Semester 3

Course Code	Course Title	Course ID	L (Hrs)	T (Hrs)	P (Hrs)	L Credits	T Credits	P Credits	Total Credits	MARKS TI	MARKS TE	MARKS PI	MARKS PE	MARKS Total
Core Course(s)														
CC-A07	Functional Analysis	241/MAT/CC301	3	1	--	3	1	--	4	30	70	--	--	100
CC-A08	Advanced Abstract Algebra	241/MAT/CC302	3	1	--	3	1	--	4	30	70	--	--	100
CC-A09	Fluid Dynamics	241/MAT/CC303	3	1	--	3	1	--	4	30	70	--	--	100
Discipline Specific Elective Courses														
DSE-03	Discrete Mathematics OR Mathematical Statistics	241/MAT/DS301A 241/MAT/DS301B	2	1	--	2	1	--	3	25	50	--	--	75
Multidisciplinary Course(s)														
MDC-03	One from Pool		2	1	--	2	1	--	3	25	50	--	--	75
Skill Enhancement Course(s)														
SEC-02	One from Pool		1	--	2	1	--	1	2	5	20	5	20	50
Value-added Course(s)														
VAC-02	One from Pool		2	--	--	2	--	--	2	15	35	--	--	50
Seminar														
Seminar		241/MAT/SM301	--	--	4	--	--	2	2	--	--	15	35	50
Internship/Field Activity#														
		241/MAT/IN301	--	--	8	--	--	4	4	--	--	30	70	100
Total Credits						**16**	**5**	**7**	**28**					

#Four credits of internship earned by a student during summer internship after 2nd semester will be counted in 3rd semester of a student who pursue 2 year PG Programme without taking exit option.

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Semester 4

Course Code	Course Title	Course ID	L (Hrs)	T (Hrs)	P (Hrs)	L Credits	T Credits	P Credits	Total Credits	MARKS TI	MARKS TE	MARKS PI	MARKS PE	MARKS Total
Core Course(s)														
CC-A10	Number Theory	241/MAT/CC401	3	1	--	3	1	--	4	30	70	--	--	100
CC-A11	Classical Mechanics & Calculus of Variations	241/MAT/CC402	3	1	--	3	1	--	4	30	70	--	--	100
Discipline Specific Elective Courses														
DSE-04	Operations Research OR	241/MAT/DS401A	2	1	--	2	1	--	3	25	50	--	--	75
	Fuzzy Set Theory	241/MAT/DS401B												
Multidisciplinary Course(s)														
MDC-04	One from Pool		2	1	--	2	1	--	3	25	50	--	--	75
Ability Enhancement Course(s)														
AEC-03	One from Pool		2	--	--	2	--	--	2	15	35	--	--	50
Community Engagement/Field Work/Survey/Seminar														
Seminar		241/MAT/SM401	--	--	12	--	--	6	6	--	--	50	100	150
Total Credits						**12**	**4**	**6**	**22**					

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M.Sc. MATHEMATICS 3rd SEMESTER

Functional Analysis

CC-A07 Maximum Marks: 100
Credits: 4(3L+1T) External Examination: 70
Max. Time: 3 hrs. Internal Assessment: 30
Course ID: 241/MAT/CC301

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Understand Inner product spaces, Hilbert spaces, orthonormal sets and sequences.
CLO2 Understand the completeness in normed linear spaces.
CLO3 Gain knowledge of the ideas behind spaces of bounded linear transformations, equivalent formulation of continuity, and bounded linear transformations.
CLO4 Understand and apply the Riesz Representation Theorem for bounded linear functionals on second conjugate spaces.

Unit-I

Inner product spaces, Hilbert spaces and their examples, Schwarz inequality, continuity of inner product, orthogonal complements and direct sums, minimizing vector, orthogonality, projection theorem, Orthonormal sets and sequences, Bessel's inequality, series related to orthonormal sequences and sets, total (complete) orthonormal sets and sequences, Parseval's identity.

Unit-II

Normed linear spaces, Metric on normed linear spaces, Completion of a normed space, Banach spaces, subspace of a Banach space, Holder and Minkowski inequality, Completeness of quotient spaces of normed linear spaces. Completeness of l^p, L^p, R^n, C^n *and* $C[a,b]$. Incomplete normed spaces.

Unit-III

Finite dimensional normed linear spaces and Subspaces, Bounded linear transformation, Equivalent formulation of continuity, Spaces of bounded linear transformations, Continuous linear functional, conjugate spaces. Hahn-Banach extension theorem (Real and Complex form).Weak and Strong convergence, their equivalence in finite dimensional spaces.

Unit-IV

Riesz Representation theorem for bounded linear functionals on Lp *and* $C[a,b]$. Second conjugate spaces, Reflexive space, Uniform boundedness principle and its consequences, open mapping theorem and its application, Projections, Closed Graph theorem.

