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SYLLABUS
M.Sc. (Mathematics)

Programme Code: 0902MT
(2 YEARS FULL TIME POST GRADUATE COURSE)

SEMESTER PATTERN
(2024)

Details of courses under Master of Science (Mathematics)

Course *Credits

	Theory + Practical
I. Core Course (13 Papers) **II. Core Course with practical (02 Papers)**	13×4 = 52 2x3=6
I. Core Course Practical / Tutorial*(02 Papers)	2×2 = 4
II. Elective Course (4 Papers)	4x4 = 16
III. Dissertation	1x6=6
Total Credit	84

M.Sc. (Mathematics)

First Semester

Subject Code	Name of Subject	Credit Theory	Credit Lab/Tutorial	ESE Marks	Internal Marks	Total Marks
0902MT101	Algebra	4		70	30	100
0902MT102	Real Analysis	4		70	30	100
0902MT103	Differential Equations	4		70	30	100
0902MT104	Discrete Mathematics	4		70	30	100
0902MT105	Elective 1	4		70	30	100
Total		20				500

Second Semester

Subject Code	Name of Subject	Credit Theory	Credit Lab/Tutorial	ESE Marks	Internal Marks	Total Marks
0902MT201	Complex Analysis	4		70	30	100
0902MT202	Partial Differential Equations	4		70	30	100
0902MT203	Linear Algebra	4		70	30	100
0902MT204	Matlab	3		70	30	100
0902MT205	Matlab (Practical)		2	35	15	50
0902MT206	Elective 2	4		70	30	100
Total		19	2			550

Third Semester

Subject Code	Name of Subject	Credit Theory	Credit Lab/Tutorial	ESE Marks	Internal Marks	Total Marks
0902MT301	Topology	4		70	30	100
0902MT302	Mathematical Methods	4		70	30	100
0902MT303	Functional Analysis	4		70	30	100
0902MT304	Latex & Mathematica	3		70	30	100
0902MT305	Latex & Mathematica (Practical)		2	35	15	50
0902MT306	Elective 3	4		70	30	100
Total		19	2			550

Fourth Semester

Subject Code	Name of Subject	Credit Theory	Credit Lab/Tutorial	ESE Marks	Internal Marks	Total Marks
0902MT401	Nonlinear Differential Equation	4		70	30	100
0902MT402	Operation Research	4		70	30	100
0902MT403	Fuzzy Sets Theory	4		70	30	100
0902MT404	Elective 4	4		70	30	100
0902MT405	Project/Dissertation	6				200
Total		22				600

LIST OF ELECTIVES

Elective 1	**Numerical Methods**	**Mathematical Statistics**	**Differential Geometry**
Elective 2	**Distribution Theory**	**Information Theory**	**Mechanics**
Elective 3	**Graph Theory**	**Mathematical Biology**	**Number Theory & Cryptography**
Elective 4	**Approximation Theory**	**Metric Spaces And Fixed Point Theory**	**Mathematical Modeling**

FIRST SEMESTER

ALGEBRA

THEORY

Total Marks: 100 (70+30)

Unit-I: Group theory: Direct products- Group action on a set: Isotropy subgroups- Orbits- Application of G-Sets to Counting: Counting theorems- p-Groups- The Sylow theorems.

Unit-II: Applications of the Sylow theory: Applications to p-groups and the class equation- Further applications. Ring theory: Rings of polynomials: Polynomials in an indeterminate - The evaluation homomorphism - Factorization of polynomials over a field.

Unit-III: Field theory: Extension fields-algebraic and transcendental elements-Irreducible polynomial over F - Simple extensions- Algebraic extensions: Finite extensions- Structure of a finite fields

Unit - IV: Automorphisms of fields- Conjugation isomorphisms- Automorphisms and fixed fields- The Frobenius automorphism- Splitting fields.

Unit-V: Separable extensions- Galois theory: Normal extensions- The main theorem- Illustrations of Galois theory: Symmetric functions

Books Recommended:

1.A *First Course in Abstract Algebra* by **J.B. Fraleigh**, Fifth Edition, Addison-Wesly Longman, Inc, Reading Massachusetts, 1999.

2.Topics in Algebra by **I.N. Herstein**, Blaisdell, New York, 1964.

3. *Algebra* by **M. Artin**, Prentice-Hall of India, New Delhi, 1991.

REAL ANALYSIS
THEORY

Total Marks: 100 (70+30)

Unit-I: RIEMANN STIELTJES INTEGRAL: Definition and existence of the integral – Properties of the integral – Integration and differentiation – Integration of vector-valued functions – Rectifiable curves.

Unit-II: SEQUENCES AND SERIES OF FUNCTIONS: Uniform convergence-Uniform convergence and continuity – Uniform convergence and integration – Uniform convergence and differentiation – Equicontinuous families of functions – The Stone-Weierstrass theorem.

Unit-III: FUNCTIONS OF SEVERAL VARIABLES Linear transformations –Differentiation - The contraction principle – The inverse function theorem – The implicit function theorem – Determinants – Derivatives of higher order – Differentiation of integrals.

Unit-IV: LEBESGUE MEASURE Outer measure – Measurable sets and Lebesgue measure – Nonmeasurable set-Measurable functions – Littlewood's three principles.

