ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering) **BH:** Basic Sciences and Humanities **CS:** Computer Sciences **EE:** Electrical Sciences **EI:** Electronic Sciences **IP:** Infrastructure and Planning **MS:** Mechanical Sciences **BT:** Biotechnology **TE:** Textile Engineering		**Level** **1:** UG/ Int. Msc. (1st Year) **2:** UG/ Int. Msc. (2nd Year) **3:** UG/ Int. Msc. (3rd Year) **4:** UG/ Int. Msc. (4th Year) **5:** UG/ Int. Msc. (5th Year) **6:** PG (1st Year) **7:** PG (2nd Year) **8:** Ph.D.	**0:** AC **1:** PC **2:** PE **3:** OE **4:** MC **5:** LC **6:** PR **7:** SE **8:** **9:**	**Serial Number (01 to 99)** 01/ 03/…/ 19: Odd Sem. (CHEM) 21/ 23/…/ 39: Odd Sem. (HUM) 41/ 43/…/ 59: Odd Sem. (MATH) 61/ 63/…/ 79: Odd Sem. (PHY) 81/ 83/…/ 99: Odd Sem. () 02/ 04/…/ 20: Even Sem. (CHEM) 22/ 24/…/ 40: Even Sem. (HUM) 42/ 44/…/ 60: Even Sem. (MATH) 62/ 64/…/ 80: Even Sem. (PHY) 82/ 84/…/ 98: Even Sem. ()	

Abbreviation used

I:	Integrated Program	PR:	Project	GE:	Generic Elective/Interdisciplinary
P:	Postgraduate Program	SE:	Seminar	SEC:	Skill Enhancement Course
PC:	Professional Core	AC:	Audit course	DSE:	Discipline Specific Elective
PE:	Professional Elective	PH:	Physics	L:	Lecture
CC:	Core Course	CY:	Chemistry	T:	Tutorial
CE:	Core Elective	MH:	Mathematics	P:	Practical
OE:	Open Elective	HS:	Humanities	IA:	Internal Assessment
MC:	Mandatory Course	CS:	Computer Science	EA:	End-Semester Assessment
LC:	Lab Course	AECC:	Ability Enhancement Compulsory Course	PA:	Practical Assessment

1st SEMESTER

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-1	BH6141	Real Analysis	3	1	0	3	40	60	-	100
PC-2	BH6143	Differential Equations	3	0	0	3	40	60	-	100
PC-3	BH6145	Discrete Mathematical Structures	3	1	0	3	40	60	-	100
PC-4	BH6147	Linear Algebra	3	0	0	3	40	60	-	100
MC-1	CS6485	Data Structure Using C++	3	0	0	2	40	60	-	100
MC-2	CS6487	Fundamentals Of Computer Systems	3	0	0	2	40	60	-	100
MC Lab-1	CS6585	Data Structure Using C++ Lab	0	0	3	2	-	-	100	100
MC Lab-2	CS6587	Systems Lab	0	0	3	2	-	-	100	100
		Total credit	**18**	**2**	**6**	**20**	**240**	**360**	**200**	**800**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH
Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.
Syllabus (Effective from 2023-24)

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

2nd Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-5	BH6142	Topology	3	1	0	3	40	60	-	100
PC-6	BH6144	Numerical Analysis	3	0	0	3	40	60	-	100
PC-7	BH6146	Complex Analysis	3	1	0	4	40	60	-	100
PC-8	BH6148	Abstract Algebra	3	0	0	3	40	60	-	100
PC-9	BH6150	Probability And Stochastic Processes	3	0	0	3	40	60	-	100
PC Lab-1	BH6542	Numerical Analysis Lab	0	0	3	2	-	-	100	100
MC-3	CS6482	Design And Analysis Of Algorithm	3	1	0	4	40	60	-	100
MC Lab-3	CS6582	Design And Analysis Of Algorithm Lab	0	0	3	2	-	-	100	100
		Total credit	**18**	**3**	**6**	**24**	**240**	**360**	**200**	**800**

3rd Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-10	BH7141	Functional Analysis	3	1	0	4	40	60	-	100
PC-11	BH7143	Matrix Computation	3	0	0	3	40	60	-	100
PC-12	BH7145	Machine Learning	3	1	0	3	40	60	-	100
PC-13	BH7147	Optimization Theory	3	1	0	3	40	60	-	100
PE-1	BH7241/ BH7243/ BH7245/ BH7247	Numerical Optimization / Numerical Solution Of Differential Equations / Differential Geometry / Computational Fluid Dynamics	3	1	0	3	40	60	-	100
PC Lab-2	BH7541	Matrix Computation & Machine Learning Lab Using R	0	0	3	2	-	-	100	100
PC Lab-3	BH7543	Optimization Lab	0	0	3	2	-	-	100	100
		Total credit	**15**	**4**	**6**	**20**	**200**	**300**	**200**	**700**

4th Semester

Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
			L	T	P		IA	EA	PA	Total
PC-14	BH7142	Number Theory And Cryptography	3	1	0	3	40	60	-	100
PC-15	BH7144	Theory Of Computation	3	1	0	3	40	60	-	100
PE-2	BH7242/ BH7244/ BH7246/ BH7248	Parallel And Distributed Computing / Fuzzy And Rough Set Theory / Advanced Machine Learning / Soft Computing	3	0	0	3	40	60	-	100
SEMINAR	BH7742	Seminar	0	0	2	1	-	-	100	100
PROJECT	BH7642	Project	0	0	6	6	-	-	100	100
		Total credit	**9**	**2**	**8**	**16**	**120**	**180**	**200**	**500**

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Semester-1

Core 1: Real Analysis (BH6141)

Prerequisites: Basics of Real Analysis

Module-I: (13hrs)
Lebesgue Measure: Introduction, Lebesgue outer measure, The σ-algebra of Lebesgue measurable sets, Outer and inner approximations of Lebesgue measurable sets. Countable additivity, Continuity and the Borel-Cantelli lemma. Non-measurable sets.
Lebesgue Measurable Functions: Sums, Products and compositions, Sequential point-wise limits and simple approximation, Littlewood's three principles, Egoroff's theorem and Lusin's theorem.

Module-II: (13hrs)
Lebesgue Integration: The Riemann integral, The Lebesgue integral of a bounded measurable function over a set of finite measure. The Lebesgue integral of a measurable non-negative function, Fatou's Lemma, Monotone Convergence theorem, Bounded Convergence theorem, Lebesgue Dominated Convergence theorem, Beppo Levi's Lemma, The general Lebesgue integral.
The L^p-Spaces: Normed linear spaces, the inequalities of Young, Hölder and Minkowski,Cauchy-Schwarz, L^p is complete, The Riesz-Fisher theorem.

Module-III: (14hrs)
Functions of Bounded Variation: Introduction - Properties of monotonic functions,Functions of bounded variation, Total variation, Additive property of total variation, Total variation on [a, x] as a function of x - Functions of bounded variation expressed as the difference of two increasing functions.Continuous functions of bounded variations.
The Riemann Stieltjes Integrals: Introduction, Notation, The definition of Riemann Stieltjes Integral, Linear operators, Integration by parts, Change of variable in Riemann Stieltjes integrals, Reduction to a Riemann Integral, Euler's summation formula, Monotonically increasing integrators. Upper and lower integrals.

Text Books:
1. Real Analysis by H.L. Royden & P. M. Fitzpatrick(4th edition) Pearson.
   Chapter 2(2.1-2.6), Chapter 3, Chapter 4(4.1 to 4.4), Chapter 7(7.1-7.3)
2. Mathematical Analysis by Tom M. Apostol, 2nd Edition, Addison-Wesley publication company Inc. New york, 1974.
   Chapter 6(6.1 to 6.8), Chapter 7(7.1 to 7.11)

Reference Books:

1. Bartle, R.G. Real Analysis, Wiley.
2. Rudin, W. Principles of Mathematical Analysis, 3rd Edition. McGraw Hill Company, New York, 1976.
3. Malik, S.C. and Savita Arora. Mathematical Analysis, Wiley Eastern Limited, New Delhi, 1991.
4. Sanjay Arora and Bansi Lal, Introduction to Real Analysis, Satya Prakashan, New Delhi, 1991.
5. Gelbaum, B.R. and J. Olmsted, Counter Examples in Analysis, Holden day, San Francisco, 1964.
6. A.L. Gupta and N.R. Gupta, Principles of Real Analysis, Pearson Education, (Indian print) 2003.
7. Measure theory and integration by G. De. Barra (Wiley Eastern Limited)

Course outcomes: After the successful completion of this course the students will be able to
1. Understand the concept of Lebesgue measure, its properties and get an idea of non- measurable functions, fundamentals of measurable functions, Lebesgue integration and be acquainted with the proofs of the fundamental theorems.

2. Learn the importance of L^p spaces from the fact that they offer a partial but useful generalization of fundamental L^2 space of square integrable functions.
3. Acquainted with functions of bounded variation, total variations and develop a reasonable argument in handling problems about functions of bounded variations.
4. Know that Riemann Stieltjes Integral is a very useful tool that makes possible the simultaneous treatment of continuous and discrete random variables.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 2: Differential Equations (BH6143)

Prerequisites: First order Ordinary Differential Equations, Higher order Differential Equations with constant/variable coefficients, Partial Differentiation.

