VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

DEPARTMENT OF MATHEMATICS
TWO- Years PG Programme
Department/Subject Specific Core or Major (DSC)

Curriculum, Teaching and Evaluation Structure

for

M.Sc.-II Mathematics

Semester-III & IV

(Implemented from academic year 2024-25 onwards)

VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

Department of Mathematics

Programme Outcomes (POs):

After completing the M. Sc. Programme, the students will able to:

PO1: Demonstrate and apply the fundamental knowledge of the basic principles of sciences in various fields.

PO2: Create awareness and a sense of responsibility towards the environment and society to solve the issues related to environmental pollution.

PO3: To apply their professional, social, and personal knowledge.

PO3: Competent to pursue research or pursue a career in the subject.

PO4: Apply knowledge to build up small-scale industries for developing endogenous products.

PO5: Communicate scientific information in a clear and concise manner both orally and in writing.

PO6: Inculcate logical thinking to address a problem and become result oriented with a positive attitude.

M.Sc. in Mathematics

Program Specific Outcomes (PSOs):

PSO1: Handle the advanced technique in algebra, analysis, computational techniques, optimization, differential equations, engineering, finance and actuarial science to analyse and design algorithm solving variety of problems related to real life problems

PSO2: Adopt changing scientific environment in the process of sustainable development by using mathematical tools

PSO3: Have necessary skills and expertise in the field of research and developments through seminar, field project and on job training.

PSO4: A student be able to apply their skills and knowledge, that is, translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or technique in order to process the information and draw the relevant conclusion

PSO5: Adapt to and keep pace with emerging technologies in the field of Mathematics, demonstrating an understanding of their applications, limitations, and implications.

NEP-2020 with Multiple Entry and Multiple Exit Option
M.Sc. (Mathematics) Programme Structure

M.Sc. (Mathematics) Part–I (Level-6.0)

Year	Level	Sem.	Major		RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandat	Electives					
I	6.0	SEM I	3*4+2	4	4	--	--	22	PG Diploma in Mathematics (after 3Yr UG Degree)
		SEM II	3*4+2	4	--	4	--	22	
Cum Cr. For PG Diploma in mathematics			28	8	4	4	--	44	
Exit option: PG Diploma in Mathematics (44 Credits) after Three Year UG Degree									
Year	Level	Sem.	Major		RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandat	Electives					
II	6.5	SEM III	3*4+2	4	--	--	4	22	MSc Mathematics Degree (after 3Yr UG Degree) OR MSc Mathematics Degree (after 4Yr UG Degree)
		SEM IV	3*4	4	--	--	6	22	
Cum Cr. For 1 year MSc mathematics Degree			26	8	--	--	10	44	
Cum Cr. For 2 year MSc mathematics Degree			54	16	4	4	10	88	
2 Years-4 Sem. MSc Mathematics Degree (88 credits) after Three Year UG Degree or 1 Year-2 Mathematics Degree (44 credits) after Four Year UG Degree									

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)
Department of Mathematics
Teaching and Evaluation Scheme
Two- Years PG Programme
Department/Subject Specific Core or Major (DSC)
First Year Semester-III & IV

