Dissemination of Education for Knowledge, Science and Culture”
- Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha’s

Vivekanand College, Kolhapur (Autonomous)

DEPARTMENT OF MATHEMATICS

M.Sc. Part - II
Semester-II & IV

SYLLABUS

Under Choice Based Credit System

to be implemented from Academic Year 2019-20

M.Sc. II (Sem -III and IV) Mathematics
Course Structure
Semester III

Course code	Title o the course	Instructions Lectures /Week	Duration of term end exam	Marks Term end exam	Marks (Internal) Continuous Assessment	Credit
Compulsory Courses						
CP-1180C	Functional Analysis	5	3 hours	90	30	5
CP-1181C	Advanced Discrete Mathematics	**5**	3 hours	90	30	5
Optional Courses						
CP-1182C	Number Theory	**5**	3 hours	90	30	5
CP-1183C	Graph Theory	**5**	3 hours	90	30	5
CP-1184C	Operational Research I	**5**	3 hours	90	30	5
CP-1185C	Lattice Theory I	**5**	3 hours	90	30	5
CP-1186C	Dynamical System I	**5**	3 hours	90	30	5
CP-1187C	Commutative Algebra	**5**	3 hours	90	30	5

Semester IV

Course code	Title o the course	Instructions Lectures /Week	Duration of term end exam	Marks Term end exam	Marks (Internal) Continuous Assessment	Credit
Compulsory Courses						
CP-1190D	Field Theory	5	3 hours	90	30	5
CP-1191D	Integral Equations	**5**	3 hours	90	30	5
Optional Courses						
CP-1192D	Algebraic Number Theory	**5**	3 hours	90	30	5
CP-1193D	Graph Theory II	**5**	3 hours	90	30	5
CP-1194D	Operational Research II	**5**	3 hours	90	30	5
CP-1195D	Fluid Dynamic	**5**	3 hours	90	30	5
CP-1196D	Dynamical System II	**5**	3 hours	90	30	5
CP-1197D	Combinatorics	**5**	3 hours	90	30	5
CP – 1198D	Fractional Differential Equation	**5**	3 hours	90	30	5

M.Sc. Mathematics Part – II CBCS
Semester - III Paper- I
Functional Analysis (CP-1180C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 To familiarize the students with the fundamental topics, principles and methods of functional analysis

CO2 Understand and apply fundamental theorems from the theory of normed and Banach spaces, including the Hahn-Banach theorem, the open mapping theorem, the closed graph theorem.

CO3 Able to understand Hilbert space and its application and acquire knowledge of orthogonal sets and operators

CO4 Understand Adjoint of an operator on a Hilbert space and concept of projection, self – adjoint, normal and unitary operator.

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	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	1
Module 2	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	1
Module 3	Hilbert spaces: examples and elementary properties, Orthogonal complements, The projection theorem, Orthogonal sets, The Bessel's inequality, Fourier expansion and Parseval's equation, separable Hilbert spaces, The conjugate of Hilbert space, Riesz's theorem, The adjoint of an operator.	15	1
Module 4	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	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

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

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

M.Sc. Mathematics Part – II CBCS
Semester - III Paper- II
Advanced Discrete Mathematics (CP-1181C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Solve discrete probability problems and use set to solve problems in combinatorics and probability theory.

CO2 Determine if a given graph is simple or a multigraph, directed or undirected graph, cyclic or acyclic, and determine the connectivity of a graph.

CO3 To determine if graph has a Euler or a Hamiltonian path or circuit, Define Pigeonhole principle and solve problems related to this.

CO4 Identify the types of Lattices and find supremum and infimum.

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	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, ECPentricity, radius and diameter of a connected graph, Peterson graph, Wheel graph. Isomorphism of Graphs. First theorem of graph theory.	15	1
Module 2	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 principal Pigeonhole principle, examples on Pigeonhole principle.	15	1
Module 3	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	1
Module 4	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	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. Lipschitz and Mark Lipson: Discrete Mathematics (second edition) , Tata McGraw Hill Publishing Company Ltd. New Delhi
2. Gorrett Birkhoff : Lattice Theory 2. Rich and Brualdi : Combinatoric
3. John Clark and Derek Holton: A first book at Graph Theory Applied Publishers Ltd.
4. C. T. Liu: Discrete Mathematics

