Semester I

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2016-17		
Course Code	University Course Type	Course Name
MAT 158	Core Theory	Advanced Abstract Algebra
MAT 159	Core Theory	Topology
MAT 160	Core Theory	Integral Transforms
MAT 161	Core Theory	Differential Geometry
BCS 108	Core Practical	Object Oriented Programming Lab with C++
ENG 109	Skill Enhancement Course	Communicative English

MAT 158

ADVANCED ABSTRACT ALGEBRA

M.Sc. (Mathematics) **Semester I**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Quotient groups- Fundamental theorem of homomorphism. Structure theory of groups- free abelian groups, finitely generated abelian groups, group actions on a set, Sylow's Theorem.

Module 2: Solvable groups, Jordan-Holder Theorem, Normal series, Quotient rings, Maximal and prime ideal. Fundamental Theorem of ring isomorphism. Field of Quotients and embedding of rings.

Module 3: Polynomial rings, Factorization theory of Integral domains, Prime fields, Extension of fields.

Module 4: Modules- Definition and examples, Sub modules and Direct sums, Ring homomorphism and Quotient modules, Completely reducible modules, Free modules over polynomial rings.

Module 5: Galois theory - Automorphism, Groups and fixed field, Normal extension and Fundamental theorem of Galois theory, Application Galois theory to classical problems such as root of unity and cyclotomic polynomial, cubic equations, cyclic extensions, symmetric functions, Construction with Ruler and Compass.

Reference Books:

1. E. Artin, Galois theory, Notre Dame, Indiana (1959).
2. K.G. Ramanathan, Lectures in Abstract Algebra,TIFR(1954)
3. N. Jacobson, Lectures in Abstract Algebra, Vol. III, Van Nostrand,Princeton(1964)
4. T. W. Hungerford, Algebra
5. G. Birkhoff and S. MacLane, Algebra
6. K. M. Hoffman and R. Kunze, Linear Algebra

MAT 159

TOPOLOGY

M.Sc. (Mathematics) **Semester I**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Definition and examples of topological spaces. Closed sets, Closure, Neighborhoods, interior, exterior, and boundary, Accumulation points and derived sets and related sets.

Module 2: Bases and sub-bases, Subspaces and relative topology, Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems, Continuous functions and homeomorphism.

Module 3: The separation axioms *T0*, *T1*, *T2*, *T3*, *T4*; their characterizations and basic properties, Urysohn's lemma, Tietze extension theorem.

Module 4: Compactness-Basic properties of compactness, Compactness and finite intersection property, Sequential, Compact space, and B-W compactness. Local compactness.

Module 5: Product space, Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.

Reference Books:

1. J. L. Kelley, General Topology, Van Nostrand, 1995.

2. K. D. Joshi, Introduction to General Topology, Wiley Eastern, 1983.

3. James R. Munkres, Topology, 2nd Edition, Pearson International, 2000.

4. J. Dugundji, Topology, Prentice-Hall of India, 1966.

5. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.

6. N. Bourbaki, General Topology, Part I, Addison-Wesley, 1966.

7. S. Willard, General Topology, Addison-Wesley, 1970.

8. S.W. Davis Topology, Tata McGraw Hill, 2006

MAT 160

INTEGRAL TRANSFORMS

M.Sc. (Mathematics) **Semester I**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Laplace transform– Definition and its properties, Rules of manipulation, Laplace transform of derivatives and integrals, Properties of inverse Laplace transform, Convolution theorem.

Module 2: Fourier transform – Definition and properties of Fourier sine, cosine and complex transforms, Convolution theorem, Inversion theorems, Fourier transform of derivatives.

Module 3: Applications of Laplace transform and Fourier transform-Solution of ordinary and partial differential equations.

Module 4: Mellin transform– Definition and elementary properties, Mellin transforms of derivatives and Integrals, Inversion theorem, Convolution theorem.

Module 5: Complex inversion formula, Infinite Hankel transform– Definition and elementary properties, Hankel transform of derivatives, Inversion theorem, Parseval Theorem.

Reference Books:

1. Integral Transforms, Schaum Series.

2. A First course in integral equations –A.M. Wazwaz (1997) (world Scientific)

3. Introduction to Integral Equation with Applications –A.J. Jerri (1999) Second edition Wiley Interscience.

MAT 161

DIFFERENTIAL GEOMETRY

M.Sc. (Mathematics) **Semester I**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Space curves, Tangent, Contact of curve and surface, Osculating plane, Principal normal and Bi normal, Curvature, Torsion, Serret- Frenet's formulae, Osculating circle and Osculating sphere, Existence and Uniqueness theorems, Bertrand curves, Involute and Evolutes.

Module 2: Conoids, Inflexional tangents, Singular points, Indicatrix. Ruled surface, Developable surface, Tangent plane to a ruled surface, Necessary and sufficient condition that a surface $\zeta = f(\xi, \eta)$ should represent a developable surface.

Module 3: Metric of a surface, first and second fundamental forms, Fundamental magnitudes of some important surfaces, orthogonal trajectories.

Module 4: Normal curvature, Principal directions and Principal curvatures, First curvature, Mean curvature,Gaussion curvature, Radius of curvature of a given section through any point on z = f(x,y). Lines of curvature, Principal radii, Relation between fundamental forms.