Unit-V: THE LEBESGUE INTEGRAL The Lebesgue integral of a bounded function over a set of finite measure –The integral of a nonnegative function – The general Lebesgue integral – Convergence in measure.

Books Recommended:

1.*Principles of Mathematical Analysis* by **W. Rudin**, McGraw-Hill, New York, 1976

2.*Real Analysis* by **H.L. Royden**, Third Edition, Macmillan, New York, 1988

DIFFERENTIAL EQUATIONS

THEORY

Total Marks: 100 (70+30)

Unit-I: Linear equations with constant coefficients: The second order homogeneous equations – Initial value problems – Linear dependence and independence - A formula for the Wronskian – The non- homogeneous equation of order two.

Unit-II: Homogeneous and non–homogeneous equations of order n – Initial value problems – Annihilator method to solve a non–homogeneous equation – Algebra of constant coefficient operators.

Unit-III: Linear equations with variable coefficients: initial value problems for the homogeneous equation- Solutions of the homogeneous equation – The Wronskian and linear independence –Reduction of the order of a homogeneous equation - Homogeneous equation with analytic coefficients – The Legendre equation.

Unit-IV: Linear equation with regular singular points: Euler equation - Second order equations with regular singular points – Exceptional cases – Bessel equation.

Unit-V: Existence and uniqueness of solutions to first order equations: Equation with variables separated– Exact equations – The method of successive approximations – The Lipschitz condition –Convergence of the successive approximations.

Books Recommended:

1.An Introduction to Ordinary Differential Equations by **E.A. Coddington**, Prentice Hall of India Ltd., New Delhi, 1957

DISCRETE MATHEMATICS

THEORY

Total Marks: 100 (70+30)

Unit I

Recurrence Relations and Generating Functions, Some number sequences, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Generating functions, Recurrences and generating functions, Exponential generating functions.

Unit II

Statements Symbolic Representation and Tautologies, Quantifiers, Predicates and validity,

Prepositional Logic. Lattices as partially ordered sets, their properties, Lattices as Algebraic systems. Sub lattices, Direct products and Homomorphism, Some special lattices e.g. complete, Complemented and Distributive Lattices.

Unit III

Boolean Algebras as Lattices, Various Boolean Identities, The switching Algebra. Example, Subalgebras, Direct Products and Homomorphism, Joint-irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms, Sum of Products, Cononical forms, Minimization of Boolean functions, Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates.) The Karnaugh method.

Unit IV

Finite state Machines and their Transition table diagrams, Equivalence of Finite State, Machines, Reduced Machines, Homomorphism. Finite automata, Acceptors, Nondeterministic, Finite Automata and equivalence of its power to that of deterministic Finite automata, Moore and Mealy Machines.

Unit V : Grammars and Language: Phrase-Structure Grammars, Requiting rules, Derivation, Sentential forms, Language generated by a Grammar, Regular, Context -Free and context sensitive grammars and Languages, Regular sets, Regular Expressions and the pumping Lemma. Kleene's Theorem. Notions of Syntax Analysis, Polish
Notations. Conversion of Infix Expressions to Polish Notations. The
Reverse Polish Notation.

Books Recommended:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition.
2. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York.
3. John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition.
4. J.P. Tremblay, R. Manohar, "Discrete mathematical structures with applications to computer science", Tata-McGraw Hill Education Pvt.Ltd.
5. J.E. Hopcraft and J.D.Ullman, Introduction to Automata Theory, Langauages and Computation, Narosa Publishing House.
6. M. K. Das, Discrete Mathematical Structures for Computer Scientists and Engineers, Narosa Publishing House.
7. C. L. Liu and D.P.Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

ELECTIVE 1
THEORY

Total Marks: 100 (70+30)

NUMERICAL METHODS

Unit-I
Introduction, difference calculus, difference operator, linear difference equations, first order equations, general results for linear equations, equations with constant coefficients, equations with variable coefficients.

Unit-II
Classification of partial differential equations, Dirichlet's problem, Cauchy's problem, Finite difference approximations to partial derivatives, Elliptic equation, Numerical solutions of Laplace and Poisson equations, Solution to elliptic equations by relaxation method, solution by Laplace equation by Alternating Direction Implicit (ADI) method.

Unit-III
Parabolic equations, Numerical solution of one dimensional diffusion & heat equations, Schmidt method, Crank-Nicholson method, Iterative methods-Dufort and Frankel method.

Unit-IV
Hyperbolic equations, the one dimensional wave equation, Numerical solutions of one-dimensional wave equation, Numerical solution of one dimensional wave equation by difference schemes, central-difference schemes, D'Alembert solution.

Unit-V
Variational finite element method with application to one-dimensional problem, solution of time dependent problems in one dimension and two dimension & steady state problems using Ritz's method.

Books Recommended:

1. Difference Equation-An Introduction with Applications by Walter G. Kelley and Allan C. Peterson, Academic Press Inc., Harcourt Brace Joranovich Publishers, 1991.
2. Numerical Solution of Differential Equations by M.K.Jain, New Age International (P) Limited, Publishers.
3. Applied Numerical Analysis by Gerald & Wheatley, Pearson Education.

MATHEMATICAL STATISTICS

Unit - I
Probability: Definition and various approaches of probability, Addition theorem, Boole inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes theorem and its applications.

Unit - II
Random variable and probability functions: Definition and properties of random variables, Discrete and continuous random variables, Probability mass and density functions, Distribution function. Concepts of bivariate random variable: joint, marginal and conditional distributions.

