Department of Mathematics
M.Sc. Mathematics and Computing
Course Structure

First Semester			
Code No.	**Subject Name**	**L-P**	**Credits**
MTH-111	Real Analysis	**3-0**	**3**
MTH-112	Linear Algebra	**3-0**	**3**
MTH-113	Differential Equations	**3-0**	**3**
MTH-114	Operations Research	**3-0**	**3**
MTH-115	Object Oriented Programming	**3-0**	**3**
MTH-116	OOP Lab	**0-1**	**1**
Total		**15-1**	**16**
Second Semester			
MTH-121	Complex Analysis	**3-0**	**3**
MTH-122	Abstract Algebra	**3-0**	**3**
MTH-123	Discrete Mathematics	**3-0**	**3**
MTH-124	Numerical Analysis	**3-0**	**3**
MTH-125	Data Structures and Algorithms	**3-0**	**3**
MTH-126	Numerical Analysis Lab	**0-1**	**1**
MTH-127	Data Structures Lab	**0-1**	**1**
Total		**15-2**	**17**
Third Semester			
MTH-231	Mathematical Methods	**3-0**	**3**
MTH-232	Probability and Statistics	**3-0**	**3**
MTH-233	Soft Computing	**3-0**	**3**
MTH-234	Elective-I	**3-0**	**3**
MTH-235	Elective-II	**3-0**	**3**
MTH-236	Mathematical Software Lab	**0-1**	**1**
MTH-237	Computational Lab-I	**0-1**	**1**
Total		**15-2**	**17**
Fourth Semester			
MTH-241	Functional Analysis	**3-0**	**3**
MTH-242	Elective - III	**3-0**	**3**
MTH-243	Elective - IV	**3-0**	**3**
MTH-234	Computational Lab-II	**0-1**	**1**
MTH-245	Dissertation	**----**	**10**
Total		**9-1**	**20**

List of Elective-I

1. MTH-234 (a): Viscous Fluid Dynamics
2. MTH-234 (b): Topology
3. MTH-234 (c): Orthogonal Polynomials and Special Functions
4. MTH-234 (d): Dynamical Systems

List of Elective-II

1. MTH-235 (a): Cryptography
2. MTH-235 (b): Computer Graphics
3. MTH-235 (c): Database Management System
4. MTH-235 (d): Parallel Algorithms
5. MTH-235 (e): Artificial Intelligence
6. MTH-235 (f): Text mining & Analytics

List of Elective-III

1. MTH-242 (a): Theory of Stability
2. MTH-242 (b): Applied Linear Algebra
3. MTH-242 (c): Advanced Operation Research
4. MTH-242 (d): Advanced Statistical Modeling

List of Elective-IV

1. MTH-243 (a): Computer Networks
2. MTH-243 (b): Software Engineering
3. MTH-243 (c): Data Mining
4. MTH-243 (d): Web Development
5. MTH-243 (e): Cloud Computing
6. MTH-243 (f): Digital Image Processing

MTH-111:REAL ANALYSIS

L– P
3 – 0

Elementary set theory,Real number system and its order completeness, sequences and series of real numbers. Metric spaces: Basic concepts, continuous functions, completeness, contraction mapping theorem, connectedness, Intermediate Value Theorem, Compactness, Heine-Borel Theorem. Differentiation, Taylor's theorem, Riemann Integral, Improper integrals Sequences and series of functions, Uniform convergence, power series, Weierstrass approximation theorem, equicontinuity, Arzela-Ascoli theorem.

TEXT AND REFERENCE BOOKS

1. W. Rudin, Principles of Mathematical Analysis, McGraw Hill Inc., 1976
2. S.C. Malik, SavitaArora, Mathematical Analysis, New Age International (P) Ltd, 2005.
3. C.C. Pugh, Real Mathematical Analysis, Springer, 2002.
4. T. M. Apostol, Mathematical Analysis, Addison-Wesley Publishing Company, 1974.
5. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill, 2004

MTH-112: LINEAR ALGEBRA

L– P
3 – 0

Systems of linear equations, Matrices, Elementary row operations, Row-reduced echelon matrices. Vector spaces, Subspaces, Bases and dimension, Ordered bases and coordinates.
Linear transformations, Rank-nullity theorem, Algebra of linear transformations, Isomorphism, Matrix representation, Linear functionals, Annihilator, Double dual, Transpose of a linear transformation.
Characteristic values and characteristic vectors of linear transformations, Diagonalizability, Minimal polynomial of a linear transformation, Cayley-Hamilton theorem, Invariant subspaces, Direct-sum decompositions, Invariant direct sums, The primary decomposition theorem, Cyclic subspaces and annihilators, Cyclic decomposition, Rational, Jordan forms.
Inner product spaces, Orthonormal bases, Gram-Schmidt process.

TEXT AND REFERENCE BOOKS

1. K. Hoffman and R. Kunze, Linear Algebra, 2nd Edition, Prentice-Hall of India, 2005.
2. M. Artin, Algebra, Prentice-Hall of India, 2005.
3. S. Axler, Linear Algebra Done Right, John-Wiley, 1999.
4. S. Lang, Linear Algebra, Springer UTM, 1997.
5. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice-Hall of India, 2004.

MTH-113: DIFFERENTIAL EQUATIONS

L– P
3 – 0

Review of fundamentals of ODEs, Existence and uniqueness theorems.

Series solution of differential equations, power series method, Bessel and Legendre differential equations, complete solutions of Hermite, Gauss's hypergeometric and chebyshev's differential equations, the generating functions and recurrence relations.
Eigen value problems and Sturm-Liouville problem, Stability of linear and nonlinear systems, Nonlinear conservative systems, Liapunov's direct method.
First-order linear and quasi-linear PDE's, lagrange'smethod, Charpits' method, Cauchy problem, Second order PDEs,Classification of PDE, Characteristics,Well-posed problems,Solution of hyperbolic, Parabolic and elliptic equations, Dirichlet and Neumann problems, Maximum principles.

TEXT AND REFERENCE BOOKS

1. S.L. Ross, Differential Equations, John Wiley and Sons, 2004.
2. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill, 1991.
3. I.N.Sneddon, Elements of Partial Differential Equations, Tata McGraw Hill, 1957.
4. E.A.Coddington and N.Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 2007.
5. H.T.H.Piaggio, Differential Equations, CBS Publisher, 2004.
6. J.N. Sharma and K. Singh, Partial differential equations for engineers and scientists, Alpha Science, 2000.
7. K. S.Rao, Introduction to Partial Differential Equations, Prentice Hall of IndiaPrivate Limited, New Delhi, 1997.

MTH-114: OPERATIONS RESEARCH

L– P
3 – 0

Hyperplane and hyperspheres, Convex sets and their properties, Convex functions, Linear Programming Problems; Formulation and examples, Basic feasible and optimal solutions, Extreme points, Graphical Method, Simplex Method, Big-M Method, Degeneracy, Duality and Dual LPP and its properties, Dual simplex Algorithm and sensitivity analysis.
Transportation problem, mathematical formulation, basic feasible solution, North-West Corner Method, Least Cost Method, Vogel's approximation Method, Optimal solution by U-V Method, Stepping Stone Method, Degeneracy in Transportation problem.
Assignment problem, mathematical formulation, solution by Hungarian Method, unbalanced problem, Traveling Sail's man problem and its solution.
Goal programming problem (GPP), mathematical formulation, Graphical goal attainment and Simplex method for solution of GPP,
Game Theory, Two-Person Zero sum games, The Maximin-minimax principle, pure and mixed strategies, graphical solution, Dominance property, General solution of mxn rectangular games, Linear programming of GP.
Network Analysis: PERT: Background, development, networking, estimating activity time, Determination of earliest expected and allowable times, determination of critical path, PERT cost, scheduling of a project, CPM method, Applications of these methods

TEXT AND REFERENCE BOOKS

1. H.A. Taha, Operation Research: An Introduction, Prentice Hall of India, 1996.
2. G. Hadley, Linear programming, Narosa Publishing House, 2002.

