PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- The objective of master of Philosophy in Mathematics is to develop a student with sound knowledge in a specific topic for higher research degree and teaching. The Master of Philosophy Program in Mathematics is being offered based on a credit system. The M. Phil. program has two semesters spreading through one year.

PROGRAMME OUTCOMES (POs):

- After completing M.Phil degree a successful student will be able to carry out independent and original mathematical research of the high quality in all the topics of Mathematics.
### SEMESTER - I

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Total number of Credits: 32

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)
### MX7101 ALGEBRA AND ANALYSIS

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#### OBJECTIVE
- To introduce the advanced topics in algebra, real and complex analysis.

#### UNIT I MODULES
**Basic Definitions** – **Quotient Modules** – **Module Homomorphisms** – **Generation of Modules** – **Direct Sums** – **Free Modules.**

#### UNIT II STRUCTURE OF MODULES
**Change of scalars** - **Simple Modules** - **Semi-simple Modules** - **Structure of Semi-simple Modules** - **Chain conditions** – **The Radical.**

#### UNIT III ABSTRACT INTEGRATION
**The concept of measurability** – **Simple functions** – **Elementary properties of measures** – **Integration of positive functions** – **Integration of complex functions** – **The role played by the sets of measure zero.**

#### UNIT IV ELEMENTARY PROPERTIES OF HOLOMORPHIC FUNCTIONS
**Complex differentiation** – **Integration over paths** – **The local Cauchy theorem** – **The power series representation** – **The open mapping theorem** – **The global Cauchy theorem** – **The calculus of residues.**

#### UNIT V FOURIER TRANSFORMS
**Formal properties** – **The inversion theorem** – **The Plancheral Theorem** - **The Banach algebra $L^1$.**

**TOTAL**: 60 PERIODS

#### OUTCOME
- The students are capable of handling the advanced topics in algebra and analysis.

#### TEXTBOOKS

#### REFERENCES

### MX7102 NONLINEAR DYNAMICS

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#### OBJECTIVE
- This subject introduces the students to the full range of current and background activity in the rapidly growing field of non-linear dynamics.
UNIT I DYNAMICS OF DIFFERENTIAL EQUATIONS 12
Integration of linear second order equations – Integration of nonlinear second order equations – Dynamics in the phase plane – Linear stability analysis – Non autonomous systems.

UNIT II HAMILTONIAN DYNAMICS 12
Lagrangian formulation of Mechanics – Hamiltonian formulation of Mechanics – Canonical transformations – Hamilton-Jacobi equation and action – Angle variables integrable Hamiltonians.

UNIT III CLASSICAL PERTURBATION THEORY 12
Elementary perturbation theory – Canonical perturbation theory – Many degrees of freedom and the problem of small divisors – The Kolmogrov – Arnold-Moser theorem.

UNIT IV NONLINEAR EVOLUTION EQUATIONS AND SOLUTIONS 12
Basic properties of the Kdv equation – The inverse Scattering transforms: Basic principles, Kdv equation – Other solution systems – Hamiltonian structure of integrable systems.

UNIT V ANALYTIC STRUCTURE OF DYNAMICAL SYSTEMS 12

TOTAL : 60 PERIODS

OUTCOME
• Emphasises a step-by-step introduction to dynamics and geometry in state space to help in understanding non linear dynamics and a thorough treatment of both differential equation models and iterated map models.

TEXT BOOK

REFERENCES
UNIT II  STRUCTURE THEOREMS  12
Structure theory for compact and locally compact Abelian groups. Some special locally compact Abelian groups.

UNIT III  HAAR MEASURE  12
The Haar integral. Haar measure. Invariant means defined for all bounded functions. Invariant means on almost periodic functions.

UNIT IV  UNITARY REPRESENTATIONS  12
Convolutions, Convolutions of functions and measures. Elements of representation theory. Unitary representations of locally compact groups.

UNIT V  DUALS  12
The character group of a locally compact Abelian group and the duality theorem.

TOTAL : 60 PERIODS

OUTCOME
• To familiarize the students with topological groups, structure theorems, haar measures and convolutions in the harmonic analysis.

TEXT BOOK

REFERENCE

MX7002  ADVANCED ANALYSIS  L T P C
4 0 0 4

OBJECTIVES
• Real Analysis is the fundamental behind almost all other branches of Mathematics.
• The aim of the course is to make the students understand the basic and advanced concepts of Real analysis.

UNIT I  $L^p$ SPACES  12

UNIT II  COMPLEX MEASURES  12
Total variation-Positive and negative variation-Absolute Continuity-Radon Nikodym theorem-Bounded linear functional in $L^p$-Riez representation theorem.

UNIT III  DIFFERENTIATION  12
Derivatives of measures Lebesgue points-Metric density-fundamental theorem of calculus-Differentiable transformations.
UNIT IV FOURIER TRANSFORMS 12

UNIT V HOLOMORPHIC FOURIER TRANSFORM 12
Two Theorems of Paley and Wiener-Quasi Analytic classes-Denjoy-Carleman Theorem.

TOTAL : 60 PERIODS

OUTCOMES
- The students get introduced to the classical Banach spaces.
- The students will get good understanding of methods of decomposing signed measures which has applications in probability theory and Functional Analysis.
- The students will get good understanding of Fourier Transform and its Holomorphic extensions.

TEXTBOOK

REFERENCE

MX7003 ADVANCED NUMBER THEORY AND CRYPTOGRAPHY L T P C 4 0 0 4

OBJECTIVE
- To introduce the fundamentals of Number Theory and Cryptography such as congruences, residues and partitions.

UNIT I CONGRUENCES 12
Congruences, Solutions of congruences, congruences of deg 1, The function $\phi(n)$ - Congruences of higher degree, Prime power moduli, Prime modulus, congruences of degree 2, Prime modulus, Power residues.

UNIT II QUADRATIC RESIDUES 12
Quadratic residues, Quadratic reciprocity, The Jacobi symbol, greatest integer function, arithmetic function, The Moebius Inversion formula, The multiplication of arithmetic functions.

UNIT III DIOPHANTINE EQUATIONS 12
Diophantine equations, The equation $ax + by = c$, Positive solutions, Other linear Equations, Sums of four and five squares, warings problem, sum of fourth powers, sum of two Squares.

