Indira Gandhi National Tribal University

Amarkantak (M. P.)-484887

(A Central University Established by an Act of Parliament)

SYLLABUS

For Ph.D. Course Work

Department of Mathematics

(Faculty of Science)

Ph.D. Program in Mathematics

Course Structure

A. Common Course (05 credits)

Course Code	Title	Nature	Credits
SCC-01	Research Methodology and Computer Application	Compulsory	04
SCC-02	Lab. Work based on SCC-01	Compulsory	01

B. Discipline-Specific Courses (05 credits)

Course Code	Title	Nature	Credits
MA-601	Advancement in Mathematics	Compulsory	05

C. Research Theme-Specific Courses (05 Credits)

Course Code	Title	Nature	Credits
MA-602 to MA-620	Specialization paper (elective)	Elective	03
	Review of literature & Presentation		02

Total Credit (A+B+C)	15
Duration of the entire course	06 month (i.e. One Semester)

Table of Contents

1. Advancement in Mathematics (MA-601)

Unit-1:
Metric completion, Baire category theorem, Contraction mapping, Banach's fixed point theorem, normed linear spaces, inequalities, Banach spaces, summability in Banach spaces.

Unit: 2

Solution methods of finite difference equations: elliptic equations, parabolic equations, hyperbolic equation, example problems, stability, convergence and consistency of the solution methods, finite element methods.

Unit-3:

Method of weighted residuals: Galerkin's method, collection method, method of least square, numerical solution of ordinary and partial differential equations using these methods.

Unit-4: MATLAB:

Basic Introduction: Simple arithmetic calculations, creating and working with arrays, numbers and matrices, creating and printing simple plots, function files, basic 2-D plots and 3-D plots. **(05 Lectures)**

Unit-5: LATEX:

Basic Introduction: Mathematical symbols and commands, Arrays, formulas, and equations, spacing, borders and colors, using date and time option in LaTeX, to create applications and letters, beamer (PPT in Latex), writing an article, pictures and graphics in LATEX.

Books:

1. G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, 2001
2. J.N. Reddy, An Introduction to Finite Element Methods, McGraw Hill, 2007
3. Chandrasekhar Rao, Functional Analysis, Alpha Science International Ltd., 7200 The Quorum, Oxford Business Park North Garsington Road, Oxford OX4 2JZ, United Kingdom.
4. Erwin Kreyszig, Functional analysis with applications, John Wiley & Sons, New York, 1978.
5. R. Pratap: Getting started with MATLAB, Oxford University Press, 2010.
6. S. Lynch, Dynamical Systems with Applications using MATLAB, Birkhäuser, 2014.
7. L.W. Lamport, LaTeX: A document Preparation Systems, Addison-Wesley Publishing Company, 1994.
8. H. Kopka, P.W. Daly, Guide to LATEX, Fourth Edition, Addison Wesley, 2004.

2. Theory of Approximations (MA-602)

Unit-1.
Concept of best approximation in a normed linear space, Existence of best approximation, Uniqueness problem, Uniform convexity, Strict convexity, continuity of best approximation operator.

Unit-2.
Carleson-Hunt theorem, Convergence of Fourier series, Divergence of Fourier, Weierstrass approximation theorem, Bernstein polynomials, Weierstrass second theorem, Monotone operators, Korovkin theorems, Modulus of continuity and its properties, Lipschitz class and its properties, Banach fixed point theorem, Jackson's theorems,

Unit-3.
General linear families, characterization theorem, Haar conditions, Alteration theorem, Markoff systems, Theorem of de la Valle Poussin, Borel summability, Abel and matrix summability, Abel transformation, Product summability transform.

Unit-4.
Strong unicily theorem, Haar's theorem, the convergence of Jackson theorems, Bernstein inequality, Bernstein theorems, Zygmund theorem, Summability theorems.

Unit-5.
Positive linear operators with their approximation properties, Local and Global approximation, Rate of convergence, weighted approximation, Direct and inverse results, Voronovskaja-type asymptotic formula, approximation in quantum calculus and (p, q)-calculus.

(Total Contact Time: 50 Hours)

BOOKS:

1. P.P. Korovkin Edited by A.R. Gairola, Korovkin's Linear operators and approximation theory, Ist revised edition**,** Hindustan Publishing Corporation, New Delhi, India, 2017.
2. G.G. Lorentz, Bernstein Polynomials, University of Toronto Press, Toronto, 1997.
3. I.P. Natanson, Constructive Function theory Vol. I, Uniform approximation (Frederick Ungar, New York, 1964.
4. M.J.D. Powell, Approximation theory and methods, Cambridge University Press, 1981.
5. H.N. Mhaskar & D.V. Pai, Fundamental of approximation theory, Narosa Publishing House, New Delhi, 2000.
6. Chandrasekhar Rao, "Functional Analysis", Alpha Science International Ltd., 7200 The Quorum, Oxford Business Park North Garsington Road, Oxford OX4 2JZ, United Kingdom.
7. R.R. Goldberg, Methods in Real Analysis, John Wiley & Sons, Inc. 1976.
8. George Bachman, Lawrence Narici & Edward Beckenstein, Fourier and Wavelet analysis, Springer 2002.