Recommended Books:

1. H.L. Royden, *Real Analysis*, MacMillan Publishing Co., Inc., New York, 4th Edition, 2010.
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley.
3. W. Rudin, *Functional Analysis*, McGraw-Hill, Inc., New York, 1991.
4. J.B. Conway, *A Course in Functional Analysis*, Springer, New York, 1990.

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M.Sc. MATHEMATICS 3rd SEMESTER
Advanced Abstract Algebra

CC-A08 Maximum Marks: 100
Credits: 4(3L+1T) External Examination:70
Max. Time: 3 hrs. Internal Assessment: 30
Course ID: 241/MAT/CC302

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Understand the ideas of algebraically closed field, field extension, algebraic and transcendental extension, irreducible polynomial, and the Eisenstein criterion.
CLO2 Demonstrate a deep understanding of splitting fields, normal extension, multiple roots, prime fields, finite fields, and separable extension.
CLO Gain Knowledge of Fundamental theorem of Galois theory and cyclic extensions.
CLO4 Understand the concepts of symmetric functions, ruler and compass construction, and polynomials solvable by radicals.

Unit-I

Irreducible polynomials; Eisenstein's criterion and Gauss's lemma. Field extensions: algebraic and transcendental extensions; degree of an extension. Algebraic closure and algebraically closed fields.

Unit-II

Splitting fields and their degrees of extension. Normal extensions; multiple roots of polynomials. Prime fields and their characterization. Finite fields and separable extensions.

Unit-III

Automorphism groups and fixed fields; Dedekind's lemma.Galois groups of polynomials; Galois extensions; fundamental theorem of Galois theory.Fundamental theorem of algebra; roots of unity and cyclotomic polynomials. Klein's four-group, cyclic extensions, and Frobenius automorphism of finite fields.

Unit-IV

Solvability of polynomials by radicals over $\mathbb{Q}$. Symmetric and elementary symmetric functions. Constructions using ruler and compass only.

Recommended Books:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, *Basic Abstract Algebra (2nd Edition)*, Cambridge University Press, Indian Edition, 2012.
2. V. Sahai and V. Bist, *Algebra*, Narosa Publishing House, 1999.
3. S. Singh and Q. Zameeruddin, *Modern Algebra*, Vikas Publishing House, 1990.
4. P. Morandi, *Field and Galois Theory*, Springer, 1996.
5. J.A. Gallian, *Contemporary Abstract Algebra*, Cengage Learning, Boston, 2016.
6. V.K. Khanna and S.K. Bhambri, *A Course in Abstract Algebra*, Vikas Publishing House Pvt. Ltd., New Delhi, 2016.

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M.Sc. MATHEMATICS 3rd SEMESTER

Fluid Dynamics

CC-A09 Maximum Marks: 100
Credits: 4(3L+1T) External Examination: 70
Max. Time: 3 hrs. Internal Assessment: 30
Course ID: 241/MAT/CC303

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Study about basic behaviour of fluid, velocity potential of fluid, continuity equation and acceleration at a point of the fluid.

CLO2 Understand about equation of motion, pressure at a point of fluid, Bernoulli equation and some energy equations of the fluid.

CLO3 Learn about the axially symmetric flow, kinetic energy due to impulsive motion, source, sink and doublet.

CLO4 Evaluate the Stoke stream function, axisymmetric flow, irrotational motion, complex potential function, and Blasius theorem.

Unit-I

Kinematics - Velocity at a point of a fluid, Eulerian and Lagrangian methods, Stream lines, path lines and streak lines, Velocity potential, Irrotational and rotational motions, Vorticity and circulation, Equation of continuity, Boundary surfaces, Acceleration at a point of a fluid.

Unit-II

Pressure at a point of a moving fluid, Euler equation of motion, Equations of motion in cylindrical and spherical polar co-ordinates, Bernoulli equation, Impulsive motion, Kelvin circulation theorem, Kinetic energy of irrotational flow, Kelvin minimum energy theorem.

Unit-III

Axially symmetric flows, Liquid streaming part a fixed sphere, Motion of a sphere through a liquid at rest at infinity, Equation of motion of a sphere, Three-dimensional sources, sinks and doublets, Images of sources, sinks, and doublets in rigid impermeable infinite plane.

Unit-IV

Two dimensional motion, Stream function, Stoke stream function, Stoke stream function of basic flows, Complex velocity potential, Milne-Thomson circle theorem, Two-dimensional sources, sinks, doublets and their images, Blasius theorem.