Sr. No.	Course Abbr.	Course code	Course Name	Teaching Scheme Hours/week		Examination Scheme and Marks				Course Credits
				TH	PR	ESE	CIE	PR	Marks	
Semester-III										
1	DSC-IX	DSC13MAT31	Functional Analysis	4	-	80	20	-	100	4
2	DSC-X	DSC13MAT32	Classical Mechanics	4	-	80	20	-	100	4
3	DSC-XI	DSC13MAT33	Complex Analysis	4	-	80	20	-	100	4
4	DSC-XII	DSC13MAT34	Advanced Discrete Mathematics	2	-	40	10	-	50	2
5	DSE-III	DSE13MAT31	Lattice Theory	4	-	80	20	-	100	4
		DSE13MAT32	Fuzzy Mathematics-II	4	-	80	20	-	100	4
		DSE13MAT33	Commutative Algebra	4	-	80	20	-	100	4
6	RP-I	RPR13MAT11	Research Project	-	4	-	-	-	100	4
Semester –III Total				**22**	**-**	**440**	**60**	**-**	**550**	**22**
Semester-IV										
1	DSC-XIII	DSC13MAT41	Field Theory	4	-	80	20	-	100	4
2	DSC-XIV	DSC13MAT42	Integral Equations	4	-	80	20	-	100	4
3	DSC-XV	DSC13MAT43	Partial Differential Equations	4	-	80	20	-	100	4
4	DSE-IV	DSE13MAT41	Combinatorics	4	-	80	20	-	100	4
		DSE13MAT42	Algebraic Number Theory	4	-	80	20	-	100	4
		DSE13MAT43	Fractional Calculus	4	-	80	20	-	100	4
5	RP-II	RPR13MAT41	Research Project		6			150	150	6
Semester –IV Total				**18**	**04**	**360**	**90**	**100**	**550**	**22**

M. Sc. Part – II Semester -III MATHEMATICS

DSC-IX: DSC13MAT31: Functional Analysis

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. To familiarize the students with the fundamental topics, principles and methods of functional analysis
2. 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.
3. Able to understand Hilbert space and its applications and acquire knowledge of orthogonal sets and operators.
4. Understand Adjoint of an operator on a Hilbert space and Concept of Positive, projection, self-adjoint, normal and unitary operator

Syllabus:

Unit	Content	Hours Allotted
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
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
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
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

Recommended Book(s):

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. M. T. Nayar, Functional Analysis: A First Course.
4. J. B. Convey, A course in Functional Analysis, Springer-Verlag, 1985.
5. B. V. Limaye: Functioned Analysis, New age international, 1996

M. Sc. Part – II Semester -III MATHEMATICS
DSC-X: DSC13MAT32: Classical Mechanics
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)
On completion of the course, the students will be able to:

1) Discuss the motion of system of particles using Lagrangian & Hamiltonian approach
2) solve extremization problem using Variational calculus.
3) Construct Hamiltonian using Routh process.
4) use infinitesimal and finite rotation to analyze motion of rigid body.

UNIT	Contents	Hours Allotted
1	Mechanics of a particle, Mechanics of a system of particles, conservation theorems, constraints, Generalised coordinates, D' Alembert's Principle, Lagrange's equations of motion, simple applications of Lagrangian formulation, Kinetic energy as a homogeneous function of generalised velocities, Non-conservation of total energy due to the existence of non-conservative forces. Cyclic co-ordinates and generalised momentum, conservation theorems.	15
2	Functional, basic lemma in calculus of variations, Euler- Lagrange's equations, first integrals of Euler- Lagrange's equations, the case of several dependent variables Undetermined end conditions, Geodesics in a plane and space, the minimum surface of revolution, the problem of Brachistochrone, Isoperimetric problems, problem of maximum enclosed area.	15
3	Hamilton's Principle, Derivation of Hamilton's principle from D'Alembert's principle, Lagrange's equations of motion from Hamilton's principle. Lagrange's equations of motion for non-conservative systems (Method of Langrange's undetermined multipliers) Hamiltonian function, Hamilton's canonical equations of motion, Derivation of Hamilton's equations from variational principle, Physical significance of Hamiltonian, the principle of least action, cyclic co-ordinates and Routh's procedure. Orthogonal transformations, Properties of transformation matrix, infinitesimal rotations.	15
4	The Kinematics of rigid body motion: The independent co-ordinates of a rigid body, the Eulerian angles, Euler's theorem on motion of rigid body, Angular momentum and kinetic energy of a rigid body with one point fixed, the inertia tensor and moment of inertia, Euler's equations of motion, Cayley- Klein parameters, Matrix of transformation in Cayley-Klein parameters, Relations between Eulerian angles and Cayley-Klein parameters.	15

Recommended Books:

1) Goldstein, H. Classical Mechanics. (1980), Narosa Publishing House, New Delhi.