3. Applied Summability Methods (MA-603)

Unit 1.
Sequence, infintite series, summability factors, Abel summability and Cesàro summability, Euler-Knopp matrix, Nörlund mean, Borel matrix, Riesz mean, The Dirichlet and Fejér kernels, Matrix transformations.

Unit 2.
Toeplitz matrix, Regularity of summability methods, almost strongly regular matrices, Banach limits and almost convergence, Absolute almost convergence, Some inclusion theorems for sequence spaces. Absolute indexed Nörlund and Riesz summability.

Unit 3.

Lambert summability and the prime number theorem, Hausdorff matrices, Nonlinear summability, Almost summability of Taylor series, Matrix summability of Fourier and Walsh Fourier series.

Unit 4.

Summability tests for singular points, Lototski summability and analytic continuation, summability methods for random variables, A-summability of a sequence of random variables, application of almost convergence in approximation theorems for functions of two variables.

Unit 5.
Statistical summability, Results on statistical convergence, statistical Cauchy sequences, Strong Cesàro summability, application to Fourier series, A-statistical convergence, statistical A-summability, Application of statistical summability (C, 1), Application of statistical A-summability, rate of statistical A-summability, statistical approximation of positive linear operators.

(Total Contact Time: 50 Hours)

BOOKS:

1. P.P. Korovkin, Linear Operators and Approximation Theory, Hindustan Publishing Corporation, Delhi, 1960.
2. I.J. Maddox, Elements of Functional Analysis, 2nd edn., The University Press, Cambridge, 1988.
3. A. Peyerimhoff, Lectures on Summability, Lectures Notes in Mathematics, vol. 107, Springer, New York, 1969.
4. M. Mursaleen and S.A. Mohiuddine, Convergence methods for double sequences and applications, Springer 2014.
5. M. Mursaleen, Applied summability methods, Springer 2014.

4. Nonlinear Analysis and Applications (MA-604)

Unit 1.

Nonlinear operators, monotone, strictly monotone and strongly monotone operators, their properties and applications. Calculus of Banach space, Frechet and Gateaux differentiability.

Unit 2.

Strict convexity and uniform convexity of norms, semi inner product spaces, Banach algebras and their second duals, Semigroups, Semigroup algebras.

Unit 3.

Fixed point theory, Banach contraction mapping theorem, Non-expansive mappings, contractive type mappings, generalizations of Banach contraction mapping theorem, fixed point theorem of other types, Applications, Optimization in Banach spaces.

Unit 4.

Measures of noncompactness, The Kuratowski and Hausdorff measures of noncompactness, The separation measure of noncompactness, Darbo Theorem, Applications, Variational inequalities.

Unit 5.

Fredholm and Volterra Integro- Differential equation, Singular and nonlinear Integral Equation, direct computation, Successive approximation, Successive substitution methods for Fredholm Integral Equations, Fredholm and Volterra Integro-Differential equation, Methods in Nonlinear Integral Equations, Applications.

(Total Contact: 50 Hours)

Books:

1. C. Cordumeanu, Integral Equations and Applications, Cambridge University Press, 1991.
2. E. Zeidler, Nonlinear Functional Analysis and its Applications, I. Fixed-Point Theorems,Translated from the German by Peter R. Wadsack, Springer-Verlag, New York, 1986.
3. J. Banas, and K. Goebel, Measures of Noncompactness in Banach Spaces, Lecture Notes in Pure and Applied Mathematics, Vol. 60, Marcel Dekker, New York, 1980.
4. K. Deimling, Nonlinear Functional Analysis, Springer-Verlag, New York, 1985.
5. B. Choudhary, S. Nanda, Functional Analysis with applications, New Age Int. (P) Ltd., New Delhi, 2015.

5. Optimization Theory and Applications (MA-605)

Unit-1: Linear Programming Problem
Linear Programming Problem (LPP), Requirements of LPP, Mathematical formulation of LPP, Examples from industrial cases, Two-Variable LP Model, Graphical LP Solution, Solution of a Maximization Model, Solution of a Minimization Model, Selected LP Applications, Advantages, Limitations, Motivation of the simplex method, Simplex method, Penalty cost method or Big M-method, Two phase method, Importance of duality concepts, Formulation of dual problem, Economic interpretation of duality, Dual simplex method.

Unit 2: Integer Programming
Motivation of Integer Programs, Formulation of various industrial problems as integer and mixed integer programming problems, Branch and bound algorithm, Cutting plane method.

Unit 3: Dynamic Programming
Multistage decision processes, Concept of Bellman's principle of optimality and recursive relationship of dynamic programming for different optimization problems.