Module 5: Asymptotic lines, Differential equation of an asymptotic line, Curvature and Torsion of an asymptotic line, Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces, Parallel surfaces, Gaussian and mean curvature for a parallel surface.

Reference Books:

1. J.A. Thorpe : Elementary Topics in Differential Geometry (Springer Verlag)
2. B Oneill : Elementary Differential Geometry (Academic - New York)
3. M. do Carmo: Differential Geometry of curves and surfaces. (Englewood Cliffs, N.J., Prentice Hall, 1976).
4. R. Millman and G. Parker : Elements of differential Geometry. (Englewood Cliffs, N.J., Prentice Hall, 1977)

ENG 109
COMMUNICATIVE ENGLISH

M.Sc. (Mathematics) **Semester I**

L - T - P – C: 2 – 0 – 0- 2 **Course Type-** Ability Enhancement Course

Module I: Communication Skills- Process, Purpose, Types and Importance of Communication, Effective Speaking- Paralinguistic Features, Barriers to Speaking, Types of Speaking, Persuasive Speaking, Public Speaking

Module II: Listening and Speaking- Introduction, Conversations, Telephonic Conversations and Etiquettes, Dialogue Writing, Case Study Method of Learning- Discussion & Presentation

Module III: Building Advanced Vocabulary- Word Formation, Synonyms, Antonyms, Homonyms, Homophones, Words often Confused, One Word Substitution, Phrasal Verbs, Idiomatic Expressions, Developing Technical Vocabulary, Eponyms

Module IV: Writing Skills- Writing reviews, Writing Reports- its Process, Structure, Kinds, Objectives and Layout, Writing Research Paper, Dissertation and Thesis

Module V: Soft Skills- How Communication Skills and Soft Skills are inter-related, Leadership Skills, Group Dynamics, Negotiation Skills

Text/Reference Books:

1. K Bhardwaj, Professional Communication, IK Int Pub House, New Delhi

2. Krizan, Merrier, Logan and Williams, Effective Business Communications, New Delhi

3. Penrose, Business Communication for Managers, Cengage, New Delhi

4. Business Communication Today, Bovee et al, Pearson

5. Business Communication, Lesiker, et al, McGraw Hill

Semester II

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2016-17		
Course Code	University Course Type	Course Name
MAT 162	Core Theory	Functional Analysis
MAT 163	Core Theory	Mathematical Programming
MAT 164	Core Theory	Combinatorics and Graph Theory
DSE1	Department Specific Elective 1	Choose any one from list of DSE Courses
MAT 180	Core Practical	Numerical Analysis Lab - I

MAT 162
FUNCTIONAL ANALYSIS

M.Sc. (Mathematics) **Semester II**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Normed linear spaces, Quotient space of normed linear spaces and its completeness, Banach spaces and examples, bounded linear transformations, Normed linear space of bounded linear transformations.

Module 2: Equivalent norms, Basic properties of finite dimensional normed linear spaces and compactness, Reisz Lemma, Multilinear mapping, Open mapping theorem, Closed graph theorem, Uniform boundness theorem.

Module 3: Continuous linear functional, Hahn-Banach theorem and its consequences, Embedding and Reflexivity of normed spaces, Dual spaces with examples, Inner product spaces, Hilbert space and its properties.

Module 4: Orthogonality and Functionals in Hilbert Spaces. Pythagorean theorem, Projection theorem, Orthonormal sets, Bessel's inequality, complete orthonormal sets, Parseval's identity, Structure of a Hilbert space, Riesz representation theorem, Reflexivity of Hilbert spaces.

Module 5: Adjoint of an operator on a Hilbert space, Self-adjoint, Positive, Normal and Unitary operators and their properties. Projection on a Hilbert space. Invariance, Reducibility, Orthogonal projections. Derivatives of a continuous map from an open subset of Banach space to a Banach space.Rules of derivation, Derivative of a composite, Directional derivative, Mean value theorem and its applications.

Reference Books:

1. A. E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.
2. B. V. Limaye, Functional Analysis, Wiley Eastern.
3. N. Dunford and J. T. Schwartz, Linear Operators, Part-I, Interscience, 1958.
4. R. E. Edwards, Functional Analysis, Holt Rinehart and Winston, 1965.
5. C. Goffman and G. Pedrick, First Course in Functional Analysis, Prentice- Hall of India, 1987.
6. K. K. Jha, Functional Analysis and Its Applications, Students' Friend, 1986

MAT 163

MATHEMATICAL PROGRAMMING

M.Sc. (Mathematics) **Semester II**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Introduction- Separating plane, supporting hyper plane and related theorems, convex function, local and global maxima and minima, theorem based on convexity and concavity of quadratic forms, simplex method and revised simplex method for solving L.P.P, bounded variable problems.

Module 2: Integer programming- Pure and mixed integer programming problems, Gomory's-cutting plane method, Branch and bound algorithm.

Module 3: Quadratic forms and Lagrangian function, Saddle points-Necessary and sufficient conditions for saddle points, Classical optimization –Nonlinear programming problem, Kuhn-Tucker Theory and Kuhn-Tucker necessary and sufficient condition for NLPP.