3. S.D. Sharma and H. Sharma, Operation Research: Theory, Methods and Applications, KedarNath& Co, 2004.
4. K. Swarup, P.K. Gupta and Manmohan, Operation Research, S. Chand & Sons, 2004.
5. G.V. Shenoy, U.K. Srivastava, S C Sharma, Operations Research for Management, New Age International (P) Ltd, 2005.

MTH-115: OBJECT ORIENTED PROGRAMMING

L– P
3 – 0

Object-Oriented Programming: Oriented Programming Paradigm, Benefits of OOPS, object oriented design and development, Comparison of structured and object-oriented programming languages

Arrays, Pointers and Functions: Arrays, Storage of arrays in memory, Initializing Arrays, Multi-Dimensional Arrays, Pointers, accessing array elements through pointers, Passing pointers as function arguments, Functions, Arguments, Inline functions, Function Overloading

Classes and Objects: Data types, operators, expressions, control structures, arrays, strings, Classes and objects, access specifiers, constructors, destructors, operator overloading, type conversion

Storage classes: Fixed vs Automatic declaration, Scope, Global variables, register specifier, Dynamic memory allocation.

Inheritance: Inheritance, Multi-level inheritance, hierarchical inheritance, hybrid inheritance, Virtual functions.

Files: Opening and closing a file, File pointers and their manipulations, Sequential Input and output operations, Random Access, command line argument, string class, Date class, Array class, List class, Queue class, User defined class.

Exception Handling: List of exceptions, catching exception, handling exception.

Graphics: Text Mode, Graphics mode, Rectangles, and Lines, Polygons.

Standard Template Library: Standard Template Library, Overview of Standard Template Library, Containers, Algorithms, Iterators, Other STL Elements, Container Classes, General Theory of Operation, Vectors.

Laboratory Work: Laboratory experiments of MTH-116 will be set in consonance with the contentof this course.

TEXT AND REFERENCE BOOKS

1. R.Lafore, Object oriented programming in C++, Pearson Education, 2008.
2. E. Balagurusamy, Object oriented programming with C++, Tata McGraw Hill, 2013.
3. B.Stroustrup, The C++ programming Language, Addison Wesley, 2013
4. G. Booch, Object Oriented Analysis and Design with Applications, Addison Wesley, 1993.
5. C.H. Pappas and W.H. Murray, The Complete Reference Visual C++6, Tata McGraw Hill, 2011.

MTH-121:COMPLEX ANALYSIS

L– P
3 – 0

Complex numbers, the topology of the complex plane, the extended complex plane and its representation using the sphere. Complex functions and their mapping properties, their limits, continuity and differentiability, analytic functions, analytic branches of a multiple-valued function. Complex integration, Cauchy's theorems, Cauchy's integral formulae. Power series, Taylor's series, zeroes of analytic functions, Rouche's theorem, open mapping theorem. Mobius transformations and their properties.
Isolated singularities and their classification, Laurent's series, Cauchy's residue theorem, the argument principle.

TEXT AND REFERENCE BOOKS

1. H.A. Priestley, Introduction to Complex Analysis, Oxford, 2006.
2. L.V. Ahlfors, Complex Analysis, TataMcGraw Hill, 2000.
3. J.E. Marsden and M.J. Hoffman, Basic Complex Analysis, W.H. Freeman, 1999.
4. J.W. Brown and R.V. Churchill, Complex Variables and Applications, McGraw Hill, 2003.
5. J.H. Mathews and R.W. Howell, Complex Analysis for Mathematics and Engineering, NarosaPublishing House, 1998.
6. T. Needham, Visual Complex Analysis, Oxford, 1997.

MTH-122:ABSTRACT ALGEBRA

L– P
3 – 0

Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems. Rings, ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pairwise coaximal ideals. Euclidean Domains, Principal Ideal Domains and Unique Factorizations Domains. Polynomial rings over UFD's. Fields, Characteristic and prime subfields, Field extensions, Finite,algebraic and finitely generated field extensions, Classical ruler and compass constructions, Splitting fields and normal extensions, algebraic closures. Finite fields, Cyclotomic fields, Separable and inseparable extensions.Galois groups, Fundamental Theorem of Galois Theory, Composite extensions, Examples (including cyclotomic extensions and extensions of finite fields). Solvability by radicals, Galois' Theorem on solvability.Cyclic and abelian extensions, transcendental extensions.

TEXT AND REFERENCE BOOKS

1. Artin, Algebra, Prentice Hall of India, 1994.
2. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley, 2002.
3. J.A. Gallian, Contemporary Abstract Algebra, NarosaPublishing House, 1999.
4. N. Jacobson, Basic Algebra I, Hindustan Publishing Co., 1984,
5. S. Lang, Algebra I, Addison Wesley, 2005

MTH-123: DISCRETE MATHEMATICS

L– P
3 – 0

Set Theory: Introduction to the theory of sets; combination of sets; power sets; finite and infinite sets; principle of inclusion and exclusion; selected problems from each topic.
Logic: Proposition, predicate logic, logic operators, logic proposition and proof, method of proofs.

Mathematical Induction: Different forms of the principle of mathematical induction. Selected problems on mathematical induction.
Graph theory: Path, cycles, handshaking theorem, bipartite graphs, sub-graphs, graph isomorphism, operations on graphs, Eulerian graphs and Hamiltonian graphs, planar graphs, Euler formula, traveling salesman problem, shortest path algorithms.
Relations and function: Definitions and properties; pigeonhole principle, Equivalence relations and equivalence classes. Representations of relations by binary matrices and digraphs; operations on relations.Closure of a relation; reflexive, symmetric and transitive closures.Warshall's algorithm to compute transitive closure of a relation, growth of function, big O, hash function., discrete numeric functions; asymptotic behaviour; generating functions.
Partially Ordered Sets and Lattices: Partial order relations, POSETS, lattices, isomorphism of lattice
Boolean Algebra and Boolean Functions: Introduction to Boolean algebra and Boolean functions. Different representations of Boolean functions. Application of Boolean functions to synthesis of circuits, circuit minimization and simplification, Karnaugh map.
Recurrence Relations: Linear recurrence relations with constant coefficients (homogeneous case); discussion of all the three sub-cases. Linear recurrence relations with constant coefficients (non-homogeneous case); discussion of several special cases to obtain particular solutions. Solution of linear recurrence relations using generating functions.

TEXT AND REFERENCE BOOKS

1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw-Hill, 1985.
2. R. A. Brualdi, Introductory Combinatorics, Pearson, 2009.
3. J. L. Mott, A.Kandel and T. P.Baker, Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall India, 1986.
4. F.Harary, Graph Theory, Narosa, 1969.
5. T. Koshy, Discrete Mathematics with Applications, Academic Press, 2004.
6. K. H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, 2007.

MTH-124: NUMERICAL ANALYSIS

L– P
3 – 0

Errors: Definition and sources of errors, Floating-point arithmetic and rounding errors, Loss of significance and Propagation of errors, Stability and accuracy.
Nonlinear Equations: Bisection method, Fixed point iteration method, secant method, Newton-Raphson method,Rate of convergence, Generalization of Newton-Raphson to multiple dimensions, Solution of a system of nonlinear equations.
Linear systems and Eigen Values: Direct methods (Gauss elimination with pivoting strategy, LU decomposition), iterative methods (Jacobi and Gauss-Seidel) and their convergence analysis, Rayleigh’s power, Jacobi’s method, Given’s method for eigen-values and eigen-vectors.
Interpolation: Lagrange interpolation, Newton interpolation,Hermite interpolation, Spline interpolation, B-splines, Bivariate interpolation, Error of the interpolating polynomials,Data fitting and least-squares approximation problem.
Differentiation and integration:Difference operators (forward, backward and central difference), Stability and accuracy of solutions,Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature,Error analysis.

Numerical solution of initial value problems: Euler and modified Euler methods, Runge-Kutta methods, Multistep methods, Predictor-Corrector method, Convergence and stability.
Boundary Value Problems: Finite difference methods, shooting methods, error and convergence analysis.

Laboratory Work: Laboratory experiments of **MTH-126** will be set in consonance with the content of this course.