Unit 4: Network Optimization Models
Motivation and introduction, Shortest Path Problem, The Minimum Spanning Tree Problem, The Maximum Flow Problem, The Minimum Cost Flow Problem, The Network Simplex Method, Applications.

Unit 5: Nonlinear Programming
Types of nonlinear programming problems, Differentiable convex function, Minimization and maximization, Convex set, Convex function, Differentiable convex functions, Sub differential of a convex function, Saddle point Conditions, Single variable optimization; Multi variable optimization with no constraints (semidefinite case, saddle point), with equality constraints (solution by direct substitution, method of constrained variation, method of Lagrange multipliers), with inequality constraints (Kuhn-Tucker conditions, constraint qualification); Convex programming problem, NLP: One dimensional minimization methods.

(Total Contact time: 50 Hours)

Books:

1. F.S. Hiller and G.J. Lieberman, Introduction to Operations Research, McGraw Hill, 8th Edition, 2005, ISBN: 978-0-07-060092-8.
2. H.A. Taha, Operations Research: An Introduction, Pearson Prentice Hall, 8th Edition, 2007, ISBN 0-13-188923·0.
3. S.S. Rao, Engineering Optimization Theory and Practice, John Wiley & Sons, Inc., 4th Edition, 2009, ISBN: 978-0-470-18352-6.
4. M.S. Bazarra, H.D. Sherali and C.M. Shetty, Nonlinear Programming Theory and Algorithms, John Wiley, New York, 1979.

6. Actuarial Mathematics (MA-606)

Unit-1:

Discrete random variables, some discrete probability distributions, discrete uniform, binomial, negative binomial, geometric and poisson distribution, some continuous probability distributions, continuous uniform, normal, exponential, and gamma distribution. **(Lecture 10)**

Unit-2:

Probability for the Age-at-Death, the survival function, time- until-death for a person aged *x,* Curtate-future-lifetime, force of mortality, life tables, relation of life table functions to the survival function, life table examples, the deterministic survivorship group, other life table functions, assumptions for fractional ages, Some analytical laws of mortality, some analytical laws of mortality, select and ultimate tables.**(Lecture 10)**

Unit-3:

Introduction to Life Insurance, insurances payable at the moment of death, level benefit insurance, endowment insurance, deferred insurance, varying benefit insurance, insurances payable at the end of year of death, relationships between Insurances payable at the moment of death and the end of year of death, recursion equation, commutation functions.**(Lecture 10)**

Unit-4:

Single payment contingent on survival, continuous life annuities, discrete life annuities, life annuities with mthly payments, commutation function formulas for annuities with level payments, varying annuities, recursion equations, complete annuities-immediate and apportionable annuities-due. **(Lecture 10)**

Unit-5:

Net premiums or benefit premiums, the random future loss under an assurance or annuity contract, state the principle of equivalence, notations and formulae of net premium for common life insurance contracts, fully discrete premiums, true monthly payment premium, commutation functions, increasing and decreasing benefit premiums, profits contract, types of bonus, calculating net premiums for with-profit contracts.**(Lecture 10)**

Books:

1. Robin Cunningham, Thomas N. Herzog, L. Richard, Models for Quantifying Risk (4^{th} edition), ACTEX Publications, 2011.
2. N. L. Bowers, H. U. Gerber, J. C. Hickman, Actuarial Mathematics, 2nd Society of Actuaries, 1997.
3. D. C. M. Dickson,M. R. Hardy, H. R. Waters, Actuarial Mathematics for Life Contingent Risks, International series on actuarial science Cambridge, 2009.
4. S. R. Deshmukh, An Introduction to Actuarial Statistics, University Press, 2009.
5. V. K. Rohatgi, Ehsanes Saleh A. K. MD, An Introduction to Probability Theory and Mathematical Statistics (2^{nd} edition), Wiley Eastern, 2003.

7. Design and Analysis of Algorithms (MA-607)

Unit-1:

Algorithm introduction, algorithm specification,pseudo code conventions, recursive algorithms,performance analysis,space Complexity, time complexity, asymptotic notation, practical complexities.**(Lecture 10)**

Unit-2:

Data structures and Queues, linear data structures,concepts of non-primitive data structures, storage structure for arrays, stacks, operations on stacks, queues,priority queues.**(Lecture 10)**

Unit-3:

Linked lists and trees, linked linear lists, operations on linked linear lists, circularly linked lists, doubly linked linear lists,non-linear data structures, trees, binary trees, operations on binary trees, storage representation and manipulations of binary trees.**(Lecture 10)**

Unit-4:

Search and Sort, Divide and conquer,general method,binary search,finding the maximum and minimum in a set of items,merge sort, quick sort, selection sort, basic traversal and search techniques for graphs,breadth first search, depth first search.**(Lecture 10)**

Unit-5:

Backtracking,the 8-Queens problem,algebraic problems, the general method, evaluation and interpolation, Horner's rule, Lagrange interpolation, Newtonian interpolation.**(Lecture 10)**

Books:

1. E. Horowitz, S.Sahni, S.Rajasekaran, Fundamentals of Computer algorithms, Galgotia Publications Pvt. Ltd., 2004.
2. J.P. Tremblay, P. G.Sorenson, An introduction to data structures with applications (2nd edition), Tata McGraw Hill Publishing Company Limited New Delhi, 1995.
3. A.V. Aho, J.E.Hopcroft, J.D. Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley Publ. Comp., 1974.
4. S. E. Goodman, S.T. Hedetniemi, Introduction to the design and analysis of algorithms, McGraw Hill International Edition, 2002.