UNIT IV TRADITION SYMMETRIC – KEY CIPHERS 12
Substitution Ciphers – Transportation Ciphers – Steam and Block Ciphers – Modern Block Ciphers – Modern Steam Ciphers – DES – AES.

UNIT V ASYMMETRIC KEY CRYPTOGRAPHY 12

TOTAL : 60 PERIODS
OUTCOME
- Students should be able to understand and apply the concepts in solving problems of cryptosystems.

TEXTBOOKS

REFERENCES

MX7004 ADVANCE IN GRAPH THEORY

OBJECTIVE
- To introduce advanced topics in Graph Theory.

UNIT I CONNECTIVITY IN GRAPHS
Vertex connectivity – Edge connectivity – Blocks – k-connected and k-edge connected graphs – Network flow problems.

UNIT II COLORING OF GRAPHS
Vertex colorings and upper bounds – Brooks’ theorem – Graphs with large chromatic number – Turan’s theorem – Counting proper colorings – Edge colouring – Characterization of line graphs.

UNIT III PLANAR GRAPHS
Embeddings and Euler’s formula – Dual graphs – Kuratowski’s theorem – 5 colour theorem – Crossing number – Surface of higher genus.

UNIT IV RAMSEY THEORY
The pigeonhole principle – Ramsey’s theorem – Ramsey numbers – Graph Ramsey theory.

UNIT V EIGENVALUES OF GRAPHS
The characteristic polynomial – Linear algebra of real symmetric matrices – Eigenvalues and graph parameters – Eigenvalues of regular graphs – Strongly regular graphs.

TOTAL : 60 PERIODS

OUTCOME
- Students will be able to pursue research in frontier areas of Graph Theory.

TEXTBOOK
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OBJECTIVE
- To introduce the branch of Algebraic concepts developed on Semigroups.

UNIT I SEMIGROUPS
- Monogenic semigroups – Ordered sets, semilattices and lattices
- Binary relations, equivalences
- Congruences – Free semigroups – Ideals and Rees congruences

UNIT II SIMPLE SEMIGROUPS
- Certain classes of semigroups – O-Simple semigroups – Principal factors – Primitive Idempotents – Congruences on completely simple O-semigroups.

UNIT III BANDS

UNIT IV INVERSE SEMIGROUPS AND SIMPLE INVERSE SEMIGROUPS
- Inverse semigroups – Natural order relation on an inverse semi group – Congruence in Inverse semigroup – Bisimple inverse semigroups – Simple inverse semigroups.

UNIT V SEMI LATTICES
- Fundamental inverse semigroups – autouniform semi lattices.

TOTAL : 60 PERIODS

OUTCOME
- The students have learnt the treatment on the theory of Semigroups.

TEXT BOOK

REFERENCES
OBJECTIVE
• To introduce advanced database in combinatorial mathematics.

UNIT I  TOOLS OF COMBINATORICS

UNIT II  POLYA THEORY OF COUNTING

UNIT III  COMBINATORIAL DESIGNS
Balanced incomplete block designs – Necessary condition for existence of \((b,v,r,k,\lambda)\) designs. Resolvable designs – Steiner triple systems – Symmetric balanced incomplete block designs – Projective plans, Latin squares and \((v,k,\lambda)\) designs.

UNIT IV  CODING THEORY
Encoding and decoding – Error correcting codes – Linear codes – Use of block designs to find error correcting codes.

UNIT V  COMBINATORIAL OPTIMIZATION

TOTAL PERIODS: 60

OUTCOME
• Students will be able to apply combinatorial techniques in design theory, coding theory and optimization problems.

TEXTBOOK

REFERENCES
UNIT I APPROXIMATION IN NORMED LINEAR SPACES 12

UNIT II CHEBYSHEV POLYNOMIALS 12

UNIT III INTERPOLATION 12

UNIT IV BEST APPROXIMATION IN NORMED LINEAR SPACES 12
Introduction - Approximative properties of sets - Characterization and Duality.

UNIT V PROJECTION 12
Continuity of metric projections - Convexity, Solarity and Chebyshevity of sets - Best simultaneous approximation.

TOTAL PERIODS : 60

OUTCOME
- The course enables the students to gain better knowledge on topics like interpolation, best approximation and projection.

TEXTBOOK

REFERENCES

MX7008 BASIC HYPERGEOMETRIC SERIES L T P C 4 0 0 4

OBJECTIVE
- To introduce an extension of Beta, Gamma functions, Hypergeometric series, bilateral series developed on q-analogue and its application on theta and elliptic functions.

UNIT I INTRODUCTION TO Q-SERIES 12
A q-Analogue of Differentiation and Integration – Simple q-Differentiation and q-Integration Formulae – The q-Binomial Theorem – q-Exponential Functions – q-Analogue of Circular Functions – q-Gamma and q-Beta Functions.
UNIT II  BASIC HYPERGEOMETRIC SERIES

UNIT III  SUMMATION AND TRANSFORMATION FORMULAS

UNIT IV  BILATERAL BASIC HYPERGEOMETRIC SERIES

UNIT V  THETA AND ELLIPTIC FUNCTIONS

TOTAL : 60 PERIODS

OUTCOME
• The students have learnt the q-analogue along with an extension of Concepts of Beta, Gamma function and its application on elliptic and theta functions.

TEXTBOOKS

REFERENCES

MX7009  BOUNDARY LAYER FLOWS  L T P C
4 0 0 4

OBJECTIVE
• To give a comprehensive overview of boundary layer theory and its application to all areas of fluid mechanics with emphasis on the flow past bodies.

UNIT I  DERIVATION AND PROPERTIES OF NAVIER-STOKE’S EQUATIONS
UNIT II  EXACT SOLUTIONS 12
Hagen – Poiseuille theory – Flow between two concentric rotating cylinders – Couette Motion – Parallel flow – Other exact solutions.

UNIT III  BOUNDARY LAYER EQUATIONS AND THEIR PROPERTIES 12
Derivation of boundary layer equations – Separation – Skin friction – Boundary layer along a flat plate – Characteristics of a boundary layer - Similar solutions – Transformation of the boundary layer equations – Momentum and integral equations.