Module 4: Quadratic programming problem Wolfe's method and Beale's method for solving quadratic programming problems.

Module 5: Dynamic programming-Introduction Bellman's principle of optimality, solution of problem with finite number of stages. Solution of LLP by Dynamic Programming.

Reference Books:

1. F. S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995.

2. G. Hadley, Nonlinear and Dynamic Programming, Addison Wesley.

3. H. A. Taha, Operations Research –An Introduction, Macmillan.

4. Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi.

5. S. S. Rao, Optimization Theory and Applications, Wiley Eastern.

6. N. S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt. Ltd., NewDelhi.

MAT 164

COMBINATORICS AND GRAPH THEORY

M.Sc. (Mathematics) **Semester II**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Combinatorics– Counting of sets and multisets. Binomial and multinomial numbers. Unordered selection with repetitions, Selection without repetition. Counting objects and functions. Functions and the Pigeonhole principle. Inclusion and exclusion principle.

Module 2: Discrete numeric functions and combinatorial problems, Generating functions and recursions, Power series and their algebraic properties, Homogeneous and non-homogeneous linear recursions.

Module 3: Graphs– Basic terminology, Simple graphs, Multi graphs and Weighted graphs, Isomorphism, complementary graphs, self-complementary graphs, Adjacency matrix & Incidence Matrix of a graph.

Module 4: Walk and Connectedness, Paths and circuits, Shortest path in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits.

Module 5: Traveling salesman problem, operations on graphs. Trees– Trees, Rooted trees, Paths lengths in rooted trees, spanning trees, minimum spanning trees.

Reference Books:

1. R. Diestel, Graph Theory, Springer.
2. Harary, Graph Theory Narosa Publishers, New Delhi.
3. Douglas B West, Introduction to Graph Theory, Prentice- Hall, New Delhi.

MAT 180

NUMERICAL ANALYSIS LAB – I

M.Sc. (Mathematics) **Semester II**

L - T - P – C: 0 - 0 – 4 - 2 **Course Type-** Core Practical

Programs Based on Numerical Analysis using any software.

Simple algorithm dealing with fundamental concepts using conditional statements, do loops, subscripted variables. Programs for solution of quadratic equation, Solution of algebraic and transcendental equations, Gauss-Seidel method, Inverse of a matrix/Gaussian elimination etc., Numerical integration , Euler's and modified Euler's methods, Runge-Kutta methods, Tridiagonal system by Thomas algorithm

Reference Books:

1. Robert J. Schilling & Sandra L. Harris, "Applied Numerical Methods for Engineers using SCILAB & C", Thomson Brooks / Cole.
2. P. N. Wartikar and J. N. Wartikar, "Elements of Applied Mathematics", Volume 1 and 2, Vidyarthi Prakashan, 1978.
3. S. S. Shastri, "Engineering Mathematics", Vol-2, PHI, 2nd Edition, 1994.
4. S.S. Shastri, "Introductory Methods of Numerical Methods" Vol-2, PHI, 2ndEdition, 1994.
5. S. C. Gupta,V. K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, 1971.
6. Erwin Kreyszing, "Advanced Engineering Mathematics", John Wiley & Sons, 2010.
7. John H. Mathews, "Numerical Methods for Mathematics, Science & Engineering", Prentice Hall, 1992.

Semester III

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2016-17		
Course Code	University Course Type	Course Name
MAT 168	Core Theory	Advanced Linear Algebra
MAT 169	Core Theory	Operations Research
MAT 170	Core Theory	Advanced Graph Theory-I
DSE2	Department Specific Elective 2	Choose any one from list of DSE Courses
MAT 181	Core Practical	Numerical Analysis Lab - II

MAT 168

ADVANCED LINEAR ALGEBRA

M.Sc. (Mathematics) **Semester III**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Vector spaces, Basis and dimension, rank of matrix, change of basis.

Module 2: Linear transformations -Algebra of linear transformation, linear functional, dual space, dual basis, linear transformation of direct sum.

Module 3: Elementary canonical form introductive, Characteristic values , annihilator polynomial. Invariant subspace, direct sum deco potion, invariant direct sum, primary decomposition theorem.

Module 4: Inner product space- inner product(real and complex), adjoint operator hermition form, linear functional and adjoint unitary operator , normal operator .

Module 5: Bilinear form : Bilinear form , symmetric bilinear form , skew symmetric bilinear form, graphs preserving bilinear form.

Reference Books:

1. K. Hoffman and Ray Kunje : Linear Algebra (Prentice - Hall of India private Ltd.)
2. M. Artin : Algebra (Prentice - Hall of India private Ltd.)
3. A.G. Hamilton : Linear Algebra (Cambridge University Press (1989))
4. N.S. Gopalkrishanan : University algebra (Wiley Eastern Ltd.)
5. J.S. Golan : Foundations of linear algebra (Kluwer Academic publisher (1995))
6. Henry Helson : Linear Algebra (Hindustan Book Agency (1994))
7. I.N. Herstein : Topics in Algebra, Second edition (Wiley Eastern Ltd.)