Reference Books:

1. Weinstock: Calculus of Variations with Applications to Physics and Engineering (International Series in Pure and Applied Mathematics). (1952), Mc Graw Hill Book Company, New York.
2. Whittaker, E. T. A treatise on the Analytical Dynamics of particles and rigid bodies. (1965), Cambridge University Press.
3. Rana, N.C. and Joag, P. S. Classical Mechanics. (1991) Tata McGraw Hill, New Delhi.
4.Bhatia, V. B. Classical Mechanics with Introduction to Non-linear Oscillation and Chaos.(1997), Narosa publishing House.
5.Gupta, A. S. Calculus of Variations with Applications (1997), Prentice Hall of India.
6.Katkar L.N.,Problems in Classical Mechanics

M. Sc. Part – II Semester -III MATHEMATICS

DSC-XI: DSC13MAT33: Complex Analysis

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1) know how to check given complex valued function is analytic or not.
2) find power series expansion of an analytic function with radius of convergence.
3) find zeros and singularities of complex valued functions.
4) evaluate integral of complex valued functions along given curve.

UNIT	Contents	Hours Allotted
1	Power series, radius of convergence, analytic functions, zeros of an analytic function, Cauchy-Riemann equations, Harmonic functions, Mobius transformations, line integral.	15
2	Power series representation of analytical function, zeros of an analytic function, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem, the index of closed curve, Cauchy's theorem and integral formula, Morera's theorem.	15
3	Counting zero's, The open mapping theorem, Goursat's Theorem, Classification of singularities, Laurent series development, Casorati-weierstrass theorem, residues, residues theorem, evaluation of real integrals.	15
4	The argument principle , Rouche's theorem, the maximum principle, Schwarz's lemma and its applications to characterize conformal maps.	15

Recommended Books:

1) Conway J.B., Functions of one complex variable. (Narosa Publishing house)

Reference Books: -

1) Ahlfors L.V. : Complex Analysis (Mc Graw Hill).
2) Churchill R.V., Brown J.W.: Complex Variables and Applications (McGraw Hill).
3) Ponnusamy S., Herb Silverman, Complex variables with applications analysis, Birkhauser,2006
4) Ponnusamy S., Foundations of complex analysis, Narosa publishing House.

M. Sc. Part – II Semester -III MATHEMATICS

DSC-XII: DSC13MAT34: Advanced Discrete Mathematics

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs)

On completion of the course, the students will be able to:

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.

UNIT	Contents	Hours Allotted
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, Eccentricity, radius and diameter of a connected graph, Peterson graph, Wheel graph. Isomorphism of Graphs. First theorem of graph theory.	15
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

Recommended Books:

1) John Clark and Derek Holton, A first look at Graph Theory, Allied Publishers Ltd., 1991.

Reference Books: -

1. Gorrett Birkhoff : Lattice Theory 2. Rich and Brualdi : Combinatoric
2. Seymon Lipschitz and Mark Lipson: Discrete Mathematics (second edition), Tata McGraw Hill Publishing Company Ltd. New Delhi.
3. C. T. Liu: Discrete Mathematics

M. Sc. Part – II Semester -III MATHEMATICS

DSE-III : DSE13MAT31: Lattice Theory

Theory: 60 Hrs

Marks: 100 (Credits 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. Understand the relation between posets and lattices
2. Study the basic properties and characterization of lattice
3. Understand and apply the distributive complemented lattice
4. Design analyse and implement the concepts of stone's theorem and its consequence, pseudo complemented lattices and it's dual