TEXT AND REFERENCE BOOKS

1. S.D. Conte, and Carl de Boor, Elementary Numerical Analysis-An Algorithmic Approach, Tata McGraw Hill, 1980.
2. K.E. Atkinson, Introduction to Numerical Analysis, John Wiley, 1989.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Analysis for Scientific and Engineering Computations, New Age international (P) Ltd, 2003.
4. S.S. Sastry, Introduction Methods of Numerical Analysis, Prentice Hall of India, 2012.
5. G.D. Smith, Numerical solution of partial differential equations: Finite difference methods, Clarendon Press, 1985.
6. K.W. Morton and D.F. Mayers, Numerical solution for partial differential equations, Cambridge University Press, 2005.
7. J.N. Sharma, Numerical Methods for Engineers and Scientists, Narosa Publishing House, New Delhi, 2007.

MTH-125:DATA STRUCTURES AND ALGORITHMS

L– P
3 – 0

Introduction: Data types, data structures, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, obtaining the complexity of an algorithm.

Array, Stacks and Queues: Notations and Analysis, Storage structures for arrays - sparse matrices - structures and arrays of structures, Stacks and Queues: Representations, implementations and applications.

Linked Lists: Singly linked lists, stacks and queues using linked lists, operations on Polynomials, Doubly Linked Lists, Circularly Linked Lists, dynamic storage management – Garbage collection and compaction.

Trees: Basic terminology, General Trees, Binary Trees, Tree Traversing: in-order, pre-order and post-order traversal, building a binary search tree, Operations on Binary Trees, Height Balanced Trees(AVL), B-trees, B+ -trees.

Graphs: Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pair shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strong components, minimum cost spanning tress, articulation points and biconnected components, graph matching.

Sorting and Searching Techniques: Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap and Heap sort, Quick sort, Radix sort and Bucket sort, Sequential searching, Binary Searching, Hash table methods.

Laboratory Work: Laboratory experiments of **MTH-127** will be set in consonance with the content of this course.

TEXT AND REFERENCE BOOKS

1. J.P. Tremblay and P.G. Sorenson, "An Introduction to Data Structures with applications", Tata McGraw Hill.
2. S. Sahni, "Data structures, Algorithms ad Applications in C++", WCB/McGraw Hill.
3. Aho Ullman and Hopcroft, " Data Structures and Algorithms".
4. Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, "Data Structures using C", Pearson Education
5. Richard F. Gilberg, Behrouz A. Forouzan, "Data Structures – A Pseudocode Approach with C", Thomson Brooks / COLE

MTH 231: MATHEMATICAL METHODS

L– P
3 – 0

Integral Transform (Laplace & Fourier): Properties, inversion formulae, convolution. Application to ordinary and partial differential equations and integral equations.

Calculus of Variations: Basic concepts of the calculus of variations such as maxima and minima, functionals, extremum, variations, function spaces, Euler's equations with the cases of one variable and several variables. Natural boundary conditions and transition conditions. The variational notation, constraints and Lagrange multipliers, variable end points. Sturm-Liouville problems, Hamilton's principle, Lagrange's equations. Generalized dynamical entities, constraints in dynamical systems. The Variational problems for deformable bodies, The variational problem for the elastic plate. The Rayleigh-Ritz method.

Integral Equations: Definition and classification of linear integral equations. Conversion of initial and boundary value problems into integral equations. Green's function approach. Linear equations in cause and effect. The influence function. Fredholm equations with separable kernels. Hilbert-Schmidt theory. Iterative methods for solving equations of the second kind. The Neumann series. Fredholm theory. Singular integral equations. Iterative approximations to characteristic functions. Approximate methods of undetermined coefficients. The method of collocation. The method of weighting functions.

TEXT AND REFERENCE BOOKS:

1. F. B. Hildebrand, Methods of applied mathematics, Dover Publications, Inc., New York, 1992.
2. R. R. Goldberg, Fourier transforms, Cambridge Tracts in Mathematics and Mathematical Physics, No. 52, Cambridge University Press, New York, 1961.

3. H. Hochstadt, Integral equations, Wiley Classics Library, John Wiley & Sons, Inc., New York, 1989.
4. M. Kot, A first course in the calculus of variations, Student Mathematical Library, 72, American Mathematical Society, Providence, RI, 2014.
5. D. Porter and D. S. G. Stirling, Integral equations: A practical treatment, from spectral theory to applications, Cambridge University Press, 1993.

MTH 232: PROBABILITY AND STATISTICS

L– P
3 – 0

Random variable. Probability mass function. Probability density function. Moments. Moment generating function and their properties.

Joint distributions. Marginal and conditional distribution.Transformation of random variables.Central limit theorem. Covariance.Correlation.

Binomial, Poisson, Geometric, Negative Binomial, Uniform, Exponential, Gamma, Weibull and Normal distributions and their properties.

The General Linear Model: Ordinary Least Square (OLS) estimation and prediction. Use of Dummy variables and seasonal adjustment. Generalizes Least Square (GLS) estimation and prediction. Heteroscedastic disturbances, Pure and Mixed estimator, grouping of observations and of equations.

Simultaneous Linear Equation Models: Examples, Identification problem. Restrictions on structural parameters- rank and order conditions. Restrictions on variances and covariances. Estimation in simultaneous equations model. Recursive systems. 2 SLS estimators, limited information estimators.

Time Series Models: Time series as discrete parameter stochastic process. Auto covariance and autocorrelation function and their properties. Test for trends and seasonality. Exponential and moving average smoothing. Holt and Winters Smoothing. Forecasting based on smoothing.

Autoregressive integrated moving average (ARIMA) models: Box-Jenkins models. Estimation of parameters in ARIMA models. Forecasting.Periodogram and Correlogram analysis.

TEXT AND REFERENCE BOOKS:

1. S. Ross, A first course in probability, ninth edition, Pearson Education India, 2013.
2. V. K. Rohtagi, and A. K. M. E. Saleh, An introduction to probability and statistics, second edition,Wiley, 2008.
3. A. Mood, F. Graybill and D. Boes, Introduction to the theory of statistics, third edition, McGraw Hill Education, 2017.
4. D. Gujarati, D. Porter and S. Gunasekar, Basic econometrics, fifth edition, McGraw Hill Education, 2017.
5. J. Johnston, Econometric Methods, fourth edition, McGraw-Hill Higher Education, 1997.
6. A. Kaytsoyianmis, Theory of Econometrics, second edition, Palgrave Macmillan, 2001.

7. G. E. P Box, G. M. Jenkins, G. C. Reinsel and G. M. Ljung, Time Series Analysis, fifth edition, Forecasting and control, Wiley-Blackwell, 2015.
8. D. C. Montgomery, E. A. Peck and G. G. Vining, Introduction to linear regression analysis, third edition, Wiley Series in Probability and Statistics: Texts, References, and Pocketbooks Section, Wiley-Interscience, New York, 2001.

MTH 233: SOFT COMPUTING

L– P
3 – 0

Neural Networks: Introduction, Biological Neuro-system, Neurons and its Mathematical Models, ANN architecture, Learning rules, Supervised and Unsupervised Learning Model, Reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.

Fuzzy Logic: Introduction, Classical and Fuzzy Sets, Membership Function, Fuzzy rule generation, Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations. Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges.

Uncertainty based Information: Significance of Uncertainty, Uncertainty and Information, Principles of Uncertainty, Reasoning Under Uncertainty(Heuristics, Empirical associations, Objective & Subjective probabilities), Nonspecificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy Sets.

Genetic Algorithm: Difference between Traditional Algorithms and GA, Working Principle, Schema theorem, convergence analysis, stochastic models, GA Encoding methods, Fitness function, GA Operators-Reproduction, Selection, Crossover, Mutation, Convergence theory of GA, Bit wise operation in GA, Applications in search and optimization-Match Word Finding, Traveling Sales Man Problem .

Swarm Intelligence: Introduction and characteristics of Swarm Intelligence, Ant Colony Optimization (ACO) system, Combinatorial Optimization, Practice Swarm Optimization (PSO) system: Parameter selection, Topologies (SPSO, APSO, stochastic star, TRIBES, and C-PSO), Applications of ACO & PSO in field of: Routing, Assignment, Scheduling, Subset.

