ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. Phil. MATHEMATICS

REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM

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.

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CURRICULA AND SYLLABI

SEMESTER - I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MX7101	Algebra and Analysis	PC	4	4	0	0	4
2.	MX7102	Nonlinear Dynamics	PC	4	4	0	0	4
3.		Elective I	PE	4	4	0	0	4
			TOTAL	**12**	**12**	**0**	**0**	**12**

SEMESTER - II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Elective II	PE	4	4	0	0	4
2.	MX7211	Project	EEC	32	0	0	32	16
			TOTAL	**36**	**4**	**0**	**32**	**20**

Total number of Credits: 32

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MX	Algebra and Analysis	PC	4	4	0	0	4
2.	MX	Nonlinear Dynamics	PC	4	4	0	0	4

PROFESSIONAL ELECTIVES (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MX7001	Abstract Harmonic Analysis	PE	4	4	0	0	4
2.	MX7002	Advanced Analysis	PE	4	4	0	0	4
3.	MX7003	Advanced Number Theory and Cryptography	PE	4	4	0	0	4
4.	MX7004	Advances in Graph Theory	PE	4	4	0	0	4
5.	MX7005	Algebraic Theory of Semigroups	PE	4	4	0	0	4
6.	MX7006	Applied Combinatorics	PE	4	4	0	0	4
7.	MX7007	Approximation Theory	PE	4	4	0	0	4
8.	MX7008	Basic Hypergeometric Series	PE	4	4	0	0	4
9.	MX7009	Boundary Layer Flows	PE	4	4	0	0	4
10.	MX7010	Differential Topology	PE	4	4	0	0	4
11.	MX7011	Finite Element Method	PE	4	4	0	0	4
12.	MX7012	Finite Volume Method	PE	4	4	0	0	4
13.	MX7013	Fixed Point Theory and its Applications	PE	4	4	0	0	4
14.	MX7014	Fluid Mechanics	PE	4	4	0	0	4
15.	MX7015	Fractional Differential Equations	PE	4	4	0	0	4
16.	MX7016	Functional Analysis and its Applications to PDE	PE	4	4	0	0	4
17.	MX7017	Fundamentals of Chemical Graph Theory	PE	4	4	0	0	4
18.	MX7018	Fuzzy Sets and Systems	PE	4	4	0	0	4
19.	MX7019	Generalized Inverses	PE	4	4	0	0	4
20.	MX7020	Harmonic Analysis	PE	4	4	0	0	4
21.	MX7021	Heat and Mass Transfer	PE	4	4	0	0	4
22.	MX7022	Mathematical Aspects of Finite Element Method	PE	4	4	0	0	4
23.	MX7023	Mathematical Finance	PE	4	4	0	0	4
24.	MX7024	Mathematical Statistics	PE	4	4	0	0	4

25.	MX7025	Measure Theory	PE	4	4	0	0	4
26.	MX7026	Modelling and Simulation	PE	4	4	0	0	4
27.	MX7027	Molecular Computing	PE	4	4	0	0	4
28.	MX7028	Networks, Games and Decisions	PE	4	4	0	0	4
29.	MX7029	Number theory	PE	4	4	0	0	4
30.	MX7030	Number theory and Cryptography	PE	4	4	0	0	4
31.	MX7031	Numerical Solution of Partial Differential Equations	PE	4	4	0	0	4
32.	MX7032	Operator Theory	PE	4	4	0	0	4
33.	MX7033	Optimization Techniques	PE	4	4	0	0	4
34.	MX7034	Queueing and Reliability Modeling	PE	4	4	0	0	4
35.	MX7035	Representation Theory of Finite Groups	PE	4	4	0	0	4
36.	MX7036	Special Functions	PE	4	4	0	0	4
37.	MX7037	Stochastic Processes	PE	4	4	0	0	4
38.	MX7038	Univalent Functions	PE	4	4	0	0	4

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MX	Project	EEC	32	0	0	32	16

MX7101 **ALGEBRA AND ANALYSIS** **L T P C**
4 0 0 4

OBJECTIVE

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

UNIT I MODULES 12

Basic Definitions – Quotient Modules – Module Homomorphisms – Generation of Modules – Direct Sums – Free Modules.

UNIT II STRUCTURE OF MODULES 12

Change of scalars - Simple Modules - Semi-simple Modules - Structure of Semi-simple Modules - Chain conditions – The Radical.

UNIT III ABSTRACT INTEGRATION 12

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 12

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 12

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

1. Pierce R.S., "Associative Algebras, Graduate Texts in Mathematics", Springer Verlag, NewYork, 1982.
2. Rudin W., "Real and Complex Analysis", Tata Mc-Graw Hill, Third Edition, 2006.

REFERENCES

1. Serge Lang, "Algebra", Addisson Wesley, Third Edition, 2005.
2. Paul R. Halmos, "Measure Theory", Springer 1974.
3. Royden, H.L., "Real Analysis", The Macmillan Company, New York, Third Edition, 1988.
4. Elras, M. Stein and Ramishakarchi, "Complex Analysis", Princeton University Press, 2003.

MX7102 **NONLINEAR DYNAMICS** **L T P C**
4 0 0 4

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 DIFFERETIAL 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

Ordinary differential equations in the complex domain – Integrable systems of ordinary differential equations – Painleve property of partial differential equations**.**

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

1. Tabor M., “Chaos and Integrability in Nonlinear Dynamics”, John Wiley and Sons, New York, 1989.

REFERENCES

1. Lakshmanan M. and Rajasekar S., “Nonlinear Dynamics”, Springer-Verlag, New York, First Edition, 2002.
2. Strogatz S.H., “Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering (Studies in Nonlinearity), Westview Press, USA, First Edition, 2001.

MX7001	**ABSTRACT HARMONIC ANALYSIS**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

OBJECTIVE

- To give a comprehensive overview of harmonic analysis and its applications to all areas of mathematical sciences.

UNIT I TOPOLOGICAL GROUPS 12

Definition of a topological group and its basic properties. Subgroups and quotient groups. Product groups and projective limits. Properties of topological groups involving connectedness. Invariant pseudo-metrics and separation axioms.

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

1. Edwin Hewitt and Kenneth A. Ross, Abstract Harmonic Analysis-I, Springer-Verlag, Berlin, 1993.

REFERENCE

1. Lynn H. Loomis, An introduction to abstract harmonic analysis, D. Van Nostrand Co. Princeton.

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

Convex functions-Jenson's inequality-L^p spaces-Schwartz, Minkowski inequality-approximation by continuous functions.