Recommended Books:

1. W.H. Besant and A.S. Ramsey, *A Treatise on Hydromechanics, Vol. 2*, CBS Publishers and Distributors, Delhi, 2006.
2. F. Chorlton, *Text Book of Fluid Dynamics*, C.B.S. Publishers, Delhi, 2004.
3. M.E. O'Neill and F. Chorlton, *Ideal and Incompressible Fluid Dynamics*, Ellis Horwood, 1986.

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4. R.K. Rathy, *An Introduction to Fluid Dynamics*, Oxford and IBH Publishing Company, New Delhi, 1976.
5. G.K. Batchelor, *An Introduction to Fluid Mechanics*, Foundation Books, New Delhi, 1994.

M.Sc. MATHEMATICS 3rd SEMESTER

Discrete Mathematics

DSE-03 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID: 241/MAT/DS301A

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Understand the basic concepts of graph theory, sub graphs and isomorphism of graphs along with paths and circuits.

CLO2 Understand concept of directed graphs, trees, spanning tree, shortest path problem and cut sets.

CLO3 Learn about formal logic, quantifier, predicates, pigeonhole principle, lattices, complemented and distributive Lattices. Join-irreducible elements, and atoms and minterms.

CLO4 Learn about Boolean algebra, Boolean forms, minterm Boolean forms, sum of products canonical forms, applications of Boolean algebra to switching theory.

Unit-I

Graph Theory: Definitions and basic concepts, special graphs, Subgraphs, isomorphism of graphs, Walks, Paths and Circuits, Eulerian Paths and Circuits, Hamiltonian Circuits, matrix representation of graphs, Planar graphs, Coloring of Graph, Directed Graphs.

Unit-II

Trees: Isomorphism of Trees, Representation of Algebraic Expressions by Binary Trees, Spanning Tree of a Graph, Shortest Path Problem, Minimal spanning Trees, Cut Sets, Tree Searching.

Unit-III

Formal logic: Statements, symbolic representation, and tautologies. Quantifiers, predicates, validity, and propositional logic.

Lattices and their properties: Lattices as algebraic systems. Sublattices, direct products, and homomorphisms. Special lattices: complete, complemented, and distributive lattices. Join-irreducible elements, atoms, and minterms.

Unit-IV

Boolean Algebra and Applications: Boolean algebras and their structure as lattices; Boolean identities. Switching algebra as an example. Subalgebras, direct products, and homomorphisms. Boolean forms and their equivalence; minterm forms and sum of products (SOP) canonical forms. Minimization of Boolean functions. Applications of Boolean algebra in switching theory; Karnaugh map method.

Recommended Books:

1. B. Ram, *Discrete Mathematics*, Vinayak Publishers and Distributors, Delhi, 2004.
2. C.L. Liu, *Elements of Discrete Mathematics*, McGraw-Hill Book Co.
3. J.L. Gersting, *Mathematical Structures for Computer Science (3rd Edition)*, Computer

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Science Press, New York.
4. J.P. Tremblay and R. Manohar, *Discrete Mathematical Structures with Applications to Computer Science*, McGraw-Hill Book Co., 1997.
5. S. Lipschutz, *Finite Mathematics (International Edition 1983)*, McGraw-Hill Book Company, New York.

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M.Sc. MATHEMATICS 3rd SEMESTER

Mathematical Statistics

DSE-03 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID: 241/MAT/DS301B

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 To learn about basic concept of probability.

CLO2 Apply theorems and properties of probability including conditional probability and Bayes' theorem.

CLO3 Demonstrate the understanding of random variable, expectation, variance and properties.

CLO4 Explore and apply standard discrete and continuous probability distributions and the Central Limit Theorem.

CLO5 Understand statistical estimation and hypothesis testing using Z-test, t-test, and Chi-square test.

Unit –I

Random Experiment, Sample Space, Events – Simple, Composite, Mutually Exclusive and Exhaustive Events, algebra of events. Various Definitions of Probability, Properties of probability function, Addition Theorem, Boole's inequality, Conditional Probability, Multiplication Theorem, Independence of Events, Baye's Theorem and its applications.

Unit –II

Random variables, Discrete and Continuous random variables, probability mass and density functions, distribution function, Bivariate random variables, Mathematical expectation: Definition, mean, variance, covariance, moment generating function and their properties.

Unit –III

Discrete distributions: Binomial, Poisson and geometric distributions with their properties. Continuous distributions: uniform, exponential, gamma and normal distributions with their properties, Central Limit Theorem.

Unit –IV

Statistical estimation, Testing of hypothesis: Null and alternative hypotheses, simple and composite hypotheses, Critical region, Level of significance, two types of errors, Large sample and small sample test: Z-test, t-test and Chi-square test and applications.

Recommended Books:

1. R.V. Hogg and A.T. Craig, *Introduction to Mathematical Statistics*, Amerind Publishing Co. Pvt. Ltd., New Delhi, 1972.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, 2014.
3. W.J. Freund, *Mathematical Statistics (5th Edition)*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1994.