Mathematical expectation: Definition and its properties. Variance, Covariance, Moment generating function- Definitions and their properties.

Unit - III

Discrete distributions: Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties.

Continuous distributions: Uniform, Exponential and Normal distributions with their properties.

Unit - IV

Testing of hypothesis: Parameter and statistic, Sampling distribution and standard error of estimate, Null and alternative hypotheses, Simple and composite hypotheses, Critical region, Level of significance, One tailed and two tailed tests, Two types of errors.

Tests of significance: Large sample tests for single mean, Single proportion, Difference between two means and two proportions.

Books recommended :

1. V. Hogg and T. Craig, Introduction to Mathematical Statistics , 7th addition, Pearson Education Limited-2014
2. A.M. Mood, F.A. Graybill, and D.C. Boes, Introduction to the Theory of Statistics, Mc Graw Hill Book Company.
3. J.E. Freund, Mathematical Statistics, Prentice Hall of India.
4. M. Speigel, Probability and Statistics, Schaum Outline Series.
5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi.

DIFFERENTIAL GEOMETRY

Unit1:

Nature of differential geometry, space curves and it's property, curvature & torsion, Serret-Ferret formulae, Involutes-Evolutes . Bertrand curve, fundamental existence theorem for space curve, uniqueness theorem for space curves.

Unit 2:

Definition of surface. Curves on a surface. Surfaces of revolution. Helicoids. Metric. Direction coefficients. Families of curves. Isometric correspondence. Intrinsic properties. Geodesics. Canonical geodesic equations.

Unit 3:

Normal property of geodesics. Existence theorems. Geodesic parallels. Geodesic curvature. Gauss Bonnet theorem. Gaussian curvature. Surfaces of constant curvature. Conformal mapping. Geodesic mapping.

Unit 4:
Second fundamental form. Principal curvatures. Lines of curvature. Developables. Developables associated with space curves. Developables associated with curves on surfaces. Minimal surfaces and ruled surfaces. Fundamental equations of Surface theory. Parallel surfaces.

Unit 5: Compact surfaces whose points are umbilics. Hilbert's lemma. Compact surfaces of constant Gaussian or mean curvature. Complete surfaces. Characterisation of complete surfaces. Hilbert's theorem. Conjugate points on geodesics. Intrinsically defined surfaces. Triangulation. Two dimensional Riemannian manifolds. Problem of metrization. Problem of continuation.

Books Recommended:
1.An introduction to Differential Geometry: T.J. Wilmore; Oxford University Press
2.Geometry of curves and surfaces: do Carmo, Academic Press.

SECOND SEMESTER

COMPLEX ANALYSIS
THEORY

Total Marks: 100 (70+30)

Unit–I: Introduction to the concept of analytic function: Limits and continuity – Analytic functions – Polynomials – Rational functions – Conformality: Arcs and closed curves – Analytic functions in regions – Conformal mapping – Length and area – Linear transformations: The linear group –The cross ratio –Elementary conformal mappings: Elementary Riemann surfaces.

Unit-II: Fundamental theorems: Line integrals rectifiable arcs – Line integrals as functions of arcs – Cauchy's theorem for a rectangle - Cauchy's theorem in a disk, Cauchy's integral formula: The index of a point with respect to a closed curve – The integral formula – Higher derivatives - Local properties of analytical functions: Removable singularities, Taylor's theorem – Zeros and poles – The local mapping – The maximum principle –The general form of Cauchy's theorem: Chains and cycles.

Unit-III: The calculus of residues: The residue theorem – The argument principle – Evaluation of definite integrals-Harmonic functions: Definition and basic properties – The mean-value property –Poisson's formula.

Unit-IV: Power series Expansions : Weierstrass theorem – The Taylor series – The Laurent series–Partial fractions and factorization: Partial fractions – Infinite products – Canonical products.

Unit-V: The Riemann mapping theorem: Statement and proof – Boundary behavior – Use of the reflection principle – Analytic arcs – Conformal mapping of polygons: The behavior at an angle– The Schwarz – Christoffel formula – Mapping on a rectangle.

Books Recommended:

1.Complex Analysis by **L.V. Ahlfors**, Third Edition, McGraw-Hill, New York, 1979.

PARTIAL DIFFERENTIAL EQUATIONS
THEORY

Total Marks: 100 (70+30)

Unit I: Nonlinear partial differential equations of the first order: Cauchy's method of characteristics –Compatible systems of first order equations – Charpit's method- Special types of first order equations – Jacobi's method.

Unit II: Partial differential equations of second order: The origin of second-order equations – Linear partial differential equations with constant coefficients – Equations with variable coefficients –Characteristic curves of second–order equations- Characteristics of equations in three variables.

Unit III: The solution of linear hyperbolic equations – Separation of variables – The method of integral transforms – Nonlinear equations of the second order.

Unit IV: Laplace's equation : The occurrence of Laplace's equation in physics- elementary solution of Laplace's equation – Families of equipotential surfaces - boundary value problems – Separation of variables- Problems with axial symmetry.

Unit V: The wave equation: The occurrence of wave equation in physics – Elementary solutions of the one-dimensional wave equation – vibrating membranes: Applications of the calculus of variations – Three dimensional problems. The diffusion equations: Elementary solutions of the diffusion equation – Separation of variables- The use of integral transforms.

