**Revised Course Structure: MTech (MC)**

**1st SEMESTER**

| Sl.No. | Course Number | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MA501 | Probability, Statistics & Stochastic Processes | 3 | 0 | 0 | 6 |
| 2 | CS501 | Database Systems and Data mining | 3 | 0 | 0 | 6 |
| 3 | | Elective-I | 3 | 0 | 0 | 6 |
| 4 | | Elective-II | 3 | 0 | 0 | 6 |
| 5 | | Elective-III | 3 | 0 | 0 | 6 |
| 6 | MC503 | Simulation Lab | 0 | 0 | 3 | 3 |
| 7 | HS5XX | HSS Elective | 2 | 0 | 0 | 4 |
| | | **TOTAL** | **17** | **0** | **3** | **37** |

**2nd SEMESTER**

| Sl.No. | Course Number | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MA502 | Numerical Optimization | 3 | 0 | 0 | 6 |
| 2 | MA504 | Computational Differential Equations | 3 | 0 | 0 | 6 |
| 3 | CS514 | Design and Analysis of Algorithms | 3 | 0 | 0 | 6 |
| 4 | | Elective-IV | 3 | 0 | 0 | 6 |
| 5 | | Elective-V | 3 | 0 | 0 | 6 |
| 6 | MC504 | Data Structures & Algorithm Lab | 0 | 0 | 3 | 3 |
| 7 | MC594 | Seminar | 0 | 0 | 4 | 4 |
| | | **TOTAL** | **15** | **0** | **7** | **37** |

**3rd SEMESTER**

| Sl.No. | Course Number | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MA603 | Project Thesis-I | 0 | 0 | 0 | 24 |
| | | **TOTAL** | **0** | **0** | **0** | **24** |

**4th SEMESTER**

| Sl.No. | Course Number | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MA604 | Project Thesis-II | 0 | 0 | 0 | 24 |
| | | **TOTAL** | **0** | **0** | **0** | **24** |

**Total Credits= 37+37+24+24 = 122**

**MA 501 : Probability, Statistics and Stochastic Processes**

Algebra of sets, probability spaces, random variables, cumulative distribution functions, mathematical expectations, conditional probability and expectation, moments and inequalities, special discrete and continuous probability distributions, function of a random variable, random vectors and their distributions, convolutions, joint, marginal and conditional distributions, product moments, independence of random variables, bivariate distributions and properties, order statistics and their distributions, sampling distributions, Central Limit Theorem, strong law of large numbers, sequence of random variables, modes of convergence, distributions of the sample mean and the sample variance for a normal population, chi-square, t and F distributions, method of moments and maximum likelihood estimation, concepts of unbiasedness, criteria for choosing estimators, consistency and efficiency of estimates, confidence intervals, pivotal quantities, confidence intervals for proportions, simple and composite hypothesis, null and alternative hypotheses, types of error, level and size of tests, the most powerful test and Neyman - Pearson Fundamental Lemma, tests for one- and two-sample problems for normal populations, tests for proportions, likelihood ratio tests, chi-sqaure test for goodness of fit. discrete and continuous stochastic processes, markov chains, transition probability matrix, state spaces, classification of states, stationary distributions, ergodicity, poisson process, birth and death process.

**References:**

(1) Rohatgi, V.K., and Saleh, A.K.Md. Ehsanes (2009).An introduction to probability and statistics. Second Edition, Wiley India.
(2) Introduction to the Theory of Statistics; Alexander M. Mood, Franklin A. Graybill, Duane C. Boes, Tata McGraw Hill.
(3) Milton, J.S. and Arnold, J.C. (2009) Introduction to Probability and Statistics, Fourth Edition, Tata Mcgraw-Hill.
(4) Ross, S.M.(2008) Introduction to Probability Models, Ninth edition, Academis Press.
(5) Statistical Inference (2007), G. Casella and R.L. Berger, Duxbury Advanced Series

**CS 501 Database Systems & Data Mining**

Data models: entity-relationship, relational model. Query languages: relational algebra, relational calculus, SQL. Theory of database design: functional dependencies; normal forms: 1NF, 2NF, 3NF, Boyce-Codd NF; decompositions; normalization; Transaction management, Concurrency control; error recovery; Need for Data Mining Techniques, Data Preprocessing, Mining Frequent Patterns, Classification, Prediction, Clustering, etc Data Mining: Knowledge Representation Using Rules, Association and Classification Rules.