TEXT AND REFERENCRE BOOKS:

1. J. A. Anderson, An Introduction to Neural Networks, PHI.
2. J. K. Hertz, R. G. Palmer, Introduction to the Theory of Neural Computation, Addison-Wesley.
3. G. J. Klir & B. Yuan, Fuzzy Sets & Fuzzy Logic, PHI.
4. M. Mitchell , An Introduction to Genetic Algorithm, PHI.
5. J. A. Freeman & D. M. Skapura, Neural Networks: Algorithms, Applications and Programming Techniques, Addison Wesley.

MTH 234 (a): VISCOUS FLUID DYNAMICS

L– P
3 – 0

Basic concepts: Fluid, Continuum hypothesis, Newton's Law of Viscosity, Some Cartesian Tensor Notations, General Analysis of Fluid Motion, Thermal Conductivity, Generalised Heat conduction.

Fundamental Equations of Motion of Viscous Fluid: Equation of State, Equation of Continuity, Navier – Stokes (NS) Equations (equation of Motion, Equation of Energy, Streamlines & Pathlines, Vorticity and Circulation (Kelvin's Circulation Theorem).

Dynamical Similarity (Reynold's Law), Inspection Analysis- Dimensional Analysis: Buckingham – π - Theorem, and its Applications π –products and coefficients, Non-dimensional parameters and their physical importance.

Exact Solutions of the Navier Stokes' Equations: Steady Motion between parallel plates (a) Velocity distribution, (b) Temperature Distribution, Plane Couette flow, plane Poiseuille flow, generalized plane Couette flow. Flow in a circular pipe (Hagen-Poiseuille flow (a) velocity distribution (b) Temperature distribution.

Flow between two concentric Rotating Cylinders (Couette flow): (a) Velocity distribution (b) Temperature distribution. Flow due to a plane wall suddenly set in motion, flow due to an oscillating plane wall. Plane Couette flow with transpiration cooling.

TEXT AND REFERENCE BOOKS:

1. J. L. Bansal, Viscous fluid dynamics, Oxford and IBH Publishing Co. Pvt. Ltd., 1977.
2. P. K. Kundu, I. M. Cohen and D. R. Dowling, Fluid mechanics, Academic Press, 2015.
3. S. K. Som, G. Biswas and S. Chakraborty, Introduction to fluid mechanics and fluid machines, Tata McGraw-Hill Education, 2012.
4. F. M. White, Fluid Mechanics, McGraw-Hill, 2003.
5. R. W. Fox and A. T. McDonald, Introduction to fluid mechanics, second edition, John Wiley & Sons, New York, 1978.

MTH 234 (b): TOPOLOGY

L– P
3 – 0

Introduction: Finite, countable, uncountable sets, functions, relations, axiom of choice, Zorn's Lemma.

Topological Spaces and Continuous Functions: Open sets, closed sets, basis for a topology, sub basis, T_1 and T_2 spaces, order topology, product topology, subspace topology, limit point, continuous function, general product topology, metric space and its topology, quotient topology.

Connectedness and Compactness: Connected spaces, connected subspaces, local connectedness, compact subspace, limit point compactness, local compactness.

Countability and Separation Axioms: Countability axioms, separation axioms, regular and normal spaces, Urysohn's Lemma, Urysohn Metrization Theorem, Tietze Extension Theorem, Tychonoff Theorem.

TEXT AND REFERENCE BOOKS:

1. J. R. Munkres, Topology, second edition, Prentice-Hall, Inc., NJ, 2000.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.
3. T. W. Gamelin and R. E. Greene, Introduction to topology, second edition, Dover Publications, Inc., Mineola, NY, 1999.
4. M. J. Mansfield, Introduction to topology, D. Van Nostrand Co., Inc., Princeton, NJ, 1963.
5. B. Mendelson, Introduction to topology, reprint of the third edition, Dover Books on Advanced Mathematics, Dover Publications, Inc., New York, 1990.

MTH 234 (c): ORTHOGONAL POLYNOMIALS AND SPECIAL FUNCTIONS

L– P
3 – 0

Orthogonal Polynomials: Definition, their zeros, expansion in terms of orthogonal polynomials, three term recurrence relation, Christofel-Darboux formula. Bessel's inequality. Relationship with chain sequences and continued fractions. Gauss Quadrature. Hermite, Laguerre, Jacobi and Ultraspherical polynomials: Definition and elementary properties. Generating functions of some standard forms including Boas and Buck type. Sister Celine's techniques for finding pure recurrence relations. Characterization: Appell, Sheffes and s-type characterization of polynomial sets.

Gamma function: Definition in the complex domain. Weierstrass's definition. Psi function and its series expansion. Difference equation. Order symbols o and O. Relationship with Beta function and its elementary properties. Infinite products, duplication formula, multiplication formula and reflection formula.

Hypergeometric Functions: Solution of homogeneous linear differential equations of second order near an ordinary and regular singular point, their convergence and solutions for large values. Differential Equations with three regular singularities, hypergeometric differential equations. Gauss hypergeometric function, elementary properties, contiguous relations, integral representation, linear and quadratic transformation and summation formulae. Confluent hypergeometric function and its elementary properties. Generalized hypergeometric function ${}_pF_q$ and its elementary properties - linear and quadratic transformations, summation formulae.

Asymptotic Series: Definition, elementary properties, term by term differentiation, integration, theorem of uniqueness, Watson's lemma. Asymptotic expansion of ${}_1F_1$ and ${}_2F_1$.

TEXT AND REFERENCE BOOKS:

1. G. E. Andrews, R. Askey and R. Roy, Special functions, Encyclopedia of Mathematics and its Applications, 71, Cambridge University Press, Cambridge, 1999.
2. T. S. Chihara, An introduction to orthogonal polynomials, Gordon and Breach Science Publishers, New York, 1978.

3. M. E. H. Ismail, Classical and quantum orthogonal polynomials in one variable, Encyclopedia of Mathematics and its Applications, 98, Cambridge University Press, Cambridge, 2009.
4. E. D. Rainville, Special functions, The Macmillan Co., New York, 1960.
5. E. T. Whittaker and G. N. Watson, A course of modern analysis, Cambridge University Press, Cambridge, 1996.

MTH 234 (d): DYNAMICAL SYSTEMS

L– P
3 – 0

Linear Dynamical Continuous Systems: First order equations, existence uniqueness theorem, growth equation, logistic growth, constant harvesting, Planner linear systems, equilibrium points, stability, phase space, n-dimensional linear systems, stable, unstable and center spaces.

Nonlinear autonomous systems: Motion of pendulum, local and global stability, Liapunov method, periodic solution, Bendixson's criterion, Poincare Bendixson theorem, limit cycle, attractors, index theory, Hartman Grobman theorem, nonhyperbolic critical points, center manifolds, normal forms, Gradient and Hamiltonian systems.

Local Bifurcation: Fixed points, saddle node, pitchfork trans-critical bifurcation, Hopf bifurcation, co-dimension.

Discrete systems: Logistic maps, equilibrium points and their local stability, cycles, period doubling, chaos, tent map, horse shoe map.

Deterministic Chaos: Duffing's oscillator, Lorenz system, Liapunov exponents, routes to chaos, necessary conditions for chaos.

TEXT AND REFERENCE BOOKS:

1. M. W. Hirsch, S. Smale and R. L. Devaney, Differential equations, dynamical systems, and an introduction to chaos, third edition, Elsevier/Academic Press, Amsterdam, 2013.
2. J. T. Sandefur, Discrete dynamical systems: Theory and applications, The Clarendon Press, Oxford University Press, New York, 1990.
3. S. H. Strogatz, Nonlinear dynamics and chaos: With applications to physics, biology, chemistry, and engineering, Westview Press, 2008.
4. S. Wiggins, Introduction to applied nonlinear dynamical systems and chaos, second edition, Texts in Applied Mathematics, 2, Springer-Verlag, New York, 2003.

MTH 235 (a): CRYPTOGRAPHY

L– P
3 – 0

Introduction: Standards Organizations, Security Components OSI Security Architecture, Aspects of Security, Passive Attacks, Active Attacks, Symmetric Cipher Model, Cryptography Classification, Cryptanalysis, Substitution: Other forms, Poly-alphabetic Substitution Ciphers, One-Time Pad, Transposition (Permutation) Ciphers, Product Ciphers.