Books Recommended:

1.Elements of Partial Differential Equations by **I. N. Sneddon**, McGraw-Hill Book Company, Singapore, 1957.

LINEAR ALGEBRA

THEORY

Total Marks: 100 (70+30)

UNIT I Vector Spaces And Linear Maps:

Vector spaces – Bases and dimension – Subspaces – Matrices and linear maps –rank nullity theorem - Inner product spaces-orthonormal basis – Gram-Schmidt Orthonormalization process.

UNIT II Diagonalization And The Primary Decomposition Theorem:

Eigen spaces-Algebraic and Geometric multiplicities – Cayley-Hamilton theorem Diagonalization – Direct sum decomposition – Invariant direct sums – Primary decomposition theorem.

UNIT III Unitary Transformations:

Unitary matrices and their properties-rotation matrices-Schur, Diagonal and Hessenberg forms and Schur Decomposition.

UNIT IV The Jordan Canonical Form:

Similarity Transformations and change of basis-Generalised eigen vectors-Canonical basis-Jordan canonical form – Applications to linear differential equations – Diagonal and the general cases.

UNIT V Applications; An error–correcting code – The method of least squares – Particular solutions of nonhomogeneous differential equations with constant coefficients – The Scrambler transformation.

Books Recommended:

1. Hoffmann K. and Kunze R., "Linear Algebra", Prentice Hall of India, 2nd Edition, 2000. (Sections: 2.1, 2.2, 2.3, 2.4, 3.1, 3.3, 3.4, 6.2, 6.4, 6.6, 6.7, 6.8, 8.2)
2. Ben Noble and James W. Daniel, "Applied Linear Algebra", Prentice Hall International Inc, 3rd Edition, 1988. (Sections: 7.3 - 7.5, 8.2)
3. Agnew J. and Knapp R.C., "Linear Algebra with Applications", Brooks/Cole Publishing Co., 1983. (Sections: 4.6, 5.4)
4. Gilbert Strang, "Linear Algebra and its applications", Thomson, 3rd Edition, 1998.
5. S. Kumaresan, "Linear Algebra: A Geometric Approach", Prentice Hall of India, 2006.

MATLAB

THEORY

Total Marks: 100 (70+30)

Unit – I: Starting with Matlab - Creating arrays - Mathematical operations with arrays.
Unit – II: Script files - Functions and function files.
Unit – III: Two-dimensional plots - Three-dimensional plots.
Unit – IV: Programming in MATLAB.
Unit – V: Polynomials, Curve fitting and interpolation - Applications in numerical analysis.

Books Recommended:

1. *MATLAB An Introduction with Application" by* **A. Gilat,** John Wiley & Sons, Singapore, 2004.
2. *Getting Started with MATLAB – A Quick Introduction for Scientists and Engineers"* by **R. Prata p**, Oxford University Press, New Delhi, 2006.
3. "*Introduction to Matlab 7 for Engineers"* by **W.J. Palm,** McGraw-Hill Education, New York, 2005.
4. "*Introduction to MATLAB 7"* by **D. M. Etter, D. C. Kuncicky and H.Moore**, Prentice Hall, New Jersy, 2004.

MATLAB
PRACTICAL

Total Marks: 50 (35+15)

ELECTIVE II
THEORY

Total Marks: 100 (70+30)

DISTRIBUTION THEORY

Unit - I: Test Functions And Distributions: Test functions - Distributions - Localization and regularization - Convergence of distributions -Tempered distributions.

Unit - II: Derivatives And Integrals: Basic Definitions - Examples - Primitives and ordinary differential equations.

Unit - III: CONVOLUTIONS AND FUNDAMENTAL SOLUTIONS The direct product of distributions - Convolution of distributions – Fundamental solutions.

Unit - IV: THE FOURIER TRANSFORM Fourier transforms of test functions - Fourier transforms of tempered distributions- The fundamental solution for the wave equation-Fourier transform of convolutions-Laplace transforms.

Unit - V: GREEN'S FUNCTIONS Boundary-Value problems and their adjoints - Green's functions for boundary-Value problems- Boundary integral methods.

Books Recommended:

1. *An Introduction to Partial Differential Equations* by **M. Renardy and R.C. Rogers**, Second Edition, Springer Verlag, New York, 2008.

2. "*The Analysis of Linear Partial Differential Operators I – Distribution Theory and Fourier Analysis"* by **L. HÖrmander**, Second Edition, Springer Verlag, Berlin, 2003.

3. "*Introduction to the Theory of Distributions*" by **F.G. Friedlander and M. Joshi,** Cambridge University Press,UK, 1998.

4. "*Generalized Functions - Theory and Technique"* by **R.P. Kanwal**, Academic Press, New York, 1983.

INFORMATION THEORY

Unit - I Basic concepts of probability, Sample spaces, Probability measure, Theorems of addition and multiplication, Conditional probability, Bayes Theorem Random, Variable, Discrete and continous probability distributions Communication processes.

Unit - II Entropy as a measure of uncertainty and information, Shannon's entropy and entropies of order, Algebraic properties and possible interpretations, Analytical properties and inqualities, Joint and conditional entropies, Mutual information. Noiseless codding, Unique decipherability, Conditions of existence of instantaneous codes, Its extention to uniquely decipherable codes, Noiseless coding theorem.