**Text Books:**


1. Abraham Silberschatz, Henry Korth, and S. Sudarshan, Database System Concepts, McGraw-Hill.
2. Raghu Ramakrishnan, Database Management Systems, WCB/McGraw-Hill.
3. Jiawei Han, Micheline Kamber and Jian Pei, Data Mining Concepts and Techniques, Morgan Kaufmann

**MC503 : Simulation Lab**

Random number and generators, algorithms for generation of random variables: Inverse transform method, convolution method, acceptance-rejection method,
Generation of continuous random variates: uniform, generalized (exponential), gamma, inverse gamma, weibull, gaussian, lognormal, Pareto, inverse gaussian, Burr type distributions, Generation of discrete random variates: discrete uniform, binomial, geometric, negative binomial, Poisson, estimation of different measures: mean, variance, quantiles, Real data analysis

References:
(1) Ross, S. M. (2011), Simulation, Academic Press
(2) Law, A. M. (2008), Simulation Modelling and Analysis, Tata McGraw Hill

**MA 502 : Numerical Optimization**

Introduction to optimization problems, Convex sets and convex funcions, their properties, convex programming problems, Lagranges Multiplier mehtod, Optimality conditions for unconstrained minimization and constrained minimization problems, KKT conditions.

Unimodal functions, Fibonnacci search, Linesearch methods, Convergence of generic line search methods, Method of steepest descent, more general descent methods, Conjugate gradient methods, Fletcher Reeves methods for nonlinear functions, Interior point methods for inequality constrained optimization, Merit functions for constrained minimization, logarithmic barrier function for inequality constraints, A basic barrier-function algorithm, perturbed optimality conditions, A practical primal-dual method

Mulitobjective programming, Efficient solutions, Dominated cones, Formulation of Goal programming problems and solution methodologies for linear Goal programming problem.

Introduction to Evolutionary methods and global optimization.

Practice of optimization algorithms using software.

Texts/References

1. J. Nocedal and S. Wright, Numerical Optimization, Springer Verlag 1999

2. P. Gill, W. Murray and M. Wright, Practical Optimization, Academic Press 1981

3. R. Fletcher, Practical Methods of Optimization, 2nd edition Wiley 1987, (republished in paperback 2000)

4. A. Conn, N. Gould and Ph. Toint, Trust-Region Methods, SIAM 2000

**MC504 :Data Structures & Algorithms Lab**

Fundamental Data structures: linked lists, arrays, matrices, stacks, queues, binary trees, tree traversals. Algorithms for sorting and searching: linear search, binary search, insertion-sort, bubble-sort, quicksort. Priority Queues: lists, heaps. Graphs: representations, depth first search, breadth first search. Hashing: separate chaining, linear probing, quadratic probing. Search Trees: binary search trees, red-black trees, AVL trees, splay trees, B-trees.

Experiments would be designed to provide hands-on experience in programming data structures and algorithms, to learn a few systems programming tools, and scripting.

References :


1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.
2. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison Wesley, 2005.
3. M. A. Weiss, Data Structures and Algorithm Analysis in C++, Addison-Wesley, 2007.

**MA 504 Computational Differential equations**

Introduction of system of linear IVP's and BVP's., Accuracy and stability of the numerical solution, Euler's Explicit and Implicit Method , Runge-Kutta Methods, Higher-Order Methods for the IVP, Linear Multistep Methods, Nonlinear Two-Point BVPs, Ansatz Methods for BVPs.
Classification of PDEs, Initial and Boundary Conditions, Finite Difference Method for PDE, Explicit Implicit Scheme, Consistency, Stability and Convergence, Stability analysis by matrix method and von Neumann method, Lax's equivalence theorem; FTCS, Backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff Method, Upwind Scheme; CFL Conditions; Finite Element Method for Ordinary Differential Equations - Variational Methods, Method of Weighted Residuals, Finite Element Analysis of One-Dimensional Problems

**References/Text**


(1) J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, 2004.
(2) W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press, 2nd Edn., 2005.
(3) J.C. Butcher, Numerical methods for ordinary differential equations, John Wiley and Sons, 2008
(4) K. E. Atkinson, W. Han, D. Stewart, Numerical solution of ordinary differential equations, John Wiley and Sons, 2009
(5) D. F. Griffiths, D.J. Higham, Numerical Methods for Ordinary Differential Equations: Initial Value Problems, Springer, 2010
(6) Tveito, R. Winther, Introduction to partial differential equations: a computational approach, Springer , 2005
(7) G. D. Smith, Numerical solution of partial differential equations: finite difference methods, Oxford University Press, 1985
(8) J. A. Trangenstein, Numerical solution of hyperbolic partial differential equations, Cambridge University Press, 2009
(9) L. Lapidus and G. F. Pinder, Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
(10) C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.
(11) R.M. M. Mattheij, S. W. Rienstra, J. H. M. ten ThijeBoonkkamp, Partial differential equations: modeling, analysis, computation, SIAM, 2005