M.Sc. Mathematics Part – II CBCS
Semester - III Paper- III
Number Theory (CBC-1182C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –

CO1 : Learn more advanced properties of primes and pseudo primes.
CO2 : Able to apply Mobius Inversion formula to number theoretic functions.
CO3 : Able to explore basic idea of cryptography.
CO4 : Understand concept of primitive roots and index of an integer relative to a given primitive root

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	Review of Divisibility: The division algorithm, G.C.D., Euclidean algorithm, Diophantine equation $ax + by = c$,Primes and their distribution: Fundamental theorem of arithmetic, The Goldbach Conjecture.	15	1
Module 2	Congruences: Properties of congruences, Linear congruences, Chinese Remainder Theorem, Special divisibility tests, Fermat's theorem, Wilsons theorem and applications	15	1
Module 3	Number Theoretic Functions: Euler's phi function, Euler's theorem, Greatest integer function, The functions $\tau$and σ, Mobius function and Mobius inversion formula, Properties of these functions and their inter relations.	15	1
Module 4	Primitive roots: The order of an integer modulo n, Primitive roots of primes, composite numbers having primitive roots, The theory of indices, The quadratic reciprocity law: Euleriancriteria, The Legendre symbol and its properties, quadratic reciprocity, quadratic reciprocity with composite moduli.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1) D. M. Burton : Elementary Number Theory, Universal book stall, New Delhi.
2) S. B. Malik : Baisc Number theory Vikas publishing House.
3) George E. Andrews : Number theory, Hindusthan Pub. Corp.(1972)
4) Niven, Zuckerman: An Introduction to theory of numbers. John Wiley & Sons
5) S. G. Telang, Number Theory, Tata Mc. Graw-Hill Publishing Co., New Delhi

M.Sc. Mathematics Part – II CBCS

Semester - III Paper -IV

Graph Theory I (CBC-1183C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –

CO1 : Understand and explore the basics of graph theory.

CO2 : Define vertex colouring and prove theorems on vertex colouring.

CO3 : Derive properties of planarity and Euler's formula.

CO4 : Evaluate or synthesize any real -world applications using graph theory

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	Trees and connectivity: Definitions and simple properties , Bridges , spanning trees , cutvertices and connectivity , Euler tours : Euler graphs, properties of Euler graph, The Chinese postman problem, Fleury's algorithm.	15	1
Module 2	Hamiltonian Cycles: Hamiltonian graph. The travelling salesman problem.Matchings :Matching and Augmenting path , The marriage problem , The personal assignment problem.	15	1
Module 3	The optimal assignment problem, A Chinese postman problem, Postscript Planar graph : Plane and Planar graphs, Euler formula, Platonic bodies Kurotowskis theorem. Non Hamiltonianplane graphs ,The dual of a plane graph	15	1
Module 4	Coloring : Vertex coloring , vertex coloring algorithms, critical graphs . cliques, Edgecoloring, map coloring. Directed graphs :Defination, Indegree and Outdegree, Tournaments , Traffic flow.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1) John Clark and Derek Holton : A first llok at graph theory, Allied publishers Ltd. Bombay.
2) Douglas B. West : Introduction to Graph Theory Person Education Asia.
3) F. Harary – Graph Theory, Narosa publishing house (1989).
4) K.R.Parthsarthy : Basic Graph Theory,Tata McGraw Hill publishing Co.Ltd. New delhi.

M.Sc. Mathematics Part – II CBCS
Semester - III Paper-V
Operational Research -I (CBC-1184C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Able to identify convex set and convex functions and construct linear integer programming models discuss the solution techniques

CO2 Solve multi –level decision problems using dynamic programming method.

CO3 Identify the appropriate methods to solve the different kinds of Optimization Problems.

CO4 Formulate the nonlinear programming models and able to find solution methods for solving the nonlinear and linear optimization problems.