MAT 169

OPERATIONS RESEARCH

M.Sc. (Mathematics) **Semester III**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Nonlinear Programming, Quadratic Programming, Duality in Quadratic Programming Problems, Unconstrained Optimization, Direct search methods, Gradient Method, Constrained Optimization, Separable Programming.

Module 2: Inventory Models-Deterministic and Probabilistic Models.

Module 3: Queuing Theory- Characteristics of queuing systems, Birth and death process, Steady state solutions, Single server model (finite and infinite capacities), Single server model (with SIRO), Models with state dependent arrival and service rates, Waiting time distributions.

Module 4: Replacement Theory-Replacement of assets that deteriorate with time, Replacement of items that deteriorate suddenly.

Module 5: Project Scheduling by PERT, CPM.

Reference Books:

1. F. S. Hiller and G. J. Leiberman, Introduction to Operations Research (6th Edition), McGraw-Hill International Edition, 1995.
2. G. Hadley, Nonlinear and Dynamic Programming, Addison Wesley.
3. H. A. Taha, Operations Research –An Introduction, Macmillan.
4. Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi.
5. S. S. Rao, Optimization Theory and Applications, Wiley Eastern.
6. N. S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt. Ltd., New Delhi.

MAT170

ADVANCED GRAPH THEORY-I

M.Sc. (Mathematics) **Semester III**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- Core Theory**

Module 1: Cut sets– Cut-sets, Cut vertices, Fundamental cut sets, Connectivity and seperativity, Net work flows, Max-flow min-cut theorem.

Module 2: Plannar Graphs– Combinatorial and geometric graphs, Kuratowski's graphs, Euler's formula, Detection of planarity, Geometric dual, Thickness and Crossing number.

Module 3: Graph Colouring, Vertex colouring, Edge colouring and Map colouring, Chromatic number, Chromatic polynomials, The four and five colour theorems.

Module 4: Digraphs– Binary relations, Directed graphs and Directed trees, Arborescence, Polish notation Method.

Module 5: Enumeration of graphs, Counting of labeled trees and unlabeled trees, Cayley's theorem, counting methods, Polya's theory, Graph enumeration with Polya's theory.

Reference Books:

1. D.B.West, Graph Theory, Pearson Publ. 2002.
2. F.Harary, Graph Theory. Narosa Publ. ND.
3. R. Diestel, Graph Theory, Springer, 2000.
4. Douglas B. West, Introduction to Graph Theory Prentice- Hall, New Delhi (1999)
5. John Clarke and D.A. Holton, A First Look at Graph Theory, Allied Publisher (1991)
6. Nora Harsfield and Gerhard Ringel , Pearls Theory, Academic Press (1990)
7. Harary, Graph Theory, Narosa Publishers, New Delhi (1989)

MAT 181

NUMERICAL ANALYSIS LAB- II

M.Sc. (Mathematics) **Semester III**

L - T - P – C: 0 - 0 – 4 - 2 **Course Type- Core Practical**

Solve (using any software):

Transportation problem – Assignment problem – Dual Simplex method – Gomory's cutting plane algorithm. Solution of L.P.P. local and global optimistic of function, Numerical Non Linear global optimization of functions.

Reference Books:

1. Hamdy A. Taha, "Operations Research an Introduction", 8th Edition, Pearson Education, 2004.

2. F.S.Hillier & G.J. Lieberman, "Introduction to Mathematical programming",Mc Graw-Hill International Edition, 2010.

3. S.S. Rao, "Optimization: Theory and Applications", 2nd Edition, Wiley EasternCompany, 2010.

4. Bazaara, Shetty and Sherali, "Non-linear Programming: Theory and Algorithms",Wiley Eastern Company, 2006.

5. Robert E. Larson and John L.Casti, "Principles of Dynamic Programming", reprint, 2011.

Semester IV

M.Sc. MATHEMATICS SCHEME EFFECTIVE FROM 2016-17		
Course Code	University Course Type	Course Name
DSE 3	Department Specific Elective 3	Choose any one from list of DSE Courses
DSE 4	Department Specific Elective 4	Choose any one from list of DSE Courses
MAT 182	Core Practical	MATLAB Lab
MAT 193	Core Practical	Seminar
MAT 184	Core Practical	Project

MAT 182
MATLAB LAB

M.Sc. (Mathematics) **Semester IV**

L - T - P – C: 0 – 0 –4 – 2 **Course Type- Core Practical**

MATLAB PROGRAMMING: Input output of data from MATLAB command. File types. Creating, saving and executing the script file. Creating and executing functions file. Working with files and directories. Matrix manipulation. Creating vectors. Arithmetic operations. Relational operations. Logical operations. Matrix functions. Determinant of matrix. Eigen values and Eigen vectors.

Programming in MATLAB: Function files, sub functions, global variations, loops, branches and control flow. Interactive input. Recursion. Publishing a report. Controlling command windows. Command line editing.

Linear Algebra and interpolation: Solving the linear equation. Gaussian elimination, matrix factorization, curve fitting, polynomial curve fitting, least squares curve fitting. General non linear fits. Interpolation.

Differential equations and graphics: First order and second order ODE. Double integration. Roots of polynomial. Two and three dimensional plots. MATLAB plotting tools. Mesh and surface plots.