## CS514 Design and Analysis of Algorithms

Data structures: linked list, stack, queue, tree, balanced tree, graph; Complexity analysis: Big O, omega, theta notation, solving recurrence relation, master theorem Sorting and searching: Quick sort, merge sort, heap sort; Sorting in linear time; Ordered statistics;
Problem solving strategies: recursion, dynamic programming, branch and bound, backtracking, greedy, divide conquer,
Graph algorithms: BFS, DFS, Shortest path, MST, Network flow; NP-completeness
Advanced topics: string matching, FFT-DFT, basics of approximation and randomized algorithms;

**References:**

1. Mark Allen Weiss, "Data Structures and Algorithms in C++", Addison Wesley, 2003.
2. Adam Drozdek, "Data Structures and Algorithms in C++", Brooks and Cole, 2001.
3. Aho, Hopcroft and Ullmann, "Data structures and Algorithm", Addison Welsey, 1984.
4. Introduction to Algorithms Book by Charles E. Leiserson, Clifford Stein, Ronald Rivest, and Thomas H. Cormen.

**MA 505Number Theory & Cryptography**

Divisibility in integers, Review of finite fields, Divisibility and Euclidean algorithm in integers, Well Ordering Property in the set of positive integers, Greatest common divisor and least common multiple and algorithms to find them, Primes, Fundamental Theorem of Arithmetic, Infinitude of primes of certain types.

Congruences, Euler's phi function, Euler-Fermat theorem, Wilson's theorem. Linear congruence equations, Chinese Remainder theorem, Multiplicativity and expression for $\varphi(n)$, Congruence equations of higher degree.

Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity Law and applications, Jacobi symbol, Tests of primality.

Multiplicative functions, Functions $\tau$, $\sigma$, and $\mu$ and their multiplicativity, Möbius inversion formula and its converse, Diophantine equations:$\mathbf{ax + by = c}$, $\mathbf{x^2 + y^2 = z^2}$, $x^4 + y^4 = z^4$, Sums of squares,Waring's problem, Binary quadratic forms over integers. Farey sequences.

Cryptosystems (definition illustrations and classical examples), the idea of public key cryptography, RSA Public Cryptosystems, RSA key generation and algorithm, the RSA conjecture, Attack on RSA crypto systems, ElGamal Public Key Cryptosystems and algorithm, Digital signature algorithm (DSA).

Elliptic curves - basic facts, Elliptic curves over $\mathbb{R}$, Q, finite fields, Group Law, Elliptic curve cryptosystems, analogue of ElGamal on elliptic curves, Primality testing and factorizations.

**Text Books:**


1. Niven and T. Zuckermann, An Introduction to the Theory of Numbers, 5th edition, Wiley Eastern, 2008.
2. D.E. Burton, Elementary Number Theory, Tata McGraw-Hill Edu. Pvt. Ltd., 7th edition, 2015.
3. Neal Koblitz, A Course in Number Theory and Cryptology, Graduate Texts in Mathematics, Springer, 1987.


**References:**


1. G. H. Hardy and E.M. Wright, Theory of Numbers, Oxford University Press, 6th edition, 2008.
2. S. G. Telang, M. Nadkarni& J. Dani, Number Theory, Tata McGraw-Hill, 2001.
3. M. Rosen and K. Ireland, A Classical Introduction to Number Theory, Graduate Texts in Mathematics, Springer, 1982.
4. D. Bressoud, Factorization and Primality Testing, Undergraduate Texts in Mathematics, Springer, 1989.
5. W. Trappe and L. Washington, Introduction to Cryptography and Coding Theory, Pearson Int.Edition, 2006.
6. R. A. Mollin, An introduction to cryptography, 2nd edition, Chapman and Hall/CRC Edition, 2007.
7. A. J. Menezes et al., Handbook of Applied Cryptography, CRC Press, 1997.

**MA508 Fuzzy sets and Artificial Intelligence**

Basic Concepts of fuzzy sets, Fuzzy logic, Types of membership functions, Structure of algebra of fuzzy sets, Basic concepts (support, singleton, height, $\alpha$-cut projections), Zadeh's extension principle, Operations on fuzzy sets, T- norms and T- conorms, Fuzzy complement, Fuzzy measures, Probability and Possibility measures, Linguistic variables and hedges, Membership function design.

Classical relations, Fuzzy relations, Fuzzy to crisp conversions, Fuzzy inference methodologies, Graphical techniques of inference, Fuzzyifications/ Defuzzification, Introducing higher order fuzzy sets.