Unit	Syllabus	Lectures/ Teaching Hours	Credit s
Module 1	Convex sets and their properties. Lines and hyper planes convex set Important Theorems, polyhedral convex set, convex combination of vectors, convex hull, convex polyhedron, convex cone, simplex and convex function, General formulation of linear programming Matrix form of LP problem, definitions of standard LPP., Fundamental Theorem of linear programming.	15	1
Module 2	Simplex method, computational procedure of simplex method, problem of degeneracy and method to resolve degeneracy. 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	1
Module 3	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	1
Module 4	Nonlinear programming unconstrained problems of maximum and minimum Lagrangian method Kuhn Tucker necessary and sufficient conditions, Wolfe's method, Beale's method.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. S. D. Sharma: Operations Research, Kedar Nath Ram Noth and co
2. Kanti Swarup,P. K. Gupta and Manmohan : Operations research, S. Chand& Co.
3. Hamady Taha: Operations Research: Mac Millan Co.
4. S. D. Sharma: Nonlinear and Dynamic programming KedarNath Ram Nath and Co. Meerut
5. R. K. Gupta: Operations Research Krishna Prakashan Mandir, Meeru
6. G. Hadley: Linear programming, Oxford and IBH Publishing Co.

M.Sc. Mathematics Part – II CBCS
Semester - III Paper-VI
Lattice Theory-I (CBC-1185C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –
CO1 : Understand the relation between posets and lattices
CO2 : Study the basic properties and characterization of lattice
CO3 : Understand and apply the distributive complemented lattice
CO4 : Design analyse and implement the concepts of stone's theorem and its consequence, pseudo complemented lattices and it's dual

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	**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. 4. Duality principle, Specialelements. 5. Homomorphism, Isomorphism and isotone maps.	15	1
Module 2	**Special types of Lattices** 1. Distributive lattices – Properties and characterizations. 2. Modular lattices – Properties and characterizations. 3. Congruence relations. 4. Boolean algebras – Properties and characterizations. s	15	1
Module 3	**Ideal theory** 1. Ideals and filters in lattices. 2. Lattice of all ideals I(L). 3. Properties and characterizations of I(L). Stone's theorem and its consequences	15	1
Module 4	**Stone algebra** 1. Pseudo complemented lattices. 2. S(L) and D(L) – special subsets of pseudo complemented lattices. 3. Distributive pseudo complemented lattice. 4. Stone lattices – properties and characterizations.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. Lattice theory: First concepts and distributive lattices by George Gratzer, W. H. Freemanand company, San Francisco, 1971.

2. B. V. Davey and H. A. Priestley: Introduction to Lattices and Order, Cambridge UniversityPress, Second edition, 2002.

M.Sc. Mathematics Part – II CBCS
Semester - III Paper-VII
Dynamical System -I (CBC-1186C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Classify equilibrium points of the dynamical system

CO2 Construct bifurcation diagrams and analyze the system for different values of parameter.

CO3 Relate the qualitative properties of the system with the eigen values of coefficient matrix.

CO4 Construct the exponential of a matrix and apply it to solve the dynamical system.

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 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-parameterfamily.	15	1
Module 2	**Special types of Lattices** Second order linear ODE as a system of first order ODEs, preliminaries from algebra, eigenvalues and eigenvectors, solution of planar linear systems, Phase portraits for planar systems: Real distinct eigenvalues, complex eigenvalues, repeated eigenvalues, changing co-ordinates, Classification of planar systems: the trace-determinant plane	15	1
Module 3	**Higher order systems:** Preliminaries from linear algebra, Higher order ODEs as a vector differential equation, real distinct, complex and repeated eigenvalues, The Exponential of a Matrix,Solving a system of first order differential equations by using exponential of a matrix, Non-autonomous systems of theform $X'(t) = AX(t) + G(t)$, Variation of parameters	15	1
Module 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).	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. M. Hirsch, S. Smale and R. L. Devaney : Differential equations, dynamical systems, and an introduction to chaos , Elsevier Academic Press, USA, 2004
2. Differential equations, dynamical systems, and an introduction to chaos by M. Hirsch, S. Smaleand R. L. Devaney, Elsevier Academic Press, USA, 2004

M.Sc. Mathematics Part – II CBCS
Semester - III Paper-VIII
Commutative Algebra (CBC-1187C)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Classify the ideals to solve the related problems.
CO2 Understand various radicals and know Hilbert basis theorem and apply it to other development
CO3 Use Nakayama Lemma for further development in Noetherion Rings.
CO4 Derive the Krull intersection theorem.