Module - I : (10 hrs)
Existence And Uniqueness Of Solutions: Picard's method of successive approximation, An existence and uniqueness theorem, Dependence of solutions on initial conditions.
Series Solutions And Special Functions: Some basic concepts and facts about power series, series solution about an ordinary point, Legendre equation and Legendre polynomial, Hermite equation and Hermite polynomial, power series solution about singular points, Frobenius method, Bessels equation and Bessel function, properties of Bessel function.
Systems Of Linear Differential Equations: Basic theory of linear systems, Trail solution method for linear systems with constant coefficient, operator method for linear systems with constant coefficients.
Module – II :(10 hrs)
Boundary Value Problems For Ordinary Differential Equations: Sturm-Liouville problem, Orthogonality of Eigen functions, Green's function.
The Laplace Equation: Boundary value problem for Laplace's Equations, Fundamental Solution of Laplace's Equation, Integral Representation of Harmonic Functions, Mean Value Formula for Harmonic Functions, Green's Functions for Laplace's Equation
Module –III :(10 hrs)
The Wave equation: Derivation of One Dimensional Wave Equation, Solution of the wave Equation (Method of separation of variables), D'Alembert's solution of the wave Equation, Derivations of Two Dimensional Wave equation, Solutions of Two Dimensional Wave equation.
The Heat equation: One Dimensional Heat Equation, Solution of One Dimensional Heat Equation Derivation of two Dimensional Heat Equation, Solution of Two Dimensional Heat Equation, Laplace Equations in Polar Coordinates.
Text Books:
1. J Sinha Roy and S Padhy, A Course on Ordinary and Partial Differential Equations, 4th Edition, Kalyani publisher.
2. K. Sankar Rao, Introduction to Partial Differential Equations, 2nd Edition, Prentice Hallof India, New Delhi. 2005.

Reference Books:

1.R.C.McOwen, Partial Differential Equations, 2nd Edn. Pearson Education, New Delhi,2005.
2. I.N.Sneddon, Elements of Partial Differential Equations, McGraw Hill, New Delhi,1983.
3.R. Dennemeyer, Introduction to Partial Differential Equations and Boundary ValueProblems, McGraw Hill, New York, 1968.
4.S. BalachandraRao,H.R.Anuradha, Differential Equations with applications and programs, Universe Press.
5.C. Henry,Edwards,David .E.Peney, Differential Equation and Boundary Value Problems, Pearson.
6.Wiliam E., Boyee,Richard C. Diprima. Elementary Differential Equations and Boundary Value Problems,Wiley.

Course Outcomes: After the successful completion of this course the students will be able to
1. assure existence of uniqueness of solution of IVP related to first order differential equation and determine an approximate solution.
2. obtain series solution of some differential equations and have adequate knowledge on some specific polynomials and functions which frequently occur in physical science and engineering.
3. solve systems of linear differential equations with appropriate method; solve BVPs and study properties of the solutions
4. Solve elliptic, parabolic and hyperbolic differential equations which govern various physical phenomena.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 3: Discrete Mathematical Structures (BH6145)

Prerequisites: Set theory.

Module-I:(13 hrs)
Propositional Logic: propositions, connectives, well-formed formula, truth tables, logically equivalent formulas, tautology, contradiction, contingency, concept of proof, inference rules and natural deduction, completeness and soundness, predicate logic: existential and universal quantifiers, laws of inference and natural deduction Proof techniques: Introduction to different standard proof techniques such as trivial proofs, Vacuous proofs, Direct proofs, Proof by Contrapositive (indirect proof), Proof by Contradiction (indirect proof) , Proof by Cases, Proofs of equivalence, Existence Proofs (Constructive & Non-constructive), Uniqueness Proofs, Mathematical Induction, Recursive definition and structural induction.
Set Theory: Review of Basic Set Operations, representation of set, finite and infinite set, countabality and uncountability, countabality of rationals, uncountability of reals,

Module-II:(13 hrs)
Relations: Relation and their properties, Partitions, Closure of Relations, Warshall's Algorithm, Equivalence relations, Partial orderings, lattice, topological ordering
Boolean Algebras :Lattices, Principle of Duality, Boolean Lattices, Boolean Algebras, Boolean Functions and Properties .
Counting: sum and product rules, permutations and combinations, number of non-negative integral solutions of a linear equation
Advanced counting techniques: Recurrence relation, Solution to recurrence relation, Generating functions, pigeonhole principle and their applications, Principle of Inclusion and exclusion and its application

Module-III:(14 hrs)
Introduction to graph theory, Graph terminology, Representation of graphs: adjacency matrix, incidence matrix, adjacency list, modeling applications using graphs, graph isomorphism, connectivity, Eulerian graphs and their characterization, Hamiltonian graphs and sufficient conditions for hamiltonicity, Shortest path problems, Planar graph, Graph coloring,
Introduction to trees, various characterizations of trees, Application of trees, Depth first search, breadth first search, testing connectedness and acyclicity, Minimum Spanning tree: Kruskal's Algorithm, Prim's Algorithm

Text Books:
1. Kenneth H. Rosen, "Discrete Mathematics and its Applications", Sixth Edition, 2008, Tata McGraw Hill Education, New Delhi. Chapters: 1, 2(2.4), 4, 6(6.1, 6.2, 6.4-6.6), 7, 8, 9
2. C. L. Liu and D. Mohapatra, "Elements of Discrete Mathematics", Third Edition, 2008, Tata McGraw Hill Education, New Delhi Chapters: 10 (10.1- 10.10), 11(11.1 – 11.7)

Reference Books:
1. Douglas B. West, "Introduction to Graph Theory" 2e, PHI
2. B. Kolman, R. C. Busby, S. C. Ross, N. Rehman , "Discrete MathematicalStructures", Pearson Education.
3. J. L. Mott, A. Kandel, T. P. Baker , "Discrete mathematics for Computer Scientists & Mathematicians", Second Edition, PHI.
4. Gosset "Discrete Mathematics "Second Edition, Wiley
5. NarsinghDeo, "Graph Theory with applications to engineering and computer science", PHI

Course Outcomes: After the successful completion of this course the students will be able to
1. Write an argument using logical notation and determine if the argument is valid or not.
2. Apply counting principles to determine probabilities.
3. Demonstrate an understanding of relations and functions and be able to determine their properties.
4. Model problems in Computer Science using graphs and trees.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 4: Linear Algebra (BH6147)

Prerequisites: Basic ideas of Matrices

Module-I:(10 hrs)
Geometric interpretation of solution of system of equations in two and three variables; matrix notation; solution by elimination and back substitution; interpretation in terms of matrices, elimination using matrices; elementary matrices, properties of operations on matrices. Definition and uniqueness; non-existence in general: singular matrices; calculation of inverse using Gauss-Jordan elimination; existence of one sided inverse implies invertibility; decomposition of a matrix as product of upper and lower triangular matrices. Vector spaces and Subspaces, Solving Ax=0 and Ax=b, Linear Independence, Basis and Dimension, The four fundamental Subspaces, graph and networks, Linear Transformations.

Module-II:(10 hrs)
Orthogonal Vectors and Subspaces, Cosines and Projections onto Lines, Projections and Least Squares, orthogonal Bases and Gram-Schmidt, The Faster Fourier Transform, Properties of the determinant, formulas for the determinant, Expansion of determinant of a matrix in Cofactors, Applications of Determinants.

Module-III:(10 hrs)
Eigen values and eigenvectors, Diagonalisation of a Matrix, Difference equations and powers A^k, Markov Matrices, complex Matrices, unitary Matrices, similarity transformations, Jordan Form, minima, maxima and saddle points, tests for positive definiteness, Test for positive definiteness, singular value decomposition, minimum principles.

Text Book:
1. Strang, Introduction to Linear Algebra, 4th ed., Wellesley Cambridge Press., Chapters-1-5, 6.1,6.2,6.3,6.4.
2. Introduction to linear algebra by V. Krishnamurty.

Reference Books:
1. An introduction to Linear Algebra by V. Krishnamurthy, V. P. Mainra and J. L. Arora, East West Publication
2. M.Artin, Algebra, Prentice-Hall of India.
3. Hoffman and Kunze, Linear Algebra, 2nd ed., PHI.
4. S. Kumaresan, Linear Algebra, a geometric approach, PHI.

Course Outcomes: After the successful completion of this course the students will be able to
1. solve systems of linear equations and to compute the inverse of an invertible matrix.
2. Use the basic concepts of vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.
3. Evaluate determinants and use them to discriminate between invertible and non-invertible matrices.
4. Orthogonally diagonalize symmetric matrices and quadratic forms.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-1: Data Structure using C++ (CS6485)

Prerequisites: Basic knowledge of C

Module I :(10hrs)
Mathematical Background, Running Time calculations, Abstract data types (ADTs), The List ADT, The Stack ADT, and The Queue ADT.

Module II :(10hrs)
Trees: Basic concepts and implementation of Trees, Tree traversals, Binary trees, Binary search trees, AVL trees, Splay Trees, Tree traversals revisited, B-Trees.
Hashing: General Idea, Hash Function, Open Hashing, Closed Hashing.

Module III :(10hrs)
Priority Queues: The Model, Simple Implementations, Binary Heap, Application of Priority Queues.
Sorting: Insertion Sort, Heap Sort, Merge Sort, Quick Sort, Sorting large objects.