UNIT IV  EXACT AND APPROXIMATE METHODS 12
Exact solutions of boundary layer equations – Flow past a wedge - Flow past a cylinder – Approximate methods – Application of the momentum equation – Von Karman and Pohlhausen method – Comparison – Methods of boundary layer control.

UNIT V  TURBULENT BOUNDARY LAYERS 12

TOTAL : 60 PERIODS

OUTCOME
• To familiarize the student with laminar transitional, boundary layers and free shear flows.

TEXTBOOK

REFERENCES

MX7010 DIFFERENTIAL TOPOLOGY 12
L T P C 4 0 0 4

OBJECTIVE
• To introduce the notion of smooth manifolds and classify compact one manifolds and smooth compact surfaces.

UNIT I  MANIFOLDS AND MAPS 12
Derivatives and tangents-inverse function theorem and immersions-submersions -homotopy and stability-Sard’s theorem and Morse functions-embedding manifolds in Euclidean space.

UNIT II  TRANSVERSALITY AND INTERSECTION 12
Manifolds with boundary- one manifolds and some consequences – transversality -intersection theory modulo 2-winding numbers and the Jordan – Brouwer separation theorem.

UNIT III  ORIENTED INTERSECTION THEORY 12
Orientation on manifolds – oriented intersection number-degrees of maps- fundamental theorem of algebra -Euler characteristic as an intersection number.
UNIT IV  APPLICATIONS OF INTERSECTION THEORY  12

UNIT V  COMPACT SMOOTH SURFACES  12
Morse functions, Morse Lemma, Connected sum, attaching handles, Handle decomposition theorem, Application to smooth classification of compact smooth surfaces.

TOTAL : 60 PERIODS

OUTCOME
- Differential manifolds occur in different fields like mathematics, physics, mechanics and economics. A course in differential topology will equip the students with techniques and results required to solve problems involving manifolds.

TEXTBOOKS

REFERENCES

MX7011  FINITE ELEMENT METHOD  L T P C
4 0 0 4

OBJECTIVE
- The aim of the course is to make the students understand the Finite element method and its implementation issues.

UNIT I  INTEGRAL FORMULATIONS AND VARIATIONAL METHODS  12
Weighted integral and weak formulations of boundary value problems - Rayleigh-Ritz method - Method of weighted residuals.

UNIT II  FINITE ELEMENT ANALYSIS OF ONE- DIMENSIONAL PROBLEMS  12
Discretization of the domain - Derivation of element equations - Connectivity of elements - Imposition of boundary conditions - Solution of equations.

UNIT III  EIGENVALUE AND TIME DEPENDENT PROBLEMS IN ONE DIMENSION  12
Formulation of eigenvalue problem - Finite element models - Applications of semi discrete finite element models for time-dependent problems - Applications to parabolic and hyperbolic equations.

UNIT IV  FINITE ELEMENT ANALYSIS OF TWO- DIMENSIONAL PROBLEMS  12
Interpolation functions - Evaluation of element matrices - Assembly of element equations - Imposition of boundary conditions - Solution of equations - Applications to parabolic and hyperbolic equations.

UNIT V  FINITE ELEMENT ERROR ANALYSIS  12
Interpolation Functions - Numerical Integration and Modeling Considerations - Various measures of errors - Convergence of solution - Accuracy of solution.

TOTAL : 60 PERIODS
OUTCOMES
- To get exposed to the implementation issues of Finite Element Method for one-dimensional and two-dimensional problems.
- To acquaint the students with various formulations and implementation of steady state and time dependent partial differential equations.

TEXTBOOK

REFERENCES

MX7012 FINITE VOLUME METHOD

OBJECTIVE
- The aim of the course is to make the students understand the Finite volume method for solving partial differential equations arising in fluid dynamics.

UNIT I CONSERVATION LAWS AND BOUNDARY CONDITIONS
12

UNIT II FINITE VOLUME METHOD FOR DIFFUSION & CONVECTION-DIFFUSION PROBLEMS
12

UNIT III SOLUTION ALGORITHMS FOR PRESSURE-VELOCITY LINKED EQUATIONS
12
Staggered grid - momentum equations - SIMPLE, SIMPLER, SIMPLEC algorithms - PISO algorithm - Solution of discretised equation: Multigrid techniques.

UNIT IV FINITE VOLUME METHOD FOR UNSTEADY FLOWS
12
One-dimensional unsteady heat conduction: Explicit - Crank-Nicolson - fully implicit schemes - Implicit method for two and three dimensional problems - transient convection - Diffusion equation and QUICK differencing scheme - Solution procedures for unsteady flow calculations and implementation of boundary conditions.
UNIT V  METHOD WITH COMPLEX GEOMETRIES

Body-fitted co-ordinate grids for complex geometries - Cartesian Vs. Curvilinear grids -
difficulties in Curvilinear grids - Block-structured grids - Unstructured grids and discretisation in
unstructured grids - Discretisation of the diffusion term - Discretisation of convective term -
Treatment of source terms - Assembly of discretised equations - Pressure-velocity coupling in
unstructured meshes - Staggered Vs. co-located grid arrangements - Face velocity
interpolation method to unstructured meshes.

OUTCOMES

- Basic concepts on governing equations on fluid flow are discussed.
- This course will emphasize on the finite volume methods for diffusion, convection-
diffusion, unsteady flows and problems with complex geometries.
- This course will also emphasize on SIMPLE, SIMPLER and PISO algorithms.

TEXTBOOK


REFERENCES


MX7013  FIXED POINT THEORY AND ITS APPLICATIONS

OBJECTIVE

- To identify all self-maps in which at least one element is left invariant.

UNIT I  THE BANACH FIXED POINT THEOREM AND ITERATIVE METHODS

The Banch fixed point theorem – The significance of Banach fixed point theorem –
Applications to nonlinear equations – The Picard – Lindelof theorem – The Main theorem for
iterative methods for linear operator equation – Applications to systems of linear equations and
to linear integral equations.

UNIT II  THE SCHAUDER FIXED POINT THEOREM AND COMPACTNESS

Extension theorem – Retracts – The Brouwer fixed point theorem – Existence principle for
systems of equations – Compact operators – Schauder fixed – point theorem – Peano’s
theorem – Systems of Integral equations and semi linear differential equations.