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 Lebsegue points-Metric density-fundamental theorem of calculus-Differentiable transformations.

UNIT IV FOURIER TRANSFORMS 12

Formal Properties-Inversion Theorem-Uniqueness theorem-Plancheral Theorem-Translation invariant subspaces-Banach Algebra L^1-Complex Homomorphisms.

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

1. Rudin, W.," Real and Complex Analysis", Third Edition, McGraw-Hill International Edition, 1987.

REFERENCE

1. Avner Friedman, "Foundations of Modern Analysis, Hold Rinehart Winston,1970.

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 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

RSA Cryptosystem – Rabin Cryptosystem – Elgamal Cryptosystem – Elliptic Curve Cryptosystem.

TOTAL : 60 PERIODS

OUTCOME

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

TEXTBOOKS

1. Ivan Niven, Herbert S.Zuckermann, Hugh L. Montgomery, "An Introduction to The Theory of Numbers", John Wiley, Fifth Edition, 2006.
2. Behrouz A. Forouzan, "Cryptography & Network Security", Tata McGraw Hill, Special Indian Edition, 2007.

REFERENCES

1. Tom M. Apostol, "Introduction to analytic number theory", Narosa Publishing House, 1980.
2. Rose H.E., "A Course in Number Theory", Clarendon Press, Second Edition, 1995.
3. Kenneth Ireland & Michael Rosen, "A Classical Introduction to Modern Number Theory", Springer International Edition, Second Edition, 2010.
4. Koblitz, N., A course in number theory and Cryptography, Springer Verlag, 1994.
5. Stinson D.R., "Cryptography: Theory and Practice", CRC Press, Third Edition, 2002.

MX7004	**ADVANCES IN GRAPH THEORY**	**L T P C**
		4 0 0 4

OBJECTIVE

- To introduce advanced topics in Graph Theory.

UNIT I CONNECTIVITY IN GRAPHS **12**

Vertex connectivity – Edge connectivity – Blocks – k-connected and k-edge connected graphs – Network flow problems.

UNIT II COLORING OF GRAPHS **12**

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 **12**

Embeddings and Euler's formula – Dual graphs – Kuratowski's theorem – 5 colour theorem – Crossing number – Surface of higher genus.

UNIT IV RAMSEY THEORY **12**

The pigeonhole principle – Ramsey's theorem – Ramsey numbers – Graph Ramsey theory .

UNIT V EIGENVALUES OF GRAPHS **12**

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

1. Douglas B. West, "Introduction to Graph Theory", Prentice Hall of India, Second Edition, 2002.

REFERENCES

1. Murthy U. S. R. and Bondy J. A., "Graph Theory", Springer, 2008.
2. Balakrishnan R. and Ranganathan K., " A textbook of Graph Theory", Springer, 2012.
3. Graham R.L., Rothschild B.L and Spencer J.H., "Ramsey Theory", Wiley Publishers, Second Edition, 1990.
4. Biggs N., "Algebraic Graph Theory", Cambridge Tracts in Mathematics 67, Cambridge University Press, 1994**.**

MX7005 ALGEBRAIC THEORY OF SEMIGROUPS **L T P C**
4 0 0 4

OBJECTIVE

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

UNIT I SEMIGROUPS 12

Monogenic semigroups – Ordered sets, semilattices and lattices Binary relations, equivalences – Congruences – Free semigroups – Ideals and Rees congruences. The equivalence L,R,H,J and D – The structure of D classes – Regular D-classes – Regular semigroups.

UNIT II SIMPLE SEMIGROUPS 12

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

UNIT III BANDS 12

Union of groups – semilattice of groups – bands – free bands – varieties of bands.

UNIT IV INVERSE SEMIGROUPS AND SIMPLE INVERSE SEMIGROUPS 12

Inverse semigroups – Natural order relation on an inverse semi group – Congruence in Inverse semigroup – Bisimple inverse semigroups – Simple inverse semigroups.

UNIT V SEMI LATTICES 12

Fundamental inverse semigroups – autouniform semi lattices.

TOTAL : 60 PERIODS

OUTCOME

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

TEXT BOOK

1. Howie, J.M., "An Introduction to Semigroup Theory", Academic Press, 1976.

REFERENCES

1. John. M. Howie, "London Mathematical Society Monographs New Series, Fundamentals of Semigroup Theory", Oxford Science Publications, 1996.
2. Gerhard O. Michler, "Theory of Finite Simple Groups", Cambridge University Press, Cambridge, 2006.

MX7006 APPLIED COMBINATORICS **L T P C**

4 0 0 4

OBJECTIVE

- To introduce advanced database in combinatorial mathematics.

UNIT I TOOLS OF COMBINATORICS 12

Generating permutations and combinations – Exponential generating function and generating function for permutations – Recurrence relation – Solving recurrence relation using generating function – Principle of inclusion and exclusion and its applications.

UNIT II POLYA THEORY OF COUNTING 12

Burnside's Lemma – Distinct colorings – Cycle index – Polya's theorem.

UNIT III COMBINATORIAL DESIGNS 12

Balanced incomplete block designs – Necessary condition for existence of $(b, \neg, r, k,$ ª $)$ designs. Resolvable designs – Steiner triple systems – Symmetric balanced incomplete block designs – Projective plans, Latin squares and $(\neg, k,$ ª $)$ designs.

UNIT IV CODING THEORY 12

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

UNIT V COMBINATORIAL OPTIMIZATION 12

Matching – Bipartite matching – System of distinct representatives – Algorithm for finding maximum matching – Networks – Maximum flow problem – The max flow algorithm – Complexity of max flow algorithm.

TOTAL PERIODS : 60

OUTCOME

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

TEXTBOOK

1. Fred S. Roberts and Barry Tesman, "Applied Combinatorics", CRC Press, Second Edition, 2009.

REFERENCES

1. Peter J. Cameron," Combinatorics: Topics, Techniques, Algorithms", Cambridge University Press, First Edition, 1995.
2. Alan Tucker, "Applied Combinatorics", Wiley, Sixth Edition, 2012.
3. Richard A. Brualdi, "Introductory Combinatorics", Pearson Education, Fifth Edition, 2011.
4. Daniel I. A. Cohen ,"Basic Techniques of Combinatorial Theory", John Wiley & Sons, 1979.