Text Book:

1. Data Structure and Algorithm Analysis in C++, Mark Allen Weiss, Addison Wesley, ISE 1999, Chapter 2 (2.4.1,2.4.2, 2.4.4), 3, 4, 5 (5.1-5.4), 6 (6.1-6.4), 7(7.1-7.2 ,7.5-7.7)

Reference Book:

1. Fundamentals of Data Structures in C++, E. Horowitz, S. Sahani, D Mehta,Galgotia Publications, 2003.

Course Outcomes: After the successful completion of this course the students will be able to

1. Choose appropriate data structure as applied to specified problem definition.
2. Handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures.
3. Apply concepts learned in various domains like DBMS, compiler construction etc.
4. Use linear and non-linear data structures like stacks, queues, linked list etc.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-2: Fundamentals of Computer Systems (CS6487)

Module I :(10 hrs)
OPERATING SYSTEM: Computer hardware, operating system structure; Process management (Process scheduling, Process state, scheduling algorithms, process attributes); Interprocess communication andsynchronization, deadlock; Memory management (Partitioning, paging, segmentation, swapping); Virtualmemory; File system management (Directories and names, File system objects and functions);Device management (hardware I/O organization, software organization, devices)

Module II : (10 hrs)
RELATIONAL DATABASE SYSTEM: Data models, Database system architecture, Relational database, Concepts (RDBMS, Relation, types of keys, relational operators, set operations on relations); Functional Dependencies (Definition, function dependencies and keys, Inference axioms for functionaldependencies, redundant functional dependencies, equivalence of functional dependencies); Normalization (First, second, and third normal forms,Data anomalies in 1nf,2nf,3nf relations, Boyce-Codd normal form); The entity-Relationship model (entities and attributes, one-one, many-one, many-many relationships, normalizing the model.

Module III:(10 hrs)
COMPUTER NETWORKING: Data Communications (multiplexing, signaling, encoding and decoding, error detection and recovery, flow control, sliding window, congestion window); Communications networks(Int.to networking, network components and topologies); Network technologies (LAN, WAN, and wireless networks); Switching (circuit and packet switching, brigges and switches, integrating switches with hubs and routers),Naming and addressing, Routing(information, protocol, hierarchical and multicast routing), Services and Applications (FTP, TFTP, Domain name system, e-mail, WWW, HTML, HTTP)

Text Book:

1. J.Archer Harris, Operating Systems, (Schaum's Outline)TMH.
2. Ramon A. Mata-toledo, P.K..Cushman, Fundamentals of Relational Databases (Schaum's Outline), TMH.
3. Ed Tittel, Computer Networking, (Schaum's Outline) TMH.

Course Outcomes:

After the successful completion of this course the students will be able to gain:

1. Basic knowledge about computer architecture
2. Basic knowledge about the operating systems
3. Fundamentals of data base managements
4. Knowledge about various network protocols

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-Lab 1: Data Structure Using C++ Lab (CS6585)
(Minimum 10 experiments to be done)

List of Experiments:

Lab 1: Simple Programs using C++
Lab 2: Implementation of Array (Insertion, Deletion, Find)
Lab 3: Implementation of Linked List (Insertion, Deletion, Find)
Lab 4: Polynomial Representation, Addition, and Multiplication using Linked List
Lab 5: Implementation of Stack (Using Array and Linked List)
Lab 6: Application of Stack (Conversion of Infix Arithmetic expression to Postfix expression, Prefix expression, Evaluation of Prefix and Postfix expression)
Lab 7: Implementation of Queue (Enque and Deque Operation) using array and Linked List
Lab 8: Implementation of Tree traversal (Inorder, Preorder, Post order) in binary tree. Implementation of BST (Insertion, Deletion, FinMin, FindMax, Find Depth of the tree)
Lab 9: Implementation of Priority Queue
Lab 10: Implementation of Insertion Sort, Merge Sort.
Lab 11: Implementation of Quick Sort, Heap Sort.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-Lab 2: Systems Lab (CS6587)

List of Experiments:

1. Use of SQL syntax: insertion, deletion, join, updation using SQL.
2. Programs on join statements and SQL queries including where clause.
3. Programs on procedures, functions, database triggers and packages.
4. Programs on data recovery using check point technique.
5. Concurrency control problem using lock operations.
6. Basic UNIX Commands and UNIX Shell Programming.
7. Programs on process creation and synchronization, inter process communication including shared memory, pipes and messages. (Dinning Philosopher problem / Cigarette Smoker problem / Sleeping barber problem)
8. Programs on UNIX System calls.
9. Simulation of CPU Scheduling Algorithms. (FCFS, RR, SJF, Priority, Multilevel Queuing)
10. Simulation of Banker's Algorithm for Deadlock Avoidance, Prevention.
11. Program for FIFO, LRU, and OPTIMAL page replacement algorithm.

Semester-2

Core 5: Topology (BH6142)

Prerequisites: Real Analysis.

Module –I:(14 Hours)
Countable and uncountable set, Infinite sets and the Axiom of choice, Well-ordered sets. Topological spaces, Basis and sub basis for a topology, the order, product and subspace topology, closed sets and limit points. Continues function and homeomorphism, Metric topology, Connected spaces, connected subspaces of the real line, Components and local connectedness.

Module –II:(13 Hours)
Compact spaces, Basic properties of compactness, Compactness and finite intersection property, Compact subspaces of the real line, Compactness in metric spaces, Limit point compactness, Sequential compactness and their equivalence in metric spaces, Local compactness and one-point compactification.

Module –III:(13 Hours)
First and second countable spaces, Product spaces, Lindelo''f space, Separable spaces, separable axioms, Hausdorff, Regular and normal spaces. The Urysohn lemma, completely regular spaces, The Urysohnmetrization theorem, Imbedding theorem, Tietze extension Theorem, Tychonoff theorem, Stone-Cech compactification.

Text Book:
1. Topology, J.R. Munkres, 2e, Pearson Education, 2000.
   Chapter: 1(7,9,10),2(excluding section 22), 3, 4 (excluding section 36), 5.

Reference Books :
1. Introduction to general Topology, by K.D.Joshi, Wiley Eastern Ltd., 1983.
2. Foundation of General Topology, by W.J. Pervin, Academic Press, 1964.
3. General Topology, by S.Nanda and S.Nanda, Macmillan India.

Course Outcomes: After the successful completion of this course the students will be able to:
1. familiar with methods and techniques of proving basic theorems on topological spaces and continuous mappings.
2. check if a given function is metric, continuous.
3. check if a given set is open, closed, dense, compact, connected.
4. apply his or her knowledge of general topology to formulate and solve problems of a topological nature in mathematics and other fields where topological issues arise.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 6: Numerical Analysis (BH6144)

Prerequisites: Numerical Methods.

Module –I: (10hrs)
Solution of Equations: Zeros of Polynomials, Horner's method, Muller's method, Interpolation & Polynomial Approximation: Lagrange polynomial, Data approximation Hermite, cubic spline and piecewise interpolation (Natural cubic splines, clamped Splines)
Numerical differentiation& Integration: Numerical differentiation, Richardson Extrapolation.
Numerical Integration & Composite Integration (Newton Cotes & Gaussian Quadrature), Romberg Integration, brief idea of Adaptive quadrature method, Asymptotic error formula,Multiple Integrals, Improper Integrals,

Module -II: (10hrs)
Numerical solution to ODE; Taylor's series methods, Adaptive Runge - Kutta method, predictor- corrector method, convergence and stability, multistep methods.
Boundary value problem for ODE: Shooting method for linear & non-linear problems, finite difference methods for linear & non-linear problems, The Rayleigh- Ritz method.

Module –III:(10hrs)
Approximating Eigen value:power method, shifted power method, inverse power, Householder's method, QR-method, error and stability.
Numerical solution to partial differential equations: Solution of parabolic, elliptic, Hyperbolic differential equations using finite difference method and stability considerations.

Text Book:

1. Numerical Analysis:Richard L. Burden&J.D.Faires.
   Cengage Learning 9th Edition (chapter –2(2.6),chapter-3(3.1,3.2,3.4-3.6),chapter4(4.1-4.9),chapter-5(5.1-5.8,5.10),Chapter9(9.1-9.5),chapter-11(11.1-11.5),chapter12(12.1-12.3))

Reference Books:

1. Numerical methods, Srimanta Pal, Oxford Higher Education.
2. Numerical methods for Scientific and Engineering Computation, M.K.Jain,,S.R.K.Iyengar (5th edition).
3. Numerical methods for Engineers by Chapra&Canale, TMH
4. An introduction to Numerical Analysis: by Kendall E. Atkinson,Wiley

Course Outcomes: After the successful completion of this course the students will be able to

1. Solve an algebraic or transcendental equation and differential equation (ODE & PDE) using an appropriate numerical method.
2. Approximate a function using an appropriate numerical method.
3. Evaluate a derivative at a value and a definite integral using an appropriate numerical method.
4. Solve a linear system of equations using an appropriate numerical method.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 7: Complex Analysis (BH6146)

Prerequisites: Basic Real Analysis.

Module-I:(10 hrs)
The complex number system: The real numbers, The field of complex numbers, the complex plane, polar representation and roots of complex numbers, Line and half planes in the complex plane. Power series and radius of convergence.

Module-II:(10 hrs)
Analytic function, Power series representation of analytic functions, Cauchy- Riemann equation, analytic function as mapping and its Mobius transformation. Zeros of analytic function, entire function,Complex integration.

Module-III:(10 hrs)
Liouville's theorem, fundamental theorem of algebra, maximum modulus theorem, Index of a closed curve, Cauchy's theorem and Cauchy's integral formula, Morera's theorem.
Classification of singularity, Poles, absolute convergence.