Reference Books:

1. Applied numerical Methods using MATLAB: Won Young Yang, Tae-Sang-Chung, John Morris: John Wiley and Sons.

2. Solving ODE’s with MATLAB: L.F. Shampine, I Gladwell, S. Thompson; Cambridge University Press.

3. Getting Started with MATLAB 7: Rudra Pratap; Oxford Press.

MAT193

SEMINAR

M.Sc. (Mathematics) **Semester IV**

L - T - P – C: 0 – 0 –4 – 2 **Course Type: Core Practical**

To enhance communication skill of the M. Sc students seminars have been incorporated in the syllabi in Semester IV .The candidates will have to choose a topic from the syllabi for seminar preparation. They will be expected to submit a write up pertaining to that topic and at the end of semester, a presentation will have to be made in presence of panel of experts from different fields of Mathematics.

MAT 184
PROJECT

M.Sc. (Mathematics) **Semester IV**

L - T - P – C: 0 – 0 –16 – 8 **Course Type- Core Practical**

Objective: To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. This would be a pre-qualifying exercise for the students for getting approval by the departmental committee for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

SYLLABUS OF DEPARTMENT SPECIFIC ELECTIVE COURSES

Course Code	Department Specific Elective
MAT 165	Integral Equations
MAT 167	Calculus of Variations & Special Functions
MAT 171	Fluid Mechanics
MAT 172	Mathematics in Multimedia
MAT 173	Mathematical Modeling
MAT 174	Wavelet Analysis
MAT 175	Fuzzy Sets and Applications
MAT 176	Cryptography
MAT 178	Algorithm Design Techniques
MAT 179	Mathematical Statistics
MAT 202	Tensor Analysis & Number Theory
MAT 203	Differential Equation and Finite Element Analysis
MAT 204	Advanced Numerical Analysis

MAT 165

INTEGRAL EQUATIONS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 – 0- 5 **Course Type- DSE**

Module 1: Linear integral equations– Definition and classification. Conversion of initial and boundary value problems to an integral equation. Eigen values and Eigen functions. Solution of homogeneous and general Fredholm integral equations of second kind with separable kernels.

Module 2: Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations. Resolvent kernel and its results. Conditions of uniform convergence and uniqueness of series solution.

Module 3: Integral equations with symmetric kernels– Orthogonal system of functions. Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen functions and bilinear form. Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.

Module 4: Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform. Solution of singular integral equations by Fourier transforms.

Module 5: Classical Fredholm theory– Fredholm theorems. Solution of Fredholm integral equation of second kind by using Fredholm first theorem.

Reference Books:

1. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY.
2. L.G.Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976,
3. R. P. Kanwal, Linear Integral Equations.
4. Harry Hochsdedt, Integral Equations.
5. Murry R. Spiegal, Laplace Transform (SCHAUM Outline Series), McGraw-Hill.

MAT 167

CALCULUS OF VARIATIONS & SPECIAL FUNCTIONS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Functional, The fundamental lemma, Euler's equations minimum surface of revolution, Brachistochrone problem, Problems on geodesics, isoperimetric problems.

Module 2: Several dependent variables, Functional dependent on higher order derivative, Functionals dependent variables, variational problems, parametric form.

Module 3: Gauss hypergeometric function and its properties, Integral representation, Linear transformation formulas, Contiguous function relations, Differentiation formulae, Linear relation between the solutions of Gauss hypergeometric equation, Kummer's confluent hypergeometric function and its propertries, Integral representation, Kummer's first transformation.

Module 4: : Legendre Polynomials and functions - Recurrence formula, Rodrigue's formula, properties , Bessel functions– recurrence formula, generating function, properties of Bessel functions.

Module 5: Hermite, Laguerre, Associated Laguerre polynomials, chebyshev functions and polynomials.

Reference Books:

1. Differential equations and calculus of variations by L. Elsgolts, Mir publishers.
2. Differential equations with applications and historical notes, G.F.Simmons, Tata McGRAW Hill.
3. Differential equations with Special Functions, Sharma and Gupta, Krishna Prakasan Mandir.
4. J.L. Bansal and H.S. Dhami, Differential Equations Vol-II, JPH, 2004.
5. E.D. Rainville, Special Functions, Chelsea Publishing Company, 1960.

MAT 171

FLUID MECHANICS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Physical Properties of fluids, Concept of fluids, Continuum Hypothesis, density, specific weight, specific volume.

Module 2: Kinematics of Fluids- Eulerian and Lagrangian methods of description of fluids, Equivalence of Eulerian and Lagrangian method, General motion of fluid element, integrability and compatibility conditions, strain rate tensor, stream line, path line, streak lines, stream function¸ vortex lines, circulation.

Module 3: Stresses in Fluids- Stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor.

Module 4: Conservation Laws- Equation of conservation of mass, equation of conservation of momentum, Navier Stokes equation, equation of moments of momentum, Equation of energy, Basic equations in different co-ordinate systems, boundary conditions.

Module 5: Irrotational and Rotational Flows- Bernoulli's equation, Bernoulli's equation for irrotational flows, Two dimensional irrotational incompressible flows, Blasius theorm, Circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows, methods of images.