8. Soft Computing (MA-608)

Unit-1:

Introduction to soft computing,evolution of computing, Soft Computing constituents, from conventional Artificial Intelligence tocomputational Intelligence, Machine Learning basics.**(Lecture 8)**

Unit-2:

Introduction to Genetic Algorithms (GAs), building block hypothesis, working principle, basic operators and terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modelling,significance of Genetic operators, Inheritance operator, cross over, inversion & deletion, mutation operator, bitwise operator, GA optimization problems, JSPP (Job Shop Scheduling Problem), TSP (Travelling Salesman Problem),Differences & similarities between GA & other traditional methods, Applications of GA. **(Lecture 14)**

Unit-3:

Neural Network, machine learning using neural network, adaptive networks, feed forward networks, supervised learning neural networks, radial basis function networks, reinforcement learning,unsupervised learning neural networks, adaptive resonance architectures and advances in neural networks.**(Lecture 10)**

Unit-4:

Fuzzy Sets, operations on fuzzy sets,fuzzy relations,membership functions, fuzzy rules and fuzzy reasoning,fuzzy inference systems,fuzzy expert systems,fuzzy decision making.**(Lecture 8)**

Unit-5:

Neuro-Fuzzy Modelling, adaptive neuro-fuzzy inference systems,coactive neuro-fuzzy modelling, classification and regression trees, data clustering algorithms,rule base structure identification, Neuro-Fuzzy Control – case studies.**(Lecture 10)**

Books:

1. J. S. Roger Jang, C. T. Sun, E.Mizutani, Neuro-Fuzzy and Soft Computing, Prentice-Hall of India, 2003
2. K. H.Lee, First course on Fuzzy Theory and Applications, SpringerVerlag Berlin Heidelberg, 2005.
3. G. J. Klir, B. Yuan, Fuzzy Sets and Fuzzy Logic-Theory and Applications, Prentice Hall, 1995.
4. J. A. Freeman, D. M. Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Edn., 2003.
5. D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison Wesley, 2007.
6. M. Gen, R. Cheng,Genetic Algorithms and Engineering Optimization, Wiley Publishers, 2000.
7. M. Melanie, An Introduction to Genetic Algorithm, Prentice Hall, 1998.
8. S.N.Sivanandam, S.N.Deepa, Introduction to Genetic Algorithms, Springer, 2007.
9. A.E. Eiben and J.E. Smith, Introduction to Evolutionary Computing, Springer, 2003

9. Energy Aware Computing (MA-609)

Unit-1:

Energy efficient network on chip architecture for multi core system, energy efficient MIPS CPU core with fine grained run time power gating,low power design of emerging memory technologies. **(Lecture 10)**

Unit-2:

Disk energy management, power efficient strategies for storage system, dynamic thermal management for high performance storage systems, energy saving technique for disk storage systems.**(Lecture 10)**

Unit-3:

Scheduling of parallel tasks,task level dynamic voltage scaling,speed scaling,processor optimization, memeticalgorithms, and online job scheduling Algorithms. **(Lecture 10)**

Unit-3:

Multi-processor system,real time tasks, energy minimization, energy aware scheduling, dynamic reconfiguration, adaptive power management, energy harvesting embedded system.**(Lecture 10)**

Unit-3:

Energy aware applications: on chip network, video codec design, surveillance camera, low power mobile storage.**(Lecture 10)**

Books:

1. I. Ahmad, S. Ranka, Handbook of Energy Aware and Green computing, Chapman and Hall/CRC,2012.
2. C. M. Kyung, S. Yoo, Energy Aware system design Algorithms and Architecture, Springer,2011.
3. B. S. Wald, C. Luero, Energy Aware computing, Intel Press,2012.