MX7007 APPROXIMATION THEORY **L T P C**

4 0 0 4

OBJECTIVE

- To introduce the basic concepts of approximation theory and its applications.

UNIT I APPROXIMATION IN NORMED LINEAR SPACES 12

Existence - Uniqueness - convexity - Characterization of best uniform approximations - Uniqueness results - Haar subspaces - Approximation of real valued functions on an interval.

UNIT II CHEBYSHEV POLYNOMIALS 12

Properties - More on external properties of Chebyshev polynomials - Strong uniqueness and continuity of metric projection - Discretization - Discrete best approximation.

UNIT III INTERPOLATION 12

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 12

Introduction - Approximative properties of sets - Characterization and Duality.

UNIT V PROJECTION 12

Continuity of metric projections - Convexity, Solarity and Cheyshevity 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

1. Hrushikesh N. Mhaskar and Devidas V. Pai., "Fundamentals of approximation theory", Narosa Publishing House, New Delhi, 2000.

REFERENCES

1. Ward Cheney and Will light, "A course in approximation theory", Brooks / Cole Publishing Company, New York, 2000.
2. Cheney E.W.," Introduction to approximation theory", Tata McGraw Hill Pvt. Ltd., New York, 1966.
3. Singer I.,"Best Approximation in Normed Linear Spaces by element of linear subspaces", Springer-Verlag, Berlin,1970.

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 12

Basic Hypergeometric Series – Heine's Transformation Formula – Heine's q-Analogue of Gauss' Summation Formula – q-Analogue of Saalschiitz's Summation Formula – The Bailey-Daum Summation Formula – Generalized q-Hypergeometric Functions – well-poised, nearly-poised and very-well-poised Basic Hypergeometric Series.

UNIT III SUMMATION AND TRANSFORMATION FORMULAS 12

A Summation Formula of terminating very-well-poised Series – Watson's Transformation Formula for Terminating very-well-poised Series – Bailey Transformation Formula for Terminating Series – Two-term transformation Formula.

UNIT IV BILATERAL BASIC HYPERGEOMETRIC SERIES 12

Bilateral Basic Hypergeometric Series – Ramanujan's sum – Bailey's sum of a very-well-poised Series – Transformation Formula for an generalized bilateral series – A General Transformation Formula for a very-well-poised Series – Transformation Formulas for very-well-poised Series.

UNIT V THETA AND ELLIPTIC FUNCTIONS 12

Theta Functions – Elementary Properties – Zeros – Relation among Squares of Theta Functions – Pseudo Addition Theorem – Infinite Products – Elliptic Functions – Differential Equations – The Function $sn(u)$, $cn(u)$, $dn(u)$ – Addition Theorem.

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

1. Gasper.G. and Rahman M., "Basic Hypergeometric Series, Encyclopedia of Mathematics and its Applications", Cambridge University Press, New York, 1990.
2. Rainville E.D., "Special Functions", Macmillan, New York, 1960.

REFERENCES

1. Exton H., "Multiple Hypergeometric Functions and Applications", Halsted Press (Ellis Horwood Limited, Chichester), John Wiley and Sons, New York, London, Sydney and Toronto, 1976.
2. Whittaker E. T., Watson G. N., "A Course of Modern Analysis", Cambridge University Press, Cambridge, London and New York, Reprint 1996.

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 12

Equations of motion and continuity – Stress system – relation between stress and strain - Stoke's hypothesis – Navire-Stoke's equations – Derivation – Interpretation – Limiting case.

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

Introduction – Turbulent flow – Mean motion and fluctuations – Apparent stresses – Derivation of the stress tensor – Fundamental equations of turbulent flows – Prandtl's mixing theory – Turbulent shearing stress.

TOTAL : 60 PERIODS

OUTCOME

- To familiarize the student with laminar transitional, boundary layers and free sheer flows.

TEXTBOOK

1. Schlichting H., "Boundary layer theory", Tata Mc Graw Hill, Seventh Edition,1979.

REFERENCES

1. Batchelor G.K., "An Introduction to fluid dynamics", Cambridge University Press, Second Edition, 2000.
2. Yuan S.W., "Foundations of fluid mechanics", Prentice-Hall, 1988.

MX7010	**DIFFERENTIAL TOPOLOGY**	**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

Lefschetz Fixed point theory – Borsuk Ulam theorem – vector fields-isotopy-Hopf degree theorem.

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

1. Guillemin V. and Pollack A., "Differential Topology" , Prentice-Hall, 1974.
2. Morris W. Hirsch, "Differential topology", Springer-Verlag, 1976.

REFERENCES

1. Milnor J., "Topology from the differentiable viewpoint, Princeton Landmarks in Mathematics", Princeton University Press, 1997.
2. Shastri A.R., "Elements of Differential Topology", CRC Press, 2011.

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

1. Reddy J.N., “An Introduction to the Finite Element Method”, Tata Mc-Graw Hill, New Delhi, Third Edition, 2005.

REFERENCES

1. Buchanen G.R. and Rudhramoorthy R., “Finite Element Analysis”, Schaum’s Outline Series, Tata McGraw Hill, New Delhi, 2006.
2. Huttan D.V., “Fundamentals of Finite Element Analysis”, Tata McGraw Hill, New Delhi, 2005.

MX7012 FINITE VOLUME METHOD L T P C
4 0 0 4

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

Governing equation of fluid flow: Mass - Momentum and Energy equations - Equation of state; Navier-Stokes equations for a Newtonian fluid - Conservative form of equations of fluid flow - Differential and integral forms of the transport equation - Classification of PDE’s and fluid flow equations - Viscous fluid flow equations - Transonic and supersonic compressible flows.

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

FVM for Diffusion Problems: one-dimensional steady sate diffusion - Two-dimensional diffusion and three-dimensional diffusion problems; FVM for Convection-Diffusion problems: one-dimensional steady state convection- diffusion - central differencing schemes for one - Dimensional convection-diffusion - Upwind differencing scheme - Hybrid differencing scheme - Higher-order differencing scheme for convection - Diffusion problems - TVD schemes.

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 12

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.

TOTAL : 60 PERIODS

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

1. Versteeg H.K. and Malalasekera W. “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education, New Delhi, Second Edition, 2008.

REFERENCES

1. Ferziger J.H and Peric. M, “Computational methods for Fluid Dynamics”, Springer (India), New Delhi, Third Edition, 2005.
2. Chung T.J., “Computational Fluid Dynamics”, Cambridge University Press, 2002.
3. Suhas V. Patankar, “ Numerical Heat Transfer and Fluid Flow”, Taylor & Francis, 2007.