Number Theory and Prime numbers: Groups, Rings, and Fields, Modular Arithmetic,

Euclid's Algorithm, Finite Fields of the Form GF(p),Polynomial Arithmetic, Finite Fields of the Form GF(2n). Generation of large prime numbers, Prime factorization, Euler Totient Function ø(n), Euler's Theorem, Primality Test- Fermat's Little Theorem, Miller Rabin Algorithm, AKS Algorithm, Cyclotomicprimality test, Elliptic Curve Primality Test, Prime Distribution, Chinese Remainder Theorem, Primitive Roots, Discrete Logarithms

Cryptographic Techniques: Perfect security, Feistel Cipher Structure, Block Cipher- DES, differential and Linear Cryptanalysis,Avalanche Effect , Double-DES, Triple-DES, Electronic Codebook Book (ECB), Cipher Block Chaining (CBC), Message Padding, Cipher Text Stealing (CTS), AES, International Data Encryption Algorithm (IDEA), Stream Cipher-Stream Modes of Operation-Cipher Feedback (CFB), Output Feedback (OFB), Counter (CTR), Storage Encryption, RC4; Pseudo number generation- Linear-Congruential Generators, Blum BlumShub Generator, Nonlinear Generators, RNGs used in Common Software Packages, Block Ciphers as PRNGs, ANSI X9.17 PRG, Hardware Random number generator.

Public-Key Cryptography and Message Authentication: The Key Distribution Problem, Public-Key Cryptosystems, The RSA Algorithm, The Key Management riddle, The Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication, requirements and functions, Message Authentication Codes, Hash Functions, Birthday Problem, SHA-X, SHA-512 overview, Authentication, Access control policies, The Message Digest (MD5) Algorithm, HMAC fundamentals, Digital Signature basics, Authentication Protocols, The Digital Signature Standard.

TEXT AND REFERENCRE BOOKS

1. D Stinson, Cryptography: Theory and Practice, Chapman & Hall.
2. Trappe & Washington, Introduction to Cryptography with Coding Theory, Prentice-Hall.
3. William Stallings, Cryptography and Network Security: Principles and Practice, Pearson Education.

MTH 235 (b): COMPUTER GRAPHICS

L– P
3 – 0

Introduction to Computer Graphics: Overview of Graphics Systems, Display Devices, Hard copy Devices. Interactive Input Devices, Display Processors, The Graphical Kernel System, Output Primitives, Line drawing algorithms, Circle Generation algorithms, Character Generation.

Raster Scan Graphics: Line Drawing Algorithms, Circle Generation, General Function Rasterization, Scan Conversion- Generation of the display, Image Compression, Polygon Filling, Fundamentals of Antialiasing.

Two-Dimensional Geometric Transformation & Viewing: Basic Transformation, Translation, Rotation, Scaling, Other Transformation Reflection, Shear, Transformation functions, Window to viewport co-ordinate transformation, Clipping Operations, Point Clipping, Line Clipping, Polygon Clipping.

Three- Dimensional Concepts & Object Representations: Three Dimensional Display Methods, Parallel Projection, Perspective Projection, Translation, Rotation, Scaling, Composite Transformation, Three dimensional Transformation function, Polygon Surfaces,

Curved Lines and surfaces, Bezier Curves and surfaces, B-Spline Curves and surfaces.

Graphics hardware: Display technology, random scan, raster scan display processing, input devices for interaction.

Visible Lines and Visible Surfaces: Visual Realism, Hidden line and hidden surface removal: depth buffer algorithm, geometric computations, scan line coherence algorithms, area coherence algorithms, priority algorithm, shading and color models, Modeling methods.

Rendering: A simple illumination model, Transparency, Refraction effects in transparent materials, Simple Transparency Models, Z-Buffer Transparency, Shadows, Texture.

TEXT AND REFERENCRE BOOKS

1. D.F. Rogers, Procedural Elements for Computer Graphics, McGraw Hill.
2. Hearn and Baker, Computer Graphics, PHI.
3. S. Harrington, Computer Graphics - A programming approach, McGraw Hill.
4. D.F. Rogers, Mathematical Elements for Computer Graphics, McGraw Hill.

MTH 235 (c): DATA BASE MANAGEMENT SYSTEM

L– P

3 – 0

Basic Concepts: Introduction to File and Database systems- Database system structure – concepts and architecture, date models, schemas & instances, DBMS architecture & data independence, database languages & interfaces, Data Model, ER model.

Relational Models: SQL – Data definition- Queries in SQL-relational model concepts, relational model constraints, relational algebra, SQL- a relational database language: date definition in SQL, view and queries in SQL, specifying constraints and indexes in SQL; relational database management systems-Updates, Views, Integrity and Security, Relational Database design, Functional dependences and Normalization for Relational Databases, normal forms based on primary keys, (1NF, 2NF, 3NF & BCNF), lossless join and dependency preserving decomposition, converting ER-diagrams into relations.

Data Storage and query Processing: Record storage and Primary file organization- Secondary storage Devices, Operations on Files, Heap File, Sorted Files, Hashing Techniques, Index Structure for files, Different types of Indexes- B-Tree - B+Tree.

Transaction Management: Transaction Processing, Need for Concurrency control, Desirable properties of Transaction, Schedule and Recoverability, Serializability and Schedules; Concurrency Control, Types of Locks, Two Phases locking, Deadlock.

TEXT AND REFERENCRE BOOKS

1. B. Desai, An introduction to database concepts, Galgotia publications.
2. C.J.Date, An introduction to database systems, Addison Wesley.
3. Elmsari and Navathe, Fundamentals of database systems, Addison Wesley.
4. J.D.Ullman, Principals of database systems, Galgotia publications.
5. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, Database System Concepts, McGraw-Hill
6. RamezElmasri and Shamkant B. Navathe, Fundamental Database Systems, Pearson Education,

7. Hector Garcia–Molina, Jeffrey D.Ullman and Jennifer Widom, Database System Implementation, Pearson Education
8. Peter Rob and Corlos Coronel, Database System, Design, Implementation and Management, Thompson Learning Course Technology

MTH 235 (d): PARALLEL ALGORITHMS

L– P
3 – 0

Introduction to Parallel algorithms: Review of sequential algorithms, Introduction to parallel algorithms and architectures: EREW, CREW, CRCW PRAMs and interconnection network models such as the mesh. Knowledge of how to efficiently sum, broadcast and search on these architectures. Parallel efficiency measures for parallel algorithms, e.g., time, speedup, cost (work), processor efficiency. Data Dependence Graph, Data Parallelism, Functional Parallelism, Pipelining and Data Clustering.

Parallelization of Algorithm: Parallel Programming Models, PVM, MPI Paradigms, Parallel Programming Language, Brent‟s Theorem, Simple parallel programs in MPI environments Parallel linear algebra routines, Loop optimizations, Implementation. Principal of Locality, Caches and Buffers. Massively Data Parallel Algorithms, Array notation, Fortran90 and HPC Fortran, Parallel and Vector C Code, Layout, Align, Replicate, Masking, Shifting, Spreading, Broadcasting, Forall Loops.

Basic Parallel Algorithmic Techniques: Pointer Jumping, Divide-and-Conquer, Partitioning, pipelining, Accelerated Cascading, Symmetry Breaking, Synchronization (Locked, Lock-free) Parallel Algorithms Data organization for shared/distributed memory , Min/Max,Sum Searching, Merging, Sorting, Parallel Sorting and Sorting Networks: Parallel Insertion Sort, Even-odd Merge Sort, Bitonic Merge Sort etc. Prefix operations , N-body problems, , Parallel algorithms on network, Addition of Matrices, Multiplication of Matrices.