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4. S.M. Ross, *Introductory Statistics*, Elsevier, 2010.
5. J. Ravichandran, *Probability and Statistics for Engineers*, Wiley India, 2019.
6. W. Feller, *An Introduction to Probability Theory and its Applications, Vol. I and II*, Wiley, New York, 1968–1971.

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M.Sc. MATHEMATICS 4th SEMESTER
Number Theory

CC-A10 | Maximum Marks: 100
Credits: 4(3L+1T) | External Examination: 70
Max. Time: 3 hrs. | Internal Assessment: 30
Course ID: 241/MAT/CC401

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Apply properties of arithmetic and multiplicative functions, including Möbius inversion, to solve recurrence and combinatorial number theory problems.

CLO2. Solve linear Diophantine equations and analyze rational solutions using unimodular matrices and quadratic forms.

CLO3. Apply Farey sequences, approximation theorems, and geometric principles to analyze irrational numbers and integer representations.

CLO4. Use continued fractions and the Euclidean algorithm to find best approximations of irrationals and solve Pell's equation.

Unit-I

Number Theoretic Functions and Applications: Greatest integer function and arithmetic functions. Multiplicative and completely multiplicative functions. Möbius inversion formula and recurrence functions. Combinational number theory.

Unit-II

Diophantine Equations and Rational Solutions: Solution of the equation $ax + by = c$; simultaneous linear equations. Unimodular matrices and Pythagorean triangles. Selected examples in Diophantine analysis. Ternary quadratic forms and rational points on curves.

Unit-III

Diophantine Approximation and Number Theory: Farey sequences and rational approximations. Hurwitz's theorem on best approximations. Irrational numbers and Blichfeldt's principle. Minkowski's convex body theorem and Lagrange's four-square theorem.

Unit-IV

Continued Fractions: Euclidean algorithm and finite/infinite continued fractions. Approximations to irrational numbers and best possible approximations. Hurwitz's theorem on continued fractions. Periodic continued fractions and Pell's equation.

Recommended Books:

1. I. Niven, H.S. Zuckerman, and H.L. Montgomery, *An Introduction to the Theory of Numbers* (5th Edition), John Wiley & Sons, 1991.
2. G.H. Hardy and E.M. Wright, *An Introduction to the Theory of Numbers (6th Edition)*, Oxford University Press, 2008.
3. K. Ireland and M. Rosen, *A Classical Introduction to Modern Number Theory* (2nd Edition), Springer, 1990,
4. T.M. Apostol, *Introduction to Analytic Number Theory*, Springer, 1976.

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M.Sc. MATHEMATICS 4th SEMESTER
Classical Mechanics & Calculus of Variations

CC-A11 | Maximum Marks: 100
Credits: 4(3L+1T) | External Examination: 70
Max. Time: 3 hrs. | Internal Assessment: 30
Course ID: 241/MAT/CC402

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Learn the laws of conservation of momentum, angular momentum, and energy, along with moments and products of inertia.

CLO2 Learn about generalised coordinates and rigid body dynamics in three dimensions.

CLO3 Understand the Hamiltonian, Canonical transformations, Variational concepts, and Lagrange's equation for potential forces.

CLO4 Understand variational issues involving various types of functionals, one must comprehend the ideas of variational calculus.

Unit-I

Moments and products of inertia; theorems of parallel and perpendicular axes.

Angular momentum of a rigid body about a fixed point and fixed axes; principal axes of inertia.

Kinetic energy of a rigid body rotating about a fixed point; momental ellipsoid and equimomental systems. Coplanar mass distributions and general motion of a rigid body.

Unit-II

Euler's equations for rigid body motion about a fixed point; properties of rigid motion without external forces; examples of three-dimensional rigid body motion; dynamics of the rotating Earth.

Introduction to dynamical systems; generalized coordinates and velocities; virtual work and generalized forces. Lagrange's equations for holonomic systems; case of conservative forces; generalized momentum and impulse; impulsive forces and corresponding Lagrangian formulation.

Kinetic energy as a quadratic function of velocities; equilibrium of conservative holonomic systems; theory of small oscillations in such systems.

Unit-III

Lagrange's equations for potential (conservative) forces; variational principles in mechanics including Hamilton's principle and the principle of least action.

Hamiltonian formulation and canonical equations of motion; basic integral invariants in mechanics. Canonical transformations and their properties; Hamilton–Jacobi equation and its applications.

Unit-IV

Functionals and their variations; Euler–Lagrange equations and their derivation. Variational problems involving one independent and one dependent variable with: (i) first derivative, (ii) higher derivatives (fixed end conditions). Variational problems for functionals involving multiple functions of a single variable, and functionals involving a function and its higher-order derivatives. Functionals depending on functions of several independent variables; variational problems in parametric form.