MX7013	FIXED POINT THEORY AND ITS APPLICATIONS	L T P C
		4 0 0 4

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 12

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 12

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 12

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 12

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 12

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

1. Zeidler E., "Nonlinear Functional Analysis and its applications", Vol. 1, Springer-Verlag, New York ,1989.

REFERENCES

1. Mohamed A. Khamsi & William A. Kirk, "An Introduction to Metric Spaces and Fixed Point Theory", John Wiley & Sons, New York, 2001.
2. Deimling K., "Nonlinear Functional Analysis", Springer-Verlag, New York, 1985.
3. Smart D.R., "Fixed Point Theory", Cambridge University Press, 1980.
4. Istratescu V.L., "Fixed Point Theory: An Introduction", D. Reidel Publishing Company, Boston, 1979.
5. Mohan C. Joshi, Ramendra K. Bose," Some Topics in Nonlinear Functional Analysis", John Wiley & Sons Australia, Limited, 1985.

MX7014 FLUID MECHANICS L T P C
4 0 0 4

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 12

Real and Ideal fluids – Velocity - Acceleration – Streamlines – Pathlines – Steady & unsteady flows – Velocity potential – Vorticity vector – Local and particle rates of change – Equation of continuity – Conditions at a rigid boundary.

UNIT II EQUATIONS OF MOTION OF A FLUID 12

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 12

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 VISCOUS FLOWS 12

Stress – Rate of strain – Stress analysis – Relation between stress and rate of strain – Coefficient of viscosity – Laminar flow – Navier-Stokes equations of motion – Some problems in viscous flow.

TOTAL : 60 PERIODS

OUTCOME

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

TEXTBOOK

1. Frank Chorlton, "Textbook of Fluid Dynamics", CBS Publishers, New Delhi, 1985.(Sections: 2.1 - 2.10, 3.1 – 3.9, 5.1 – 5.12, 8.1 – 8.10, 8.15)

REFERENCES

1. Batchelor G.K., "An Introduction to Fluid Dynamics", Cambridge University Press, 1993.
2. White F.M., "Fluid Mechanics", McGraw-Hill, 2000.
3. Milne Thomson L.M., "Theoretical Hydrodynamics", Macmillan, 1967.
4. White F.M., "Viscous Fluid Flow", McGraw-Hill, 1991.

MX7015 FRACTIONAL DIFFERENTIAL EQUATIONS

L	T	P	C
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

Gamma Function - Mittag-Leffler Function – Wright Function.

UNIT II FRACTIONAL DERIVATIVESAND INTEGRALS 12

Grunwald-Letnikov Derivatives – Riemann- Liouville Fractional Derivatives – Caputo's Fractional Derivatives – Properties of Fractional Derivatives – Laplace Transform of Grunwald-Letnikov, Riemann-Liouville and Caputo's Derivatives.

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 **12**

The Mellin Transform Method – Power Series Method – Babenko's Symbolic Calculus Method – Method of Orthogonal Polynomials. Numerical Evaluation of Fractional Derivatives.

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.
- Generilaze, Empasize 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

1. Podlubny, I., "Fractional Differential Equations", New York, Academic Press, 1998 (Unit -1, 2 pp. 1-80 and 103-108, Unit – 3 pp.121-133, Unit- 4, 5 pp.149-189 and 199-209).
2. Kelin Oldham and J. Spanier, "The fractional Calculus", New York: Academic Press, 1974.

REFERENCES

1. Miller, K.S., and B. Ross, "An Introduction to the Fractional Calculus and Fractional differential equations", John Wiley and Sons, New York, 1993.
2. Kilbass, A.A.., H.M. Srivastava and J.J. Trujillo, "Theory and applications of Fractional differential equations", North-Holland mathematics Studies, 204, Elsevier Science B.V., Amsterdam, 2006.

MX7016	FUNCTIONAL ANALYSIS AND ITS APPLICATIONS TO PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		4	0	0	4

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 **12**

Distributions, operations with distributions, support and singular support, convolutions, fundamental solutions, Fourier transform, tempered distributions.

UNIT II SOBOLEV SPACES **12**

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 **12**

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 12

Galerkin method, maximum principles, eigenvalue problems, introduction to the mathematical theory of the finite element method.

UNIT V EVOLUTION EQUATIONS 12

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

1. Kesavan, S., "Topics in Functional Analysis and Applications", New Age International Ltd., New Delhi, 1989, (Reprint 2008).

REFERENCES

1. Evans L. C., "Partial Differential Equations, Graduate Studies in Mathematics" 19, AMS, University Press, Hyderabad, 2009.
2. McOwen R.C., "Partial differential Equations", Pearson Education, New Delhi, 2003.

MX7017 FUNDAMENTALS OF CHEMICAL GRAPH THEORY

L T P C
4 0 0 4

OBJECTIVE

- To study the connection between Chemistry and Graph Theory.

UNIT I THE ORIGINS OF CHEMICAL GRAPH THEORY 12

The first use of Chemical Graphs – The emergence of Structure Theory – The concept of valence – The growth of Chemical Graph Theory – The introduction to Topological Indices – Elementary Bonding Theory.

UNIT II ELEMENTS OF GRAPH THEORY FOR CHEMIST 12

Some Graph Theoretical Terms – Connectedness of Graphs – Planarity of Graphs – Operations on Graphs – Matrix Representation of graphs – Distances in Graphs and Digraphs – Metric and Topological Spaces for simple graphs – Graphs in Quantum Chemistry.

UNIT III POLYNOMIALS IN GRAPH THEORY 12

On Chemical Applications of Graphic Polynomials – Polynomials – The Characteristic Polynomial – Matching Polynomial – More graphic polynomials.

UNIT IV ENUMERSATIONS OF ISOMERS 12

Introduction – Definitions and Mathematical background – Polya's theorem – Generalized polya theorem – Valence isomers – Polyhexes – Isomers and computer programme for their generations – Isomerism and Reaction Graphs.

UNIT V GRAPH THEORY AND MOLECULAR ORBITALS 12

Introduction – Elements of Graph Spectral Theory – Huckel Theory – Isomorphism of Huckel Theory and Graph Spectral Theory – Topological Resonance Theory.

TOTAL : 60 PERIODS

OUTCOME

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

TEXTBOOK

1. Bonchev D. and Rouvray D.H, "Chemical Graph Theory: Introduction and Fundamentals", Abacus Press / Gordon & Breach Science Publishers, New York, 1991.