10. Intelligent Computing (MA-610)

Unit-1:

Introduction to basic intelligent computing techniques, Evolutionary Computation: Genetic Algorithms, Evolutionary Strategies, Evolutionary Programming, Particle Swarm Optimization, Ant Colony Optimization, Artificial Immune Systems,Harmony Search, Honey-Bee Optimization, Memetic Algorithms, CoEvolution, Multi-Objective Optimization, Artificial Life, Constraint Handling. **(Lecture 10)**

Unit-2:

Neural Networks: mathematical model of neural networks, artificial neural network learning methods and learning strategies, activation functions, multilayer-perceptron network, Selforganizing Map (Kohonen network), Hopfield Network, Radial Basis Function (RBF) network. **(Lecture 10)**

Unit-3:

Fuzzy Logic: Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions,basic operations on fuzzy sets, properties of fuzzy sets, fuzzy relation,hybrid system and its applications. **(Lecture 10)**

Unit-4:

Computational Logic: modal logic and temporal logic,some applications of modal logic and temporal Logic,multi agent systems,agent and their characteristics, multi agent paradigm, coordination and communication and cooperation. **(Lecture 10)**

Unit-5:

Application to intelligent tutoring systems, E-commerce and Elearning.**(Lecture 10)**

Books:

1. E. Eberhart, Y. Shi, Computational Intelligence: Concepts and Implementations, Morgan Kaufmann San Diego, 2007.
2. S. Rajasekaran, G.A.VijaylakshmiPai, Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India, 2003
3. A. P.Engelbrecht, Computational Intelligence: An Introduction, John Wiley, New York, 2003.
4. A. Konar, Computational Intelligence: Principles, Techniques, and Applications, Springer, Berlin, Germany, 2005.
5. M. Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, Addison Wesley, 2002.
6. D. B. Fogel, C.J. Robinson,Computational Intelligence: The Experts Speak, John Wiley, New York, 2003.

11. Parallel Computing (MA-611)

Unit 1:

Review of multiprocessor and distributed systems, Conditions of parallelism, program partitioning and program flow mechanisms. Parallel Models: Shared memory model, message memory model, data parallel model, object-oriented model, functional and logic models.**(Lecture 10)**

Unit 2:

Parallel Algorithms: Cost, Efficiency, PRAM algorithms, Mesh algorithms, hypercube algorithms, combinational circuit algorithms. **(Lecture 10)**

Unit 3:

Parallel languages and compilers: Language features for parallelism, parallel language constructs, optimizing compilers for parallelism, dependency analysis, code optimization and scheduling, loop parallelization and pipelining. **(Lecture 10)**

Unit 4:

Parallel program development: Parallel programming environments, synchronization and multiprocessing modes, shared variable program structures, message passing, program development, mapping programs onto, multicomputers. **(Lecture 10)**

Unit 5:

Multiprocessor UNIX (design goals), Master slave and multithreaded Unix, multicomputer Unix extension, Mach/OS kernel architecture, OSF/1 architecture and programming environment.**(Lecture 10)**

Books:

1. M. J. Quinn, Parallel Computing – theory and practice, McGRAW-HILL, 1994.
2. K. Hwang, Z. Xu, Scalable Parallel Computing: Technology, Architecture, Programming, McGRAW HILL, 1997.
3. B. Wilkinson, MiChael Allen, Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, Prentice Hall, 2005.
4. J. Dillimore, T. Kindberg, Distributed Systems: Concepts and Design, George Coulouris, Addison Wesley, 2005.

12. Mathematical modeling for Health Care (MA-612)

Unit 1:

Introduction to health care information, health care data quality, health care information regulations, laws and standards. **(Lecture 8)**

Unit 2:

History and evolution of health care information systems,current and emerging use of clinical information systems, system acquisition, system implementation and support. **(Lecture 10)**

Unit 3:

Information architecture and technologies that support health care information systems, health care information system standards, security of health care information systems. **(Lecture 10)**

Unit 4:

Management of IT challenges: Organizing information technology services – IT alignment and strategic planning, IT governance and management. **(Lecture 10)**

Unit 5:

IT Initiatives: Management's role in major IT initiatives, Assessing and achieving value in health care information systems. Case study.**(Lecture 12)**

Books:

1. K. A. Wager, F. W. Lee, J. P. Glaser,Managing Health Care Information Systems: A Practical Approach for Health Care Executives, John Wiley, 2009.
2. M. J. Ball, C. Weaver, J. Kiel,Healthcare Information Management Systems: Cases, Strategies, and Solutions, Springer, 2010.
3. R. V. DeVelde and P.Degoulet, Clinical Information Sytems: A Componenet based approach, Springer 2005.
4. K. Beaver,Healthcare Information Systems, Best PracticesCRC Press, 2002.
5. M. J. Ball, Healthcare Information Management Systems: A Practical Guide, SpringerVerlag GmbH, 1995.