Module-IV:(10 hrs)
Laurent series development,Residue theorems, evaluation of integrals by using residue theorem, Argument principle, Rouche's theorem, Maximum Modulus theorem, Schwarz's Lemma.

Text Book:

1. Functions of one Complex variable- J. B. Conway (Springer Verlag, International student edition, Narosa Publishing house, Chapter-1(1.1-1.5), Chapter-3(3.1- 3.3), Chapter-4(4.2 - 4.5), Chapter-5(5.1-5.3), Chapter-6(6.1 - 6.2).

Reference Books:

1. Complex Analysis by Alhfors, TMH.
2. Complex Variable; Theory &Application:Kasana, PHI

Course Outcomes: After the successful completion of this course the students will be able to

1. Explain the fundamental concepts of complex analysis and their role in modern mathematics and applied contexts.
2. Demonstrate accurate and efficient use of complex analysis techniques for evaluation of different types of integrals.
3. Learn mapping and series expansion of complex valued function.
4. Apply problem-solving using complex analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 8: Abstract Algebra (BH6148)

Prerequisites: Set, Relation, Mapping, Group, Ring, Field.

Module-I:(10 hrs)
Normal subgroup, Isomorphism theorem, Automorphisms, Permutation group: Cyclic decomposition and Alternating group A_n. Structure theorems for groups: Direct Product, finitely generated abelian group. Structure theorem for groups: Invariants of a finite abelian group, Sylows theorem. Unique factorization domain, Principal ideal domain, Euclidean domains, polynomial rings over UFD.

Module-II: (10 hrs)
Algebraic extension of fields: Irreducible polynomials and Einstein criterion, Adjunction of roots, Algebraic extension. Algebraically closed fields, Normal separable extensions: splitting fields, normal extensions. Normal separable extension: Multiple roots, Finite fields, Separable extensions.

Module-III: (10 hrs)
Galois Theory: Automorphism groups and fixed fields, Fundamental theorem of Galois theory. Application of Galois theory to classical problems: Roots of unity and Cyclotomic polynomials, Cyclic extensions, Polynomials solvable by radicals, Symmetric functions, Ruler and compass constructions.

Text Book:
1. P.B. Bhattacharya, S. K Jain and S.R.Nagpaul: Basic Abstact Algebra, Cambridge University Press. Chapters: 5 (Art 2,3), 7(Art 1,2), 8(Art 1-4), 11 (Art 1-4), 15(Art 1-3), 16(Art 1-5), 17(Art 1,2), 18(1-5).

Reference Books:
1. VivekSahai and VikasBist: Algebra (Narosa publication House).
2. I.S. Luthar and I.B.S. Passi: Algebra Vol. 1 Groups (Narosa publication House).
3. I.N. Herstein**:** Topics in Algebra (Wiley Eastern Ltd.).
4. Surjit Singh and QuaziZameeruddin:Modern Algebra (Vikas Publishing House).
5. S.K. Jain & S.R. Nagpal: Basic Abstract Algebra (Cambridge University Press 1995).
6. Dummit: Abstract Algebra, Wiley
7. Modern Algebra by A. R. Vasishtha, Krishna PrakashanMandir, Meerut.

Course Outcomes: After the successful completion of this course the students will be able to
1. Apply algebraic ways of thinking.
2. Demonstrate knowledge and understanding of fundamental concepts including groups, subgroups, normal subgroups, homeomorphisms and isomorphism.
3. Demonstrate knowledge and understanding of rings, fields and their properties.
4. Understand and prove fundamental results and solve algebraic problems using appropriate techniques.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 9: Probability and Stochastic Processes (BH6150)

Prerequisites: Probability Distribution and Expectation of single random variable.

Module-I:(10 hrs)
Probability measure and Probability space, Multiple random variables, Functions of several random variables, Covariance, Correlation and Moments, multivariate binomial and normal distribution, conditional expectation. Modes of convergence of a sequence of random variables, Weak law of large numbers, Strong law of large numbers, Central limit theorem.

Module-II:(10 hrs)
Introduction to Stochastic process, Specification of stochastic process, Markov chain, Transition probability, Classification of states and chains, Determination of higher transition probability, Markov chain with discrete and continuous space.

Module-III:(10 Hours)
Poisson process with related distribution, Generalization of Poisson process: Pure birth process, Birth and death process.

Text book

1. An Introduction of Probability and Statistics by V. K. Rohatgi and A. K. Md.E. Saleh,2^{nd} Edition, Wiley Publication. (Chapter 4 and Chapter 6).
2. Stochastic Process by Sheldon M. Ross, Wiley & sons, (2^{nd} edition)

Reference book

1. Fundamentals of Mathematical Statistics by S.C.Gupta&V.K.Kapoor, S Chand & Sons.
2. Stochastic Process by D N Shanbhag, C R Rao, Gulf Publishing.
3. Stochastic Methods by Crispin Gardiner, Springer.
4. Probability, Random Variables and Stochastic Processes, 4^{th}Edn., A. Papoulis and S. U. Pillai, TMH Publication.

Course outcomes: After the successful completion of this course the students will be able to

1. Have a general overview of discrete and continuous random variables and their statistical properties
2. Understand how random variables and stochastic processes can be described and analyzed and Know the law of large numbers and their application
3. Overview of Markov process and applications.
4. Application of Poisson process and birth and death problems.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PC-Lab 1: Numerical Analysis Lab (BH6542)

List of Experiments:

1. Write a computer-oriented algorithm & the corresponding C Program to fit a st. line of the form y = a x + b, for a given data, using the method of least square.
2. Write a computer oriented algorithm & the corresponding C Program to find the smallest positive root using fixed point iteration method.
3. Write a computer oriented algorithm & the corresponding C Program to find the smallest positive root using Newton- Raphson method.
4. Write a computer oriented algorithm & the corresponding C Program to find the solution of the system of linear equations using Gauss Seidel Method.
5. Write a computer oriented algorithm & the corresponding C Program to interpolate y using the given pair of values of x and y by Lagrange's interpolation.
6. Write a computer oriented algorithm & the corresponding C Program to find the derivative at the initial point using Newton 's Forward DifferenceMethod.
7. Write a computer oriented algorithm & the corresponding C Program to find the derivative at the final point using Newton 's Backward DifferenceMethod.
8. Write a computer oriented algorithm & the corresponding C Program to integrate Numerically using Trapezoidal & Simpson's Rule.
9. Write a computer oriented algorithm & the corresponding C Program to integrate Numerically using Gauss Quadrature Rule.
10. Write a computer oriented algorithm & the corresponding C Program to solve the Differential Equation. $\frac{dy}{dx} = f(x, y),\ y(x_0) = y_0$ at the specified pivotal points by using the Runge-Kutta Method of 4^{th} order.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-3: Design and Analysis of Algorithm (CS6482)

Prerequisites: Discrete Mathematics. Data Structure.

Module- I:(10 hrs)
Introduction to design and analysis of algorithms, Growth of Functions (Asymptotic notations, standard notations and common functions), Recurrences, solution of recurrences by substitution, recursion tree and Master methods, worst case analysis of Merge sort, Quick sort and Binary search, Design & Analysis of Divide and conquer algorithms.
Heapsort: Heaps, Building a heap, The heapsort algorithm, Priority Queue, Lower bounds for sorting.

Module – II : (10 hrs)
Dynamic programming algorithms (Matrix-chain multiplication, Elements of dynamic programming, Longest common subsequence)
Greedy Algorithms - (Assembly-line scheduling, Achivity- selection Problem, Elements of
Greedy strategy, Fractional knapsac problem, Huffman codes).
Data structure for disjoint sets: - Disjoint set operations, Linked list representation, Disjoint set forests.

Module – III : (10 hrs)
Graph Algorithms: Breadth first and depth-first search, Minimum Spanning Trees, Kruskal and Prim's algorithms, single- source shortest paths (Bellman-ford and Dijkstra's algorithms), All- pairs shortest paths (Floyd – Warshall Algorithm). Back tracking, Branch and Bound.

Module – IV: (10 hrs)
Fast Fourier Transform, string matching (Rabin-Karp algorithm), NP - Completeness (Polynomial time, Polynomial time verification, NP - Completeness and reducibility, NP-Complete problems (without Proofs), Approximation algorithms (Vertex-Cover Problem, Traveling Salesman Problem).

Text Book:

1. T.H. Cormen, C.E. Leiserson, R.L. Rivest, C.Stein : Introduction to algorithms -2nd edition, PHI,2002. Chapters: 1,2,3,4 (excluding 4.4), 6, 7, (7.4.1), 8 (8.1) 15 (15.1 to 15.4), 16 (16.1, 16.2, 16.3), 21 (21.1,21.2,21.3), 22(22.2,22.3), 23, 24(24.1,24.2,24.3), 25 (25.2), 30,32 (32.1, 32.2) 34, 35(35.1, 35.2)

Reference Books:

1. Algorithms – Berman, Cengage Learning
2. Computer Algorithms: Introduction to Design & Analysis, 3rd edition-by Sara Baase,Allen Van Gelder, Pearson Education
3. Fundamentals of Algorithm-by Horowitz &Sahani, 2nd Edition, Universities Press.
4. Algorithms by Sanjay Dasgupta, UmeshVazirani – McGraw-Hill Education
5. Algorithm Design – Goodrich, Tamassia, Wiley India.