REFERENCES

1. Trinajstic N., "Chemical Graph Theory", CRC Press, Florida, Volume I and II, 2000.
2. Douglas B. West, "Introduction to Graph Theory", Prentice Hall of India, 2002.

MX7018	**FUZZY SETS AND SYSTEMS**	**L T P C**
		4 0 0 4

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 12

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 12

General Discussion - Fuzzy Controllers: An Overview - Fuzzy Controllers: An Example - Fuzzy Systems and Neural Networks - Fuzzy Automata - Fuzzy Dynamic Systems. PATTERN RECOGNITION**:** Introduction - Fuzzy Clustering- Fuzzy Pattern Recognition - Fuzzy Image Processing. APPLICATIONS: General Discussion - Natural, Life, and Social Sciences – Engineering – Medicine - Management and Decision Making - Computer Science - Systems Science - Other Applications.

UNIT III INTUITIONISTIC FUZZY SETS 12

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 12

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 12

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.

TOTAL : 60 PERIODS

OUTCOME

After the completion of the course students can able to,

- Apply the fuzzy set concepts to all the areas of Mathematics.

TEXTBOOKS

1. George J. Klir and Bo Yuan, “Fuzzy sets and fuzzy logic: Theory and Applications”, Prentice Hall of India Private Limited, New Delhi, 2008. (UNIT I and UNIT II)
2. Krassimir T Atanassov, “Intuitionistic Fuzzy Sets: Theory and Applications” ,Physica - Verlag, Heidelberg, 1999.(UNIT III, UNIT IV and UNIT V)

REFERENCES

1. Zimmermann, H.J., “Fuzzy Set Theory—and Its Applications”, Kluwer Academic Publishers, Boston, 2001.
2. Kaufmann,A.,” Introduction to the Theory of Fuzzy Subsets”, Vol. 1: Fundamental Theoretical Elements, Academic Press, New York, 1975.

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

The penrose equations – Existence and construction of generalized inverses – Properties - Full rank factorizations – Explicit formula for Moore – Penrose inverse of a matrix.

UNIT II LINEAR SYSTEMS AND CHARACTERIZATION OF GENERALIZED INVERSES 12

Solution of linear systems – Characterization of classes of generalized inverses - Generalized inverses and orthogonal projectors – Application of Generalized inverses in Interval Linear Programming.

UNIT III MINIMAL PROPERTIES OF GENERALIZED INVERSES 12

Least - squares solutions of inconsistent linear systems – Solutions of minimum norm –Extremal property of the Bott-Duffin inverse with application to electrical Network.

UNIT IV SPECTRAL GENERALIZED INVERSES 12

Introduction – The group inverse – Spectral properties of the group inverse – The Drazin inverse – Spectral properties of the Drazin - Inverse – Other spectral generalized inverses.

UNIT V GENERALIZED INVERSES OF PARTITIONED MATRICES 12

Introduction – Partitioned matrices and linear equations – Generalized inverses of partitioned matrices and bordered matrices.

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

1. Ben-Israel A., and Greville T.N.E., "Generalized Inverses: Theory and Applications", Springer – Verlag, New York, Second Edition, 2003.

REFERENCES

1. Nashed M.Z., "Generalized Inverses and Applications", Academic Press, 1976.
2. Rao C.R. and Mitra S. K., "Generalized inverses of Matrices and its Applications", John Wiley, New York, 1971.

MX7020	HARMONIC ANALYSIS	L T P C
		4 0 0 4

OBJECTIVE

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

UNIT I FOURIER SERIES 12

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 12

The classical kernels. Fejer's Poisson's and Dirichlet's summability in norm and point wise summability. Fatou's theorem. The inequalities of Hausdorff and Young. Examples of conjugate function series. The Fourier transform. Kernels on R. The Plancherel theorem on R. Plancherel measure on R, T, Z. Maximal ideal space of L^1(R), L^1(T), L^1(Z).

UNIT III HARDY SPACES 12

Hardy spaces on the unit circle, Invariant subspaces. Factoring. Proof of the F. and M. Riesz theorem. Theorems of Beurings and Szego in multiplication operator form. Structure of inner and outer functions. The inequalities of Hardy and Hilbert.

UNIT IV MAXIMAL FUNCTIONS 12

Conjugate functions. Theorems of Kolmogorov & Zygmund and M. Rieze & Zygmund on conjugate functions. The conjugate function as a singular integral. Statement of the Burkholder-Gundy Silverstein Theorem on T. Maximal functions of Hardy and Littlewood ranslation.

UNIT V WIENER TAUBERIAN THEOREM 12

The Theorems of Wiener and Beurling. The Titchmarsh Convolution Theorem. Wiener's Tauberian theorem. Spectral sets of bounded functions.

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

1. Henry Helson, "Harmonic Analysis", Addison-Wesley, 1983.

REFERENCES

1. Hewitt E. and Ross K.A., "Abstract Harmonic Analysis", Springer-Verlag, Vol. 1, Fourth Edition, 1993.
2. Yitzhak Katznelson., "An introduction to Harmonic Analysis", Cambridge University Press, 2004.
3. Paul Koosis, "Introduction of H_p spaces", Cambridge University Press, Second Edition, 1999.

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MX7021	HEAT AND MASS TRANSFER	L T P C
		4 0 0 4

OBJECTIVE

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

UNIT I HEAT CONDUCTION 12

Concept of Heat conduction – Fundamental law of heat conduction - Steady state heat conduction – Unsteady heat conduction – Numerical solutions of heat conduction equations.

UNIT II FLOW ALONG SURFACES AND IN CHANNELS 12

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 12

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 plane walls – mixed free and forced convection.

UNIT IV FORCED CONVECTION IN LAMINAR FLOW 12

Heat flow equation – energy equation – plane plate in longitudinal flow – arbitrarily varying wall temperature – exact solutions of energy equation.

UNIT V MASS TRANSFER 12

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

1. Eckert E.R.G., and Drake R.M., “Heat and mass transfer”, Tata McGraw Hill Publishing Co., Second Edition, 1979.

REFERENCES:

1. ebhart B., “Heat transfer “, McGraw Hill Publishing Co., New York , Second Edition, 1971.
2. Schlichting H., “Boundary Layer Theory”, McGraw Hill Publishing Co., Second Edition, 1979.
3. Cengel Y.A., “Heat Transfer”, Mc Graw Hill, Second Edition, 2003.