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Natural and transition boundary conditions; invariance of Euler's equation; conditional extremum. Variational problems with moving boundaries.
Classical problems in calculus of variations: shortest path, minimal surface of revolution, Brachistochrone, isoperimetric and geodesic problems.

Recommended Books:

1. F. Chorlton, *Text Book of Dynamics (2nd Edition)*, CBS, 2002.
2. F. Gantmacher, *Lectures in Analytical Mechanics*, Mir Publishers, 1975.
3. F. B. Hilderbrand, *Methods of Applied Mathematics*, Dover Publications, 1992.
4. A.S. Gupta, *Calculus of Variations with Applications*, PHI Learning Pvt. Ltd., 1996.
5. H. Goldstein, C.P. Poole and J.L. Safko, *Classical Mechanics (3rd Edition)*, Pearson, 2011.
6. I.M. Gelfand and S.V. Fomin, *Calculus of Variations*, Dover Publications, 2012.
7. S.K. Sinha, *Classical Mechanics*, Alpha Science International Limited, 2009.
8. L.N. Hand and J.D. Finch, *Analytical Mechanics*, Cambridge University Press, 2008.

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M.Sc. MATHEMATICS 4th SEMESTER

Operations Research

DSE-04 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID: 241/MAT/DS401A

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of five short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Learn about the origin, definition and scope of operations research, formulation and solution of linear programming problems by different methods.
CLO2 Understand the transportation and assignment problems and their solutions by different methods.
CLO3 Knowledge of different queuing models and their solutions by single and multiple servers.
CLO4 Learn about the different inventory control models.

Unit - I

Operations Research: Origin, definition and its scope, Solution of Linear Programming problems by using Simplex methods, Big - M and Two-phase methods. Degeneracy in linear programming. Duality in linear programming.

Unit - II

Transportation Problems: Basic Feasible Solutions, Optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, trans-shipment problem.

Unit - III

Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

Unit - IV

Introduction to queuing models: Basic components of a queuing system. General birth-death equations in queuing theory.
Steady-state solutions of Markovian queuing models with single and multiple servers: (M/M/1, M/M/C, M/M/1/k, M/M/C/k).

Recommended Books:

1. F. Hillier and G.J. Lieberman, *Introduction to Operation Research*, Holden Day, 1990.
2. H.A. Taha, *Operation Research – An Introduction*, Prentice Hall of India, 2017.
3. J.K. Sharma, *Mathematical Model in Operations Research*, Tata McGraw Hill, 1989.
4. K. Swaroop, P.K. Gupta and Man Mohan, *Operations Research*, Sultan Chand and Sons, 2010.
5. N.S. Kambo, *Mathematical Programming Techniques*, McGraw Hill, 2008.
6. P.K. Gupta and D.S. Hira, *Operations Research*, S. Chand & Co., 1976.
7. S.D. Sharma, *Operation Research*, Kedar Nath Ram Nath Publications, 2009.

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M.Sc. MATHEMATICS 4th SEMESTER
Fuzzy Set Theory

DSE-04 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID: 241/MAT/DS401B

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of five short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Using characteristic and membership functions, draw comparisons between crisp and fuzzy set operations.
CLO2 Acquire knowledge about fuzzy sets through language, then use membership functions to express these sets.
CLO3 Describe the mapping of fuzzy sets by a function; concepts related to fuzzy sets: support, normalcy, convexity, and α-level sets.
CLO4 Understand Fuzzy integers, morphisms, fuzzy graphs and relations; extension principle; α-level sets; arithmetic operations on fuzzy numbers.

Unit-I

Fuzzy Sets: Sets, Operation of Sets, Characteristics of Crisp Set, Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set. .

Unit-II

The Operation of Fuzzy Set: Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations In Fuzzy Set, T-norms and T-conorms.

Unit-III

Fuzzy Relation and Composition: Crisp Relation, Properties of Relation on a Single Set, Fuzzy Relation, Extension of Fuzzy Set

Unit-IV

Fuzzy Graph and Relation: Fuzzy Graph, Characteristics of Fuzzy Relation, Classification of Fuzzy Relation, Other Fuzzy Relations.

Recommended Books:

1. K.H. Lee, *First Course on Fuzzy Theory and Applications*, Springer International Edition, 2005.
2. H.J. Zimmerman, *Fuzzy Set Theory and its Applications*, Allied Publishers Ltd., New Delhi, 1991.
3. J. Yen and R. Langari, *Fuzzy Logic – Intelligence, Control and Information*, Pearson Education, 1999.
4. L. A. Zadeh and G. J. Klir, *Fuzzy Sets, Fuzzy Logic, Theory and Applications* (1st Edition), Prentice Hall, New Jersey, 1995.
5. George J. Klir and Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications* (1st Edition), Prentice Hall, New Jersey, 1995.
6. P. K. Maji and R. Biswas, *Fuzzy Sets, Logic and Rough Sets* (1st Edition), Narosa Publishing House, New Delhi, 2006.