UNIT III  FIXED POINTS OF MULTIVALUED MAPS

Generalized Banach fixed point theorem – Upper and lower semi continuity of multi-valued
maps – Generalized Schauder fixed point theorem – Variational inequalities and Browder fixed
point theorem.

UNIT IV  NONEXPANSIVE OPERATORS AND ITERATIVE METHODS

Uniformly convex Banach spaces – Demiclosed operators – The fixed point theorem of
Browder, Gohde and Kirk – Demicompact operators – Convergence principles in Banach
spaces – Modified successive approximations – Applications to periodic solutions.
UNIT V  CONDENSING MAPS
A noncompactness measure – Condensing maps – Operators with closed range and an approximation technique for constructing fixed points – Sadovskii’s fixed point theorem for condensing maps – Fixed point theorem for perturbed operators – Application to differential equations in Banach spaces.

TOTAL : 60 PERIODS

OUTCOME
• The student will be able to apply fixed point theory in various branches of applied mathematics.

TEXTBOOK

REFERENCES

MX7014  FLUID MECHANICS

OBJECTIVE
• To give a comprehensive overview of basic concepts of fluid mechanics and its application to all areas of mathematics with emphasis on the flow past bodies.

UNIT I  KINEMATICS OF FLUIDS IN MOTION

UNIT II  EQUATIONS OF MOTION OF A FLUID
Pressure at a point in a fluid – Boundary conditions of two inviscid immiscible fluids – Euler’s equations of motion – Bernoulli’s equation – Some potential theorems – Flows involving axial symmetry.

UNIT III  TWO DIMENSIONAL FLOWS
Two-Dimensional flows – Use of cylindrical polar co-ordinates – Stream function, complex potential for two-dimensional flows, irrotational, incompressible flow – Complex potential for standard two-dimensional flows –Two dimensional image systems – Milne-Thomson circle theorem – Theorem of Blasius.
UNIT IV CONFORMAL TRANSFORMATION AND ITS APPLICATIONS 12
Use of conformal transformations – Hydrodynamical aspects of conformal mapping - Schwarz Christoffel transformation – Vortex rows.

UNIT V VISCOS FLOWS 12

TOTAL : 60 PERIODS

OUTCOME
• To familiarize the student with kinematics, equations of motion, two dimensional, laminar and viscous flows.

TEXTBOOK

REFERENCES

MX7015 FRACTIONAL DIFFERENTIAL EQUATIONS 4 0 0 4

OBJECTIVES
• Propose new methods to approximate Fractional differential equations solution.
• Use the new method to approximate the solution of partial Fractional differential equations.
• Discuss the perturbation of the solution of Fractional differential equations.

UNIT I SPECIAL FUNCTIONS OF FRACTIONAL CALCULUS 12

UNIT II FRACTIONAL DERIVATIVES AND INTEGRALS 12

UNIT III LINEAR FRACTIONAL DIFFERENTIAL EQUATIONS 12
Fractional Derivatives of a General Form – Existence and Uniqueness Theorems as Method of Solutions. Dependence of a solution on initial data.

UNIT IV FRACTIONAL GREEN’S FUNCTIONS 12
Definition and some properties. One-Term Equation – Two –Term Equation – Three Term Equation Four Term Equation – General n-term Equation.
UNIT V OTHER METHODS OF SOLUTIONS OF FRACTIONAL- ORDER EQUATIONS


TOTAL : 60 PERIODS

OUTCOMES
After the completion of this course students can able to

- Explain the basic concepts of Fractional order derivatives.
- Obtain and Explain the Fundamental Definitions, Concepts, Theorems , Stability and Applications of Fractional Dynamical Systems.
- Gain Experience on Fractional order Differential Equations.
- Generalize, Emphasize and Apply the concept of Theory of Ordinary Differential Equations to the Fractional order Differential Equations.
- Interpret the Stability results and Applications of Fractional Dynamical Systems.

TEXTBOOKS

REFERENCES

MX7016 FUNCTIONAL ANALYSIS AND ITS APPLICATIONS TO PARTIAL DIFFERENTIAL EQUATIONS

OBJECTIVE
- The aim of the course is to make the students understand the functional analytic concepts and techniques used in Partial Differential Equations.

UNIT I DISTRIBUTION THEORY
Distributions, operations with distributions, support and singular support, convolutions, fundamental solutions, Fourier transform, tempered distributions.

UNIT II SOBOLEV SPACES
Basic properties, approximation by smooth functions and consequences, imbedding theorems, Rellich - Kondrasov compactness theorem, fractional order spaces, trace spaces, dual spaces, trace theory.

UNIT III WEAK SOLUTIONS OF ELLIPTIC EQUATIONS
Abstract variational results (Lax-Milgram lemma, Babuska- Brezzi theorem), existence and uniqueness of weak solutions for elliptic boundary value problems (Dirichle Neumann and mixed problems), regularity results.
UNIT IV  GALERKIN METHODS
Galerkin method, maximum principles, eigenvalue problems, introduction to the mathematical theory of the finite element method.

UNIT V  EVOLUTION EQUATIONS
Unbounded operators, exponential map, \( C_0 \)-semigroups, Hille-Yosida theorem, contraction semigroups in Hilbert spaces, applications to the heat, wave and Schrodinger equations, inhomogeneous problems.

TOTAL : 60 PERIODS

OUTCOME
• The course, apart from providing a through understanding of the functional analytic concepts and techniques used in partial differential equations, will enable them to solve the partial differential equations of various problems arising in Science and Engineering.

TEXTBOOK

REFERENCES
OUTCOME
- On successful completion of the course, students should be able to apply Graph Theory in chemical problems.

TEXTBOOK

REFERENCES

MX7018 FUZZY SETS AND SYSTEMS

OBJECTIVE
- To introduce the basic concepts of fuzzy sets, fuzzy systems, Intuitionistic Fuzzy Sets and its extensions to understand the concepts and apply to Mathematics.

UNIT I CRISP SETS AND FUZZY SETS
Introduction - crisp sets: An overview - the notion of fuzzy sets - classical logic: an overview - fuzzy logic. OPERATIONS ON FUZZY SETS: General discussion - fuzzy complement - fuzzy union - fuzzy intersection - combinations of operations - general aggregation operations. FUZZY MEASURES: belief and plausibility measures - probability measures - possibility and necessity measures.