Reference Books:

1. An Introduction to fluid dynamics, R.K. Rathy, Oxford and IBH Publishing Co.1976.
2. Theoretical Hydrodynamics, L. N. Milne Thomson, Macmillan and Co. Ltd.
3. Textbook of fluid dynamics, F. Chorlton, CBS Publishers, Delhi.
4. Fluid Mechanics, L. D. Landau and E.N. Lipschitz, Pergamon Press, London.
5. Fluid Dynamics, J.L.Bansal, JPH(Raj.)
6. F. Charlton, A Text Book of Fluid Dynamics, CBC.
7. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall..

MAT 172

MATHEMATICS IN MULTIMEDIA

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Multimedia Introduction to Multimedia: Concepts, uses of multimedia, hypertext and hypermedia.; Image, video and audio standards.

Module 2: Audio: digital audio, MIDI, processing sound, sampling, compression.

Module 3: Video: MPEG compression standards, compression through spatial and temporal redundancy, inter-frame and intra-frame compression.

Module 4: Animation: types, techniques, key frame animation, utility, morphing.

Module 5: Virtual Reality concepts.

Reference Books:

1. Mukherjee, Fundamentals of Computer graphics & Multimedia, PHI.
2. Elsom Cook – “Principles of Interactive Multimedia” – McGraw Hill
3. Sanhker, Multimedia –A Practical Approach, Jaico.
4. Buford J. K. – “Multimedia Systems” – Pearson Education.

MAT 173

MATHEMATICAL MODELING

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Introduction To Mathematical Modeling using Differential Equations: Principles of Mathematical Modeling, Compartment Model, Population Models, Framing of Population Model, Growth and Decay, Drug absorption (Case of single cold pill, Case of a course of cold pills).

Module 2: Applications Of First Order Differential Equations : Reaction To Stimulus, Alcohol Absorption (Accident Risk), Artificial Kidney Machine, The Spread of Technological Innovations, Rocket flight.

Module 3: Applications of first Order Linear Differential Equations: Sales Response to Advertising, Art Forgeries, Electric Circuits, Pollution of the Great Lakes, Exploited Fish Populations, Neoclassical Economic Growth.

Module 4: Applications of Second Order Linear Differential Equations: Mechanical Oscillations, Consumer Buying Behavior, Electrical Networks and Testing for Diabetes.

Module 5: Applications of Systems of Differential Equations to Models: Spring-Mass System, The Dynamics of Arms Races, Epidemics, Interacting Species, Competing Species (The Struggle for Existence).

Reference Books:

1. D. N. Burghes, Modelling with Difference Equations, Ellis Harwood and John Wiley.

2. J. N. Kapur, Mathematical Modelling, Willey Eastern Limited, Reprint, 2000.

3. D. J. G. James and J. J. Macdonald, Case studies in Mathematical Modelling, Stanly Thames, Cheltonham.

4. M. Crossand and A. O. Moscrcadini, The art of Mathematical Modelling, Ellis Harwood and John Wiley.

5. C. Dyson, Elvery, Principles of Mathematical Modelling, Academic Press, New York.

MAT 174

WAVELET ANALYSIS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Fourier analysis: Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions. Fourier series, Basic Convergence Theory and Poisson's Summation formula.

Module 2: Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainity principle. The integral wavelet transforms Dyadic wavelets and inversions. Frames.

Module 3. Wavelet Series. Scaling Functions and Wavelets: Multi resolution analysis, scaling functions with finite two scale relations. Direct sum decomposition of L2(R). Linear phase filtering.

Module 4: Compactly supported wavelets, Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets. Identification of orthogonal two-scale symbols,

Module 5: Construction of Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

Reference Books:

1. C. K. Chui, A First Course in Wavelets, Academic press NY 1996.

2. I. Daubechies, Ten Lectures in Wavelets, Society for Industrial and Applied Maths, 1992.

MAT 175

FUZZY SETS AND APPLICATIONS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Fuzzy sets – Basic definitions, level sets, convex fuzzy sets – Basic operations on fuzzy sets – Types of fuzzy sets – Cartesian products – Algebraic products bounded sum and difference.

Module 2: Extension principle and application – Zadeh extension principle, image and inverse image of fuzzy sets – Fuzzy numbers – Elements of fuzzy arithmetic.

Module 3: Fuzzy relations on fuzzy sets, The union and intersection of fuzzy relation -Composition of fuzzy relations – Min-max composition and its properties – Fuzzy equivalence relation.

Module 4: Fuzzy decision-Fuzzy linear programming problem- Symmetric fuzzy linear programming problem-Fuzzy linear programming with crisp objective function-Fuzzy graph.

Module 5: Fuzzy logic: An overview of classic logic, its connectives – Tautologies – Contradiction fuzzy logic – Fuzzy quantities – Logical connectives for fuzzy logic – Applications to control theory.

Reference Books:

1. Didier Dubois, Henri M. Prade, "Fuzzy Sets and Systems: Theory and Applications", Academic Press, 1994.

2. H. J. Zimmermann, Fuzzy set theory and its applications, Allied publishers Ltd., New Delhi, 2001.

3. G. J. Klir & B. Yuan, "Fuzzy sets and Fuzzy logic; Theory and Applications", Prentice Hall of India 1995.

MAT 176

CRYPTOGRAPHY

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Time estimates for doing arithmetic - Divisibility and the Euclidean algorithm – Congruences - Modular exponentiation - Some applications to factoring.