MX7022 MATHEMATICAL ASPECTS OF FINITE ELEMENT METHOD **L T P C**
4 0 0 4

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 12

Weak formulation of Boundary Value Problems - Ritz-Galerkin approximation - Error Estimates - Piecewise polynomial spaces - Finite Element Method - Relationship to Difference Methods - Local Estimates.

UNIT II SOBOLEV SPACES 12

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 12

Review of Hilbert spaces - Projections onto subspaces and Riesz representation theorem - Symmetric and non-symmetric variational formulation of elliptic and parabolic boundary value problems - Lax-Milgram Theorem - Error estimates for General Finite Approximation.

UNIT IV CONSTRUCTION OF FINITE ELEMENT SPACE AND APPROXIMATION THEORY IN SOBOLEV SPACES 12

The Finite Element - Triangular finite elements - Lagrange element - Hermite element, Rectangular elements - Interpolant - Averaged Taylor polynomials - Error representation - Bounds for the Interpolation error - Inverse estimates.

UNIT V HIGHER DIMENSIONAL VARIATIONAL PROBLEMS 12

Higher-dimensional examples - Variational formulation and approximation of Poisson’s and Neumann equations - Coercivity of the variational problem - Elliptic regularity estimates - Variational approximations of general Elliptic and Parabolic 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

1. Brenner S. and Scott R., "The Mathematical Theory of Finite Element Methods", Springer-Verlag, New York, 1994.
2. Claes Johnson, "Numerical Solutions of Partial Differential Equations by the Finite Element Method", Cambridge University Press, Cambridge, 1987.

REFERENCES

1. Ciarlet P.G., "The Finite Element Methods for Elliptic Problems", North Holland, Amsterdam, 1978.
2. Thomee V., "Galerkin Finite Element Methods for Parabolic Problems", Lecture Notes in Mathematics, Vol.1054, Springer-Verlag, Berlin, 1984.

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

Probability and Events - Conditional probability - Random Variables and Expected values - Covariance and Correlation - Normal Random Variables - Properties of Normal Random Variables - Central Limit theorem - Geometric Brownian Motion as a limit of simpler models - Brownian motion.

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

The Arbitrage theorem - Multiperiod binomial model - Black-Scholes formula - Properties of Black - Scholes option cost - Delta Hedging Arbitrage Strategy - Pricing American put options.

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

Barrier options - Asian and look back options - Monte Carlo Simulation - Pricing exotic option by simulation - More efficient simulation estimators - Options with non-linear pay offs - pricing approximations via multi-period binomial models.

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

1. Sheldon M. Ross, "An Elementary Introduction to Mathematical Finance", Cambridge University Press, Third Edition, 2011.

REFERENCES

1. Steven Roman, "Introduction to the Mathematics of finance", Springer International edition, 2004.
2. Williams, R.J., "Introduction to the Mathematics of finance", AMS, Universities Press (India) Pvt. Ltd, 2006.

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, χ^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

1. Freund J.E.," Mathematical Statistics", Prentice Hall of India, Fifth Edition, 2001.
2. Johnson R.A. and Wichern D.W., "Applied Multivariate Statistical Analysis", Pearson Education Asia, Sixth Edition, 2007.

REFERENCES

1. Gupta S.C. and Kapoor V.K.," Fundamentals of Mathematical Statistics", Sultan Chand & Sons, Eleventh Edition, 2003.
2. Devore J.L. "Probability and Statistics for Engineers", Brooks/Cole (Cengage Learning), First India Reprint, 2008.

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 12

Lebesgue Outer Measure- Measurable sets-Regualrity-measurable functions-Borel and Lebesgue measurability-Hausdorff measures

UNIT II ABSTRACT MEASURES SPACES 12

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 12

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

UNIT IV SIGNED MEASURES 12

Hahn-Jordan Decompositions-Radon-Nikodym theorem-applications.

UNIT V MEASURES IN PRODUCT SPACES 12

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

1. G. De Barra, "Measure Theory and Integration", New Age International Publishers, Second Edition, 2013.

REFERENCE

1. Avner Friedman, "Foundations of Modern Analysis", Hold Rinehart Winston, 1970.

MX7026 **MODELING AND SIMULATION** **L T P C**
4 0 0 4

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 **12**

Systems – modeling – general – systems theory – Concept of simulation – Simulation as a decision making tool types of simulation.

UNIT II RANDOM NUMBERS **12**

Pseudo random numbers – methods of generating random variables –discrete and continuous distributions – testing of random numbers.

UNIT III DESIGN OF SIMULATION EXPERIMENTS **12**

Problem formulation – data collection and reduction– time flow mechanism – key variables – logic flow chart –starting condition–run size, experimental design consideration – output analysis and interpretation validation.

UNIT IV SIMULATION LANGUAGES **12**

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

UNIT V CASE STUDY **12**

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

1. Jerry Banks John S. Carson, Barry L. Nelson, and David M.Nicol, "Discrete "Event System Simulation", 3rd Edition, Prentice Hall, India, 2002.
2. Geoffrey Gordon, "System Simulation", second Edition, Prentice Hall, India, 2002.
3. Narsingh Deo, "System Simulation with Digital Computer, "Prentice Hall, India, 2001.
4. Shannon, R.E. Systems simulation, The art and science, Prentice Hall, 1975.
5. Thomas J. Schriber, Simulation using GPSS, John Wiley, 1991.

MX7027 **MOLECULAR COMPUTING** **L T P C**
4 0 0 4

OBJECTIVE

- To introduce molecular computing and its recent applications.

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 Enumerable 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

1. Rozenberg, "DNA Computing", Springer Verlag, 1997.

REFERENCES

1. Adleman L.M., Rothemund PWK, Roweis, S. and Winfree E., "On applying molecular computation to the data Encryption standard", in proceedings of the 2nd DIMACS Workshop on DNA based computers, 1996.

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.

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 frame work of Networks.
- Identifies competitive situations which can be modeled and solved by game theoretic formulations.
- Offers interesting techniques to quantity and effectively obtain the solution of various decision making situations.

TEXT BOOK

1. Taha, H.A. "Operations Research: An Introduction", Pearson Education India, Ninth Edition, 2012.

REFERENCES

1. Hillier F.S., Lieberman G.J., Nag, Basu, "Introduction to Operations Research", Tata Mc-Graw Hill, New Delhi, Ninth Edition, 2011.
2. Winston W.L., "Operations Research", Brooks/Cole Cengage Learning, Fourth Edition, 2003.