UNIT II FUZZY SYSTEMS

UNIT III INTUITIONISTIC FUZZY SETS
Definition – operations and relations - properties – intuitionistic fuzzy sets of a certain level - cartesian product and intuitionistic fuzzy relations - necessity and possibility operators - topological operators.

UNIT IV INTERVAL VALUED INTUITIONISTIC FUZZY SETS
Intuitionistic fuzzy sets and interval valued fuzzy sets - definition, operations, and relations on interval valued intuitionistic fuzzy sets - norms and metrics on interval valued intuitionistic fuzzy sets.

UNIT V OTHER EXTENSIONS OF INTUITIONISTIC FUZZY SETS
Intuitionistic L-Fuzzy Sets - intuitionistic fuzzy sets over different universes - temporal intuitionistic fuzzy sets - intuitionistic fuzzy sets of second type - some future extensions of intuitionistic fuzzy sets.
OUTCOME
After the completion of the course students can able to,
- Apply the fuzzy set concepts to all the areas of Mathematics.

TEXTBOOKS

REFERENCES

MX7019 GENERALIZED INVERSES L T P C 4 0 0 4

OBJECTIVES
- To acquaint the students with various techniques of generalized inverses related with optimal and spectral theory.
- To develop generalized inverses of partitioned matrices.

UNIT I EXISTENCE AND CONSTRUCTION OF GENERALIZED INVERSES 12

UNIT II LINEAR SYSTEMS AND CHARACTERIZATION OF GENERALIZED INVERSES 12

UNIT III MINIMAL PROPERTIES OF GENERALIZED INVERSES 12

UNIT IV SPECTRAL GENERALIZED INVERSES 12

UNIT V GENERALIZED INVERSES OF PARTITIONED MATRICES 12

TOTAL : 60 Periods
OUTCOME
• The students are expected to have good knowledge of generalized inverses which will be helpful for research in this field.

TEXTBOOK

REFERENCES

MX7020 HARMONIC ANALYSIS

OBJECTIVE
• The aim of the course is to make the students to understand the basic concepts of Harmonic Analysis.

UNIT I FOURIER SERIES
Basic properties of topological groups, subgroups, quotient groups and connected groups. Discussion of Haar Measure without proof on R, T, Z, and some simple matrix groups. $L^1(G)$ and convolution with special emphasis on $L^1(R)$, $L^1(T)$, $L^1(Z)$. Approximate identities. Fourier series. Fejer’s theorem.

UNIT II FOURIER INTEGRALS

UNIT III HARDY SPACES

UNIT IV MAXIMAL FUNCTIONS

UNIT V WIENER TAUBERIAN THEOREM

TOTAL : 60 PERIODS
OUTCOMES
- The students will have good understanding of Fourier series and intricacies of convergence.
- The student will be able to understand the intricacies of Wiener Tauberian Theorem and invariant subspace problem.

TEXTBOOK

REFERENCES

MX7021 HEAT AND MASS TRANSFER

OBJECTIVE
- To enable the students to understand the concept of heat and mass transfer and its applications.

UNIT I HEAT CONDUCTION

UNIT II FLOW ALONG SURFACES AND IN CHANNELS
Boundary layers and turbulence – momentum equation- laminar flow boundary layer equation- plane plate in longitudinal flow – pressure gradients along a surface – exact solutions for a flat plate.

UNIT III FREE CONVECTION
Laminar heat transfer on a vertical plate and horizontal tube – turbulent heat transfer on a vertical plate – free convection in a fluid enclosed between two plate walls – mixed free and forced convection.

UNIT IV FORCED CONVECTION IN LAMINAR FLOW

UNIT V MASS TRANSFER
Diffusion – flat plate with heat and mass transfer – integrated boundary layer equations of mass transfer – similarity relations for mass transfer – evaporation of water into air.

TOTAL : 60 PERIODS

OUTCOME
- The students are capable of solving various complex problems using FEM.
TEXTBOOK

REFERENCES:

MX7022 MATHEMATICAL ASPECTS OF FINITE ELEMENT METHOD

OBJECTIVE
• The aim of the course is to make the students understand the mathematical aspects of finite element method required for solving partial differential equations.

UNIT I BASIC CONCEPTS

UNIT II SOBOLEV SPACES
Review of Lebesgue integration theory - Weak derivatives - Sobolev norms and associated spaces - Inclusion relations and Sobolev’s inequality - Trace Theorems - Negative norms and duality.

UNIT III VARIATIONAL FORMULATIONS

UNIT IV CONSTRUCTION OF FINITE ELEMENT SPACE AND APPROXIMATION THEORY IN SOBOLEV SPACES

UNIT V HIGHER DIMENSIONAL VARIATIONAL PROBLEMS

TOTAL : 60 PERIODS

OUTCOME
• The students will be in position to tackle complex problems involving partial differential equations arising in the mathematical models of various problems in Science and Engineering by finite element techniques.
TEXTBOOKS

REFERENCES

MX7023  MATHEMATICAL FINANCE  L T P C  4 0 0 4

OBJECTIVE
- The principal aim of this course is to provide students with an appreciation and understanding of how the application of mathematics, particularly stochastic mathematics, to the field of finance may be used to illuminate this field and model its randomness, resulting in greater understanding and quantification of investment returns and basics of option pricing. It would also be helpful to understand the fundamentals of LP models and their duals while grasping the proof of the Arbitrage theorem.

UNIT I  PROBABILITY AND RANDOM VARIABLES  12

UNIT II  PRESENT VALUE ANALYSIS AND ARBITRAGE  12
Interest rates - Present value analysis - Rate of return - Continuously varying interest rates - Pricing contracts via Arbitrage - An example in options pricing.

UNIT III  ARBITRAGE THEOREM AND BLACK-SCHOLES FORMULA  12

UNIT IV  EXPECTED UTILITY  12
Limitations of arbitrage pricing - Valuing investments by expected utility - The portfolio section problem - Capital assets pricing model - Rates of return - Single period and geometric Brownian motion.