Course Outcomes:
After the successful completion of this course the students will be able to
1. analyze worst-case running times of algorithms using asymptotic analysis,
2. describe the dynamic-programming paradigm and explain when an algorithmic design situation calls for it. Recite algorithms that employ this paradigm. Synthesize dynamic-programming algorithms, and analyse them.
3. Explain what competitive analysis is and to which situations it applies. Perform competitive analysis.
4. Compare between different data structures. Pick an appropriate data structure for a design situation.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

MC-Lab 3: Design and Analysis of Algorithm Lab (CS6582)

List of Experiments:

1. Using a stack of characters, convert an infix string to postfix string.
2. Implement insertion, deletion, searching of a BST.
3. (a) Implement binary search and linear search in a program (b) Implement a heap sort using a max heap.
4. (a) Implement DFS/ BFS for a connected graph. (b) Implement Dijkstra's shortest path algorithm using BFS.
5. (a) Write a program to implement Huffman's algorithm. (b) Implement MST using Kruskal/Prim algorithm.
6. (a) Write a program on Quick sort algorithm. (b) Write a program on merge sort algorithm. Take different input instances for both the algorithm and show the running time. 7. Implement Strassen's matrix multiplication algorithm.
7. Write down a program to find out a solution for 0 / 1 Knapsack problem.
8. Using dynamic programming implement LCS.
9. (a) Find out the solution to the N-Queen problem. (b) Implement back tracking using game trees.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

<u>Semester-3</u>

Core 10: Functional Analysis (BH7141)

Prerequisites: Real Analysis, Linear Algebra.

Module-I: (10hrs)
Normed spaces, Banach spaces, Compactness and Finite Dimension, Linear Oprators, bounded and Continuous linear Operators, Linear Functionals, Linear Operators and Functionals on FiniteDimensional Spaces, Normed Space of Operators, Dual Space, Duals of $L^{P}[a,b]$, C[a,b], etc. ,Algebraically Reflexive Spaces, Reflexive Spaces.

Module-II: (10hrs)
Inner product spaces, Hilbert Spaces, Orthogonal Complements and Direct Sum, Orthonormal sets and Sequences, Bessel Inequality, Projections, RieszRepresentation Theorem. Hilbert Adjoint Operator, Normal,Unitary and Self-AdjointOperators.

Module-III: (10hrs)
Totally Ordered Set, Partially Ordered Set, Zorn's, Lemma, Hahn-BanachTheorems, Category, Bair's Category Theorem, Uniform boundedness Theorem, Strong and weak Convergence, Convergence of Sequences of Operators and Functionals.

Module-IV: (10hrs) Application-Divergence of Fourier Series of Continuous Functions, Closed Graph Theorem, Open Mapping Theorem, Bounded Inverse Theorem, Spectrum of Bounded Linear Operators, Compact Operators.

Text book:
1. B. V. Limaye: Functional Analysis (2nd Edition)- New Age International Limited.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons (Asia), pvt.ltd., 2006.

Reference book:
1. John B. Conway, A course in Functional Analysis, 2nd edition, Springer verlag, 2006
2. G. Bachman, L. Narici, Functional Analysis, Academic Press

Course Outcomes: After the successful completion of this course the students will be able to
1. Define and thoroughly explain Banach and Hilbert spaces and self-adjoint operators.
2. Apply Hilbert space-theory.
3. work with families of applications appearing in the course.
4. Produce examples and counterexamples illustrating the mathematical concepts presented in the course.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 11: Matrix Computation (BH7143)

Prerequisites: Determinant, Matrices, MATLAB.

Module-I:: (10 hrs)
Gaussian Elimination and Its Variants: Matrix Multiplication Systems of Linear Equations, Triangular Systems, Positive Definite Systems; Cholesky Decomposition, Banded Positive Definite Systems, Sparse Positive Definite Systems, Gaussian Elimination and the LU Decomposition, Gaussian Elimination with Pivoting, Sparse Gaussian Elimination, Sensitivity of Linear Systems: Vector and Matrix Norms, Condition Numbers.

Module-II:: (10 hrs)
The Least Squares Problem, The Discrete Least Squares Problem, Orthogonal Matrices, Rotators, and Reflectors, Solution of the Least Squares Problem, The Gram-Schmidt Process, Geometric Approach, Updating the QR Decomposition, The Singular Value Decomposition, Introduction, Some Basic Applications of Singular Values.

Module-III:: (10 hrs)
Systems of Differential Equations, Basic Facts, The Power Method and Some Simple Extensions, Similarity Transforms, Reduction to Hessenberg and Tridiagonal Forms, The QR Algorithm, Implementation of the QR algorithm, Use of the QR Algorithm to Calculate Eigenvectors, The SVD Revisited, Eigen values and Eigen vectors, Eigen spaces and Invariant Subspaces, Subspace Iteration, Simultaneous Iteration, and the QR Algorithm, Eigen values of Large, Sparse Matrices, Eigen values of Large, Sparse Matrices, Sensitivity of Eigen values and Eigenvectors, Methods for the Symmetric Eigenvalue Problem, The Generalized Eigenvalue Problem.

Text Book:
1. Fundamentals of Matrix Computation by David S Watkins
   Ch1. Ch 2.1,2.2, Ch 3, Ch 4.1,4.2, Ch 5, Ch 6.

Reference Book:
1. Matrix Computations by Gene H. Golub, Charles F.Van Loan The Johns Hopkins University Press, Baltimore.

Course Outcomes: After the successful completion of this course the students will be able to

1. Account for basic concepts of projections, transformations, sensitivity of linear systems vector and matrix norm .
2. Use matrix computations in theory and practice to solve linear system of equations, eigen value problems.
3. practice and to have in-depth understanding on orthogonality and angles, rank, matrix factorizations and least square problems.
4. Apply a scientific approach to analyse and compile results w.r.t. the conditioning of the problems and stable algorithms.

Core 12: Machine Learning (BH7145)

Prerequisites: Probability, Statistics.

Module-I: (14 hrs)
Testing of hypothesis, inference analysis of machine learning algorithms,Linear methods for Regression and Classification: Overview of supervised Learning, Linear regression models and least squares,Logistic regression, Multiple Regression, Subset selection, Ridge regression, least angle regression and Lasso.

Module-II:(13 hrs)
Cluster analysis, Principal Component Analysis, Gaussian mixtures and selection,Linear discriminate analysis. Additive Models, Decision Trees and Boosting: Generalized additive models, Regression and Classification trees.

Module-III:(13 hrs)
Boosting Methods- exponential loss and AdaBoost, Random forests and analysis, Basis expansion and regularization, Kernel smoothing methods, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest Neighbor classifiers.

Text Books

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning-Data Mining Inference and Prediction, Second Edition, Springer Verlag, 2009.
2. Ethem Aipaydin, Introduction to Machine Learning, The MIT Press.

References

1. C.M. Bishop- Pattern Recognition and Machine Learning, Springer,2006.
2. L. Wasserman- All of statistics.

Course Outcomes: - After the successful completion of this course the students will be able to

1. Understand concepts of Large Numbers and different distributions in statistics and their limitations;
2. Understand modern notions in data analysis-oriented computing;
3. be capable of confidently applying common Supervised & Unsupervised Learning algorithms in practice and implementation;
4. Capable of performing distributed computations.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 13: Optimization Theory (BH7147)

Prerequisites: Operation Research.

Module-I: (13 hrs)

Linear programming: Introduction to LPP, Simplex method, Big M method, Two Phase method, Revised simplex method, Duality theory and Dual simplex method,

Integer programming: Branch and bound method, Zero-one- Programming, Gomory Cutting method, Dynamic programming problem.

Module-II:(13 hrs)

Calculus on R and Rn,Convex Analysis, One Dimensional Optimization: Function Comparison Methods, Polynomial Interpolation Methods, Iterative Methods, Two Point Equal Interval Search, Method of Bisection, Fibonacci search Method, Golden Section Search Method, Quadratic Interpolation, Cubic Interpolation, Iterative Methods: Newton’s Method, Secant Method.

.

Module-III:(14 hrs)

Unconstraint Optimization:One dimensional Optimization, Optimization without constraints, Conjugate Gradient method, Steepest Descent Method, Newton’s, Quasi-Newton’s Method

Constraint Optimization: Method of Multipliers, Lagrange Multiplier, Kuhn-Tucker conditions, Convex Optimization, Penalty Function Techniques.

Text Books

1. Mohan C Joshi, Kannan M Moudgalya, “Optimization Theory and Practice”, Narosa Publishing House Pvt. Ltd.
2. Ashok D Belegundu, A R Chandrupatla, Second Edition Cambridge University Press.

Reference Books

1. A. Ravindran, K.m.Rasdell, G.V. Reklaitis, “Engineering optimization” 2nd edition, Wiley India Pvt. Ltd.
2. Kalyamoy Deb, “Optimization for Engineering Design”, PHI Learning Pvt Ltd
3. Stephen G. Nash, A. Sofer,” Linear and Non-Linear Programming”, McGraw Hill
4. Ashok D Belegundu, A R Chandrupatla, Second Edition Cambridge University Press.