UNIT	Contents	Hours Allotted
1	Basic concepts. Posets, Definition and examples of posets. Two definitions of lattices and their equivalence, examples of lattices. Description of Lattices, some algebraic concepts. Duality principle, Special elements. Homomorphism, Isomorphism and isotone maps.	15
2	Special types of Lattices. Distributive lattices – Properties and characterizations. Modular lattices – Properties and characterizations. Congruence relations. Boolean algebras – Properties and characterizations.	15
3	Ideal theory, Ideals and filters in lattices. Lattice of all ideals I(L). Properties and characterizations of I(L). Stone's theorem and its consequences.	15
4	Stone algebra, Pseudo complemented lattices. S(L) and D(L) – special subsets of pseudo complemented lattices. Distributive pseudo complemented lattice. Stone lattices – properties and characterizations	15

Recommended Books:

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

Reference Books: -

1. B. V. Davey and H. A. Priestley: Introduction to Lattices and Order, Cambridge University Press, Second edition, 2002.
2. G. Birkhoff: Lattice theory Amer. Math. Soc. Coll. Publications, Third Edition 1973

M. Sc. Part – II Semester -III MATHEMATICS
DSE-III: DSE13MAT32: Fuzzy Mathematics-II
Theory: 60 Hrs
Marks: 100 (Credits 04)

Course Outcomes (COs)
On completion of the course, the students will be able to:

1. Acquire the concept of fuzzy relations
2. Understand the basic concepts of fuzzy logic and fuzzy algebra
3. Construct approximate solutions of fuzzy relation equations
4. Solve problems in Engineering and medicine

UNIT	Contents	Hours Allotted
1	Projections and cylindrical extensions, binary fuzzy relations on single set, fuzzy equivalence relations, fuzzy compatibility relations, fuzzy ordering relations, fuzzy morphisms sup-i composition and inf-wi composition.	15
2	Fuzzy relation equations, problem partitioning, solution methods, fuzzy relational equations based on sup-i and inf-wi compositions, approximate solutions.	15
3	Fuzzy propositions, fuzzy quantifiers, linguistic hedges, inference from conditional fuzzy propositions, qualified and quantified propositions	15
4	Approximate reasoning: fuzzy expert systems, fuzzy implications, selection of fuzzy implications, multi-conditional approximate reasoning, the role of fuzzy relation equations, internal valued approximate reasoning.	15

Recommended Books:

1. George J Klir, Bo Yuan, Fuzzy Sets and Fuzzy Logic. Theory and applications, PHI.Ltd. (2000)

Reference Books:

1. John Mordeson, Fuzzy Mathematics, Springer,2001
2. M. Grabish, Sugeno, and Murofushi, Fuzzy Measures and Integrals: Theory and Applications PHI, 1999.
3. H.J. Zimmerermann, Fuzzy set: Theory and its Applications, Kluwer, 1984.
4. M. Ganesh, Introduction to Fuzzy sets & Fuzzy Logic; PHI Learning Private Limited, New Delhi,2011.

M. Sc. Part – II Semester -III MATHEMATICS
DSE-III: DSE13MAT33: Commutative Algebra
Theory: 60 Hrs
Marks: 100 (Credits 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. classify the ideals to solve the related problems.
2. understand various radicals and know Hilbert basis theorem and apply it to other development.
3. use Nakayama Lemma for further development in Noetherian Rings.
4. Derive the Krull intersection theorem

UNIT	Contents	Hours Allotted
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
2	Modules and modules homomorphisms, Submodules and quotient modules, Operations On submodules, Direct sum and product, Finitely generated modules, Exact sequences.	15
3	Tensor product of modules, Restriction and extension of scalars, Exactness properties Of the tensor product, Algebras of tensor products.	15
4	Rings and modules of fractions, Local properties, Extended and contracted ideals in rings of fractions, primary decomposition.	15

Recommended Book:

1) M. F. Atiyah and I. G. MacDonald – Introduction to commutative Algebra, Addison Wesley publishing company.

.