UNIT V  EXOTIC OPTIONS  12

TOTAL : 60 PERIODS
OUTCOME
• The students would have a clear perception of the power of mathematical ideas and tools and would be able to demonstrate the application of mathematics to problems drawn from industry and financial services. Also, they would be able to describe the main equilibrium asset pricing models and perform calculations using such models; understand the relationship between investment risk and return and calculate the option prices using the studied models.

TEXTBOOK

REFERENCES

MX7024 MATHEMATICAL STATISTICS L T P C
4 0 0 4

OBJECTIVE
• To teach various statistical techniques from both applied and theoretical points of view.

UNIT I SAMPLING DISTRIBUTIONS AND ESTIMATION THEORY 12
Sampling distributions - Characteristics of good estimators - Method of Moments - Maximum Likelihood Estimation - Interval estimates for mean, variance and proportions.

UNIT II TESTING OF HYPOTHESIS 12
Type I and Type II errors - Tests based on Normal, t, \( \chi^2 \) and F distributions for testing of mean, variance and proportions - Tests for Independence of attributes and Goodness of fit.

UNIT III CORRELATION AND REGRESSION 12
Method of Least Squares - Linear Regression - Normal Regression Analysis - Normal Correlation Analysis - Partial and Multiple Correlation - Multiple Linear Regression.

UNIT IV DESIGN OF EXPERIMENTS 12
Analysis of Variance - One-way and two-way Classifications - Completely Randomized Design - Randomized Block Design - Latin Square Design.

UNIT V MULTIVARIATE ANALYSIS 12
Mean Vector and Covariance Matrices - Partitioning of Covariance Matrices - Combination of Random Variables for Mean Vector and Covariance Matrix - Multivariate, Normal Density and its Properties - Principal Components: Population principal components - Principal components from standardized variables.

TOTAL : 60 PERIODS

OUTCOME
• This course will be helpful for the students, who want to apply the various modern statistical tools in Science, Engineering, Industry, Operations Research, Biomedical and Public policy.
TEXTBOOKS

REFERENCES

MX7025

MEASURE THEORY
L T P C
4 0 0 4

OBJECTIVES
• To gain understanding of the abstract measure theory and definition and main properties of the integral. To construct Lebesgue’s measure on the real line and in n-dimensional Euclidean space.
• To explain the basic advanced directions of the theory.

UNIT I MEASURES ON THE REAL LINE
Lebesgue Outer Measure- Measurable sets-Regularity-measurable functions-Borel and Lebesgue measurability-Hausdorff measures

UNIT II ABSTRACT MEASURES SPACES
Measures and outer measures-Extension of a measure-Uniqueness of the extension-completion of a measure-integration with respect to a measure.

UNIT III CONVERGENCE
L^p spaces-completeness-Convergence in measure-Almost Uniform convergence

UNIT IV SIGNED MEASURES
Hahn-Jordan Decompositions-Radon-Nikodym theorem-applications.

UNIT V MEASURES IN PRODUCT SPACES
Measurablity in a product space-product measures-Fubni’s Theorem-Lebesgue measure in Euclidean space-Laplace and Fourier Transform.

TOTAL : 60 PERIODS

OUTCOME
• To introduce the concepts of measure and integral with respect to a measure, to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems.

TEXTBOOK

REFERENCE
OBJECTIVES

- In this course, modeling and simulation (M&S) methodologies considering both practical and theoretical aspects. Primarily in the context of defense industry and game programming will be studied in details.
- A wide range of M&S concepts that will lead to develop students own M&S applications.

UNIT I INTRODUCTION


UNIT II RANDOM NUMBERS


UNIT III DESIGN OF SIMULATION EXPERIMENTS


UNIT IV SIMULATION LANGUAGES

Comparison and selection of simulation languages – study of anyone simulation language.

UNIT V CASE STUDY

Development of simulation models using simulation language studied for systems like queuing systems – Production systems – Inventory systems–maintenance and replacement systems and Investment analysis.

TOTAL : 60 PERIODS

OUTCOMES

After the completion of the course an ability
- To develop simulations in software
- To apply the experimental process to acquire desired simulation results;
- To apply visualization techniques to support the simulation process;
- To use appropriate techniques to verify and validate models and simulations;
- To analyze simulation results to reach an appropriate conclusion.

REFERENCES

UNIT I BIOLOGICAL INTRODUCTION (DNA STRUCTURE AND PROCESSING) 12
Structure of DNA – Operations on DNA molecules – Reading out the sequence.

UNIT II BEGINNINGS OF MOLECULAR COMPUTING 12
Adleman’s experiment – SAT problem – Breaking DES code.

UNIT III REPRESENTATION OF LANGUAGES 12
Representations of Regular and Linear Languages – Characterizations of Recursively Enumerably Languages.

UNIT IV STICKER SYSTEM AND SPLICING SYSTEM 12
Operations of Sticking – Sticker systems classifications – Generative capacity of Sticker System – Operations of Splicing – Non-Iterated Splicing as an operation with Languages – Iterated Splicing as an operation with Languages.

UNIT V APPLICATIONS OF MOLECULAR COMPUTING 12
Recent applications of Molecular Computing to various problems of Mathematics and Theoretical Computer Science.

TOTAL : 60 PERIODS

OUTCOME
• Students should be able to understand and apply molecular computing to problems in Mathematics and Theoretical Computer Science.

TEXTBOOK

REFERENCES

MX7028 NETWORKS, GAMES AND DECISIONS L T P C
4 0 0 4

OBJECTIVE
• Introduces network optimization techniques, games and decision making – three important areas in OR / Optimization.

UNIT I NETWORK MODELS 12
Scope and definition of network models - Minimal spanning tree algorithm - Shortest -route problem - Maximal-flow Model.

UNIT II CPM AND PERT 12
Network representation - Critical path (CPM) computations - Construction of the time schedule - Linear programming formulation of CPM - PERT calculations.

UNIT III GAME THEORY 12
Optimal solution of two-person zero-sum games - Mixed strategies - Graphical solution of (2 x n) and (m x 2) games - Solution of m x n games by linear programming.

TOTAL : 60 PERIODS

OUTCOME
• Students should be able to understand and apply molecular computing to problems in Mathematics and Theoretical Computer Science.