Course Outcomes: After successful completion of the course, students will be able to

1. understand and use methods for constrained and unconstrained optimization,
2. understand the solution for simple multistage problems using dynamic programming and geometric programming,
3. formulate and solve nonlinear programming problems from real field data,
4. demonstare the ability to choose and justify optimization techniques that are appropriate for solving realistic engineering problems.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 1: Numerical Optimization (BH7241)

Prerequisites: Optimization Theory

Module-I: (13hrs)
Newton Methods: Inexact Newton Steps, Line Search Newton Methods, Line Search Newton–CG Method, Modified Newton's Method, Hessian Modifications, Eigenvalue Modification, Adding a Multiple of the Identity,Modified Cholesky Factorization. Gershgorin Modification, Modified Symmetric Indefinite Factorization,
Trust-Region Methods: The Cauchy Point and Related Algorithms, The Cauchy Point, Improving on the Cauchy Point, The Dogleg Method, Two-Dimensional Subspace Minimization, Steinhaug's Approach, Trust-Region Newton Methods, Newton–Dogleg and Subspace-Minimization Methods, Accurate Solution of the Trust-Region Problem, Trust-Region Newton–CG Method, Preconditioning the Newton–CG Method, Local Convergence of Trust-Region Newton Methods

Module-II:(13hrs)
Quasi-Newton Methods: The BFGS Method, Properties of the BFGS Method, Implementation,TheSR1Method, Properties of SR1 Updating, The Broyden Class, Properties of the Broyden Class,Convergence Analysis, Global Convergence of the BFGS Method, Super linear Convergence of BFGS,Convergence Analysis of the SR1Method,
Large-Scale Quasi-Newton and Partially Separable Optimization: Limited-Memory BFGS Relationship with Conjugate Gradient Methods ,General Limited-Memory Updating ,Compact Representation of BFGS Updating ,SR1Matrices ,Unrolling the Update ,Sparse Quasi-Newton Updates, Partially Separable Functions, Internal Variables ,Invariant Subspaces and Partial Separability, Sparsity vs. Partial Separability ,Group Partial Separability ,Algorithms for Partially Separable Functions ,Exploiting Partial Separability in Newton's Method ,Quasi-Newton Methods for Partially Separable Functions.

Module-III: (14hrs)
Fundamentals of Algorithms for Nonlinear Constrained Optimization
Initial Study of a Problem, Categorizing Optimization Algorithms, Elimination of Variables, Simple Elimination for Linear Constraints, General Reduction Strategies for Linear Constraints, The Effect of Inequality Constraints, Measuring Progress: Merit Functions
Quadratic Programming: Portfolio Optimization ,Equality–Constrained Quadratic Programs,Properties of Equality-Constrained QPs,Solving the KKT System,Direct Solution of the KKT System, Range-Space Method,Null-Space Method ,Method Based on Conjugacy,Inequality-Constrained Problems,Optimality Conditions for Inequality-Constrained Problems,Degeneracy,Active-Set Methods for Convex QP,Specification of the Active-Set Method for Convex QP, Finite Termination of the Convex QP Algorithm, Updating Factorizations,Active-Set Methods for Indefinite QP, Choice of Starting Point.

Text books:
1. Numerical Optimization, Jorge Nocedal& Stephen J. Wright, Springer.

Reference books:
1. Linear and Nonlinear Programming, David G. Luenberger&Yinyu Ye, Springer
2. Numerical Optimization: Theoretical and Practical Approach, J.FredericBonnans,J.Charles Gilbert, Claude Lemarechal, Claudia A. Sagas

Course Outcomes: After successful completion of the course, students will be able to
1. use sophisticated scientific computing and visualization environments to solve application problems involving matrix computation algorithms,
2. analyse numerical algorithms, and understand the relationships between the computational effort and the accuracy of these algorithms,
3. interpret the results produced by computer implementations of numerical algorithms,
4. explain the effects of errors in computation and how such errors affect solutions.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 1: Numerical Solution of Differential Equations (BH7243)

Prerequisites: Differential Equation. Numerical Analysis.

Module-I: (13hrs)
Finite Difference Methods for Parabolic Equations: stability, consistence and convergence, 1-D parabolic equations, 2-D and 3-D parabolic equations.
Finite Difference Methods for Hyperbolic Equations: some basic difference scheme, dissipation and dispersion errors, extensions to conservation laws, the second-order hyperbolic PDEs.
Finite Difference Methods for Elliptic Equations: numerical solution of linear systems, error analysis with a maximum principle.

Module-II:(13hrs)
Finite Element Methods:Basic Theory: introduction to one-dimensional problems, introduction to two-dimensional problems, abstract finite element theory, examples of conforming finite element spaces, examples of nonconforming finite elements, finite element interpolation theory, finite element analysis of elliptic problems, finite element analysis of time-dependent problems.

Module- III:(14hrs)
Finite Element Methods: Programming: FEM mesh generation. Forming FEM equations, calculation of element matrices, assembly and implementation of boundary conditions, the MATLAB code for P_1 element, the MATLAB code for Q_1 element.

Text Book:

1. Computational Partial Differential Equations using MATLAB by J. Li and Y-T Chen *CRC Press Chapman & Hall.*Chapters: 2, 3, 4, 6, 7

Course Outcomes: After successful completion of the course, students will be able to

1. apply numerical methods to obtain approximate solutions to differential equations,
2. derive numerical methods for various mathematical operations and tasks,
3. analyse and evaluate the accuracy of common numerical methods,
4. write efficient, well-documented MATLAB code and present numerical results in an informative way.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 1: Differential Geometry (BH7245)

Prerequisites: Differential Calculus.

Module-I : (14 hrs)
PreliminaryCommentson R^n,TopologicalManifolds,DifferentiabilityforFunctions ofSeveralVariables,DifferentiabilityofMappings andJacobians,The Space ofTangentVectorsatapointof R^n. Definition of a Differential Manifold, Example of Differential Manifolds, Differentiable Functions and Mappings, The Tangent Space at a point of a Manifold, Vector, Fields, Tangent Covectors, Covectors on Manifolds, Covector Fields and Mappings, Bilinear Forms, The Riemannian Metric, Riemannian Manifolds as Metric Spaces, Tensors on a Vector Space.

Module-II: (13 hrs)
LieGroups,TheAction of a Lie GrouponaManifold,TheActionofaDiscreteGrouponaManifold,Oneparameterandlocaloneparameter Groupsactingon aManifold,TheLieAlgebraofVectorFieldsonaManifold.
Tensor Fields, mapping and Covariant Tensors, Symmetrizing and Alternating transformations, Multiplication of Tensors on a Vector Space, Multiplication of Tensor Fields, Exterior Multiplication of Alternating Tensors, Exterior Algebra on Manifolds, Exterior Differentiation.

Module-III: (13 hrs)
DifferentiationofVectorFieldsalongcurvesin R^n,TheGeometryofSpaceCurves, d ifferentiationof VectorFieldsonSub-manifolds of R^n,FormulasforCovariantDerivatives,Differentiation onRiemannianManifolds,TheCurvatureTensor,TheRiemannianConnectionandExteriorDifferentialForms,B asic PropertiesofRiemannianCurvatureTensor,TheCurvatureFormsandtheequationsofStructure.

Text Book:

1. William Boothby; An Introduction to Differentiable manifolds and Riemannian Geometry, Academic Press, New York.
2. U. C. De, A. A. Shaikh; Differential Geometry of Manifolds, Narosa Publishing House Pvt. Ltd., New Delhi, Chennai, Mumbai, Kolkata, 2007 Reprinted 2009.
   The course is covered by Chapters II, III, IV, V, VI, VII and VIII.

Reference Book:

1. Loring W. Tu; An Introduction to Differentiable manifolds, Second Edition, Springer International Edition, First Indian Reprint 2012.
2. Wilmore- Differential and Riemannian geometry, Oxford University Press, 1996.
3. Warner-Foundations of differential geometry and Lie groups Springer, 1983.

Course Outcomes: After successful completion of the course, students will be able to

1. Definetheequivalenceoftwocurves and analysetheequivalenceoftwocurvesby applying some theorems.
2. Expressdefinitionandparametrization of surfaces
3. Expresstangentspaces ofsurfaces and explaindifferentialmapsbetweensurfaces and finding derivativesofsuchmaps.
4. Listing topologicalaspectsofsurfaces,definingtheconceptofmanifolds withexamplesandinvestigate their properties.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 1: Computational Fluid Dynamics (BH7247)

Module-I: (13 hrs)
Basic Concepts, Continuum Hypothesis, Viscosity, Strain Analysis, Stress Analysis, Relation between Stress and rate of Strain components, Thermal Conductivity, Law of heat Conduction, Equation of Continuity in Vector Form and in Various Co-ordinate Systems, Boundary Conditions

Module-II :(13 hrs)
Navier-Stokes Equations, Energy Equations, Vorticity and Circulation in Viscous Flow, Bernoulli's equation, Dynamical Similarity by Inspection Analysis, Physical Importance of Non- Dimensional Parameters, Important Non-Dimensional Coefficients in the Dynamics of Viscous Fluids, Exact Solution of Navier-Stokes Equations (Flow between Parallel Plates, Circular Pipes -Velocity and Temperature Distribution).

Module-III: (14 hrs)
Finite Difference methods for Parabolic Equation in one Space Variable (Explicit Method and Its Convergence, Fourier Analysis of the Error, Implicit andWeighted Average Methods and Their Convergence). Finite Difference Method for Hyperbolic Equations in one Space Dimension, characteristics, The CFL Condition, Furior Error Analysis of The Upwind Scheme, The Lax-Wendroff Shceme and its Application to Conservation Laws. Consistency, Convergence and Stability of Finite Difference Methods

Text Books

1. J. L. Bansal- Viscous Fluid Dynamics, Oxford University Press.
2. K.W,Morton & D. F. Mayers: Numerical Solution of Partial Differential Equations, Second Edition, 2005, Cambridge University Press.