13. Problem Solving and Programming (MA-613)

Unit 1:

Introduction: the problem solving aspect, top down design, implementation of algorithm,program verification, the efficiency of algorithm,the analysis of algorithm. **(Lecture 8)**

Unit 2:

Programs and programming, building blocks for simple programs, programming life cycle phases, pseudo code representation, flow charts, algorithm, programming languages, compiler, interpreter, loader and linker, program execution, classification of programming language, structured programming concept. **(Lecture 10)**

Unit 3:

Identifier, keywords,variables,constants – I/O statements, operators, initialization, expressions, expression evaluation, Lvalues and Rvalues, type conversion in C, formatted input and output functions, specifying test condition for selection and iteration, conditional execution and selection,iteration and repetitive execution, go to Statement, Nested Loops- Continue and break statements. **(Lecture 10)**

Unit 4:

Array – One dimensional character arrays,multidimensional arrays- arrays of strings,two dimensional character array, functions, parameter passing mechanism scope, storage classes, recursion, comparing iteration and recursion, pointers, pointer operators, uses of pointers, arrays and pointers, pointers and strings, pointer indirection, pointers to functions, dynamic memory allocation. **(Lecture 12)**

Unit 5:

Structures, initialization, nested structures, structures and arrays, structures and pointers, union,typedef and enumeration types, bit fields, File Management in C, Files and Streams, file handling functions, sequential access file,random access file, command line arguments.**(Lecture 10)**

Books:

1. R.G. Dromey, How to solve it by computer, Pearson education, 2007.
2. P. Dey, M. Ghosh, Fundamentals of Computing and Programming in C, Oxford University Press, 2009.
3. A.N.Kamthane, Programming with ANSI and Turbo C, Pearson Education Delhi,2006.
4. Deitel and Deitel, C How to Program, Pearson Education. 2010.
5. B. W. Kernighan, D. M. Ritchie,The C programming Language,Prentice-Hall,2006.
6. Y. Kanetkar, Understanding Pointers In C (4^{th} edition), Bpb Publications,2008.
7. Cormen,Leiserson, Rivest, Stein, Introduction to Algorithms, McGraw Hill Publishers, 2002.
8. P. Norton, Introduction to Computers, Tata McGraw Hill Publications, 2007.
9. R. Thareja, Programming in C, Oxford University Press, 2011.

14. Artificial Intelligence (MA-614)

Unit-1:

General Issues and Overview of AI: The AI problems, what is an AI technique, characteristics of AI applications, Introduction to LISP programming: syntax and numeric functions, basic list manipulation functions, predicates and conditionals, input output and local variables, iteraction and recursion, property lists and arrays.**(Lecture 10)**

Unit-2:

Problem solving, search and control Strategies, general problem solving, production systems, control strategies forward and backward chaining, exhausive searches depth first breadth first search. Heuristic Search Techniques Hill climbing, branch and bound technique, best first search & A* algorithm, AND / OR graphs, problem reduction & AO* algorithm, constraint satisfaction problems.**(Lecture 10)**

Unit-3:

Knowledge representations first order predicate calculus, skolemization, resolution principle & unification, interface mechanisms, horn's clauses, semantic networks, frame systems and value inheritance, scripts, conceptual dependency.**(Lecture 10)**

Unit-4:

Natural language processing parsing techniques, context free grammer, recursive transitions nets (RNT), augmented transition nets (ATN), case and logic grammers, symantic analysis. game playing minimax search procedure, alpha-beta cutoffs, additional refinments,planning overview an example domain the block word, component of planning systems, goal stack planning, nonlinear planning.**(Lecture 10)**

Unit-5:

Probabilistic reasoning and uncertainty probability theory, bayes theorem and bayesian networks, certainty factor,expert systems introduction to expert system and application of expert systems, various expert system shells, vidwan frame work, knowledge acquisition, case studies, MYCIN,learning rote learning, learning by induction, explanation based learning.**(Lecture 10)**

Books:

1. E. Rich, K. Knight, Artifical Intelligence, Tata McGrawHill, 1991.
2. M. Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, Addison Wesley, 2002.
3. E. Eberhart, Y. Shi, Computational Intelligence: Concepts and Implementations, Morgan Kaufmann San Diego, 2007.
4. S. Rajasekaran, G. A.VijaylakshmiPai, Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India, 2003
5. A. P. Engelbrecht, Computational Intelligence: An Introduction, John Wiley, New York, 2003.
6. A. Konar, Computational Intelligence: Principles, Techniques, and Applications, Springer, Berlin, Germany, 2005.

15. Mathematical Control Theory (MA-615)

Prerequisite: Linear Algebra, Functional Analysis

Unit 1:

Linear differential equations, finite-dimensional linear control systems, transition matrix, controllability matrix, Kalman rank condition, observability.

Unit 2:

Stability, stable polynomial, Routh theorem, Liapunov equation, stabilizability and controllability.

Unit 3:

Infinite-dimensional linear control systems, introduction to semigroups of linear operators, controllability operator, stability, Liapunov equation, stabilizability and controllability.

Unit 4:

Nonlinear control systems, linearization, controllability, stability, Liapunov function, La Salle's theorem, topological stability

Unit 5:

Optimal control problems, introduction to calculus of variations, maximum principle.

Text Books:

1. Zabczyk Jerzy, Mathematical Control Theory: An Introduction, Series: Modern Birkhäuser Classics, 2nd ed. printing 1995. Reprint, 2008.
2. R.G. Cameron and S. Barnett, Introduction to Mathematical Control Theory, Oxford Univ Press, 1990.