Writing Parallel Programs GPU: Compute Architecture: Introduction to Graphics Processing Units (GPUs), CUDA programming model, Key principles, Threads and blocks, Language extensions, Attributes, Builtin types and variables, Kernel invocation operator, CUDA runtime API, Asynchronous execution, Handling runtime errors in CUDA, Querying GPU capabilities, CUDA, Memory organization in CUDA, Multi-Core CPU programming, Implementing basic data processing; Parallel reduction, Prefix sum (scan), CUDA implementation, CUDPP implementation, CUDA Streams, Concurrent kernels execution, Example: matrix multiplication, Example: Multi-GPU Async Copy ; Debugging: Principles and terminology, gdb, cuda-gdb, Nsight, CUDA (Visual) Profiler, cuda-memcheck ; Optimization Techniques: Understanding thread and blocks execution, Coalescing memory access, Shared memory bank conflicts, Optimizing CPU-GPU usage; OpenCL,, OpenCL host API, Developing and deploying OpenCL kernels, Comparison with CUDA, CUDA Libraries, CUBLAS, CUSPARSE, CUFFT, CURAND

TEXT AND REFERENCRE BOOKS

1. J. Jaja, An Introduction to Parallel Algorithms, Addison-Wesley Professional.
2. J. Sanders, CUDA by Example: An Introduction to General-Purpose GPU Programming, Edward Kandrot.
3. M. J. Quinn, Parallel Programaming in C with MPI and openMP, McGraw Hill.
4. Crichlow, Introduction to Distributed and Parallel Computing, PHI
5. S. G.Akl, The Design and Analysis of Parallel Algorithms, PHI

MTH 235 (e): ARTIFICIAL INTELLIGENCE

L– P
3 – 0

Introduction: Introduction to AI, AI techniques, level of model, criteria for success, Turing test

Problems, Problem Spaces &Search: Defining problem as a space, search, production system, problem characteristics, production system characteristics, issues in the design of search programs.

Intelligent agents: Reactive, deliberative, goal-driven, utility-driven, and learning agents Artificial Intelligence programming techniques

Problem-solving through Search: Forward and backward, state-space, blind, heuristic, problem-reduction, A, A*, AO*, minimax, alpha-beta cut off, constraint propagation, neural, stochastic, and evolutionary search algorithms, genetic algorithm, PSO.

Knowledge Representation and Reasoning: Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; frame representation, semantic network, predicate logic, resolution, natural deduction, situation calculus, description logics, reasoning with defaults, reasoning about knowledge.

Representing and Reasoning with Uncertain Knowledge: Probability, connection to logic, independence, Bayes rule, bayesian networks, probabilistic inference

Machine Learning and Knowledge Acquisition: Learning from memorization, examples, explanation and exploration.Learning nearest neighbor, naive Bayes, and decision tree classifiers.

TEXT AND REFERENCRE BOOKS

1. S. Kaushik, Artificial Intelligence, Cengage Learning India Pvt Ltd.
2. N.J. Nilsson, Principles of Artificial Intelligence, Narosa Publishing House.
3. E. Rich and Knight, Artificial Intelligence, McGraw Hill International.
4. S. Russell, P. Norvig, Artificial Intelligence – A Modern Approach, Pearson Education / Prentice Hall of India.
5. S. Kaushik, Logic and Prolog Programming, New Age International Pvt Ltd.

MTH 235 (f): TEXT MINING & ANALYTICS

L– P
3 – 0

Introduction: Definition, Objectives, Functional Overview, Relationship to DBMS, Digital libraries and Data Warehouses, organization, representation, and access to information, use of codes, formats, and standards, data structures for unstructured data; design and maintenance of such databases, indexing and indexes, retrieval and classification schemes

Information Retrieval System Capabilities: Search, Browse, Miscellaneous, Cataloging and Indexing: Objectives, Indexing Process, Automatic Indexing, Information Extraction. Data Structures: Introduction, Stemming Algorithms, Inverted file structures, N-gram data structure, PAT data structure, Signature file structure, Hypertext data structure.

Automatic Indexing: Classes of automatic indexing, Statistical indexing, Natural language, Concept indexing, Hypertext linkages, Document and Term Clustering: Introduction, Thesaurus generation, Item clustering, Hierarchy of clusters

User Search Techniques: Search statements and binding, Similarity measures and ranking, Relevance feedback, Selective dissemination of information search, Weighted searches of Boolean systems, Searching the Internet and hypertext, analysis, crowd sourcing search, construction and evaluation of search and navigation techniques; and search engines

Information Visualization: Introduction, Cognition and perception, Information visualization technologies.

Text Search Algorithms: Introduction, Software text search algorithms, Hardware text search systems.

Information System Evaluation: Introduction, Measures used in system evaluation, Measurement example – TREC results, Evaluation of Asian language text retrieval, question answering and text summarization, cross-language information retrieval

Query Expansion: Thesauri, Semantic Networks, Integrating Structured Data and Text

TEXT AND REFERENCRE BOOKS

1. G. Kowalski, Information Retrieval Systems: Theory and Implementation, Kluwer Academic Publishers.
2. I. Witten, M. Gori, T. Numerico, Web Dragons: Inside the Myths of Search Engine Technology, Morgan Kauffman.
3. C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval by Cambridge University Press.
4. W.B. Frakes, R. B.Yates, Information Retrieval Data Structures and Algorithms, Prentice Hall.
5. R. Korfhage, Information Storage & Retieval, John Wiley & Sons.

MTH 241: FUNCTIONAL ANALYSIS

L– P
3 – 0

Review of Hölder inequality, Minkowski inequality and vector spaces with examples of ℓ_{p} and L_p spaces.

Normed linear spaces, Banach spaces with examples, convergence and absolute convergence of series in a normed linear space. Inner product spaces, Hilbert spaces, relation between Banach and Hilbert spaces. Schwarz inequality.

Convex sets, existence and uniqueness of a vector of minimum length, projection theorem. Orthogonal and orthonormal system in Hilbert spaces with examples, Bessel's inequality, Parseval's identity, Characterization of complete orthogonal systems.

Continuity of linear maps on normed linear spaces, equivalent norms, conjugate and dual spaces, The Riesz Representation Theorem.

Adjoint operators, self adjoint operators, normal operators, unitary operators on Hilbert spaces (H) and their properties. Isometric isomorphism of H onto itself under unitary

operators and their importance. Projection operators on Banach spaces and Hilbert spaces. Orthogonal projections.

Contraction mapping with examples, Banach-fixed point theorems and its applications.

Eigenvalues, eigenvectors and eigen-spaces, invariant spaces, spectral theorem on finite dimensional Hilbert spaces.

The Closed Graph Theorem, The Uniform Boundedness Principle and its applications, The Hahn-Banach Extension and Separation theorems, Open Mapping Theorem and its applications.

TEXT AND REFERENCE BOOKS:

1. E. Kreyszig, Introductory functional analysis with applications, Wiley Classics Library, John Wiley & Sons, Inc., New York, 1989.
2. M. T. Nair, Functional Analysis: A First Course, PHI Learning Pvt. Ltd., 2004.
3. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1972.
4. J. B. Conway, A course in functional analysis, second edition, Graduate Texts in Mathematics, 96, Springer-Verlag, New York, 1990.
5. L. K. Debnath and P. Mikusiński, Introduction to Hilbert Spaces with Applications, Academic Press, 2005.
6. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.

MTH 242 (a): THEORY OF STABILITY

L– P
3 – 0

Basic concepts of linear theory, stability, instability, neutral curves, principle of exchange of stabilities, Marginal stability; overstability, thermal instability.

Rayleigh-Bénard Problem: The nature of the physical problem, governing equations, derivation of stability equations, and general characteristics, free-free, rigid-free and rigid-rigid boundary conditions. The effect of rotation and magnetic field. Discussion of some more effects on stability problems.

Convection in generalized fluids: Newtonian Fluids, Non-Newtonian Fluids, Ferromagnetic fluids, Micropolar fluids, The Bénard problem for generalized fluids.

The stability of superposed fluids: The Rayleigh-Taylor and Kelvin-Helmholtz instability problems, the effect of rotation and magnetic field.

TEXT AND REFERENCE BOOKS:

1. S. Chandrasekhar, Hydrodynamic and hydromagnetic stability, Dover Publications, 1981.
2. R. E. Rosensweig, Ferrohydrodynamics, Dover Publications, 1997.
3. D. A. Nield and A. Bejan, Convection in porous media, second edition, Springer-Verlag, New York, 1999.

4. B. Straughan, The energy method, stability, and nonlinear convection, second edition, Applied Mathematical Sciences, 91, Springer-Verlag, New York, 2004.
5. M. B. Banerjee and J. R. Gupta, Studies in hydrodynamic and hydromagnetic stability, Silver Line Publications, Shimla, 1989.