Module 2: Finite Fields - Multiplicative generators – Uniqueness of fields with prime power elements - Quadratic residues and reciprocity.

Module 3: Some simple crypto systems - Digraph transformations - Enciphering Matrices – Affine enchipering transformations RSA - Discrete Log - Diffie-Hellman key exchange – The Massey – Omura cryptosystem - Digital Signature standard - Computation of discrete log.

Module 4: Pseudo primes - Strong pseudo primes - Solovay-Strassen Primality test – Miller - Rabin test - Rho method - Fermat factoring and factor bases - Quadratic sieve method.

Module 5: Elliptic Curves - Elliptic curve primality test - Elliptic Curve factoring - Pollard's p – 1 method -Elliptic curve reduction modulo n - Lenstras Method.

Reference Books:

1. Neal Koblitz, “A course in Number Theory and Cryptography”, 2nd Edition, Springer-Verlag, 2010.

2. Menezes A, Van Oorschot and Vanstone S.A, “Hand book of Applied Cryptography”,Taylor & Francis, 1996.

MAT 178

ALGORITHM DESIGN TECHNIQUES

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Introduction – Notion of Algorithm – Fundamentals of Algorithmic Solving – Important Problem types – Fundamentals of the Analysis Framework – Asymptotic Notations and Basic Efficiency Classes. Mathematical Analysis of Non-recursive Algorithm –Mathematical Analysis of Recursive Algorithm – Example: Fibonacci Numbers –Empirical Analysis of Algorithms – Algorithm visualization.

Module 2: Brute Force – Selection Sort and Bubble Sort – Sequential Search and Brute – force string matching – Divide and conquer – Merge sort – Quick Sort – Binary Search –Binary tree- Traversal and Related Properties – Decrease and Conquer – InsertionSort – Depth first Search and Breadth First Search.

Module 3: Tree Vertex Splitting– Multistage Graphs – All pairs shortest paths– Single – Source Shortest paths – Flow shop scheduling.

Module 4: Transform and conquer – Presorting – Balanced Search trees – AVL Trees – Heaps and Heap sort – Dynamic Programming – Warshall’s and Floyd’s Algorithm – Optimal Binary Search trees – Greedy Techniques – Prim’s Algorithm – Kruskal’s Algorithm – Dijkstra’s Algorithm – Huffman trees.

Module 5: Backtracking – n-Queen’s Problem – Hamiltonian Circuit problem – Subset - Sumproblem – Branch and bound – Assignment problem – Knapsack problem – Traveling salesman problem.

Reference Books:

1. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Second Edition, MIT Press, McGraw-Hill Book Company, 2001.

2. Michael T Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, John Wiley & Sons, 2006.

3. Sara Baase and Allen Van Gelder, “Computer Algorithms - Introduction to Design and Analysis”, 3 rd edition,Pearson Education Asia, 2003.

MAT 179
MATHEMATICAL STATISTICS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Random Variables- Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions.

Module 2: Discrete distributions: Uniform, Binomial, Poisson, Geometric and Negative Binomial distributions and their properties**. Continuous distributions:** Uniform, Normal and Exponential distributions and their properties.

Module 3: Sampling Theory: Types of Sampling, errors in sampling, Parameter and Statistic, Tests of Significance: Null Hypothesis, Alternative Hypothesis, One-tailed, Two-tailed tests. Sampling Attributes: Tests of Significance for single proportion and difference of proportions. Sampling of Variables.

Module 4: Sampling Distributions: Chi-Square Distribution, Moment generating function of Chi-Square and its applications. Student's **-** ***t*** distribution. ***F*** and ***Z*** distributions.

Module 5: Estimation Theory: Characteristics of Estimators, Efficient estimator, Most Efficient estimator, Minimum variance unbiased estimators. Methods of estimation.

Reference Books:

1. Gupta, S. C., and Kapoor , V. K. *Fundamentals of Mathematical Statistics*, New Delhi: Sultan Chand & Sons, 2002.
2. E.J. Dudewicz and S.N.Mishra , Modern Mathematical Statistics, John Wiley and Sons, New York, 1988.
3. V.K.Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern New Delhi, 1988(3rd Edn)
4. G.G.Roussas, A First Course in Mathematical Statistics, Addison Wesley Publishing Company, 1973
5. B.L.Vander Waerden, Mathematical Statistics, G.Allen & Unwin Ltd., London, 1968.
6. M. Fisz , Probability Theory and Mathematical Statistics, John Wiley and sons.
7. Baisnab, and Jas, M. *Element of Probability and Statistics*, New Delhi: Tata McGraw Hill, 2001.

MAT 202
TENSOR ANALYSIS & NUMBER THEORY

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module1: Kronecker delta, Contravariant and Covariant tensors, Symmetric tensors, Quotient law of tensors, Relative tensor. Riemannian space. Metric tensor, Indicator, Permutation symbols and Permutation tensors.

Module2 : Christoffel symbols and their properties, Covariant differentiation of tensors. Ricci's theorem, Intrinsic derivative, Geodesics, Differential equation of geodesic, Geodesic coordinates, Field of parallel vectors.