Reference Books:

1. Eduardo D. Sontag, Mathematical Control Theory: Deterministic Finite Dimensional Systems, Series: Texts in Applied Mathematics , Vol. 6, Springer, 1998.
2. D. Subbaram Naidu, Optimal Control Systems, Electrical Engineering Series, CRC Press, 2002.

16. Abstract Differential Equations (MA-616)

Prerequisites: Theory of Ordinary and Partial Differential Equations, Functional Analysis

Unit 1:

Semigroup of bounded linear operators, infinitesimal generator, Hille-Yoshida theorem, Lumer-Phillips theorem, pseudo resolvents, adjoint semigroup, semigroup of compact operators.

Unit 2:

Differentiability, analytic semigroups, contraction semigroups, fractional powers of closed operators, perturbation of: bounded linear operators, infinitesimal generator of analytic and contraction semigroups.

Unit 3:

Abstract Cauchy problems, homogeneous and inhomogeneous initial value problems, classical solution, mild solution, regularity and asymptotic behaviour of solutions, invariant and admissible subspaces.

Unit 4:

Evolutions equations, stable family of generators, evolution systems in hyperbolic and parabolic cases, regularity and asymptotic behaviour of solutions, Lipschitz perturbation of evolution equations, semilinear equations with compact and analytic semigroups, quasilinear evolution equations.

Unit 5:

Applications to partial differential equations: heat equation, wave equation, Schrodinger equation, Korteweg-de Vries equation.

Books:

1. A. Pazy, Semigroups of Linear Operators and Applications to Partial Differential Equations, Springer-Verlag, 1983.
2. K.J. Engel and R. Nagel, One-Parameter Semigroups of Linear Evolution Equations, Springer-Verlag, 2000.
3. G.E. Ladas and V. Lakshmikantham, Differential Equations in Abstract Spaces, Academic Press, 1972.

17. Applicable Analysis (MA-617)

Prerequisites: Functional Analysis

Unit 1:

Reflexivity, weak convergence, dual spaces, self-adjoint operators, compact operators, monotone operators, positive operators, accretive operators, unbounded operators.

Unit 2:

Spectrum and resolvent sets, spectral theory for bounded and unbounded operators, perturbation theory.

Unit 3:

Fixed point theorems due to Banach, Brouwer, Schauder, Schaefer, Krasnoselskii, Leray-Schauder, Kakutani.

Unit 4:

Test functions and distributions, support and singular support, convolution of distributions, Fourier transform, Schwartz space, Fourier inversion formula, tempered distribution.

Unit 5:

Sobolev spaces definition and basic properties, approximation by smooth functions, extension theorem, imbedding theorem, compactness theorem, dual spaces, fractional order spaces, trace spaces.

Books:

1. M. Thamban Nair, Functional Analysis: A First Course, Prentice Hall India, 2002. (Units 1 & 2)
2. R.E. Showalter, Monotone Operators in Banach Spaces and Nonlinear Partial Differential Equations, American Mathematical Society, 1997. (Unit 1)
3. K. Yoshida, Functional Analysis, Springer-Verlag, 1980. (Units 1 & 2)
4. D.R. Smart, Fixed Point Theorems, Cambridge University Press, 1974. (Unit 3)
5. S. Kesavan, Topics in Functional Analysis and Applications, New Age Publishers, 2003. (Units 4 & 5)

18. Dynamical Systems (MA-618)

Prerequisite: Systems of Linear Equations

Unit 1:

Dynamical systems and vector fields, fundamental theorem of ordinary differential equations, existence and uniqueness of solution, continuity of solutions in initial conditions, extending solutions, global solutions.

Unit 2:

Flow of a differential equation, nonlinear sinks, stability of equilibrium, stability theory, Liapunov functions, gradient systems.

Unit 3:

Limit sets, attractors, periodic orbits, limit cycles, separatrix cycles, monotone sequences in planar dynamics.

Unit 4:

Poincare map, Poincar-Bendixson theorem, Lienard systems, Poincare sphere and behaviour at infinity,

Unit 5:

Differential equations in electrical circuits, Van der Pol's equation, Hopf bifurcation, bifurcation analysis for: one species, prey-predator species, competing species.
Introduction to discrete dynamical systems.

Books:

1. M.W. Hirsh and S. Smale, Differential Equations, Dynamical Systems and Linear Algebra, Academic Press Inc.
2. L. Perko, Differential Equations and Dynamical Systems 3rd ed. Springer-verlag, 2001.
3. M. Brin and G. Stuck, Introduction to Dynamical Systems, Cambridge University Press, 2004.
4. G. Teschl, Ordinary Differential Equations and Dynamical Systems, American Mathematical Society.

19. Fluid Mechanics (MA-619)

Unit 1:

Kinematics of fluid in motion: real fluids and ideal fluids, stream lines, steak lines and path lines, steady and unsteady flows, velocity potential, vorticity vector, Lagrangian and Eulerian description, continuity of mass flow (different coordinates also), circulation, rotational and irrotational flows, boundary surface, Reynolds transport theorem, Bernoulli's theorem, compressible and incompressible flows, Kelvin's theorem.