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	Rings and ring homomorphism, Ideals. Quotient rings, Zero divisors. Nilpotent elements. Units, Prime ideals and Maximal ideals, Nilradicals and Jacobson radical, Operations on ideals, Extension and contraction	15	1
Module 2	Modules and modules homomorphisms, Submodules and quotient modules , Operations On submodules ,Direct sum and product ,Finitely generated modules ,Exact sequences	15	1
Module 3	Tensor product of modules , Restriction and extension of scalars , Exactness properties Of the tensor product , Algebras of tensor products	15	1
Module 4	Rings and modules of fractions, Local properties , Extended and contracted ideals in rings of fractions , primary decomposition	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. M. F. Atiyah and I. G. MacDonald – Introduction to commutative Algebra, Addison Wesley publishing company
2. M.D. Larsen and P. J. MCParthy ; Multiplicative theory of ideals, Academic press,1971
3. D.G. Nortcot Ideal theory, Cambridge University press,1953

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-I
Field Theory (CP-1190D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Apply the knowledge of algebra to attain a good mathematical maturity and enables to build mathematical thinking and reasoning

CO2 Identify and analyse different types of algebraic structures such as algebraically closed fields, splitting fields, finite field extension to understand and use the fundamental results in Algebra

CO3 Design analyse and implement the concepts of Gauss lemma, separable extension etc.

CO4 Identify the challenging problems in advanced algebra to pursue further research

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	Field Extensions Extension of a field, Algebraic extensions, algebraically closed fields, Derivatives and multiple roots, Finite Fields	15	1
Module 2	Galois Theory Separable and normal extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory	15	1
Module 3	Finite Fields Prime fields, Fundamental theorem of algebra, Cyclic extensions, Cyclotomic extensions	15	1
Module 4	Applications of Galois theory Constructions by ruler and compass, Solvable groups, Polynomials solvable by radicals	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. U. M. Swamy, A. V. S. N. Murthy, Algebra: Abstract and Modern, Pearson Education, 2012
2. Nathan Jacobson, Basic Algebra I, second edition, W. H. Freeman and company, New York
3. M. Artin, Algebra, PHI, 1996.
4. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
5. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, 2nd edition, Narosa Publishing House, New Delhi
6. John Fraleigh : A first course in Abstract Algebra (3rd edition) Narosa publishing house, New Delhi.

M.Sc. Mathematics Part – II CBCS

Semester – IV Paper-II

Integral Equations (CP-1191D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –

CO1 : Solve linear Volterra and Fredholm integral equations using appropriate methods.

CO2 : Understand the relationship between integral and differential equations and transform one type into another.

CO3 : Find out the iterate kernel and Resolvent kernel of Volterra, Fredholm integral equation**.**

CO4 : Formulate and solve initial and boundary value problems for the heat and wave equations in spherical and cylindrical coordinates

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	Classification of linear integral equations, Conversion of initial value problemto 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 eigen functions	15	1
Module 2	Solutions of Fredholm integral equations by: SuCPessive approximations Method, SuCPessive substitution Method, Adomian decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties, Solutions of Volterra integral equations: SuCPessive approximations method, Neumann series, SuCPessivesubstitution Method.	15	1
Module 3	Solution of Volterra integral equations by Adomian decomposition method, and the modified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels, Applications of Laplace and Fourier transforms to solutions of Volterra integral equations, Symmetric Kernels**:** Fundamental properties of eigenvalues andeigenfunctions for symmetric kernels, expansion in eigenfunctions and bilinear form.	15	1
Module 4	Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations, 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 boundaryvalue problems..	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1) R. P. Kanwal, Linear Integral Equation- Theory and Technique, Academic Press, 1971.
2) Abdul-Majid Wazwaz, Linear and Nonlinear Integral Equations-Methods andApplications, Springer, 2011
3) L. G. Chambers, Integral Equations- A Short Course, International Text Book Company,1976.
4) M. A, Krasnov, et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
5) J. A. Cochran, The Analysis of Linear Integral Equations, Mc Graw HillPublications,

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-III
Algebraic Number Theory (CP-1192D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Understand The concept (definition and significance) of algebraic numbers and algebraic integers.

CO2 Understand and clearly define number fields and their ring of integers, in particular quadratic number fields and cyclotomic number fields.