MTH 242 (b): APPLIED LINEAR ALGEBRA

L– P
3 – 0

Linear Operators: Functions, Linear operators, Null space and range, Rank and nullity theorem, Operator inverses, Application to matrix theory, Computation of the range and null space of a matrix, Matrix of an operator, Operator algebra, Change of basis and similar matrices, Applications.

Inner Product Spaces: Inner product between two vectors, orthogonal and orthonormal vectors, normed space, isometries, projection theorems and best approximations, orthogonal direct-sum, Riesz representation theorems, adjoint of a linear operator, unitary diagonalizability, normal operators, special types of normal operators, self-adjoint operators, unitary operators and isometries, structure of normal operators, orthogonal projection, orthogonal resolution of identity, spectral theorem, positive operators. Gram-Schmidt process for orthogonalisation, projection operator, quadratic forms, positive definite forms.

Eigen Decomposition: Eigenvectors, Eigenvalues, Gershgorin circles, Characteristic polynomial, Eigen spaces, Diagonalizability conditions, Invariant subspaces, Spectral theorem, Rayleigh quotient.

TEXT AND REFERENCE BOOKS:

1. K. Hoffman and R. Kunze, Linear algebra, Prentice-Hall Mathematics Series, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1961.
2. C. D. Meyer, Matrix analysis and applied linear algebra, Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 2000.
3. B. Noble and J. W. Daniel, Applied linear algebra, second edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1977.
4. P. J. Olver and C. Shakiban, Applied linear algebra, Pearson Prentice Hall, Upper Saddle River, NJ, 2006.
5. T. S. Shores, Applied linear algebra and matrix analysis, Undergraduate Texts in Mathematics, Springer, New York, 2007.

MTH 242 (c): ADVANCED OPERATIONS RESEARCH

L– P
3 – 0

Nonlinear Programming: *One Dimensional Minimization Methods*: Unimodel function, Elimination methods, unrestricted search, Exhaustive search, Dichotomous search, Fibonacci Method, Golden selection method. *Unconstrained Optimization Techniques*: Direct Search Method, Pattern search method, Descent methods, steepest descent method.

Dynamic Programming: Decision Tree and Bellman's principle of optimality, Concept of dynamic programming, minimum path problem, Mathematical formulation of multistage Model, Backward & forward Recursive approach, Application in linear programming.

Quadratic Programming: Formulation, converting into LPP, Simplex approach.

Stochastic Programming: Basic Properties of Probability theory, stochastic linear, nonlinear and dynamic programming.

Queuing Theory: Steady-state solution solutions of Markovian Queuing Models: M/M1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited space, M/G/1.

TEXT AND REFERENCE BOOKS:

1. F. S. Hillier and G. J. Lieberman, Introduction to operations research, third edition, Holden-Day, Inc., Oakland, CA, 1980.
2. H. A. Taha, Operations research: An introduction, The Macmillan Co., New York, 1971.
3. G. Hadley, Nonlinear and dynamic programming, Addison-Wesley Publishing Co., Inc., Reading, MA, 1964.
4. J. K. Sharma, Operations Research: Problems and Solutions, third edition, Laxmi Publications, 2009.
5. M. S. Bazaraa, H. D. Sherali and C. M. Shetty, Nonlinear programming, third edition, Wiley-Interscience, Hoboken, NJ, 2006.
6. S. D. Sharma, Operations Research, Kedarnath & Co., 2014.
7. S. Chandra, Jaydeva and A. Mehra, Numerical Optimization with Applications, Narosa Publishing House, 2009.
8. S. S. Rao, Optimization: theory and applications, Wiley Eastern Ltd., New Delhi, 1978.

MTH 242 (d): ADVANCED STATISTICAL MODELING

L– P
3 – 0

Background and Motivation: Background: Types of Data, Taxonomies, Basic Properties, Preliminary Concepts (Spatial Structures and Modeling). Motivation: Objectives and Applications. Challenges.

Review of Types of Data with Applications: Point level models. Spatial point processes.Areal (lattice) models.

Estimation and modeling of spatial correlations: Estimating variogram. Fitting parametric models: Matern class. Maximum likelihood estimation. Restricted maximum likelihood.

Prediction and Kriging: Lagrange multiplier approach. Conditional inference approach. Predicting at multiple sites. Model misspecification in kriging.

Spatial-Temporal Models: Separable vsnonseparable models. Continuous time models when spatial dependence is nuisance. Spatial models when time dependence is nuisance. Misalignment. Data integration.

Bayesian spatial statistics: Bayesian estimation. Bayesian kriging. Bayesian priors for covariance parameters. Hierarchical Bayesian methods.

TEXT AND REFERENCE BOOKS:

1. N. Cressie, Statistics for Spatial Data,Wiley-Blackwell, Revised edition, 2015.
2. S. Banerjee, B. P. Carlin, and A. E. Gelfand, Hierarchical modeling and analysis for spatial data, second edition, Chapman and Hall/CRC, 2014.
3. N. Cressie, and C. K. Wikle, Statistics for Spatio–Temporal data, Wiley-Blackwell, 2011.
4. M. L. Stein, Interpolation of spatial data: Some theory for Kriging, Springer, first edition, 2012.
5. O. Schabenberger and C. A. Gotway, Statistical methods for spatial data analysis, first edition, Chapman and Hall/CRC, 2004.
6. R. Haining, Spatial data analysis: Theory and practice, Cambridge University Press, 2003.
7. D. D. Sharma, Geostatistics with applications in earth sciences, second edition, Springer, 2009.

MTH 243 (a): COMPUTER NETWORKS

L– P
3 – 0

Introductory Concepts: Goals and Applications of Networks, LAN, WAN, MAN, Wireless network, Network software: Protocol hierarchies, design issues of layers, Interfaces and services. Reference Model: The OSI reference model, TCP/IP reference model, Example networks: The ARPANET, The Internet.

Physical Layer: Fourier Analysis, Maximum data rate of a channel, Transmission media, Wireless transmission, Virtual circuits, Circuit switching.

Data Link Layer: Data link layer design issues, services provided to network layers, Framing, Error control, Flow control, Error detection and correction, Elementary data link protocols, An unrestricted Simplex protocol, A Simplex Stop-and-Wait protocol, Simplex Protocol for a noisy channel, Sliding Window protocols, A one-bit Sliding protocol, A protocol using go-back-N, A protocol using selective repeat.

Medium Access Sublayer: Channel Allocations, Static and dynamic allocation in LAN and MAN, Multiple Access protocols, ALOHA, Carrier Sense multiple access protocols, Wireless protocols, Collision free protocols, Limited contention protocols, IEEE standard 802.3 and Ethernet, IEEE standard 802.4, Token bus IEEE standard 802.5, Token Ring, Distributed Queue Dual bus, Logical link control, bridges, High speed LAN.

Network Layer: Network Layer design issue, Routing algorithms, Congestion Control Algorithms, Internetworking.

Transport Layer: Transport services, Design issues, elements of transport protocols, simple transport protocols, Connection management, TCP, UDP.

Session, Presentation and Application Layer: Session Layer - Design issues, remote procedure call. Presentation Layer - Design issues. Application Layer - File Transfer, Access and Management, Electronic mail.

TEXT AND REFERENCRE BOOKS

1. A.S. Tanenbaum, Computer Networks, Prentice Hall of India.

2. J. Kurose and K.W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, Addison-Wesley.
3. W. Stallings, Data and Computer Communication, Prentice Hall of India.

MTH 243 (b): SOFTWARE ENGINEERING

L– P
3 – 0

Introduction: Problem domain, software engineering challenges, software engineering approach.

Software Processes: Software process, characteristics of software process, software development process models, other processes.

Software Requirements analysis and specification: Software requirements, problem analysis, requirements specification, functional specification with use cases, validation, matrices.

Software Architecture: Role of software architect, architecture views, component and connector view, architecture style for C & C view, discussion and evaluating architectures.

Planning a software project: Effort estimation, project scheduling and staffing, software configuration management plan, quality assurance plan, risk management, project monitoring plan.

Function oriented design: Design principles, module level concepts, design notation and specification, structured design methodology, verification, metrics.

Object oriented design: OO concepts, design concept, Unified Modeling Language, design methodology, metrics.

