COURSES OF STUDIES

FOR

2 yr. M.Sc

In

Mathematics & Computing

BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ODISHA

1ST Semester				2nd Semester			
Theory		**Contact Hours**		**Theory**		**Contact Hours**	
Code	**Subject**	**L-T-P**	**Credit**	**Code**	**Subject**	**L-T-P**	**Credit**
15 MMCC101	Real Analysis	3-1-0	4	15 MMCC201	Topology	3-1-0	4
15 MMCC102	Differential Equation	3-1-0	4	15 MMCC202	Numerical Analysis	3-0-0	3
15 MMCC103	Discrete Mathematics	3-1-0	4	15 MMCC203	Complex Analysis	3-1-0	4
15 MMCC104	Abstract Algebra	3-0-0	3	15 MMCC204	Linear Algebra	3-0-0	3
15 MMCF107	Data Structure Using C++	3-0-0	3	15 MMCF207	Computer Network	3-1-0	4
15 MMCF108	RDBMS	3-0-0	3	15 MMCF208	Design & Analysis of Algorithm	3-0-0	3
		Total	21			**Total**	21
Practical/Sessional				**Practical/Sessional**			
Code	**Subject**	**L-T-P**	**Credit**	**Code**	**Subject**	**L-T-P**	**Credit**
15 MMCF151	Data Structure Lab	0-0-3	2	15 MMCF251	DAA Lab	0-0-3	2
15 MMCF152	RDBMS Lab	0-0-3	2	15 MMCC251	Numerical Analysis lab	0-0-3	2
		Total	4			**Total**	4
		Total	21+4=25			**Total**	21+4=25

3rd Semester				4th Semester			
Theory		**Contact Hours**		**Theory**		**Contact Hours**	
Code	**Subject**	**L-T-P**	**Credit**	**Code**	**Subject**	**L-T-P**	**Credit**
15 MMCC301	Functional Analysis	3-1-0	4	15 MMCF407	Theory of Computation	3-1-0	4
15 MMCC302	Matrix Algebra	3-1-0	4	15 MMCC401	Differential Geometry	3-1-0	4
15 MMCC303	Probability Theory	3-1-0	4		Elective-III	3-0-0	3
15 MMCC304	Optimization Technique	3-0-0	3				
	Elective-I	3-0-0	3				
	Elective-II	3-0-0	3				
		Total	21			**Total**	21
Practical/Sessional				**Practical/Sessional**			
Code	**Subject**	**L-T-P**	**Credit**	**Code**	**Subject**	**L-T-P**	**Credit**
15 MMCC351	Optimization Lab	0-0-3	2	15 MMCC451	Seminar (Twice in a Week)		4
15 MMCC352	MAT Lab	0-0-3	2	15 MMCC452	Project		10
		Total	4			**Total**	14
		Total	21+4=25			**Total**	11+14=25

List of Elective-I			List of Elective-II		
Sl. No.	**Code**	**Subject**	**Sl. No.**	**Code**	**Subject**
1	15 MMCE401	Numerical optimization	1	15 MBEE401	Advanced Software Engineering
2	15 MMCE402	Numerical Solution of Differential Equation	2	15 MBEE402	Parallel & Distributed Computing
3	15 MMCE403	Statistics	3	15 MBEE403	Cloud Computing
4	15 MMCE404	Data Science	4	15 MBEE404	Mobile Computing
5	15 MMCE405	Fuzzy & Rough Set Theory	5	15 MBEE405	Data Mining
List of Elective-III			6	15 MBEE406	Machine Learning
Sl. No.	Code	Subject	7	15 MBEE407	Soft Computing
1	15 MBCE4014	Computational Finance	8	15 MBEE408	Pattern Analysis
2	15 MBCE4015	Bio-Informatics			
3	15 MBCE4016	Algebraic Graph Theory			
4	15 MBCE4017	Number Theory & Cryptography			
5	15 MBCE4018	Finite Element Method			

15 MMCC 101 REAL ANALYSIS (3-1-0)

Module – I : (14 Hours)

Introduction to Metric spaces, compact set, connected set, Weistrass Approximation Theorem, Sequence and series of function, Uniform convergence.Lebesgue measure: Introduction, outer measure, measurable sets and Lebesgue measure, A non measurable set, measurable function.The Lebesgue Integral: The Rimann integral, The Lebesgue integral of a bounded function over a set of finite measure, The integral of a non negative function, The general Lebesgue integral.

Module –II : (14 Hours)

Measure and Integration: measure spaces, measureable functions, Integration, General convergence theorem, Signed measures, The Random-Nikodyn theorem, The L^p spaces.

Measure and Outer measure: Outer measure and measurability, The extension theorem, The Lebesgue-Stieltjes integral, Product measures, Integral operators, Inner measure, Extension by sets measure zero.

Module –III : (12 Hours)

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 variation.

The Riemann Stieltjes Integrals: Introduction, Notation, The definition of Riemann Stieltjes Integral, Linear operators, Integration by parts, Change of variable in Riemann StetiItjes integrals, Reduction to a Riemann Integral, Euler's summation formula, Monotonically increasing integrals.