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 diaphantine equations and some special cases of Femat's Last theorem.

TEXTBOOK

1. Niven I., Zuckerman H.S., and Montgomery H.L., "An introduction to the theory of numbers", John Wiley & Sons (Asia) Pvt., Ltd., Singapore, Fifth Edition, 2004.

REFERENCES

1. Graham R.L., Knuth D.E. and Patachink O., "Concrete Mathematics", Pearson education Asia, Second Edition, 2002.
2. Bressoud D., Wagon S., "A Course in Computational Number Theory", Key College Publishing, 2000.

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

RSA Cryptosystem – Rabin Cryptosystem – Elgamal Cryptosystem – Elliptic Curve Cryptosystem.

TOTAL : 60 PERIODS

OUTCOME

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

TEXTBOOKS

1. Ivan Niven, Herbert S.Zuckermann, Hugh L. Montgomery, “An Introduction to The Theory of Numbers”, John Wiley, Fifth Edition, 2006.
2. Behrouz A. Forouzan, “Cryptography & Network Security”, Tata McGraw Hill, Special Indian Edition, 2007.

REFERENCES

1. Tom M. Apostol, “Introduction to analytic number theory”, Narosa Publishing House, 1980.
2. Rose H.E., “A Course in Number Theory”, Clarendon Press, Second Edition, 1995.
3. Kenneth Ireland & Michael Rosen, “A Classical Introduction to Modern Number Theory”, Springer International Edition, Second Edition, 2004. 2010
4. Koblitz, N., “A course in number theory and Cryptography”, Springer Verlag ,1988.1994
5. Stinson D.R., “Cryptography: Theory and Practice”, CRC Press, Third Edition, 2002.

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

Iterative methods for solving large linear systems of algebraic equations: Jacobi, Gauss-seidel and S.O.R methods - Conditions for convergence of them - Methods for accelerating convergence: Lyusternite’s & Aitken’s methods - Optimum acceleration parameter for S.O.R method.

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

Vector and matrix norms - Eigenvalues of a common tridiagonal matrix - Gerischgorin’s theorems - Stability by matrix and Fourier-series methods - A.D.I. methods.

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

1. Smith G.D., “Numerical Solution of P.D.E.”, Oxford University Press, New York, 1995.

REFERENCES
1. Mitchel A.R. and Griffiths S.D.F., "The Finite Difference Methods in Partial Differential Equations", John Wiley and sons, New York, 1980.
2. Morton K.W., Mayers, D.F., "Numerical Solutions of Partial Differential Equations", Cambridge University Press, Cambridge, 2002.
3. Iserles A., "A first course in the Numerical Analysis of Differential Equations", Cambridge University press, New Delhi, 2010.

MX7032	OPERATOR THEORY	L T P C
		4 0 0 4

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 12

Hyper-Kernel and Hyper-Range of an operator- Semi-regular operators on Banach spaces- Analytical core of an operator- The Semi-regular spectrum of an operator.

UNIT II GENERALIZED KATO DECOMPOSITION PROPERTY 12

The Generalized Kato decomposition- Semi-Fredholm operators- Quasi-nilpotent of operator- Two-Spectral mapping theorems.

UNIT III SINGLE-VALUED EXTENSION PROPERTY (SVEP) 12

Local spectrum and SVEP- The SVEP at a point- A Local spectral mapping theorem.

UNIT IV SVEP AND FREDHOLM THEORY 12

The Single-valued Extension Property (SVEP): Algebraic spectral subspaces. The SVEP and Fredholm Theory: Ascent, descent and the SVEP- The SVEP for operators of Kato type.

UNIT V SPECTRA OF SOME SPECIAL OPERATORS 12

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
1. Conway, J. B., A Course in Functional Analysis, Second Edition, Springer- Velag, New York, 1990.
2. Lawsen, K. B., M. M. Neumann, An Introduction to Local Spectral Theory, London Mathematical Society, Monographs 20, Clarendon press, Oxford, 2000.

MX7033 **OPTIMIZATION TECHNIQUES** **L T P C**
4 0 0 4

OBJECTIVE

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

UNIT I ADVANCED LINEAR PROGRAMMING AND GOAL PROGRAMMING 12

Dantzig – Wolfe decomposition algorithm – Karmarkar interior – point algorithm – Goal programming algorithms.

UNIT II HEURISTIC PROGRAMMING 12

Greedy Heuristics: Discrete variable heuristic - Continuous variable heuristic – Metaheuristic: Tabu search algorithm - Simulated annealing algorithm - Genetic algorithm.

UNIT III NON-LINEAR PROGRAMMING 12

Unconstrained algorithms: Direct search method - Gradiant method – Constrained algorithms: Separable programming, Chance – constrained programming.

UNIT IV INVENTORY MODELS 12

Static economic – order quantity models: Classical EOQ model – EOQ with price breaks – Dynamic EOQ models: No set up EOQ Model – Set up EOQ model - Continuous review models: Probabilitized EOQ model, Probabilistic EOQ model – Single - period models: No-Setup model, setup model (s-S policy).

UNIT V SIMULATION 12

Nature and need for simulation-Monte-Carlo simulation – Generation of pseudo random numbers by mid-square method, Congruence multiplier method – Test for randomness – Generating random variates for Uniform, Exponential, Erlangian, Poisson, Normal distributions - Applications to simple problems in operations research.

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

1. Hamdy A.Taha, "Operations Research-An Introduction", Pearson Education, New Delhi, Ninth Edition, 2012.
2. Geoffrey Gordon, "System Simulation", Prentice Hall of India Pvt. Ltd., New Delhi, Second Edition, 1978.

REFERENCES

1. Harvey M. Wagner, "Principles of Operations Research with Applications to Managerial Decisions", Prentice-Hall of India Pvt. Ltd., New Delhi, Second Edition, 1975.
2. Rao S.S., "Engineering Optimization: Theory and Practice", Wiley and New Age International, Fourth Edition, 2009.
3. Mokhtar S. Bazara, Hanif D. Sherali and Shetty C.M., "Non-linear Programming-Theory and Algorithms", John Wiley & Sons Inc Singapore, Second Edition, 1993.

MX7034 QUEUEING AND RELIABILITY MODELLING

	L	T	P	C
	4	0	0	4

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.