Unit - III Construction of optional codes, Discrete memory less channels, Models for communication channel capacity, Clasification of channels, Calculation of channel capacity, Decoding scheme. fundamental theorems, Expontial error bound weak converse of Fundamental theorem.

Unit - IV Extension of definition of entropies to continous memory less channels and properties. Characterization theorem for entropies due to Shannon, Tevberg, Chaundy and Mechleod, Kandall, Daroczy, Campbell and Hayarda- Charvat.

Unit - V Error correcting codes- maximum distance, Principal and error correcting properties, Gamming bounds, Pairy coding, Upper and Lower bounds of parity cheek codes.

Books Recommended:

1. R. Ash, Information Theory, Interscience Publishers, New York, 1965.
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

4. Mathai A.M. and Rathi P.N. : Axomatic Foundations of some concepts of Information Theory.

MECHANICS

Unit-I: Indroductory Concepts**:** The mechanical system – Generalized coordinates – Constraints – Virtual work – Energy and momentum.
Unit-II: Lagrange's Equations :Derivations of Lagrange's equations- Examples –Integrals of the motion.
Unit-III: Hamilton's Equations**:** Hamilton's principle – Hamilton's equations.
Unit-IV: Hamilton – Jacobi Theory: Hamilton's principal function –The Hamilton – Jacobi equation – Separability.
Unit-V: Canonical Transformations: Differential forms and generating functions – Lagrange and Poisson brackets.

Books Recommended:

1.*Classical Dynamics* by **D.T. Greenwood**, Prentice Hall of India Pvt.Ltd, New Delhi, 1979.
2. "*Classical Mechanics*" by **H. Goldstein, C. Poole & J. Safko**, Pearson Education, Inc., New Delhi, 2002.

THIRD SEMESTER

TOPOLOGY
THEORY

Total Marks: 100 (70+30)

Unit-I: Spaces and maps: Topological spaces-Sets in a space-Maps-Subspaces-Sum and product of spaces.
Unit-II: Identification and quotient spaces-Homotopy and isotopy.
Unit-III: Properties of spaces and maps**:** Separation axioms and compactness.
Unit-IV Connectedness – Pathwise connectedness – Imbedding theorems.
Unit-V Extension theorems-Compactification-Hereditary properties.

Books Recommended:

1. *Introduction to Topology* by **S.T. Hu**, **Tata** – McGraw-Hill, New Delhi, 1979.
2. Topology by **J. Dugunj**i, Allyn and Bagon, Boston, 1966.
3. Topology by **K. Kuratowski,** Academic Press, New york, 1966
4. Topology, A First Course ” by **J.R. Munkres,** Prentice Hall , Englewood Cliffs, 1975.
5. General Topology by **S. Willard,** Addison-Wesley, Reading, 1970 **.**

MATHEMATICAL METHOD

THEORY

Total Marks: 100 (70+30)

Unit-I: Integral Equations: Introduction: Integral equations with separable kernels - Reduction to a system of algebraic equations, Fredholm alternative, an approximate method, Fredholm integral equations of the first kind, method of successive approximations - Iterative scheme, Volterra integral equation, some results about the resolvent kernel, classical Fredholm theory - Fredholm’s method of solution - Fredholm’s first, second, third theorems.
Unit-II: Applications Of Integral Equations : Application to ordinary differential equation - Initial value problems, boundary value problems - Singular integral equations - Abel integral equation. **CALCULUS OF VARIATIONS**
Unit-III: The Method Of Variations In Problems With Fixed Boundaries: Variation and its properties - Euler's equation - Functionals of the form $\int F(x,y1,y2,\ldots yn,y1',y2',\ldots yn')dx$, Functionals dependent on higher order derivatives - Functionals dependent on the functions of several independent variables - Variational problems in parametric form - Some applications.
Unit-IV: Sufficient Conditions For An Extremum**:** Field of extremals - The function E(x,y,p,y') - Transforming the Euler equations to the canonical form.
Unit-V: Direct Methods In Variational Problems: Direct methods - Euler's finite difference method - The Ritz method - Kantorovich's method.

Books Recommended:

1. Linear Integral Equations - Theory and Technique by **R. P. Kanwal**, Second Edition, Birkhauser, Boston, 1997.
2. *Differential Equations and the Calculus of Variations* by **L. Elsgolts**, MIR Publishers, Moscow, 1970.
3. *Integral Equations and Applications* by **C. Corduneanu**, Cambridge University Press, Cambridge, 1991.
4.*Calculus of Variations, with Applications to Physics and Engineering* by **R. Weinstock**, McGraw-Hill Book Co., Inc., New York, 1952.

FUNCTIONAL ANALYSIS

THEORY

Total Marks: 100 (70+30)

Unit-I: Banach spaces: Definition and examples – Continuous linear transformations – The Hahn Banach theorem .
Unit-II The natural imbedding – Open mapping theorem – The conjugate of an operator.
Unit-III Hilbert spaces: Definition and simple properties – Orthogonal complements – Orthonormal sets– Conjugate space.
Unit-IV The adjoint of an operator-Self –adjoint operators-Normal and unitary operators-Projections. Algebras of operators
Unit-V General Preliminaries on Banach Algebras: The definitions and some examples-Regular and singular elements-Topological divisors of zero-The spectrum-The formula for the spectral radius.