Fuzzy systems and algorithms, Approximate reasoning, Applications of fuzzy Sets in management, decision making, medicine and computer Science.

Introduction to Artificial Intelligence, Production System and Artificial Intelligence, Lambda expression, Fault locate and fault detect system, Logic of atleast-atmost, Decision making, Game playing, Theory of evidence, Conceptual dependency, Knowledge Bases and Expert Systems, Neuro Fuzzy Approaches, Case Studies in Various Domain.

Texts:


- S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 2nd Ed, Prentice Hall, 2003.
- H.J.Zimmermann, *Fuzzy Set Theory and Its Applications*, 2nd Ed., Kluwer Academic Publishers, 1996.
- D.Dubois and H. Prade, *Fuzzy Sets and Systems: Theory and Applications*, Academic Press, 1980.
- P. Klement, *Triangular Norms.* London: Kluwer Academic Press, 2000.
- H T. Nguyen, E A. Walker, *Fuzzy Logic.* New York: Chapman and Hall, 2000.


References:


- E. Charniak and D. McDermott, *Introduction to Artificial Intelligence*, Addison-Wesley, 1985.
- E. Rich, *Artificial Intelligence*, McGraw-Hill, 1983.
- P. H. Winston, *Artificial Intelligence*, Addison Wesley, 1993.
- J.Yen and R.Langari, Fuzzy Logic Intelligence, Control, and Information, Pearson Education, 2005.
- T.J.Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill, 1997.
- J.Kacprzyk, *Multistage Fuzzy Control*, Wiley, 1997.

# MA511 - LARGE SCALE SCIENTIFIC COMPUTATION

**Introduction to Direct Methods:** Direct Methods for solving linear systems and Application to BVP, Discritization of PDE's. (06 Lectures)

**Sparse Matrices:** Introduction to sparse matrices, Storage Schemes, Permutations and Reorderings, Sparse Direct Solution Methods.(06 Lectures)

**Basic iterative methods:** Iterative method for solving linear systems: Jacobi, Gauss – Seidel and SOR and their convergence, projection method: general projection method, steepest descent, MR Iteration, RNSD method (6 Lectures)

**Krylov subspace methods**: Introduction to Krylov subspace, Arnoldi's method, GMRES method, Conjugate gradient algorithm, Lanczos Algorithm, Block KrylovMethods (6 Lectures)

**Preconditioners**: Introduction to preconditioners, ILU preconditioner,preconditioned CG. (6 Lectures)

**Parallel implementation:** Architecture of parallel computers, introduction to MPI &openMP, HPC kernels (BLAS, multicore and GPU computing)(6 Lectures)

**Introduction to domain decomposition and multigrid methods** (6 Lectures)

**Texts / References**


- Yousef Saad; Iterative Methods for Sparse Linear Systems; SIAM 2003
- C.W. Ueberrhuber; Numerical Computation : Methods, Software and Analysis; Springer-Verlag, Berlin, 1997.
- P. Wesseling; An Introduction to Multigrid Methods; John Wiley & Sons 1992.
- A. Grama, A. Gupta, G. Karypis, V Kumar; Introduction to Parallel Computing; Pearson Education Limited 2003

**MA 539 Mathematical Modeling**

System of differential equations; Linear and nonlinear stability; Basic idea of bifurcation; some illustrations with help of computer programming

Introduction to modeling; Elementary mathematical models and General modeling ideas; General utility of Mathematical models, Role of mathematics in problem solving; Concepts of mathematical modeling; System approach; formulation, Analyses of models; Pitfalls in modeling;

Illustrations models such as Population dynamics, Traffic Flow, Social interactions, Viral infections, Epidemics, Finance, Economics, Management, etc. (*The choice and nature of models selected may be changed with mutual interest of lecturer and students.*)

Introduction to probabilistic models.

***Text & References:***


1. D. N. P. Murthy, N. W. Page, Ervin Y. Rodin, Mathematical modelling: a tool for problem solving in engineering, physical, biological, and social sciences, Pergamon Press, 1990.
2. W. E. Boyce and R.C. DiPrima, Elementary Equations and Boundary Value Problems, 7th Edition, Wiley, 2001.
3. J. D. Murray, Mathematical Biology, Vol I, 3rd Ed, Springer, 2003.
4. Wei-Bin Zhang, Differential equations, bifurcations, and chaos in economics, Series on Advances in Mathematics for Applied Sciences, Vol 68, World Scientific, 2005.