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Multidisciplinary Course from the department for pool of the Courses in the University (These courses are to be offered to students of different discipline/Subject)

Semester 1

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
MDC-1	Aptitude Reasoning-I	241/MAT/MD101	2	1	--	2	1	--	3	25	50	--	--	75

Semester 2

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
MDC-2	Aptitude Reasoning-II	241/MAT/MD201	2	1	--	2	1	--	3	25	50	--	--	75

Semester 3

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
MDC-3	Fundamentals of Mathematics	241/MAT/MD301	2	1	--	2	1	--	3	25	50	--	--	75

Semester 4

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
MDC-4	Fundamentals of Statistics	241/MAT/MD401	2	1	--	2	1	--	3	25	50	--	--	75

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Skill Enhancement Course from the department for pool of the Courses in the University

(These courses are offered by each department for students of other departments/same department and is designed to provide value-based and/or skill-based knowledge and should contain both theory and lab/hands- on/training/field work.)

Semester 2

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
SEC-1	Computational Techniques using MATLAB	241/MAT/SE201	1	--	2	1	--	1	2	5	20	5	20	50

Semester 3

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
SEC-2	LaTeX	241/MAT/SE301A	1	--	2	1	--	1	2	5	20	5	20	50
	Python for Statistical Analysis	241/MAT/SE301B	1	--	2	1	--	1	2	5	20	5	20	50

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Ability Enhancement Course from the department for pool of the Courses in the University

(These courses are offered by department of Indian and Foreign Languages for students of other departments/same department and leads to enhancement in the ability of learn
Regional and foreign languages)

Semester 1

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
AEC-1	Language		2	--	--	2	--	--	2	15	35	--	--	50

Semester 2

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
AEC-2	Language		2	--	--	2	--	--	2	15	35	--	--	50

Semester 4

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
AEC-3	Language		2	--	--	2	--	--	2	15	35	--	--	50

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Value Added Course from the department for pool of the Courses in the University

(All the departments will offer value added course for the students of same or different departments.

Semester 1

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
VAC-1	Mathematics in Everyday Life	241/MAT/VA101	2	--	--	2	--	--	2	15	35	--	--	50

Semester 3

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs.)			Credits				TI	TE	PI	PE	Total
VAC-2	Vedic Mathematics	241/MAT/VA301	2	--	--	2	--	--	2	15	35	--	--	50

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Marks

M.Sc. MATHEMATICS 3rd SEMESTER

Fundamentals of Mathematics

MDC-03 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID:

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Understand set theory, logic, and functions to solve problems.
CLO2 Solve linear systems using matrices, determinants, rank, and eigenvalues.
CLO3 Apply differentiation and integration techniques to solve problems.
CLO4 Solve first-order differential equations using standard methods.

Unit-I

Sets, subsets, Venn diagrams, operations on sets, Relations and functions, Mathematical logic: propositions, truth tables.

Unit-II

Matrices: types, operations, determinants, inverse, Systems of linear equations, rank,eigenvalues and eigenvectors.

Unit-III

Limits and derivatives, Basics of differentiation, graphical significance of differentiation and its applications. Methods of Integration: integration by parts, integration by partial fractions and their applications

Unit-IV

Linear differential equations and its applications. First order differential equations, separable variables, homogeneous equations, exact differential equations, solution of exact differential equations.

Recommended Books:

1. K.H. Rosen, *Discrete Mathematics and Its Applications* (7th Edition), McGraw-Hill, 2012.
2. S. Lipschutz, *Linear Algebra*, Schaum's Outline Series, McGraw-Hill, 3rd Edition, 2005.
3. S.L. Ross, *Differential Equations* (3rd Edition), John Wiley & Sons, 2004.
4. S. Narayan and P.K. Mittal, *Integral Calculus* (21st Revised Edition), S. Chand & Company Ltd., New Delhi, 2017.

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M.Sc. MATHEMATICS 3rd SEMESTER

LaTeX

SEC-02
Credits: 2(1L+1P)
Max. Time: 2 hrs.
Course ID:

Maximum Marks: 50
Theory External: 20
Theory Internal: 05
Practical External: 20
Practical Internal: 05

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Understand the fundamentals of LaTeX and create structured documents with appropriate formatting and organization.

CLO2 Apply packages and features to enhance document layout, footnotes, tables, and navigation tools like table of contents.

CLO3 Typeset complex mathematical expressions, insert figures and plots, and visualize data using LaTeX tools.

CLO4 Compile bibliographies, cite references, use multi-file projects, and prepare professional presentations and reports in LaTeX.