TOTAL PERIODS : 60

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

1. Gross D. and Harris C.M., "Fundamentals of Queueing Theory", John Wiley and Sons, New York, 1998.
2. Balagurusamy E., "Reliability Engineering", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1984.

REFERENCES

1. Govil A.K., "Reliability Engineering", Tata-McGraw Hill Publishing Company Ltd., New Delhi, 1983.
2. Charless E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill, New Delhi, 2000.
3. Kleinrock. L., "Queueing Systems: Volume 1", John Wiley and Sons, Newyork, 1975.
4. Medhi J, "Stochastic models of Queueing Theory", Academic Press, Elsevier, Amsterdam, 2003.

MX7035 REPRESENTATION THEORY OF FINITE GROUPS L T P C
4 0 0 4

OBJECTIVE

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

UNIT I GROUP REPRESENTATIONS 12

Fundamental concepts – Matrix representations – G-Modules and Group algebra.

UNIT II REDUCIBILITY AND G-HOMOMORPHISMS 12

Redubility – Complete reducibility and Maschke's theorem – G-homomorphisms and Schur's lemma – Commutant and Endomorphism algebras.

UNIT III CHARACTERS AND TENSOR PRODUCTS 12

Group characters – Inner product of characters – decomposition of group algebra – tensor products – restricted and induced representations..

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

1. Bruce E. Sagan., "The symmetric group. Representations, combinatorial algorithms, and symmetric functions", The Wadsworth & Brooks/Cole Mathematics Series. Wadsworth & Brooks/Cole Advanced Books & Software, Pacific Grove, CA, 1991.

REFERENCES

1. William Fulton, "Young tableaux, With applications to representation theory and geometry", London Mathematical Society Student Texts, 35, Cambridge University Press, Cambridge, 1997.
2. C.W. Curtis and I.Reiner., "Representation theory of finite groups and associative algebras", AMS Chelsea Publishing, Providence, RI, 2006.
3. G. James and A. Kerber., "The Representation theory of the symmetric group", Encyclopedia of Mathematics and its Applications, 16. Addison-Wesley Publishing Co., Reading, Mass., 1981.

MX7036 **SPECIAL FUNCTIONS** **L T P C**
4 0 0 4

OBJECTIVE

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

UNIT I SPECIAL FUNCTIONS 12

Beta and Gamma Functions – Euler Reflection Formula – The Hurwitz and Riemann zeta functions – Stirling's Asymptotic Formula – Gauss's Multiplication Formula – Ratio of two gamma functions – Integral Representations for Logarithm of Gamma function - The Bohr-Mollerup Theorem

UNIT II HYPERGEOMETRIC FUNCTIONS 12

Hypergeometric Differential Equations – Gauss Hypergeometric Function – Elementary Properties – Contiguous Relations – Integral Representation – Linear and Quadratic Transformation and Summation Formulae.

UNIT III GENERALIZED HYPERGEOMETRIC FUNCTIONS 12

Generalized Hypergeometric Functions – Elementary Properties – Contiguous Relations – Integral Representation – Transformation and Summation Formulae – Whipple's Transformation.

UNIT IV ORTHOGONAL POLYNOMIALS 12

Zeros – Fundamental Recurrence Formula, Systematic Moment Functions –Representation Theorem – Spectral Points and zeros of Orthogonal Polynomials – Chain Sequence and Orthogonal Polynomials – Some Spectral Analysis – Orthogonal Polynomials whose zeros are dense in intervals – Kreine's Theorem.

UNIT V SPECIFIC ORTHOGONAL POLYNOMIALS 12

Some specific systems of orthogonal polynomials like Hermite – Laguerre – Jacobi, Ultraspherical – q-Polynomials of Al-Salam and Carlitz – Wall Polynomials.

TOTAL : 60 PERIODS

OUTCOME

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

TEXTBOOKS

1. Andrews G.E., Askey,R., Ranjan Roy, "Special Functions, Encyclopedia of Mathematics and its Applications", Cambridge University Press, 1999.
2. Nevai P.G., "Orthogonal Polynomials", Memoirs of AMS, 1981.

REFERENCES

1. Copson.E.T., "Theory of Functions of Complex Variables", Oxford University Press, London, 1935.
2. Rainville E.D., "Special Functions", Macmillan, New York, 1960.
3. Chihara T.S., "An Introduction to Orthogonal Polynomials", Gordon and Breach, 1978.
4. Szego G., "Orthogonal Polynomials", Memoirs of AMS, 1939.

MX7037 **STOCHASTIC PROCESSES** **L T P C**
4 0 0 4

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

Specification of Stochastic Processes - Stationary Processes - Poisson Process - Generalizations - Birth and Death Processes - Martingales - Erlang Process.

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

Brownian motion - Wiener process - Diffusion and Kolmogorov equations - First passage time distribution for Wiener process - Ornstein - Uhlenbeck process.

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

1. Medhi J., "Stochastic Processes", New Age International (P) Ltd., New Delhi, Third Edition, 2009.

REFERENCES

1. Narayan Bhat U. and Gregory K. Miller, "Elements of Applied Stochastic Processes", Wiley – Inter science, Third Edition, 2002.
2. Karlin S. and Taylor H.M., "A First Course in Stochastic Processes", Academic press, New York, Second Edition, 1975.
3. Cox D.R. and Miller H.D., "The theory of Stochastic Process", Methuen, London,1965.
4. Ross S. M. ,"Stochastic Processes", Wiley, New York, Second Edition,1996.

MX7038 **UNIVALENT FUNCTIONS** **L T P C**
4 0 0 4

OBJECTIVE

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

UNIT I ELEMENTARY THEORY OF UNIVALENT FUNCTIONS 12

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 12

A Primitive Variational Method-Growth of Integral Means-Odd Univalent functions-Asymptotic Bieberbach Conjecture.

UNIT III SUBORDINATION 12

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

UNIT IV GENERAL EXTREMAL PROBLEMS 12

Functionals of Linear Spaces-Representation of Linear Functionals-Extreme Points and Support Points- Properties of extremal Functions - Extreme Points.

UNIT V INTEGRAL TRANSFORMS 12

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

1. Goodman, A.W., “Univalent Functions”, Volumes I and II, Polygonal Publishing House, 1983.

REFERENCES

1. Peter L. Duren., “Univalent Functions”, Springer Verlag, 2001.
2. Sanford S. Miller, Petru T. Mocanu,” Differential Subordinations: Theory and Applications”, Marcel Dekker, 2000.