Module 3: Riemann-Christoffel tensor and its properties. Covariant curvature tensor, Einstein space. Bianchi's identity. Einstein tensor, Flate space, Isotropic point, Schur's theorem.

Module 4: Congruences: Some elementary properties and theorems, linear and systems of linear congruences. Chinese Remainder Theorem. Quadratic congruences, Quadratic Reciprocity Law, Primitive roots.

Module5: Some elementary arithmetical functions and their average order, Mobius Inversion formula, integer partitions, simple continued fractions, definite and indefinite binary quadratic forms ,some diophantine equations.

Reference Books:

1.U.C. De, Absos Ali Shaikh and Joydeep Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004.

2. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.

3. C.E.Weatherburn, Riemannian Geometry and the Tensor Calculus, Cambridge Univ. Press, 2008.
4. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007.

5. Niven, H.S. Zuckerman & H.L. Montgomery, Introduction to the Theory of Numbers, Wiley, 2000.

6. D. Burton; Elementary Number Theory, McGraw-Hill, 2005.

WEF.A.Y.2018-2019

MAT 203
DIFFERENTIAL EQUATION AND FINITE ELEMENT ANALYSIS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Non Linear differential equations of particular form. Riccati's equation - General solution and the solution when one ,two or three particular solutions are known. Total differential equations – necessary and sufficient equations, method of solution, geometric meaning of total differential equations.

Module 2 : Partial differential equations of second order with variable coefficients- Monge's method, Classification of Second order Partial differential equations with variable coefficients , Canonical forms, Cauchy's problem for first order partial differential equations, method of separation of variables, Laplace wave and diffusion equations.

Module 3 : linear homogeneous boundary value problems. Eigen values and eigen functions, Strum Liouville boundary value problems. Orthogonality of eigen functions, Reality of eigen values.

Module 4: General theory of finite element methods, Difference between finite element and finite difference, Review of some integral formulae, Concept of discretization, Convergence requirements, Different coordinates, One dimensional finite elements, shape functions, stiffness matrix, connectivity, boundary conditions, equilibrium equation, FEM procedure.

Module 5: Generalization of the finite element concepts-weighted residual and variational approaches (Ritz method, Galerkin method, collocation method etc.) Numerical integration, Interpolation formulas and shape functions, Axis symmetric formulations, solving one-dimensional problems.

Reference Books:

1. George, F Simmons, *Differential equations with applications and historical notes*, New Delhi: Tata McGraw Hill, 1974.).
2. Ross S. L., *Differential Equation*s, New Delhi: John Wiley and Sons (2004).
3. Sneddon I. N., *Elements of Partial Differential Equations*, New Delhi: Tata McGraw Hill (1957).
4. Piaggio H. T. H., *Differential Equations*,New Delhi: CBS Publisher (2004).
5. Raisinghania, M.D. *Advanced Differential Equations*, New Delhi: S.Chand & Company Ltd. 2001
6.Braess, D., Schumaker and Larry L. *Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics*, New York: Cambridge University Press, 2001.
7. Desai C. S. *Introductory Finite Element Method*, Boca Raton: CRC Press, 2001.
8.Smith, G. D. *Numerical solution of Partial Differential Equations*, Oxford: Clarendon Press, 1986.
9.Bradie, B. *A friendly introduction to Numerical Analysis*, Delhi: Pearson, 2005.
10.Reddy, J. N. *An introduction to Finite Element Methods*, Delhi: McGraw-Hill Higher Education, 2005.

MAT 204
ADVANCED NUMERICAL ANALYSIS

M.Sc. (Mathematics) **Semester II/III/IV**

L - T - P – C: 4 – 1 –0 – 5 **Course Type- DSE**

Module 1: Iterative methods- Theory of iteration method, acceleration of the convergence, Chebyshev method, Muler's method, Methods of multiple and complex roots, Newton Raphson's method for simultaneous equations, Convergence of iteration process in the case of several unknowns.

Module 2: Solution of polynomial equations- Polynomial equation, Real and complex roots, Synthetic Division, the Birge- Vieta, Bairstow and Graeffe's root square method.

Module 3: system of simultaneous equations(linear)- Direct Method , Method of determinant, Gauss Jordan, Lui –Factorization- Dolittle's , Crout's and Cholesky's Partion method. Method of successive Approximation- Conjugate gradient and relaxation methods.

Module 4: Curve fitting and function Approximation- Least square error criteria, linear regression, polynomial fitting and other curve fittings, approximation of functions by Taylor series and Chebyshev polynomials

Module 5: Numerical Solution of ordinary differential equations- Taylor's series method, Runge-Kutta method of fourth order, Multistep method, Predictor-Corrector strategies, Stability Analysis-single and multistep methods. BVP's of ordinary differential equations- shooting methods, finite difference methods.

Reference Books:

1. Shastry, S. S. Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., 2005.
2. Xavier, C. C Language and Numerical Methods, New Age Int. Ltd., 2007.
3. Gerald, C.F. and Wheatley, P.O. Applied Numerical Analysis, 7th Edition, Pearson Education Asia.2003
4. Bradie, B. A friendly introduction to Numerical Analysis. Delhi: Pearson Education, 2007
5. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.