Unit-I

Introduction to LaTeX: Purpose of LaTeX, advantages over word processors, introduction to typesetting systems, setting up LaTeX environments (TeX Live, MiKTeX, Overleaf), writing the first `.tex` document, document structure (preamble, body, compiling), formatting text, font styles and sizes, sections, subsections, and paragraphs.

Unit-II

Structuring and Enhancing Documents: Using LaTeX packages, creating lists (itemized, enumerated, description), inserting footnotes and margin notes, working with headers and footers, setting page margins, generating a table of contents, list of figures and tables, cross-referencing using labels, and designing professional tables.

Unit-III

Mathematics and Graphics in LaTeX: Mathematical typesetting: inline and display math modes, commonly used symbols, equation arrays, `amsmath` package, inserting and positioning images using `graphicx`, captions, figure references, plotting graphs using `pgfplots` and `tikz`, creating diagrams and flowcharts.

Unit-IV

Citations, Bibliographies, and Advanced Applications: Creating bibliographies with `bibtex` and `biblatex`, in-text citations, bibliography styles (APA, IEEE, etc.), custom commands and environments, using `beamer` for presentations, writing research articles and theses, exporting to PDF.

Recommended Books:

1. S. Kottwitz, *LaTeX Beginner's Guide*, Packt Publishing Ltd., 2011.
2. H. Kopka and P.W. Daly, *Guide to LaTeX*, Pearson Education, 2003.

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3. F. Mittelbach *et al.*, *The LaTeX Companion*, Addison-Wesley Professional, 2004.
4. D.F. Griffiths and D.J. Higham, *Learning LaTeX*, Society for Industrial and Applied Mathematics, 2016.

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M.Sc. MATHEMATICS 3rd SEMESTER

Python for Statistical Analysis

SEC-02
Credits: 2(1L+1P)
Max. Time: 2 hrs.
Course ID:

Maximum Marks: 50
Theory External: 20
Theory Internal: 05
Practical External: 20
Practical Internal: 05

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Develop fundamental programming skills in Python, including syntax, control structures, and basic input-output operations.

CLO2 Efficiently manipulate and analyze data using essential Python libraries such as NumPy and Pandas.

CLO3 Apply data visualization techniques to represent data insights using Matplotlib and Seaborn.

CLO4 Implement basic statistical analysis using Python, including descriptive statistics, hypothesis testing, and data visualization for statistical insights.

Unit-I

Introduction to Python and Basic Concepts: Installation, IDEs (Jupyter Notebook, VS Code), Basic Syntax: Variables, Data Types, Operators, Control Structures: Conditional Statements (if, else), Loops: for and while loops, Basic Input and Output, Functions: Definition, Calling, Parameters, Return Values, Simple Exercises: Basic calculations, conditional logic.

Unit-II

Data Structures and Manipulation: Lists, Tuples, Sets, and Dictionaries, Accessing, Modifying, and Iterating through data structures, Comprehensions: List and Dictionary Comprehensions, File Handling: Reading from and Writing to Files, Introduction to Libraries: Importing and Using Packages (like NumPy), Basic Data Manipulation with Lists and Dictionaries, Simple Exercises: Reading data from files, basic data processing.

Unit-III

Data Handling and Visualization: Working with Numpy for Numerical Operations, Introduction to Pandas for Data Frames and Data Handling, Data Cleaning and Preprocessing: Handling Missing Values, Basic Data Visualization with Matplotlib and Seaborn, Creating Line, Bar, and Scatter Plots, Simple Exercises: Creating plots from data, basic data analysis.

Unit-IV

Basic Statistical Analysis with Python: Introduction to Statistical Concepts: Mean, Median, Mode, Variance, Stand
ard Deviation, using Python Libraries for Statistical Analysis: Scipy and Statsmodels, Descriptive Statistics with Pandas, Data Visualization for Statistical Insights: Boxplots,

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Histograms, Simple Hypothesis Testing: t-test, Chi-Square Test, Practical Examples: Analyzing simple datasets for insights.

Recommended Books:

1. W. McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython*, O'Reilly Media, Inc., 2012.
2. P. Bruce and A. Bruce, *Practical Statistics for Data Scientists*, O'Reilly Media, Inc., 2020.
3. A.B. Downey, *Think Stats: Exploratory Data Analysis in Python*, O'Reilly Media, Inc., 2014.
4. J. VanderPlas, *Python Data Science Handbook*, O'Reilly Media, Inc., 2016.
5. A.C. Müller and S. Guido, *Introduction to Machine Learning with Python*, O'Reilly Media, Inc., 2016.
6. M. Lutz, *Programming Python*, O'Reilly Media, Inc., 2001. *(Supplementary reference for core Python concepts).*