CO3 Able to factorize an algebraic integer into irreducible and find the ideals of an algebraic number ring.

CO4 Able to compute the class groups and the group of units of a number field.

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	Revision of rings, polynomial rings and fields, Field extensions, Symmetric polynomials, Modules, Free Abelian groups.	15	1
Module 2	Algebraic Numbers, Algebraic number fields, Conjugates and Discriminants, Algebraic integers, Integral Bases, Norms and Traces, Ring of integers, Quadratic fields, Cyclotomic fields.	15	1
Module 3	Factorization into irreducible, Noetherian rings, Dedekind rings, Examples of Non- Unique factorization into irreducible, Prime factorization, Euclidean Domains, Euclidean quadratic fields.	15	1
Module 4	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 .	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. I.N. Stewart & D.O. Tall, Algebraic Number Theory , Academic press.
2. N. Jacobson, Basic Algebra - I, Hindustan Publishing Corporation (India), Delhi.
3. P. Samuel, Algebraic Theory of Numbers, Hermann, Paris (1970).
4. Mathematical Pamphlet, Algebraic Number Theory,TIFR, Bombay.
5. Paulo Ribenboim, Classical Theory of Algebraic Numbers, Springer, New York (2001).
6. N.S. Gopalkrishnan, University Algebra, New Age International(P) Ltd. Publisher

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-IV
Graph Theory -II (CP-1193D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –

CO1 : Analyse the significance of graph theory in different engineering disciplines

CO2 : Demonstrate algorithms used in interdisciplinary engineering domains

CO3 : Explain the properties of trees and connectivity

CO4 : Explain major theorems and inventions in the history of graph theory and understand how it made the subject to develop to the present state.

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	Preliminaries, Incidence Matrix : Rank, Minors, Path Matrix, Integer generalized inverse,Moore –Perose inverse, 0-1 incidence matrix, matchings in bipartile graphs.	15	1
Module 2	Adjacency Matrix, Eigenvalues of some graphs, Determinant, Bounds, Energy ofgraphs, Antiadjacency matrix of directed graph, nonsingular trees	15	1
Module 3	Laplacian matrix : Basic properties, Computing Laplacian egien values, Marrix treetheorem, Bounds for Laplacian special radius, Edge – Laplacian of a tree, Cycles and cuts,Fundamental cycles and fundamental cut, Fundamental matrices, Minors.	15	1
Module 4	Regular graphs :Person – Frobinius Theory,Adjacency algebra of regular graphs, Strongly regular graph and Friendship theorem, Graphs with maximum energy,Algebraic connectivity, classification of trees, spanning tress and binary trees. Kruskal's Algorithm forshortest spanning trees.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1 R.B. Bapat : Graphs and matrices, Hindustan book agency.
2 Douglas B. West : Introduction to Graph Theory Person Education Asia.
3 F. Harary – Graph Theory, Narosa publishing house (1989).

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-V
Operational Research -II (CP-1194D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Decide an optimal replacement period/policy for a given item/equipment/machine

CO2 Understand the various selective inventory control techniques and its applications. Capability to develop deterministic inventory models

CO3 Understand the mathematical modeling of queuieng systems To apply and extend queueing models to analyze real world systems.

CO4 Understand application of PERT and CPM techniques and able to construct network diagrams

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credi ts**
Module 1	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	15	1
Module 2	Inventory – Cost involved in inventory problems, variables in inventory problem, symbols in inventory concept of EOQ, Methods with calculus method ,Model I (a) The economiclot 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.,(EOQ production model) EOQ model with shortages , Model II(a) The EOQ with constant rate of demand, scheduling, time constant.	15	1
Module 3	Queuing Theory, Queuing systems, Queuing Problems: transient and steady states, traffic intensity, Probability distributions in Queuing systems Poisson process, Properties, Exponential process, Classification of Queuing Models,Model I:(M/M/I) : (∞/FCFS), Model II (a) : General Erlang queuing model.	15	1
Module 4	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	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. S.D.Sharma : Operations Research Kedarnath and co. 1999.
2. KantiSwarup ,P.K.Gupta and Manmohan : Operations research, S.Chand& Co.
3. HamadyTaha : Operations Research :Mac Millan Co.
4. R.K.Gupta : Operations Research Krishna PrakashanMandir, Meerut

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-VI
Fluid Dynamics (CP-1195D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to –

CO1 : Apply Bernoulli's equation to fluid flow problems and boundary layer theory to determine lift and drag forces on a submerged body.

