M.Sc. Mathematics.

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**					

241/MAT/CC401

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.

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. 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.

M.Sc. MATHEMATICS 4th SEMESTER

Operations Research

DSE-04
Credits: 3(2L+1T)
Max. Time: 2 hrs.
Course ID: 241/MAT/DS401A

Maximum Marks: 75
External Examination: 50
Internal Assessment: 25

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.

M.Sc. MATHEMATICS 4th SEMESTER

Fuzzy Set Theory

DSE-04
Credits:3(2L+1T)
Max. Time: 2 hrs
Course ID: 241/MAT/DS401B

Maximum Marks: 75
External Examination: 50
Internal Assessment: 25

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.