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M.Sc. MATHEMATICS 3rd SEMESTER
Vedic Mathematics

VAC-02 Maximum Marks: 50
Credits: 2(2L) External Examination: 35
Max. Time: 2 hrs. Internal Assessment: 15
Course ID:

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Course Learning Outcomes:

CLO1 Develop the understanding of objectives and features of Vedic maths.
CLO2 Understand and apply Ekanyunena Purvena, Nikhilam Navatahcarmam Dastah, and Cross Digit Sum for solving arithmetic and algebraic problems.
CLO3 Apply Vedic Sutras to find square and cube of arithmetic and algebraic problems.
CLO4 Learn about Square root, Cube root, and divisibility by using Vedic sutras.
CLO5 To learn about solution of simultaneous linear equations by using Vedic sutras.

Unit I

Introductions & History of Vedic Mathematics, Introduction to Father of Vedic Mathematics "Jagatguru Bharti Krishan Tirthji" Multiplications-using Sutras- Ekanyunena Purvena, Ekadhikena Purvena, Nikhilam Navatahcarmam Dastah, Vertically & Crosswise, Sum of Products, Difference of products, Sum and difference of Products in arithmetic and algebra. Cross digit sum to check the answers of addition, multiplication and subtraction.

Unit II

Square using Sutras- Ekadhikena Purvena, Nikhilam Navatahcarmam Dastah, Duplex in arithmetic and Algebra, Sum of squared numbers, difference of squared numbers, Sum and difference of squared Numbers, Cube using Sutras-Nikhilam and Anurupyena.

Unit III

Square root using Vilokanam and Duplex, Cube root upto 9 digits, divisibility by denominator ending digits 1, 3, 7 & 9, Division by Sutras-Paravartya, Ekadhikena, Nikhilam Navatahcarmam Dastah, Dhwajank having divisor upto 3 digits, Division of Algebraic Expressions having divisor linear and quadratic.

Unit IV

Solution of Simple equations, Solutions of simultaneous linear equations in two variables, factorization in arithmetic, factorization of quadratic and cubic expressions, Highest Common Factors in arithmetic and algebraic expressions.

Recommended Books:

1. A. Gupta, *The Power of Vedic Maths* (2nd Revised & Updated Edition), Jaico Publishing House, 2004.
2. V.E. Stevens, *Pebble Maths: A New and Successful Way to Teach Vedic Math to Beginner Learners of All Ages and Abilities*, Pebble Maths Publishing House.
3. R.K. Thakur, *The Essentials of Vedic Mathematics* (1st Edition), Rupa Publications, India, 2013.

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M.Sc. MATHEMATICS 4th SEMESTER

Fundamentals of Statistics

MDC-04 Maximum Marks: 75
Credits: 3(2L+1T) External Examination: 50
Max. Time: 2 hrs. Internal Assessment: 25
Course ID: 241/MAT/MD401

Note: *There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of seven short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.*

Course Learning Outcomes:

CLO1 Summarize and interpret data using measures of central tendency, dispersion, and graphical tools.

CLO2 Understand apply probability concepts and distributions to model and analyze random phenomena.

CLO3 To learn about discrete probability distributions, continuous probability distributions.

CLO4 To learn about large sample theory and statistical inference.

Unit -I

Measures of central tendency: Mean, median, mode, Measures of dispersion: Range, variance, standard deviation, and interquartile range, Moments, skewness and kurtosis, Graphical representation of data: Histogram, bar chart, pie chart, and boxplot, Exploratory data analysis.

Unit –II

Basic concepts of probability, Conditional probability and independence, Bayes' theorem and its applications, Random variables: Discrete Random variables, Continous Random variables and probability distributions. Karl pearson's coefficients of Correlation, Linear regression.

Unit -III

Discrete probability distributions: Binomial, Poisson, and geometric distributions, Continuous probability distributions: Normal, exponential, and uniform distributions, Moment-generating functions, Central Limit Theorem and its significance, Applications in real-world scenarios.

Unit –IV

Concept of Population and Sample, Sampling Techniques, Concept of estimation, Properties of good estimators, Hypothesis testing: Null and alternative hypotheses, Types of errors, Significance level and power of a test, Z-test, t-test, Chi-square Test.

Recommended Books

1. R.V. Hogg and A.T. Craig, *Introduction to Mathematical Statistics*, Amerind Publishing Co. Pvt. Ltd., New Delhi, 1972.
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, 2014.
3. W.J. Freund, *Mathematical Statistics (5th Edition)*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1994.

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4. S.M. Ross, *Introductory Statistics*, Elsevier, 2010.
5. J. Ravichandran, *Probability and Statistics for Engineers*, Wiley India, 2019.
6. W. Feller, *An Introduction to Probability Theory and its Applications, Vol. I and* Wiley, New York, 1968–1971.

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