Text Book :

1. Real Analysis by H.L. Royden (3rd edition)PHI
Chapter 3(3.1 to 3.5), Chapter(4.1 to 4.4), Chapter(11), Chapter(12.1 to 12.7).
2. Mathematical analysis by Tom M.Apostol,2nd Edition, Addison-Wesley publication company Inc. Newyork,1974.
Chapter6(6.1 to 6.8), Chapter7(7.1 to 7.11)

Reference Book :

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 Anslysis, 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 (willey estern ltd)

15 MMCC 102 DIFFERENTIAL EQUATIONS (3-1-0)

UNIT - I (**14 hours)**

EXISTANCE AND UNIQUENESS OF SOLUTIONS: Picards 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, Legendere equation and Legendere 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.

UNIT – II (**14 hours)**

BOUNDARY VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS: Sturm-Liouville problem, Orthogonality of Eigen functions, Green's function.

ELLIPTIC DIFFERENTIAL EQUATIONS: Derivation of Laplace and Poisson equation - BVP - Separation of Variables - Dirichlet's,Problem and Newmann Problem for a rectangle - Solution of Laplace equation in Cylindrical and spherical coordinates - Examples.

UNIT-III (**12 hours)**

PARABOLIC DIFFERENTIAL EQUATIONS: Formation and solution of Diffusion equation - Dirac-Delta function - Separation of variables method - Solution of Diffusion Equation in Cylindrical and spherical coordinates - Examples.

HYPERBOLIC DIFFERENTIAL EQUATIONS: Formation and solution of one-dimensional wave equation - canocical reduction - IVPd'Alembert's solution - IVP and BVP for two-dimensional wave equation – Periodic solution of one-dimensional wave equation in cylindrical and spherical coordinate systems - Uniqueness of the solution for the wave equation - Duhamel's Principle -Examples.

Text Book

J Sinha Roy and S Padhy, A Course On Ordinary And Partial Differential Equations, KALYANI PUBLISHER.
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 Eduction, 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. Balachandra Rao,H.R.Anuradha, Differential Equations with applications and programs, Universe Press.
5.C. Henry,Edwards,David .E.Peney, Differential Equationd and Boundary Value Problems, Pearson.
6.Wiliam E., Boyee,Richard C. Diprima. Elementary Differntial Equations and Boundary Value Problems,Wiley

15 MMCC 103 Discrete Mathematics (3-1-0)

Module-I : (13 Hours)

Propositional logic operations, truth , First order logic, basic logical Operations Propositional Equivalence, Predicates and Universal & Existential Quantifiers, Nested Quantifiers,

Rules of Inference, Proof methods and Strategies, Sequences and Summations, Mathematical Induction, Recursive definition and structural induction, Program Correction

Recurrence relation, Solution to recurrence relation, Generating functions, Principle of Inclusion and exclusion, Application of Inclusion and Exclusion Principle,

Set Theory, Relation and their properties, Partitions, Closure of Relations, Warshall,s Algorithm, Equivalence relations, Partial orderings, .

Module-II : (14 Hours)

Introduction to graph theory, Graph terminology, Representation of graphs, Isomorphism,

Connectivity, Euler and Hamiltonian paths, Shortest path problems, Planar graph, Graph coloring,

Introduction to trees, Application of trees, Tree Traversal, Minimum Spanning tree.

Module-III : (13 Hours)

Matrix representation of a graph: Basic ideas of Incidence matrix, sub matrix, circuit matrix fundamental circuit matrix, cut set matrix, path matrix and adjacency matrix, Coloring :Chromatic number, chromatic partitioning ,chromatic polynomial,matching ,covering

Algebraic systems, Lattices, Distributive and Complemented Lattices, Boolean Lattices and

Boolean Algrebra, Boolean Functions and Boolean Expressions.

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)

3. Douglas B. West, “Introduction to Graph Theory ” 2e, PHI

Reference:

1. J. L. Mott, A. Kandel, T. P. Baker, “Discrete mathematics for Computer Scientists & Mathematicians”, Second Edition, PHI.

2. Gosset “ Discrete Mathematics “Second Edition, Wiley

15 MMCC-104 ABSTRACT ALGEBRA (3-0-0)

Module-I (10 hours)

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 hours)

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 (10hours)

Galois Theory: Automorphism groups and fixed field s, 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

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

Reference Books:

1. **Vivek Sahai and Vikas Bist :** 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 Quazi Zameeruddin :** 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 Prakashan Mandir, Meerut.

15 MMCF 107 DATA STRUCTURE using C++ (3-0-0)

Module – I [10 hours] Introduction to data structures: storage structure for arrays, sparse matrices, Stacks and Queues: representation and application. Linked lists: Single linked lists, linked list representation of stacks and Queues. Operations on polynomials, Double linked list, circular list.

Module – II [10 Hours] Dynamic storage management-garbage collection and compaction, infix to post fix conversion, postfix expression evaluation. Trees: Tree terminology, Binary tree, Binary search tree, General tree, B+ tree, AVL Tree, Complete Binary Tree representation, Tree traversals, operation on Binary tree-expression Manipulation.