TEXTBOOK

REFERENCES
UNIT IV DECISION ANALYSIS 12
Decision making under certainty: analytic hierarchy process (AHP) - Decision making under risk - Decision under uncertainty.

UNIT V MARKOVIAN DECISION PROCESS 12
Scope of the Markovian decision problem - Finite stage dynamic programming model - Infinite stage model - Linear programming solution.

TOTAL : 60 PERIODS

OUTCOMES
- Helps in formulating many practical problems in the framework of Networks.
- Identifies competitive situations which can be modeled and solved by game theoretic formulations.
- Offers interesting techniques to quantify and effectively obtain the solution of various decision making situations.

TEXT BOOK

REFERENCES

MX7029 NUMBER THEORY L T P C 4 0 0 4

OBJECTIVE
- To introduce the students basic number theory concepts.

UNIT I DIVISIBILITY 12
Introduction - Divisibility - Primes - The binomial theorem.

UNIT II CONGRUENCES 12
Congruences - Solutions of congruences - The chinese remainder theorem - Techniques of numerical calculation.

UNIT III APPLICATION OF CONGRUENCE AND QUADRATIC RECIPROCITY 12
Public - Key cryptography - Prime power moduli - Prime modulus - Primitive roots and power residues - Quadratic residues - The Gaussian reciprocity law.

UNIT IV FUNCTIONS OF NUMBER THEORY 12
Greatest integer function - Arithmetic functions - Mobius inversion formula - Recurrence functions - Combinational number theory.

UNIT V DIOPHANTINE EQUATIONS AND FAREY FRACTIONS 12
The equations ax + by = c Pythagorean triangle - Shortest examples - Farey sequences - Rational approximations.

TOTAL : 60 PERIODS
OUTCOMES
- The students will be introduced to Quadratic Residues and reciprocity.
- The students will be able to solve some diophantine equations and some special cases of Fermat’s Last theorem.

TEXTBOOK

REFERENCES

MX7030 NUMBER THEORY AND CRYPTOGRAPHY L T P C
4 0 0 4

OBJECTIVE
- To introduce the fundamentals of Number Theory and Cryptography such as congruences, residues and partitions.

UNIT I CONGRUENCES 12
Congruences, Solutions of congruences, congruences of deg 1, The function 0(n) - Congruences of higher degree, Prime power moduli, Prime modulus, congruences of degree 2, Prime modulus, Power residues.

UNIT II QUADRATIC RESIDUES 12
Quadratic residues, Quadratic reciprocity, The Jacobi symbol, greatest integer function, arithmetic function, The Moebius Inversion formula, The multiplication of arithmetic functions.

UNIT III DIOPHANTINE EQUATIONS 12
Diophantine equations, The equation ax + by = c, Positive solutions, Other linear Equations, Sums of four and five squares, warings problem, sum of fourth powers, sum of two Squares.

UNIT IV TRADITION SYMMETRIC – KEY CIPHERS 12
Substitution Ciphers – Transportation Ciphers – Steam and Block Ciphers – Modern Block Ciphers – Modern Steam Ciphers – DES – AES.

UNIT V ASYMMETRIC KEY CRYPTOGRAPHY 12

TOTAL : 60 PERIODS

OUTCOME
- Students should be able to understand and apply the concepts in solving problems of cryptosystems.
TEXTBOOKS

REFERENCES

MX7031 NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS L T P C
4 0 0 4

OBJECTIVE
• The aim of the course is to make the students understand the mathematical concepts of numerical methods for solving partial differential equations, their implementation and analysis.

UNIT I LINEAR SYSTEMS OF EQUATIONS 12

UNIT II ONE DIMENSIONAL PARABOLIC EQUATIONS 12
Explicit and Crank-Nicolson Schemes for $u_t = u_{xx}$ - Weighted average approximation - Derivative boundary conditions - Truncation errors - Consistency, Stability and convergence - Lax Equivalence theorem.

UNIT III MATRIX NORMS & TWO DIMENSIONAL PARABOLIC EQUATION 12

UNIT IV HYPERBOLIC EQUATIONS 12
First order quasi-linear equations and characteristics - Numerical integration along a characteristic - Lax-Wendroff explicit method - Second order quasi-linear hyperbolic equation - Characteristics - Solution by the method of characteristics.

UNIT V ELLIPTIC EQUATIONS 12
Solution of Laplace and Poisson equations in a rectangular region - Finite difference in Polar coordinate Formulas for derivatives near a curved boundary when using a square mesh - Discretisation error - Mixed Boundary value problems.

TOTAL : 60 PERIODS

OUTCOME
• The students will be able to apply the concepts and techniques for the solution of partial differential equations arising in various problems of Science and Engineering.

TEXTBOOK
REFERENCES

MX7032 OPERATOR THEORY

OBJECTIVE
- The interplay between the ideas and methods from operator theory and functional analysis with methods and ideas from function theory, commutative algebra and algebraic, analytic and complex geometry gives the field a strong interdisciplinary character.

UNIT I KATO DECOMPOSITION PROPERTY

UNIT II GENERALIZED KATO DECOMPOSITION PROPERTY

UNIT III SINGLE-VALUED EXTENSION PROPERTY (SVEP)
Local spectrum and SVEP- The SVEP at a point- A Local spectral mapping theorem.

UNIT IV SVEP AND FREDHOLM THEORY

UNIT V SPECTRA OF SOME SPECIAL OPERATORS
The SVEP on the components of (T)- The Fredholm, Weyl and Browder spectra- Compressions.

TOTAL : 60 PERIODS

OUTCOME
- Operator Theory provides an introduction to functional analysis with an emphasis on the theory of linear operators and its application to differential and integral equations, approximation theory, and numerical analysis.

TEXTBOOK
1. Aiena, P., “Fredholm and Local Spectral Theory, with Applications to Multipliers”, Kluwer Academic Publishers, New York, Boston, Dor Drecht, London, Moscow, 2004. (Unit I: Chapter 1- Sections 1-4, Unit II: Chapter 1- Sections 5-8, Unit III: Chapter 2- Sections 1-3, Unit IV: Chapter 2- Section 4, Chapter 3- Sections 1-2, Unit V: Chapter 3- Sections 3-5)

REFERENCES
OBJECTIVE

- To introduce various operations research tools in decision making in an organization.

