frobenius Theorem,
Permutation Groups and Their Cycle Indices , Polya's Enumeration Theorems.

Course Outcome:

Upon successful completion of this course students will:

1. Students will familiar with fundamental combinatorial structures that naturally appears in various other fields of mathematics.
2. Learn how to use these structures to represent mathematical of applied questions.
3. Students will be able to present technical information clearly in both oral of written formulas
4. Able to use generating function to solve a variety of combinatorial problems.

Recommended Books:

1. **Richard A. Brualdi** ,Introductory Combinatorics 5th Edition 2009.
2. **Alan Tucker**, Applied Combinatorics 6th Edition ,Wiley 2012.

Reference Books:

1. **Mitchel T.Keller and Willian T.Trotter** ,Applied Combinatorics,2017 Edition.
2. **V.K. Balakrishnan** ,Schum's Outline of Theory and problems of combinatorics. Mc. Grew Hill Education 1994.

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Paper: MMT 408

Title of Paper : Fuzzy Mathematics-II

Course Objectives:

1. Provide and understanding of basic Mathematical elements of fuzzy sets.
2. Provide an emphasis on the differences and similarities between fuzzy sets and classical sets.
3. To establish through background knowledge of Fuzzy Relation Equation and its properties.
4. To solve real world optimization problems by using fuzzy logic.

Unit I **15 L**

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_i compositions.

Unit II **15 L**

Fuzzy Relation Equation, Problem Partitioning, solution methods, Fuzzy relational equations based on sup-I and inf-wi compositions, Approximate solutions

Unit III **15 L**

Fuzzy propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from conditional fuzzy propositions, Qualified and quantified propositions

Unit IV **15 L**

Approximate Reasoning:-Fuzzy expert systems, Fuzzy implications, selection of Fuzzy implications, Multi-conditional Approximate Reasoning, Role of fuzzy relational equations, Interval valued Approximate Reasoning

Course Outcome:

Upon successful completion of this course students will able to:

1. To understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, Approximate reasoning, fuzzy logic control.
2. Learn about formal methods to represent fuzzy relationship.
3. Combine some of the traditional design approaches with fuzzy logic concepts.
4. Evaluate the fuzzy statistics applications.

Recommended Book

1. **George J Klir, Bo Yuan**, Fuzzy sets and Fuzzy Logic. Theory and applications, PHI, Ltd.2000.

Reference Books

1. **M.Grabish, Sugeno, and Murofushi**, Fuzzy Measures and Integrals: theory and Applications, PHI, 1999.
2. **M. Ganesh**, Introduction to Fuzzy sets & Fuzzy Logic; PHI Learning Private Limited, New Delhi. 2011

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.
2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary

Paper: MMT 407

Title of Paper : Graph Theory-II

Course Objectives:

1. Explain the fundamental structure of Path matrix and its related graphs.
2. Demonstrate different transversal methods for trees and graphs.
3. Apply problem solving of Adjacency algebra of regular graphs, distance matrix of tree, Eigenvalues of distance matrix of tree.
4. Compute bounds for Laplacian special radius

Unit I **15 L**

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

Unit II **15 L**

Adjacency Matrix, Eigenvalues of some graphs, Determinant, Bounds, Energy of graph, Anti-adjacency matrix of directed graph, non-singular trees.

Unit III **15 L**

Laplacian Matrix: Basic properties, Computing Laplacian eigenvalues, Matrix tree theorem, Bounds for Laplacian special radius, Edge-Laplacian of a tree, Cycles and cuts, Fundamental cycles and fundamental cut, Fundamental matrices.

Unit IV **15 L**

Regular Graphs: Perron –Frobinius Theory, Adjacency algebra of regular graphs, Strongly regular graph and Friendship theorem, Graphs with maximum energy, Algebraic connectivity, classification of trees, distance matrix of tree, Eigenvalues of distance matrix of tree.

Course Outcome:

Upon successful completion of this course students will able to:

1. Understand Incidence Matrix, Adjacency Matrix, Different types of Graphs and Theorems related to them, Trees and bridges and their applications.
2. Student will have developed a basic understanding of properties of graphs and an appreciation of the combinatorial methods used to analyses discrete structures.
3. Understand and be able to use different models of random graphs and random networks.
4. Be able to do basic uses of the probabilistic method in graph theory.

Recommended Book:

1. R. B. Bapat, Graphs and Matrices, Hindustan Book Agency.

Reference Books

1. Douglas B.West, Introduction to Graph Theory 2nd Edition ,Pearson Education Asia,2015.
2. K. R. Parthsarthy, Basic Graph Theory, Tata McGraw Hill publishing Co.Ltd.New Delhi

Note: 1. The details of field work ,seminars, Group discussion and oral examination be given Whenever necessary.

2. One hour per week for problem solving/tutorial/seminars
3. General/specific instructions for Laboratory safety should be given whenever necessary