Reference Book:

1. M.D. Larsen and P. J. McCarthy ; Multiplicative theory of ideals, Academic press,1971
2. D.G. Nortcot Ideal theory, Cambridge University press,1953

M. Sc. Part – II Semester -III MATHEMATICS

RP-I: RPR13MAT31: Research Project.
Marks-100 (Credits: 04)

M. Sc. Part – II Semester -IV MATHEMATICS

DSC -XIII: DSC13MAT41: Field Theory

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. Apply the knowledge of algebra to attain a good mathematical maturity and enables to build mathematical thinking and reasoning
2. 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
3. Design analyse and implement the concepts of Gauss lemma, separable extension etc.
4. Identify the challenging problems in advanced algebra to pursue further research.

UNIT	Contents	Hours Allotted
1	Field Extensions Extension of a field, Algebraic extensions, algebraically closed fields, Derivatives and multiple roots, Finite Fields	15
2	Galois Theory Separable and normal extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory.	15
3	Finite Fields Prime fields, Fundamental theorem of algebra, Cyclic extensions, Cyclotomic extensions.	15
4	Applications of Galois theory Constructions by ruler and compass, Solvable groups, Polynomials solvable by radicals.	15

Recommended Books:

1. U. M. Swamy, A. V. S. N. Murthy, Algebra: Abstract and Modern, Pearson Education, 2012.

Reference Books:

1. M. Artin, Algebra, PHI, 1996.
2. Nathan Jacobson, Basic Algebra I, second edition, W. H. Freeman and company, New York.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
4. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, 2nd edition, Narosa Publishing House, New Delhi.
5. John Fraleigh, A first course in Abstract Algebra (3rd edition) Narosa publishing house, New Delhi
6. I. T. Adamson, Introduction to Field Theory, second edition, Cambridge University Press,1982.

M. Sc. Part – II Semester -IV MATHEMATICS

DSC -XIV: DSC13MAT42: Integral Equations

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1) solve linear Fredholm and Volterra Integral equations.
2) compare properties of Differential and Integral equations.
3) solve Initial and Boundary value problems by converting to equivalent integral equations
4) analyze the properties of symmetric kernel.

UNIT	Contents	Hours Allotted
1	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 eigen functions.	15
2	Solutions of Fredholm integral equations by: Successive approximations Method, Successive substitution Method, Adomian 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	15
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 and eigenfunctions for symmetric kernels, expansion in eigenfunctions & bilinear form.	15
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 & its use in solving boundary value problem	15

Recommended Books:

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

Reference Books:

1. Wazwaz A.M., Linear and Nonlinear Integral Equations-Methods and Applications, Springer, 2011.
2. Chambers L.G., Integral Equations-A Short Course, International Text Book Comp., 1976.
3. Krasnov M.A., et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
4. Cochran J.A., The Analysis of Linear Integral Equations, Mc Graw Hill Publications,1972.
5. Green C.D., Integral Equation Methods, Thomas Nelson and sons, 1969.

M. Sc. Part – II Semester -IV MATHEMATICS

DSC -XV: DSC13MAT43: Partial Differential Equations
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1) classify partial differential equations and transform into canonical form
2) solve boundary value problems for Laplace's equation, the heat equation, the wave equation by separation of variables, in Cartesian, polar, spherical and cylindrical coordinates
3) use different method to solve boundary value problem specially use wave equations, Heat equations
4) apply method of characteristics to find the integral surface of a quasi linear partial differential equations.

UNIT	Contents	Hours Allotted
1	Curves and surfaces, First order Partial Differential Equations, classification of first order 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.	15
2	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.	15
3	Second order Partial Differential Equations. Origin of Partial differential equation, wave equations, Heat equation. Classification of second order partial differential equation. Vibration of an infinite string (both ends are not fixed) Physical Meaning of the solution of the wave equation. Vibration of an semi 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.	15
4	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.	15

Recommended Book:

1. Amarnath T.: An elementary course in Partial differential equations, Narosa publication, 1987.

Reference Books:

1. Sneddon I. N.,: Elements of Partial Differential Equations, McGraw Hill Int.
2. Frite John: Partial Differential Equations