UNIT I ADVANCED LINEAR PROGRAMMING AND GOAL PROGRAMMING 12

UNIT II HEURISTIC PROGRAMMING 12

UNIT III NON-LINEAR PROGRAMMING 12
Unconstrained algorithms: Direct search method - Gradient method – Constrained algorithms: Separable programming, Chance – constrained programming.

UNIT IV INVENTORY MODELS 12

UNIT V SIMULATION 12

TOTAL : 60 PERIODS

OUTCOME

- Students will be capable of using advanced techniques in various OR/OM tools in decision making and able to formulate organization problems into OR models for seeking optimal solutions.

TEXTBOOKS


REFERENCES

OBJECTIVES

- To get exposed to various queueing models available in the literature and some of their real time applications.
- To familiarize with the concept of system reliability, availability and maintainability which opens up new avenues for research.

UNIT I  MARKOVIAN QUEUES  12
Steady State Analysis - Single and multiple channel queues - Erlang’s formula - Queues with unlimited service - Finite source queues - Transient behavior - Busy period analysis.

UNIT II  ADVANCED MARKOVIAN QUEUES  12
Bulk input model - Bulk service model - Erlangian Models - Priority queue Discipline.

UNIT III  NON-MARKOVIAN QUEUES  12
M/G/1 queueing model - Pollaczek-Khintchine formula - Steady-state system size probabilities - Waiting time distributions - Generalization of Little’s formula - Busy period analysis.

UNIT IV  SYSTEM RELIABILITY  12
Reliability and hazard functions - Exponential, normal, weibull and Gamma failure distributions - Time-dependent hazard models, Reliability of series and parallel systems, k- out-of-m systems.

UNIT V  MAINTAINABILITY AND AVAILABILITY  12
Maintainability and Availability functions - Frequency of failures - Two unit parallel system with repair - k out of m systems.

OUTCOME

- To acquaint the students with various mathematical techniques that help to obtain explicit analytic solution to problems arising in real world applications in both steady state and time dependent regime.

TEXTBOOKS


REFERENCES

OBJECTIVE
- To introduce the concepts the representation theory of Finite Groups and its Applications.

UNIT I   GROUP REPRESENTATIONS  12

UNIT II  REDUCIBILITY AND G-HOMOMORPHISMS  12
Reducibility – Complete reducibility and Maschke’s theorem – G-homomorphisms and Schur’s lemma – Commutant and Endomorphism algebras.

UNIT III CHARACTERS AND TENSOR PRODUCTS  12

UNIT IV  REPRESENTATION OF SYMMETRIC GROUPS  12
Young subgroups, tableaux and tabloids – dominance and lexicographic ordering – specht modules – branching rule – Kostka numbers.

UNIT V   APPLICATIONS IN COMBINATORICS  12
The Robinson-Schensted algorithm – column insertion – increasing and decreasing subsequences – Knuth relations – the hook formula – the determinant formula.

TOTAL : 60 PERIODS

OUTCOME
- Students will gain in-depth knowledge in Representation theory of Finite groups to pursue research.

TEXTBOOK

REFERENCES
OBJECTIVE
- To give an expertise treatment in various special function and orthogonal polynomial.

UNIT I  SPECIAL FUNCTIONS  12

UNIT II  HYPERGEOMETRIC FUNCTIONS  12

UNIT III  GENERALIZED HYPERGEOMETRIC FUNCTIONS  12

UNIT IV  ORTHOGONAL POLYNOMIALS  12

UNIT V  SPECIFIC ORTHOGONAL POLYNOMIALS  12

TOTAL : 60 PERIODS

OUTCOME
- Students are exposed to various special functions and orthogonal polynomials.

TEXTBOOKS

REFERENCES
OBJECTIVE

- This course aims at providing the necessary basic concepts in stochastic processes. Knowledge of fundamentals and applications of random phenomena will greatly help in the understanding of topics such as signals and systems, pattern recognition, voice and image processing and filtering theory.

UNIT I  MARKOV AND STATIONARY PROCESSES  12

UNIT II  RENEWAL PROCESSES  12
Renewal processes in discrete and continuous time - Renewal equation - Stopping time - Wald’s equation - Renewal theorems - Delayed and Equilibrium renewal processes - Residual and excess life times - Renewal reward process - Alternating renewal process - Regenerative stochastic process.

UNIT III  MARKOV RENEWAL AND SEMI–MARKOV PROCESSES  12
Definition and preliminary results - Markov renewal equation - Limiting behaviour – First passage time.

UNIT IV  BRANCHING PROCESSES  12
Generating functions of branching processes - Probability of extinction - Distribution of the total number of progeny - Generalization of classical Galton - Watson process - Continuous time Markov branching process - Age dependent branching process.

UNIT V  MARKOV PROCESSES WITH CONTINUOUS STATE SPACE  12

TOTAL : 60 PERIODS

OUTCOME

- The students would understand and characterize phenomena which evolve with respect to time in a probabilistic manner and also study advanced topics for future research involving stochastic modeling.

TEXTBOOK


REFERENCES

OBJECTIVE
- To introduce theory and advanced techniques in Univalent functions (advanced Complex Analysis)

UNIT I ELEMENTARY THEORY OF UNIVALENT FUNCTIONS
The Area theorem-Growth and Distortion Theorems-Coefficient Estimates-Convex and Starlike functions-Close to Convex functions-Spirallike functions-Typically Real functions.

UNIT II VARIATIONAL METHODS

UNIT III SUBORDINATION
Basic Principles-Coefficient Inequalities-Sharpened Forms of the Schwartz Lemma – Majorization-Univalent Subordinate Functions.

UNIT IV GENERAL EXTREMAL PROBLEMS
Functionals of Linear Spaces-Representation of Linear Functionals-Extreme Points and Support Points- Properties of extremal Functions - Extreme Points.

UNIT V INTEGRAL TRANSFORMS
Linear Operators – Nonlinear operators – Conclusion operators - Alexander Transforms – Libera Transforms – Bernardi Transforms.

TOTAL: 60 PERIODS

OUTCOME
- Students will gain in-depth knowledge in Univalent functions theory to pursue research.

TEXTBOOK

REFERENCES