References

1. P. Wesseling–Principles of Computational Fluid Dynamics, Springer Verlag, 2000.
2. T. Petrila and D. Trif–Basics of fluid Mechanics and Introduction to Computational Fluid Mechanics, Springer Verlag, 2005.
3. Z. U. A. Warsi – Fluid Dynamics–Theoretical and Computational Approach, C R C Press.
4. M. D. Raisinghania – Fluid Dynamics, S. Chand and Company.

Course Outcomes: After successful completion of the course, students will be able to:

1. Describe the physical properties of a fluid, the principles of motion for fluids and their formulation.
2. Calculate the pressure distribution for incompressible fluids, the hydrostatic pressure and force on plane and curved surfaces.
3. Demonstrate the application point of hydrostatic forces on plane and curved surfaces.
4. Use the dimensional analysis and derive the dimensionless numbers, apply the similitude concept and set up the relation between a model and a prototype.

PC Lab 2: Matrix Computation &Machine Learning Laboratory Using R Programming (BH7541)

Syllabus:

Implementation of following methods using R Programming

Simple and multiple linear regression, Logistic regression, Linear discriminant analysis, Ridge Regression, Cross validation and boot strap, Fitting Classification and Regression trees, K-nearest neighbours, Principal component analysis, K-means clustering.

Reference (For R Programming)

1. G.James, D.Witten, T.Hastie, R.Tibshirani-An introduction to statistical learning with applications in R, Springer,2013.

Course Outcomes: Upon successful completion of the course students will be able to

1. apply R Programming to solve statistical problems,
2. understand about statistical based computer programming,
3. apply different programming tools on various statistical problems,
4. code statistical functions.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PC Lab 3: Optimization Lab (BH7543)

Syllabus:

1. Introduction to linear programming problem, solving LPP by MATLAB (Introduction)
2. Solve various simplex problem using MATLAB Function
3. Solve Transportation and assignment problem using, Any suitable simulator
4. Compare. between Transportation, Assignment problem by Using MATLAB
5. Explore queuing theory for scheduling, resource allocation, and traffic flow applications using mat lab
6. Elementary concept of Modelling and Simulation using Mat-lab
7. Solve Various Decision Problem Using Matlab
8. Introduction to Nonlinear Programming by any suitable simulator
9. Iterative method for optimization problem by any suitable simulator
10. Application of nonlinear programming using Mat lab

Course Outcomes: After successful completion of the course, students will be able to:

1. solve various types of optimization problems using MATLAB,
2. understand the idea of simulation of optimization problems,
3. apply MATLAB program to solve various nonlinear programming problems.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Semester-4

Core 14: Number Theory and Cryptography (BH7142)

Prerequisites: Set of Integers, Permutation & Combination, Programming language.

Module-I: (13 hrs)
Euclidean GCD Algorithm, Extended GCD Algorithm, Congruences and Modular Arithmetic: Modular Exponentiation, Fast Modular Exponentiation, Linear Congruences: Chinese Remainder Theorem, Polynomial Congruences: Hensel Lifting, Quadratic Congruences: Quadratic Residues and Non-Residues, Legendre Symbol, Jacobi Symbol, Multiplicative Orders: Primitive Roots, Computing Orders, Prime Number Theorem and Riemann Hypothesis
Polynomial-Basis Representation, Fermat's Little Theorem for Finite Fields, Multiplicative Orders of Elements in Finite Fields, Normal Elements, Minimal Polynomials,
Application to cryptography: The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream Ciphers.

Module-II:(13 hrs)
Primality Testing: Fermat Test, Solovay-Strassen Test, Miller-Rabin Test, AKS Test, Integer Factorization: Trial Division, Pollard's Rho Method, Floyd's Variant, Block GCD Calculation, Brent's Variant, Pollard's p-1 Method: Large Prime Variation, Quadratic Sieve Method: Sieving, Incomplete Sieving, Large Prime Variation, Multiple-Polynomial Quadratic Sieve Method
The RSA Cryptosystem: Introduction to Public-key Cryptography, Implementing RSA Cryptosystem, Other Attacks on RSA: Computing $\phi(n)$, The Decryption Exponent, Wiener's Low Decryption Exponent Attack, Cryptographic Hash Functions: Hash Functions and Data Integrity, Security of Hash Functions : The Random Oracle Model, Algorithms in the Random Oracle Model, Comparison of Security Criteria, Discrete Logarithms: The ElGamal Cryptosystem, Algorithms for the Discrete Logarithm Problem: Shank's Algorithm , The Pollard Rho Discrete Logarithm Algorithm, Security of ElGamal Systems.

Module-III:(14 hrs)
Elliptic Curves: Elliptic Curves over the Reals, Elliptic Curves Modulo a Prime, Properties of Elliptic Curves, Point Compression and the ECIES, Computing Point Multiples on Elliptic Curves. Signature Schemes: Introduction, Security Requirements for Signature Schemes, Signatures and Hash Functions, The ElGamal Signature Schemes, Security of the ElGamal Signature Scheme, Variants of the ElGamal Signature Schemes: The Schnorr Signature Scheme, The Digital Signature Algorithm, The Elliptic Curve DSA, Elliptic Curve Primality Test.

Text Books:
1. Computational Number Theory-Abhijit Das, CRC Press (First Indian Reprint,2015) Chapter 1(1.2-1.7, 1.9) ,Chapter 2 (2.2.1,2.4.1,2.4.2, 2.4.3, 2.4.4), Chapter 5 (5.2.1,5.2.2, 5.2.3, 5.3.2) , Chapter 6(6.1-6.6, 6.8).
2. Cryptography Theory and Practice- Douglas R. Stinson, Chapman & Hall/ CRC (Third Edition) Chapter 1, Chapter 4 (4.1 ,4.2), Chapter 5(5.1,5.3,5.7), Chapter 6 (6.1,6.2,6.5,6.7), Chapter 7(7.1-7.4)

Reference Books:
1. Neal Koblitz: A Course in number theory and Cryptography, Springer Veriag, Chapter 6(section 3)

Course Outcomes:
After successful completion of the course, students will be able to:
1. develop a deeper conceptual understanding of the theoretical basis of number theory and identify how number theory is related to and used in cryptography.

2. identify the order of an integer, primitive roots, Euler's criterion, the Legendre symbol, Jacobi symbol and their properties.
3. acquire knowledge of a wide variety of number theoretic ideas and techniques like Divisibility results, Euclid's algorithm, Fermat's little Theorem , Chinese Remainder Theorem, Diophantine equations, finite field etc.
4. Understand modular arithmetic number-theoretic functions, RSA scheme and apply them to cryptography.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

Core 15: Theory of Computation (BH7144)

Prerequisites: Discrete Mathematics.

Module – I: (13 hrs)
Alphabet, languages and grammars. Production rules and derivation of languages. Chomsky hierarchy of languages. Regular grammars, regular expressions and finite automata (deterministic and nondeterministic). Closure and decision properties of regular sets. Pumping lemma of regular sets. Minimization of finite automata. Left and right linear grammars.

Module – II:(13 hrs)
Context free grammars and pushdown automata. Chomsky and Griebach normal forms. Parse trees, Cook, Younger, Kasami, and Early's parsing algorithms.
Ambiguity and properties of context free languages. Pumping lemma, Ogden's lemma, Parikh's theorem. Deterministic pushdown automata, closure properties of deterministic context free languages.

Module – III:(14hrs)
Turing machines and variation of Turing machine model, Turing computability, Type 0 languages. Linear bounded automata and context sensitive languages. Primitive recursive functions. Cantor and Godel numbering. Ackermann's function, mu- recursive functions, recursiveness of Ackermann and Turing computable functions.
Church Turing hypothesis. Recursive and recursively enumerable sets. Universal
Turing machine and undecidable problems. Undecidability of Post correspondence problem. Valid and invalid computations of Turing machines and some undecidable properties of context free language problems. Time complexity class P, class NP, NP completeness.

Text Books:

1. Introduction to Automata Theory, Languages and Computation: J.E. Hopcroft and J.D Ullman, Pearson Education, 3rd Edition.
2. Introduction to the theory of computation: Michael Sipser, Cengage Learning

Reference Books:

1. Introduction to Languages and the Theory of Computation: Martin, Tata McGraw Hill, 3rdEdition
2. Introduction to Formal Languages, Automata Theory and Computation: K. Kirthivasan, Rama R, Pearson Education.
3. Theory of computer Science (Automata Language & computations) K.L. Mishra N. Chandrashekhar, PHI.
4. Elements of Theory of Computation: Lewis, PHI
5. Theory of Automata and Formal Languages: Anand Sharma, Laxmi Publication
6. Automata Theory: Nasir and Srimani, Cambridge University Press.
7. Introduction to Computer Theory: Daniel I.A. Cohen, Willey India, 2nd Edition.
8. Theory of computation by Saradhi Varma, Scitech Publication

Course Outcomes: After successful completion of the course, students will be able to:

1. analyze and design finite automata, difference between complete system and NFA, Pushdown automata, Turing machines, Formal languages, and Grammars,
2. Demonstrate and understanding of key notions, such as algorithm, computability, decidability, and complexity through problem solving,
3. Prove the basic results of the Theory of Computation,
4. Model, compare and analyze different computational models,state and explain the relevance of the Church-Turing hypothesis

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 2: Parallel & Distributed Computing (BH7242)

Module – I: (10 hrs)
Introduction to parallel computing.
Parallel programming platforms: Trends in microprocessor Architectures, Limitations of memory system performance, Dichotomy of parallel computing platforms, physical organization of parallel platforms, communication costs in parallel machines, Routing mechanisms for interconnection network, Impact of process processors mapping and mapping techniques.