Books Recommended:

1.*Introduction to Topology and Modern Analysis* by **G.F.Simmons**, McGraw-Hill, New York, 1963.
2.*A Course in Functional Analysis* by **J. B. Conway**, Springer, New York, 1990.
3. *First Course in Functional Analysis* by **C. Goffman & G. Pedrick**, Prentice-Hall of India, New Delhi, 2002.
4. *Elements of Functional Analysis* by **L. A. Lusternik & V. J. Sobolev**, Hindustan Publishing Co, New Delhi, 1985.
5. *Introduction to Functional Analysis* by **A. E. Taylor**, John Wiley, New York, 1958.

LATEX & MATHEMATICA

THEORY

Total Marks: 100 (70+30)

Unit – I: Special Characters, Document layout and organization – Document class, Page style, Parts of the document, Centering and indenting, Lists, Theorem–like declarations, Boxes, Tables.
Unit – II: Footnotes and marginal notes, Mathematical formulas – Mathematical environments, Main elements of math mode, Mathematical symbols, Additional elements, Fine–tuning mathematics, Drawing pictures with LATEX.
Unit – III: Introduction To Mathematica: Running Mathematica - Numerical calculations – Building up calculations – Using the Mathematica system – Algebraic calculations - Symbolic mathematics - Numerical mathematics.
Unit – IV: Advanced Mathematics In Mathematica: Numbers - Mathematical functions – Algebraic manipulation – Manipulating equations - Calculus.
Unit – V: Series, limits and residues - Linear algebra.

Books Recommended:
1. A Guide to LATEX by **H. Kopka** and **P.W. Daly**, Third Edition, Addison – Wesley, London, 1999.
2.The Mathematica Book by **S. Wolfram,** Fourth Edition, Cambridge University Press, Cambridge, 1999.

LATEX & MATHEMATICA
PRACTICAL

Total Marks: 50 (35+15)

ELECTIVE III
THEORY

Total Marks: 100 (70+30)

GRAPH THEORY

Unit - I
Definition and types of graphs, Walks, Paths and Circuits, Connected and Disconnected graphs, Applications of graphs, operations on Graphs, Graph Representation, Isomorphism of Graphs.
Unit - II
Eulerian and Hamiltonian paths, Shortest Path in a Weighted Graph, The Travelling Sales person Problem, Planar Graphs, Detection of Planarity and Kuratowski Theorem, Graph Colouring.
Unit - III

Directed Graphs, Trees, Tree Terminology, Rooted Labeled Trees, Prefix Code, Binary Search Tree, Tree Traversal.

Unit - IV

Spanning Trees and Cut Sets, Minimum Spanning Trees, Kruskal Algorithm, Prim Algorithm, Decision Trees, Sorting Methods.

Unit - V

Coloring and covering of graphs, Chromatic. Polynomial, chromatic partitioning, Dimmer problem, Dominating sets, Independent sets, Four colour conjecture.

Books Recommended:

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice –Hall of India Pvt. Ltd, 2004.
2. F. Harary: Graph Theory, Addition Wesley, 1969.
3. G. Chartrand and P. Zhang. Introduction to Graph Theory, Tata McGraw-Hill, 2006.
4. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition, 1999.
5. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York, 2007.
6. John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition, 2005.
7. C. L. Liu and D.P.Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

MATHEMATICAL BIOLOGY

Unit-I

Continuous Growth Models, Delay Models, Linear Analysis of Delay Population Models, Harvesting a Single Natural population, population Model with Age Structure, Fishery Management model.

Unit-II

Predator- Prey models, Lotka- Volterra Systems, Competition Models, Principle of competitive exclusion, Mutualism or Symbiosis, Stability analysis of Predator- Prey Models, Stability – Analysis of Competition Models.

Unit-III

Epidemic models and the dynamics of infectious diseases: Simple epidemic models, SIS, SIR and SIRS Epidemic Models, Modelling Venereal Diseases, Multi- group Model for Gonorrhea, AIDS: Modelling the Transmission Dynamics of HIV.

Unit-IV

Introduction to Compartment models, Discrete and continuous transfers, Discrete population Models for a single species, Discrete logistic model, Discrete delay models for single species, solution by eigen value analysis

Unit-V

Introduction to tracer methods in physiology, Bath-tub models, Continuous infusion into a compartment, Elementary pharmacokinetics, Parameter Estimation in Two-Compartment models, The homogeneous and Non-homogeneous cases.

Books Recommended:

1. Mathematical Biology (Biomathematics, Volume 19) by J.D. Murray, Springer verlag.
2. Linear Models in Biology by M.R. Cullen, Ellis Horwood Ltd.
3.Mathematical Models in Biology and Medicines by J.N. Kapur.
4.Introduction to Mathematical Biology by S.I. Rubinow, John Wiley & Sons. 1975.