Unit 2:

Stress and strain and relation between stress and strain, Stokes hypothesis, formulation of the Navier-Stokes equations, special forms of Navier-Stokes equations: Stokes equations and Euler equations, classification of partial differential equations and physical behavior,

Unit 3:

Fully developed flows with examples, some solvable problem in viscous flow: (i) steady flow between parallel plates, (ii) steady flow in a pipe, (iii) steady flows between concentric cylinders (iii) Couette flow, derivation of energy equation, dissipation of energy, diffusion of vorticity, Boussinesq approximation.

Unit 4:

Dimensional analysis, physical signification of some non-dimensional parameters: Prandtl, number, Mac number, Reynolds number, Froud number, Reyleigh number, Grashof number, Nusselt number etc.

Concept of boundary layers, boundary layer thickness, Prantdtls boundary layer, similarity solution, boundary layer on flat plate: Blassius solution, von-Karman momentum integral equation, Effect of pressure gradient, wall shear stress, separation of the boundary layer.

Unit 5:

Concept of the laminar and turbulent flow, hydrodynamic stability analysis: mathematical formulation of the stability problem of incompressible flow, method of normal modes, thermal instability: the Benard problem, centrifugal instability: Taylor problem, Kelvin-Helmholtz instability, Squire's theorems and Orr-Sommerfeld equation.

Books:

1. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 2000
2. H. Schlichting, Boundary Layer Theory, McGraw Hill Education, 2014
3. P. K. Kundu, I. M. Cohen, D. R. Dowling, Fluid Mechanics (Fifth Edition), Academic Press (Elsevier, 4th Edition).
4. S. W. Yuan, Foundation of Fluid Mechanics (3rd Edition), Prentice Hall of India Private Limited, 1976
5. F. M. White, Fluid Mechanics (Sixth Edition), Tata McGraw-Hill, New Delhi (2008).

6. K. Muralidhar, G. Biswas, Advanced Engineering Fluid Mechanics, Narosa Publishing House, 2006
7. R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH publishing Company, New Delhi, 1976
8. P.G. Drazin, W.H. Reid, Hydrodynamic Stability, Cambridge University Press, 2004
9. S. Chandrasekhar, Hydrodynamic and Hydromagnetic Stability, Oxford, 1961.
10. P. J. Schmid, D. S. Henningson, Stability and Transition in Shear Flows, Applied Mathematical Sciences, Springer, 2000

20. Computational Fluid Dynamics (MA-620)

Unit 1:
Brief introduction of ODE (IVP and BVP) and PDE, initial and boundary conditions, classification of PDE, kinematics of fluid in motion, discussion about experimental, theoretical and numerical approaches in fluid mechanics, mathematical description of the physical phenomena, governing equations mass, momentum, energy, classification of partial differential equations, physical classification, mathematical classification, well-posed problems, some solvable problem in viscous flow: (i) steady flow between parallel plates, (ii) steady flow in a pipe.

Unit 2:
Physical description of FDM, derivation of finite differences formulas with high accuracy, multidimensional formulas, accuracy of finite difference solutions, solution methods of finite difference equations: elliptic equations, parabolic equations, hyperbolic equation, example problems, stability, convergence and consistency of the solution methods.

Unit 3:
ADI-method, application of finite difference methods to the equations of fluid mechanics, vorticity formulation: solution of viscous incompressible flows by the stream function.

Unit 4:
Galerkin's method, collocation method, method of least square, numerical solution of ordinary and partial differential equations using these methods, introduction of finite element method and basic difference between finite element and finite difference method, linear and quadratic and higher order elements in one dimensional, assembly of elements, solution of ODE (related to fluid mechanics) by FEM.

Unit 5:
Introduction to finite volume methods: basic formulations, finite-volume method for diffusion problems.

Books:

1. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 2000
2. H. Schlichting, Boundary Layer Theory, McGraw Hill Education, 2014
3. T. J. Chung, *Computational Fluid Dynamics*, 2nd ed. Cambridge University Press, 2010.
4. G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, 2001.
5. C. E. Froberg, Introduction to Numerical Analysis, 2nd Ed., Addison Wesley, 2004
6. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, 2nd ed, Taylor & Francis, 1997.
7. J. D. Anderson, *Computational Fluid Dynamics*, McGraw-Hill International Edition, 1995.
8. *K*. Muralidhar, T. Sundararajan, *Computational Fluid Flow and Heat Transfer* (2nd Edition) Narosa , 2011.
9. J.N. Reddy, An Introduction to Finite Element Methods, McGraw Hill, 2007
10. K.J Bathe, Finite element Procedures, Prentice Hall, 2003
11. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere, 2000.
12. C.A.J Fletcher, Computational Technique for Fluid Dynamics, Springer Verlag.