Module – II:(10 hrs)
Principles of parallel algorithm design: Preliminaries, Decomposition techniques, Characteristics of tasks and interactions, Mapping techniques for load balancing, Methods for containing. Interactions overheads, Parallel algorithm models. Basic communication operations: One-to-All Broadcast and All-to-One Reduction, All-to-All broadcast and reduction All-Reduce and prefix sum operations, scatter and gather, All-to-All personalized communication, circular shift, Improving the speed of some communication operation.

Module – III:(10 hrs)
Analytical modeling of parallel programs: Performance metrics for parallel systems, Effect of granularity of performance, scalability of parallel system, Minimum execution time and minimum cost-optimal execution time, Asymptotic analysis of parallel programs, other scalability metrics.
Programming using the message passing paradigm:
Principle of message – Passing programming, Send and receive operations, the message passing interface, Topologies and embedding, Overlapping communication with computation, collective communication and computation operations, Groups and communicators.
Dense matrix algorithm: Matrix-vector multiplication, Matrix-matrix algorithm, Solving a system of linear equations.

Text Book:
1. Introduction to Parallel Computing, Second Edition, Ananth Gram, Anshul Gupta, George Karypis, Vipin Kumar Person Education.
2. Parallel computing Theory and Practice, Second Edition, Michael J. Quinn, TMH.

Course Outcomes: After successful completion of the course, students will be able to:
1. develop and apply knowledge of parallel and distributed computing techniques and methodologies.
2. apply design, development, and performance analysis of parallel and distributed applications.
3. Use the application of fundamental Computer Science methods and algorithms in the development of parallel applications.
4. Explain the design, testing, and performance analysis of a software system, and to be able to communicate that design to others.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 2: Fuzzy and Rough Set Theory (BH7244)

Prerequisites: Set theory.

Module-I:(10 hrs)
Crisp sets and Fuzzy sets**:** Introduction – crisp sets an overview – the notion of fuzzy sets –basic concepts of fuzzy sets – membership functions – methods of generating membership functions – defuzzification methods- operations on fuzzy sets - fuzzy complement – fuzzy union – fuzzy intersection – combinations of operations – General aggregation operations. Fuzzy arithmetic and Fuzzy relations: Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations- crisp and fuzzy relations – binary relations – binary relations on a single set – equivalence and similarity relations – compatibility or tolerance relations.

Module-II:(10 hrs)
Fuzzy measures – belief and plausibility measures – probability measures – possibility and necessity measures – possibility distribution - relationship among classes of fuzzy measures.
Fuzzy Logic and Applications: Classical logic: an overview – fuzzy logic – approximate reasoning - other forms of implication operations - other forms of the composition operations – fuzzy decision making –fuzzy logic in database and information systems - fuzzy pattern recognition – fuzzy control systems.

Module-III:(10 hrs)
Basic concept of rough sets: Approximation space and set approximation, rough membership function
Rough set in data analysis: Information system, Indiscernibility relation, Set approximation, rough sets and membership function, Dependency of attributes, Reduction of attributes, Reducts and core, Discernibility matrices and functions, Decision rule synthesis.

Text Book:
1. George J Klir and Tina A.Folger, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, 1988.
2. An introduction to rough set theory and application: A tutorial, by Z. Suraj
3. Rough sets: Mathematical Foundation by L. Polkowski, Spinger-Verlag, Berlin
4. H.J. Zimmerman, Fuzzy Set theory and its applications, 4^{th} Edition, Kluwer Academic Publishers, 2001.

Reference Book:
1. Goerge J Klir and Bo Yuan, Fuzzy sets and Fuzzy logic: Theory and Applications. Prentice Hall of India, 1997.
2. Hung T Nguyen and Elbert A. Walker, First Course in Fuzzy Logic, 2^{nd}Edition, Chapman & Hall/CRC, 1999.
3. Jerry M Mendel, Uncertain Rule – Based Fuzzy Logic Systems; Introduction and New Directions, PH PTR, 2000.
4. John Yen and Reza Langari, Fuzzy Logic: Intelligence Control and Information, Pearson Education, 1999.
5. Timothy J Ross, Fuzzy Logic with Engineering Applications, McGraw Hill International Editions, 1997.

Course Outcomes: After successful completion of the course, students will be able to:
1. decide the difference between crips set and fuzzy set theory
2. make calculation on fuzzy set theory and gain the methods of fuzzy logic
3. recognize fuzzy logic membership function
4. recognize fuzzy logic fuzzy inference systemsmake applications on Fuzzy logic membership function and fuzzy inference systems

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 2: AdvanceMachine Learning (BH7246)

Prerequisites: Statistics, Linear Algebra, Probability

Syllabus:
Module –I:(10 hrs)
Introduction: generative models for discrete data (Bayesian concept learning, Naïve Bayes classifier), Gaussian discriminant analysis, Inference in jointly Gaussian distributions, Bayesian statistics, Bayesian linear and logistic regression, General linear models and exponential family, Mixture models and EM algorithm, Gaussian Processes.

Module –II:(10 hrs)
Review of SVM, Multiclass SVM, kernels for building generative models, kernels for strings.Neural Networks-Perceptron, MLP and back propagation, Methods of acceleration of convergence of BPA, Introduction to Deep Learning.

Module –III:(10 hrs)
Dimensionality Reduction (Factor Analysis, Kernel PCA, Independent Component Analysis, ISOMAP, LLE), feature selection, Spectral Clustering, Markov and Hidden Markov Models, Performance Analysis, Model Assessment, Bias Variance Trade-off, Training error, Test error, Model Complexity, Cross Validation and Boot Strap Method.

Text Books:

1. Machine Learning: A Perspective Tom Mitchell. First Edition, McGraw- Hill, 1997.
2. Introduction to Machine Learning Edition 2, by EthemAlpaydin.

Course Outcomes: Upon successful completion, students will be able to:

1. Understand the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc
2. Understand the strengths and weaknesses of many popular machine learning approaches,
3. appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning,
4. Design and implement various machine learning algorithms in a range of real-world applications.

School/ Department: School of Basic Sciences & Humanities
Course: M. Sc., Programme: Mathematics and Computing,
Duration: 2 years (Four Semesters)

PE 2: Soft Computing (BH7248)

Module – I:(10 hrs)
NEURAL NETWORK: Models of a Neuron, Neural Networks viewed as Directed Graph, Least Mean Square Algorithm, Perceptron, Perceptron Convergence Theorem, Some Preliminaries Multilayer Perceptron, Back Propagation Algorithm, XOR Problem, Heuristics for making the Back Propagation Algorithm Perform Better, Virtues and Limitation of Back Propagation Learning, Accelerated Convergence of Back Propagation Learning, Supervised Learning viewed as an Optimization Problem, Introduction to Deep Learning.

Module – II:(10 hrs)
Fuzzy Logic and Neuro Fuzzy System
Fuzzy sets: Introduction, Basic Definitions and Terminology, Set theoretic Operations, MF Formulation and Parameterization, MF's of One and Two Dimensions, Derivatives of Parameterized MF's, Fuzzy Complement, Fuzzy Intersection and Union, Parameterized T-norm and T- conorm
Fuzzy Rules and Fuzzy Reasoning: Extension Principle and Fuzzy Relations, Linguistic Variables, Fuzzy If-Then Rules, Compositional Rule of Inference and Fuzzy Reasoning
Fuzzy Inference Systems: Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Input Space Partitioning, Fuzzy Modeling
ANFIS: Adaptive Neuro-Fuzzy Inference Systems:- ANFIS Architecture, Hybrid Learning Algorithm, Learning Method that Cross-fertilize ANFIS and RBFN,ANFIS as a Universal Approximator, Simulation Example of Modeling a Two-Input Sinc Function.

Module – III:(10 hrs)
Introduction to Genetic Algorithms: Working Cycle of a Genetic Algorithm, Binary- Coded GA, Crossover or Mutation, Fundamental theorem of GA/ Schema Theorem, Limitations of Binary-Coded GA, GA parameters Setting, Constraints Handling in GA, Penalty Function Approach, Advantages and Dis advantages of Genetic Algorithms, Combination of Local and Global Optimum Search Algorithms, Real- Coded GA, Crossover Operators, Mutation Operators,
Combined Genetic Algorithms: Fuzzy Logic:- Fuzzy Genetic Algorithm, Brief Literature Review and Working Principle of Genetic- Fuzzy Systems,
Combined Genetic Algorithms: Neural Networks: Introduction, Working Principle of Genetic- Neural Systems, Forward Calculation and Hand Calculation.

Text Book:

1. Neural Network by Simon Haykin, Pearson Prentice Hall.
2. Neuro Fuzzy and Soft Computing, J. S. R. JANG,C.T. Sun, E. Mitzutani, PHI
3. Soft Computing: Fundamentals and Applications, Dilip K. Pratihar, Narosa

Reference Book

1. Neural Networks, Fuzzy Logic, and Genetic Algorithm (synthesis and Application) S.Rajasekaran, G.A. VijayalakshmiPai, PHI

Course Outcomes: After successful completion of the course, students will be able to:
1.Application of soft computing on various engineering problems.
2. Hybridization of various soft computing tools for prediction and analysis of various data sets.

3. Application of genetic programming for optimization.
4. Knowledge about performance measure of a data set using soft computing tools

Seminar: Seminar(BH7742)

[Will be decided by the Department]

Major Project: Project (BH7642)

[Will be decided by the Department]