NUMBER THEORY & CRYPTOGRAPHY

UNIT I Introduction To Number Theory:
Time estimates for doing arithmetic - Divisibility and the Euclidean algorithm – Congruences - Modular exponentiation - Some applications to factoring
UNIT II Quadratics Residues And Reciprocity
Finite Fields - Multiplicative generators – Uniqueness of fields with prime power elements - Quadratic residues and reciprocity
UNIT III Cryptosystems:
Some simple crypto systems - Digraph transformations - Enciphering Matrices - Affine enchipering transformationsRSA - Discrete Log - Diffie-Hellman key exchange - The Massey – Omura cryptosystem - Digital Signature standard - Computation of discrete log
UNIT IV Primality And Factoring - I
Pseudoprimes - Strong pseudo primes - Solovay-Strassen Primality test – Miller - Rabin test - Rho method - Fermat factoring and factor bases - Quadratic sieve method
UNIT V Primality And Factoring - II
Elliptic Curves - Elliptic curve primality test - Elliptic Curve factoring - Pollard's p - 1 method -Elliptic curve reduction modulo n - Lenstras Method.

Books Recommended:

1. Neal Koblitz, "A course in Number Theory and Cryptography", 2nd Edition, Springer-Verlag, 1994.
2. Menezes A, "Van Oorschot and Vanstone S.A, Hand book of Applied Cryptography", CRC Press, 1996.

FOURTH SEMESTER

NONLINEAR DIFFERENTIAL EQUATION
THEORY

Total Marks: 100 (70+30)

Unit-I: First order systems in two variables and linearization: The general phase plane - Some population models – Linear approximation at equilibrium points – Linear systems in matrix form.

Unit-II: Averaging Methods: An energy balance method for limit cycles – Amplitude and frequency estimates – Slowly varying amplitudes ; Nearly periodic solutions - Periodic solutions: Harmonic balance – Equivalent linear equation by harmonic balance – Accuracy of a period estimate.

Unit-III: Perturbation Methods: Outline of the direct method – Forced oscillations far from resonance- Forced oscillations near resonance with weak excitation – Amplitude equation for undamped pendulum – Amplitude perturbation for the pendulum equation – Lindstedt's method – Forced oscillation of a self – excited equation – The Perturbation method and Fourier series.

Unit-IV: Linear systems: Structure of solutions of the general linear system – Constant coefficient system – Periodic coefficients –Floquet theory – Wronskian.

Unit-V: Stability: Poincare stability – Solutions, paths and norms – Liapunov stability- Stability of linearsystems – Comparison theorem for the zero solutions of nearly-linear systems.

Books Recommended:

1. "*Nonlinear Ordinary Differential Equations"* by **D.W.Jordan and P.Smith**, Clarendon Press, Oxford, 1977.
2."Differential Equations" by **G.F. Simmons**, Tata McGraw-Hill, New Delhi, 1979.
3. "*Ordinary Differential Equations and Stability Theory"* by **D.A. Sanchez**, Dover, New York, 1968.
4. "*Notes on Nonlinear Systems"* by **J.K. Aggarwal**, Van Nostrand, 1972.

OPERATION RESEARCH
THEORY

Total Marks: 100 (70+30)

Unit-I

Introduction, Nature and Meaning of O.R. Modelling in operations Research, Features of Operation research, scope of operations research Linear Programming Problem: formulation of L.P.P. solution of L.P.P. Graphical Method, Simplex Methods in Duality, Integer Programming.

Unit-II

Assignment problems: Mathematical formulation, reduction theorem, unbalanced assignment problem, Transportation problem formulation, basic feasible solution – North-West-corner method, Least cost method, Vogel's Approximation method, Optimum solution: MODI method.

Unit-III

Job sequencing: Processing n jobs through 2 machines, Processing n jobs through 3 machines, Processing 2 Jobs through m machines, Replacement problems: Replacement policy for items whose maintenance cost increase with time and money value is constant, Money value changes with constant rate.

Unit-IV

Project management: Introduction, network diagram representation, time estimates and critical path with saddle point, rectangular game with out saddle point, Principle of dominance, Graphical method.

Unit-V

Queuing Theory: Introduction, queuing system Transient and steady traffic inlets, Distribution of arrival distribution of departure, M/M/I: ∞/ FCFS model nonlinear programming: Kuhn-Tucker conditions.

Books Recommended:

1. Linear Programming by G. Hadley, Narosa Publishing House, 1995.
2. Operations Research by R.K. Gupta.
3. Introduction to Operations Research (Sixth Edition) by F.S. Hillier and G.J. Lieberman Mc Graw Hill International Edition, Industrial Engineering Series, 1995.
4. Operations Research by S.D. Sharma.

FUZZY SETS THEORY
THEORY

Total Marks: 100 (70+30)

Unit- I

Fuzzy Sets-Basic definitions, A-level sets, convex fuzzy sets, Basic operations on fuzzy sets Types of fuzzy sets, Cartesian products, Algebraic products, Bounded sum and difference, t-Norms and t- co norms.

Unit-II

The Extension Principle – The Zadeh's extension principle, Image and inverse image of fuzzy sets, Fuzzy numbers, Elements of fuzzy arithmetic.

Unit-III

Fuzzy Relation and Fuzzy Graphs-Fuzzy relation on fuzzy sets, Composition of fuzzy relations, Min-Max composition and its properties, Fuzzy equivalence relation, Fuzzy compatibility relations, Fuzzy relation equations, Fuzzy graphs, Similarity relation.

Unit-IV

Possibility Theory-Fuzzy measures, Evidence theory, Necessity measure, Possibility measure, Possibility distribution, Possibility theory and fuzzy sets, Possibility theory versus probability theory.

Unit-V

Fuzzy Logic-An overview of classical logic, Multivalued logics, Fuzzy propositions, Fuzzy quantifiers, Linguistic variables and hedges, Inference from conditional fuzzy propositions, the compositional rule of inference.