**MA 503. Discrete Structures** **(3-0-0-6)**

Mathematical Logics, Sets, Relations and Mappings:
Statements, Logical connectives, Truth tables,Equivalence, Inference and deduction, Predicates, Quantifiers. Relations, Equivalence relations, PartialOrder relations and lattices, Chains, Antichains, Dilworth's Theorem, Composition of mappings, one-oneand onto mappings, Pigeonhole Principle, Counting techniques, Countable and Uncountable sets.

Semigroups and Monoids:
Semigroups, Monoids, Subsemigroups/monoids, Congruence and quotientsemigroups/monoids, Homomorphism, isomorphism and the basic isomorphism theorem.

Graph Theory:
Basic concepts of graphs, directed graphs and trees, Adjacency and incidence matrices,Spanning trees, Matchings and Coverings, Hall's condition, Graph Coloring, Planar Graphs, Eulerian andHamiltonian graphs.

Combinatorics:
Permutation, Combination, Principle of inclusion and exclusion, Recurrence relations,Generating functions

Boolean Algebra:
Boolean algebra and their various identities, Homomorphisms and isomorphisms,Atoms and the Stone's theorem (finite case), Boolean functions, their simplification.

Texts and References:

1.C.L. Liu, Elements of Discrete Mathematics, McGraw-Hill, 1985

2.D.B. West, Introduction to Graph Theory, 2nded., 2001, PHI Learning

3.P.J. Cameron, Combinatorics: Topics, Techniques, Algorithms, First Ed. 1994, Cambridge University Press

4.I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to the Theory of Numbers, 1991, John Wiley and sons.

5.P.R. Halmos, Naive Set Theory, UTM, Springer, 1

**MA 509 Graph Theory (3-0-0-6)**

Basic notions of Graph theory: Subgraphs, Factors, Paths, Cycles, Connectedness, Eulerian graph, Bipartite graph, Adjacency and Incidence matrices, Graph isomorphism, Bipartite graph and matrices, Diameter and eigenvalues, Trees, Leaves, Forests, Counting labelled trees, Spanning subgraphs, Minimum spanning trees and algorithms of Kruskal, Prim .Colouring Graphs, Colouring Trees and Cycles.Distance between spanning tree of a connected graph, eccentricity, Centre(s) of trees and connected graph, diameter of tree and connected graph. Cut-sets, Fundamental cut set.
The Marriage theorem, Weighted Bipartite matching, Matching in general graph, Connectivity, k-connected graphs. Cliques and minors in a graph.Planar graphs, planarity detection, Euler's formula, genus of a graph. The five colour theorem, Vertex coloring and Chromatic Number, Chromatic Partitioning, Minimal dominating set, Chromatic Polynomial,Edge colouring, Hamiltonian cycles. Maximal independent sets, coverings, Number of a connected graph, Flows in networks, Max –Flow –Min-Cut Theorem and its applications.

Regular graphs, Eigen values of regular graphs, Diameter of regular graphs, Ramanujan graphs. Groups as Groups of Symmetries of a graph, Normal Subgroups, Isomorphism Theorems, Cyclic groups, Dihedral Groups.Permutation groups.

Text and References:

1.S.M. Cioaba, M. Ram Murty, A first Course in Graph Theory and Combinatorics, TRIM, Hindustan Book Agency, 2009.
2.J A Bondy and USR Murty : Graph Theory, GTM 244, Springer, 2008
3.D. Jungnickel, Graphs, Networks and Algorithms, Springer, 2005.
4.Reinhard Diestel, Graph Theory, Graduate Texts in Mathematics, Springer, 1997.
3.B. Bollobas, Graph theory an introductory course, GTM 63, Springer-Verlag, New york, 1979.
4.J.H. van Lint and R.M. Wilson, A course in combinatorics, Cambridge University press, 19

**List of Electives:**

| | |
|---|---|
| MA505 | Number Theory & Cryptography |
| MA508 | Fuzzy sets and Artificial Intelligence |
| MA511 | Large Scale Scientific Computation |
| MA539 | Mathematical Modeling |
| MA 503 | Discrete Structures |
| MA 509 | Graph Theory |
| CS561 | Artificial Intelligence |
| CS503 | Advances in Algorithm |
| CS504 | Advanced Graph Theory |
| CS547 | Foundation of Computer Security |
| CS544 | Introduction to Network Science |
| CS542 | Software Testing |
| CS543 | Distributed Systems |
| CS528 | CAD for VLSI |
| CS548 | Wireless Networks |
| CS549 | Computer and Network Security |
| CS508 | Formal methods for analysis and verification |
| CS743 | Advanced topics on Database |
| CS502 | Pattern Recognition |

In addition other relevant courses as decided by the department may be opted.