CO2 : Apply appropriate equations and principles to analyze pipe flow problems.

CO3 : solve inviscid flow problems using stream functions and velocity potentials

CO4 : Apply concepts of mass, momentum and energy conservation to flows

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	**Physical properties of fluids and kinematics of fluids:** Concepts of fluids, continuum hypothesis, density, specific weight, specific volume, pressure, viscosity, surface tension,Eulerion& Lagrangian methods of description of fluids, Equivalence Eulerian and Lagrangian method,General motion of a fluid element, Integrability and compatibility conditions, stream lines, pathlines, streak lines, stream function, vortex lines, circulation	15	1
Module 2	**Stresses in fluids:** Strain rate tensor, stress tensor, normal stress, shearing stress, symmetry of stress tensor, Transformation of stress components from one co-ordinate systemtoanother, principle axes and principle values of stress tensor. Newtonian fluids, non Newtonian fluids, purely viscous fluids, Constitutive equations	15	1
Module 3	**Conservation laws:** Equation of conservation of mass, equation of conservation of momentum, Navier-Stokes equation, equation of moment of momentum, Equation of energy,Basicequations in different co-ordinate systems: Cartesian co-ordinate system, Cylindrical coordinatesystem, Spherical co-ordinate system, general orthogonal curvilinear co-ordinate system, boundary conditions.	15	1
Module 4	**Rotational and irrotational flows, Dynamic Similarity:** Theorems about rotational and irrotational flows: Kelvins minimum energy theorem, Gauss theorem, Kinetic energy of aninfinite fluid, uniqueness of irrotational flows Bernoullis's equation, Bernoullis equation for irrotational flows, Two dimensional irrotational incompressible flows,	15	1

	Blasius theorem, circletheorem, 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.		
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. An introduction to Fluid Dynamics' R. K. Rathy, Oxford & IBH publishing company
2. Text book of Fluid Dynamics' F. Chorton CHS Publishers, Delhi, 1985

M.Sc. Mathematics Part – II CBCS
Semester – IV Paper-VII
Dynamical System II (CP-1196D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Test for the existence and uniqueness of solution of nonlinear system.
CO2 Relate the stability of the system with its linearization.
CO3 Distinguish between stable and unstable sets corresponding to the given system.
CO4 Identify the chaotic behavior in the system by using Lyapunov exponents.

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	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	1
Module 2	Stability analysis: The flow defined by a differential equation, Linearization, Stable manifold theorem, Hartman Grobman theorm, Stability and Lyapunov functions, Bifurcation.	15	1
Module 3	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	1
Module 4	Applications and computer experiments: Application of chaos to secure communication, Introduction to fractals, Use of computer software's 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	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. Perko Differential Equations and Dynamical Systems, Springer, New York.
2. Alligood, Sauer and Yorke Chaos - an introduction to dynamical systems, Springer, New York.

3. M. Hirsch, Smale and R.L. Devaney Differential equations, dynamical systems, and an introduction to chaos, Elsevier Academic Press, USA, 2004.
4. Strogatz, Nonlinear dynamics and chaos, , Perseus Books, New York.
5. Wiggins, Introduction to applied nonlinear dynamics and chaos, Springer, New York.
6. Arrowsmith and Place Dynamical systems: differential equations, maps and chaotic behavior, Chapman and Hall, London. (Applications)

M.Sc. Mathematics Part – II CBCS

Semester – IV Paper-VIII

Combinatorics (CP-1197D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Students will familiar with fundamental combinatorial structures than naturally appears in various other field of mathematics.

CO2 Learn how to use those structure to represent mathematical applied questions.

CO3 Able to use generating function to solve a variety of combinatorial problems.

CO4 Identify the challenging problems in arrangement and selections.