Books Recommended:

1. Fuzzy set theory and its Applications by H.J. Zimmermann, Allied Publishers Ltd., New Delhi, 1991.
2. Fuzzy sets and Fuzzy logic by G.J. Klir and B. Yuan Prentice-Hall of India, New Delhi, 1995.
3. Fuzzy Sets, Uncertainty and Information by G.J.Klir, Tina A. Folger Prentice-Hall of India.

ELECTIVE 4

THEORY

Total Marks: 100 (70+30)

APPROXIMATION THEORY

UNIT I Approximation In Normed Linear Spaces:
Existence- Uniqueness – convexity – Characterization of best uniform approximations – Uniqueness results – Haar subspaces – Approximation of real valued functions on an interval.
UNIT II Chebyshev Polynomials:
Properties – More on external properties of Chebyshev polynomials – Strong uniqueness and continuity of metric projection – Discretization – Discrete best approximation.
UNIT III Interpolation:
Introduction – Algebraic formulation of finite interpolation – Lagrange's form –extended Haar subspaces and Hermite interpolation – Hermite – Fejer interpolation.
UNIT IV Best Approximation In Normed Linear Spaces:
Introduction – Approximative properties of sets – Characterization and Duality.
UNIT V Projection
Continuity of metric projections – Convexity, Solarity and Cheyshevity of sets – Best simultaneous approximation.

Books Recommended:

1. Hrushikesh N. Mhaskar and Devidas V. Pai., "Fundamentals of approximation theory", Narosa Publishing House, New Delhi, 2000.
2. Ward Cheney and Will light, "A course in approximation theory", Brooks / Cole Publishing Company, New York, 2000.
3. Cheney E.W.,"Introduction to approximation theory", McGraw Hill, New York, 1966.
4. Singer I. ,"Best Approximation in Normed Linear Spaces by element of linear subspaces", Springer-Verlag, Berlin ,1970

METRIC SPACES AND FIXED POINT THEORY

UNIT I Metric Contraction Principles:
Banach's Contraction principle – Further Extension of Banach's principle – The Caristis–Ekeland Principle – Equivalents of the Caristis-Ekeland Principle – Set values contractions – Generalized contractions.
UNIT II Hyperconvex Spaces And Normal Structures In Metric Spaces**:**
Hyperconvexity - Properties of hyperconvex spaces - A fixed point theorem – Approximate fixed points. Normal structures in Metric spaces: A fixed point theorem – Structure of the fixed point set – Fixed point set structure – Separable case.
UNIT III Continuous Mapping In Banach Spaces:
Brouwer's theorem – Further comments on Brouwer's theorem – Schauder's Theorem –Stability of Schauder's Theorem – Banach Algebras: Stone Weierstrass Theorem – Leray–Schauder degree – Condensing mappings – Continuous mappings in hyperconvex spaces.
UNIT IV Metric Fixed Point Thoery:
Contraction mappings – Basic theorem for nonexpansive mapping – Structure of the fixed point set - Asymptotically regular mapping – Set valued mappings.
UNIT V Banach Space Ultrapowers:
Some fixed point theorem – Asympotitically nonexpansive mappings – The demiclosedness principle.

Books Recommended:
1. Mohamed A. Khamsi & William A. Kirk, "An Introduction of Metric Spaces and Fixed Point theory", John Wiley & sons, 2001. (Chapter 3, 4, 5, 7, 8, and 9)
2. Zeidler E., "Nonlinear Functional Analysis and its applications", Vol. I, Springer–Verlag New York, 1986.
3. Deimling K., "Nonlinear Functional Analysis", Springer–Verlag, New York, 1985.
4. Smart D.R.," Fixed Point Theory", Cambridge University Press, 1974.
5. Istratescu V. l.," Fixed Point theory", D. Reidel Publishing Company, Boston, 1979.

MATHEMATICAL MODELING

Unit - I Techniques, classification and simple illustrations. Mathematical Modelling through ordinary differential equation of first order.
Unit - II Mathematical Modelling through systems of ordinary differential equation of first order. Mathematical Modelling through ordinary differential equation of second order.
Unit - III Mathematical Modelling through difference equation. Mathematical Modelling through partial differential equations.
Unit - IV Mathematical Modelling through graphs. Mathematical Modelling through functional Integral, Delay-differential.

Unit - V Mathematical Modelling through calculus of variations and dynamic programming. Mathematical Modelling through mathematical programming, maximum principle and maximum entropy principle.

Books Recommended:

1. J.N. Kapur, Mathematical Modeling, New Age International Limited.
2. J.N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press (P) Ltd.
3. Mathematical Models in the Social, Management and Life Sciences, D.N. Burghes and A.D. Wood, John Wiley & Sons.
4. Mathematical Modeling, J.G. Andrews & R.R Mclone, Butterworths (Pub.) Inc
5. Mathematical Modelling : Dr. Maurya Navkar pub. Ajmer

PROJECT / DISSERTATION

Total Marks: 200 (150+50)

(A) : Project work/ Dissertation

Topic will be based on the major elective opted by students. Project will include laboratory/field-based work followed by submission of report and presentation.

(B) : Seminar

Students are required to deliver a seminar on a current topic related to the subject and to be evaluated by a panel of examiners