M. Sc. Part – II Semester -IV MATHEMATICS
DSE -IV: DSE13MAT41: Combinatorics
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)
On completion of the course, the students will be able to:

1. Students will familiar with fundamental combinatorial structures than naturally appears in various other field of mathematics
2. Learn how to use those structure to represent mathematical applied questions
3. Able to use generating function to solve a variety of combinatorial problems
4. Identify the challenging problems in arrangement and selections

UNIT	Contents	Hours Allotted
1	The sum Rule and the product Rule, Permutations and combinations, The Pigeonhole Principle, Ramsey Numbers, Catalan Numbers, Stirling Numbers.	15
2	Generalized Permutations and combinations, Multinomial Theorem, The Inclusion – Exclusion principle, Sieve's formula, Derangements, System of Distinct Representatives (SDR), Combinatorial Number theory.	15
3	Rook- Polynomial, Ordinary and Exponential generating functions, Partitions of a positive integer, Recurrence Relations, Fibonacci sequence.	15
4	Group Theory in Combinatorics, The Burnside Frobenius Theorem, Permutation Groups and Their Cycle Indices, Polya's Enumeration Theorems.	15

Recommended Book:

1 V.K. Balakrishnan Schum's Outline of Theory and problems of combinatorics. Schum's Outline Series Mc. Grew Hill INC.

Reference Books:

1 Richard A Broadly, Introductory combinatorics New Holland.
2 Alan Tucker – Applied Combinatorics. – John Willey Sons.
3 Sharad Sane- Combinatorial Techniques-Hindustan Book Agency

M. Sc. Part – II Semester -IV MATHEMATICS

DSE -IV: DSE13MAT42: Algebraic Number Theory

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. Understand The concept (definition and significance) of algebraic numbers and algebraic integers.
2. Understand and clearly define number fields and their ring of integers, in particular quadratic number fields and cyclotomic number fields.
3. Able to factorise an algebraic integer into irreducible and find the ideals of an algebraic number ring.
4. Able to compute the class groups and the group of units of a number field.

UNIT	Contents	Hours Allotted
1	Revision of rings, polynomial rings and fields, Field extensions, Symmetric polynomials, Modules, Free Abelian groups.	15
2	Algebraic Numbers, Algebraic number fields, Conjugates and Discriminants, Algebraic integers, Integral Bases, Norms and Traces, Ring of integers, Quadratic fields, Cyclotomic fields.	15
3	Factorization into irreducible, Noetherian rings, Dedekind rings, Examples of Non- Unique factorization into irreducible, Prime factorization, Euclidean Domains, Euclidean quadratic fields	15
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

Recommended Books:

1. I.N. Stewart & D.O. Tall, Algebraic Number Theory by Academic press.

Reference Books: -

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

M. Sc. Part – II Semester -IV MATHEMATICS

DSE -IV: DSE13MAT43: Fractional Calculus

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be 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

UNIT	Contents	Hours Allotted
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, RL fractional derivative	15
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 terminal	15
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 integrals and fractional derivative, Mellin transforms of Caputo derivative.	15
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

Recommended Book(s):

1. Igor Podlubny, Fractional differential equations. San Diego: Academic Press; 1999.
2. L. Debnath, D. Bhatta, Integral Transforms and Their Applications, CRC Press

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. Shantanu Das, Functional Fractional Calculus, Springer, 2011

M. Sc. Part – II Semester -IV MATHEMATICS

RP-II: RPR13MAT41: Research Project.
Marks-150 (Credits: 06)

Nature of Question Paper
(CREDIT:4)

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: 80**

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/True or False (2 Marks each) 08

Q.2) A)

B)

C)

OR

A)

B)

Q.3) A)

B)

C)

OR

A)

B)

Q.4) A)

B)

C)

OR

A)

B)

Q.5) A)

B)

C)

OR

A)

B)

Q.6) A)

B)

C)

OR

A)

B)

Q.7) A)

B)

C)

OR

A)

B)

REMARK:

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