Unit	**Syllabus**	**Lectures/ Teaching Hours**	**Credits**
Module 1	The sum Rule and the product Rule, Permutations and combinations, The Pigeonhole Principle, Ramsey Numbers, Catalan Numbers, Stirling Numbers.	15	1
Module 2	Generalized Permutations and combinations, Multinomial Theorem, The Inclusion – Exclusion principle, Sieve's formula, Derangements, System of Distinct Representatives (SDR), Combinatorial Number theory.	15	1
Module 3	Rook- Polynomial, Ordinary and Exponential generating functions, Partitions of a positive integer, Recurrence Relations, FibonaCPi sequence.	15	1
Module 4	Group Theory in Combinatorics, The Burnside Frobenius Theorem, Permutation Groups and Their Cycle Indices, Polya's Enumeration Theorems.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. V.K. Balakrishnan Schum's Outline of Theory and problems of combinatorics. Schum's Outline
   Series Mc. Grew Hill INC
2. Alan Tucker – Applied Combinatorics. – John Willey Sons.
3. Richard A Broadly, Introductory combinatorics New Holland.
4. Sharad Sane- Combinatorial Techniques-Hindustan Book Agency

M.Sc. Mathematics Part – II CBCS

Semester – IV Paper-IX

Fractional Differential Calculus (CP-1198D)

Theory: 60Hour **Credits -05**

Course Outcomes: After the completion of the course the student will be able to -

CO1 Understand G-L and RL-fractional integral and evaluate fractional integrals of some common functions

CO2 RL and Caputo-fractional derivatives and evaluate fractional derivatives of some common functions

CO3 To Solve Linear Fractional Differential Equation using the Laplace and Mellin transform.

CO4 The study of fractional differential

Unit	Syllabus	Lectures/ Teaching Hours	Credits
Module 1	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 , 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.	15	1
Module 2	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 theory.	15	1
Module 3	Laplace transforms of fractional derivatives- Laplace transform of the RiemannLiouville 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	15	1

	integrals and fractional derivative, Mellin transforms of Caputo derivative.		
Module 4	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.	15	1
Module 5	Examples, seminars, group discussions on above four units	15	1

Reference Books:

1. Igor Podlubny, Fractional differential equations. San Diego: Academic Press; 1999.
2. A. Kilbas, H.M. Srivastava, J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam, 2006.
3. Kai Diethelm, The Analysis of Fractional Differential Equations, Springer, 2010.
   L. Debnath, D. Bhatta, Integral Transforms and Their Applications, CRC Press

SCHEME OF MARKING (THEROY)

Sem.	CP	Marks	Evaluation	Answer Books	Standard of passing
I	CP-1180C TO CP1187A	90	Semesterwise	As per Instruction	35% (36 marks)
II	CP-1190D TO CP-1198D	90	Semesterwise	As per Instruction	35% (36 marks)

SCHEME OF MARKING (CIE) Continuous Internal Evaluation

Sem.	CP	Marks	Evaluation	Answer Books	Standard of passing
I	CP1180C TO CBC1187C	30	Concurrent	As per Instruction	35% (12 marks)
II	CP-1190D TO CBC-1198D	30	Concurrent	As per Instruction	35% (12 marks)

***A separate passing is mandatory**

Nature of Question Paper

Instructions: 1) Questions **No. 1** is **compulsory**.

2) Attempt any **four** questions from que. no. 2 to que. no. 7.

3) All questions carry equal marks.

4) Figures to right indicates full marks.

5) Use of log table/calculator is allowed.

Time: 3 hours **Total Marks: 90**

Q. 1. A) Choose correct alternative. (2 Marks each) [08]

i)

A) B) C) D)

ii)

A) B) C) D)

iii)

A) B) C) D)

iv)

A) B) C) D)

B) Fill in the blanks. (2 Marks each) [10]

Q.2. A) **[18]**

B)

C)

OR

A) **[18]**

B)

Q.3. A) **[18]**

B

C)

OR

A) **[18]**

B)

Q.4 A) **[18]**
B)
C)

OR

A) **[18]**
B)

Q.5. A) **[18]**
B)
C)

OR

A) **[18]**
B)

Q.6. A) **[18]**
B)
C)

OR

A) **[18]**
B)

Q.7. A) **[18]**
B)
C)

OR

A) **[18]**
B)

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REMARK:

Note that the distribution of marks for A, B, C or A, B (Q.N.2 to Q.N.-7)may vary aCPording to the nature of question.