Detailed Design, Software Measurements, metrics and Models: Detailed design and PDL, verification, Metrics and their scope, Qualities of a good Software metrics, classification of metrics, Cost estimation models COCOMO, Quality attributes, SQA, Quality Standards, ISO 9000 and CMM.

Coding: Programming principles and guidelines, coding process, refactoring, verification, metrics.

Testing: Testing fundamentals, black-box testing, white-box testing, testing process, defect analysis and prevention, metrics - reliability estimation.

CASE Tools: Types of CASE tools, advantages and components of CASE tools, Unified Modeling Language

TEXT AND REFERENCRE BOOKS

1. P. Jalote, An integrated approach to software engineering, Narosa Publishing.
2. R. R. Pressman, Software Engineering: A Practitioner’s Approach, TMH.
3. R. Mall, Fundamentals of Software Engineering, Pretence Hall of India.
4. T. Pender, UML Bible, Wiley Dreamtech.

MTH 243 (c): DATA MINING

L– P
3 – 0

Introduction: Data warehousing Definition, usage and trends. DBMS vs data warehouse, Data marts, Metadata, Multidimensional data mode, Data cubes, Schemas for Multidimensional Database: stars, snowflakes and fact constellations.

Architecture: Data warehouse process & architecture, OLTP vs OLAP, ROLAP vs MOLAP, types of OLAP, servers, 3-Tier data warehouse architecture, distributed and virtual data warehouses, data warehouse manager.

Implementation: Data warehouse implementation, computation of data cubes, modeling OLAP data, OLAP queries manager, data warehouse back end tools, complex aggregation at multiple granularities, tuning and testing of data warehouse.

Data mining & tools: Data mining definition & task, KDD versus data mining, data mining techniques, tools and applications. Data mining query languages, data specification, specifying knowledge, hierarchy specification, pattern presentation & visualization specification, data mining languages and standardization of data mining. KDD Dataset.

Data mining techniques: Association rules, Clustering techniques, Decision tree knowledge discovery through Neural Networks & Genetic Algorithm, Rough Sets, Support Victor Machines and Fuzzy techniques.

Mining complex data objects: Spatial databases, Multimedia databases, Time series and Sequence data; mining Text Databases and mining Word Wide Web.

TEXT AND REFERENCRE BOOKS

1. S. Anahory & D. Murray, Data Warehousing in the Real World, Pearson.
2. J. Han & M. Kamber, Data Mining-Concepts & Techniques, Morgan Kaufmann.
3. P. Adriaans & D. Zantinge, DataMining, Pearson
4. A. Berson, Data Warehousing, Data Mining and OLTP, McGraw Hill.
5. Mallach, Data warehousing System, McGraw Hill.
6. W. H. Inman, Building the Data Warehouse, John Wiley & Sons.
7. W. H Ionhman C. Klelly, Developing the Data Warehouses, John Wiley & Sons.
8. W. H. Inman, C. L. Gassey, Managing the Data Warehouses, John Wiley & Sons.

MTH 243 (d): WEB DEVELOPMENT

L– P
3 – 0

Introduction to Web: Course Overview, The Internet and World Wide Web, Introduction to Markup, Essential HTML document structure, Essential HTML for content, HTML forms

CSS: CSS mechanics and basic selectors, CSS text properties, CSS block model, Colors and Images, CSS and lists, Multiple CSS stylesheets, The cascade and specificity of CSS, Fonts, CSS and Layouts, CSS frameworks, CSS Loose Ends, Image types (PNG, JPEG, GIF), features, properties and typical use, Tools for image creation and manipulation

JavaScript: JavaScript Events, DOM, jQuery, Focus on using and integrating JavaScript functionality, Slideshows, form validation, navigation, social media widgets, JSON, Ajax, JavaScript templates, Server Side : HTTP Overview, Caching, Compressing, Custom Error Pages, Redirects, HTTPS / TLS, Cookies

PHP: PHP Overview, PHP File Includes, PHP Web Applications, Example: Web Application Using Database and Templates, Web Content Management Systems (Web CMS)

XML: Introduction, Tree, Syntax, Elements, Attributes, Namespaces, HTTP Requests, Parser, XPath, XQuery

TEXT AND REFERENCRE BOOKS

1. J. Robbins, Learning Web Design, O'Reilly Media.
2. P. Deitel , H. Deitel, A. Deitel ,Internet and world wide web – How to Program, Prentice Hall.

MTH 243 (e): CLOUD COMPUTING

L– P
3 – 0

Introduction to Cloud Computing: Roots of Cloud Computing, Layers and Types of Clouds, Features of a Cloud, Cloud Infrastructure Management, Infrastructure as a Service Providers, Platform as a Service Providers, and Challenges and Opportunities.

Virtualization and Resource Provisioning in Clouds: Introduction and Inspiration, Virtual Machines (VM), VM Provisioning and Manageability, VM Migration Services, VM Provisioning in the Cloud Context, and Future Research Directions.

Cloud Computing Architecture: Cloud Benefits and Challenges, Market-Oriented Cloud Architecture, SLA-oriented Resource Allocation, Global Cloud Exchange; Emerging Cloud Platforms, Federation of Clouds

Programming Enterprise Clouds using Aneka: Introduction, Aneka Architecture, Aneka Deployment, Parallel Programming Models, Thread Programming using Aneka, Task Programming using Aneka, and MapReduce Programming using Aneka, Parallel Algorithms, Parallel Data mining, Parallel Mandelbrot, and Image Processing.

Advanced Topics and Cloud Applications: Integration of Private and Public Clouds, Cloud Best Practices, GrepTheWeb on Amazon Cloud, ECG Data Analysis on Cloud using Aneka, Hosting Massively Multiplayer Games on Cloud, and Content Delivery Networks Using Clouds, and Hosting Twitter and Facebook on Cloud.

TEXT AND REFERENCE BOOKS

1. R. Buyya, J. Broberg and A. Goscinski, Cloud Computing: Principles and Paradigms, ISBN-13:978-0470887998, Wiley Press, New York, USA.

2. A. T. Velte, T. J. Velte, Robert Elsenpeter, Cloud Computing : A Practical Approach, The McGraw-Hill.
3. B. Sosinsky, Cloud Computing Bible, Wiley Publishing.
4. M. J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, & IaaS), Wiley Publishing.

MTH 243 (f): DIGITAL IMAGE PROCESSING

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Introduction: Digital image representation, Fundamental steps in image processing, Elements of Digital Image processing systems, Elements of visual perception, Image model, Sampling and quantization, Relationship between pixels, Imaging geometry.

Image Enhancement: Enhancement by point processing, Sample intensity transformation, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters, Sharpening filters, Frequency domain: Low-Pass, High-Pass, Homomorphic filtering.

Image Compression: Coding redundancy, Inter-pixel redundancy, fidelity criteria, Image compression models, Error-free compression, Variable length coding, Bit-plane coding, Loss-less predicative coding, Lossy compression, Image compression standards, Fractal Compression, Real-Time image transmission, JPEG and MPEG.

Image Segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region oriented segmentation, Use of motion in segmentation, Spatial techniques, Frequency domain techniques.

Spatial Operations and Transformations: Spatially dependent transform template and convolution, Window operations, 2- Dimensional geometric transformations.

Pattern Recognition: Classification and description, Structure of a pattern recognition system, feature extraction, Classifiers, Decision regions and boundaries, discriminate functions, Supervised and Unsupervised learning, PR-Approaches statistics, syntactic and neural.

Statistical Pattern Recognition: Statistical PR, Classifier Gaussian Model, Classifier performance, Risk and error, Maximum likelihood estimation, Bayesian parameter estimation approach, clustering for unsupervised learning and classifiers.

TEXT AND REFERENCRE BOOKS

1. R. Gonzalez and R. E. Wood, Digital Image Processing, Prentice Hall of India.
2. A. Low, Introductory Computer Vision and Image Procession, McGraw Hill.
3. R. Schalkoff, Pattern Recognition-Statistical, Structural and neural approach, John Willey & Sons
4. W.K. Pratt, Digital Image Processing, McGraw Hill.
5. A. K. Jain, Fundamentals of Image Processing, Pearson.