Module –III [10 Hours] Graphs: Graph terminology, Representation of graphs, path matrix, BFS (breadth first search), DFS (depth first search), topological sorting, Warshall's algorithm (shortest path algorithm.) Sorting and Searching techniques – Bubble sort, selection sort, Insertion sort, Quick sort, merge sort, Heap sort, Radix sort. Linear and binary search methods, Hashing techniques and hash functions.

Text Books:

1. Gilberg and Forouzan: "Data Structure- A Pseudo code approach with C++" by Thomson publication

2. "Data structure in C++" by Y. Kanetkar TMH publication.

Reference Books:

1. Pai: "Data Structures & Algorithms; Concepts, Techniques & Algorithms "Tata McGraw Hill.

2. "Fundamentals of data structure" Horowitz, Sahani & Freed, Computer Science Press.

3. "Fundamental of Data Structure" (Schaums Series) Tata-McGraw-Hill. 22 BE

15 MMCF108 Relational Database Management System(3-0-0)

Module I : (10 hours)
Database System Architecture - Data Abstraction, Data Independence, Data Definitions and Data Manipulation Languages. Data models - Entity Relationship(ER), Mapping ER Model to Relational Model, Network .Relational and Object Oriented Data Models, Integrity Constraints and Data Manipulation Operations.

Module II : (10 hours)
Relation Query Languages, Relational Algebra and Relational Calculus, SQL.
Relational Database Design: Domain and Data dependency, Armstrong's Axioms, Normal Forms, Dependency Preservation, Lossless design.
Query Processing Strategy.

Module III: (10 hours)
Transaction processing: Recovery and Concurrency Control. Locking and Timestamp based Schedulers.
Database Recovery System: Types of Data Base failure & Types of Database Recovery, Recovery techniques

Text Books:

1. Database System Concepts by Sudarshan, Korth (McGraw-Hill Education)

2. Fundamentals of Database System By Elmasari & Navathe- Pearson Education

References Books:

(1) An introduction to Database System – Bipin Desai, Galgotia Publications

(2) Database System: concept, Design & Application by S.K.Singh (Pearson Education)

(3) Database management system by leon &leon (Vikas publishing House).

(4) Fundamentals of Database Management System – Gillenson, Wiley India

(5) Database Modeling and Design: Logical Design by Toby J. Teorey, Sam S. Lightstone, and Tom Nadeau, “”, 4th Edition, 2005, Elsevier India Publications, New Delhi

15 MMCF 151 DATA STRUCTURE LAB (0-0-3)

(Minimum 10 experiments to be done)

Experiment No.1 Write a C++ program to perform matrix multiplication using array. **Experiment No.2** (a) Write a C program to create a stack using an array and perform (i) push operation (ii) pop operation (b) Write a C program to create a queue and perform i) Push ii) pop iii) Traversal

Experiment No. 3 Write a C++ program that uses Stack operations to perform the following: i) Converting infix expression into postfix expression ii) Evaluating the postfix expression

Experiment No. 4 Write a C++ program that uses functions to perform the following operations on Single linked list: i) Creation ii) Insertion iii) Deletion iv) Traversal in both ways

Experiment No. 5 Write a C++ program that uses functions to perform the following operations on Double linked list: i) Creation ii) Insertion iii) Deletion

Experiment No. 6 Write a C++ program that uses functions to perform the following operations on Binary Tree: i) Creation ii) Insertion iii) Deletion

Experiment No. 7 Write C++ programs that use both recursive and non recursive functions to perform the Linear search operation for a Key value in a given list of integers: i) Linear search

Experiment No. 8 Write C++ program that use both recursive and non recursive functions to perform the Binary search operation for a Key value in a given list of integers:

Experiment No.9 Write a C++ program that implement Bubble Sort method to sort a given list of integers in descending order.

Experiment No.10 Write a C++ program that implement Quick Sort method to sort a given list of integers in ascending order:

Book:- 1. Gilberg and Forouzan: “Data Structure- A Pseudo code approach with C++” by Thomson publication.

15 MMCF152 Relational Database Managements System Lab(0-0-3)

1. Use of SQL syntax: insertion, deletion, join, updation using SQL. (1 class)
2. Programs on join statements and SQL queries including where clause. (1 class)
3. Programs on procedures and functions. (1 class)
4. Programs on database triggers. (1 class)
5. Programs on packages. (1 class)
6. Programs on data recovery using check point technique. (1 class)
7. Concurrency control problem using lock operations. (1 class)
8. Programs on ODBC using either VB or VC++. (1 class)
9. Programs on JDBC. (1 class)
10. Programs on embedded SQL using C / C++ as host language. (1 class)

15 MMCC 201 Topology (3-1-0)

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 : (14 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 : (12 Hours)

First and second countable spaces, Lindelo''f space, Separable spaces, separable axioms, Hausdorff, Regular and normal spaces. The Urysohn lemma, completely regular spaces, The Urysohn metrization theorem, Imbedding theorem, Tietn extension Theorem, Tychonoff theorem, Stone-Cech campactification.

Text Book :

1. Topology, J.R. Munkhres, 2e, Pearson Education, 2000.

Chapter: 1(7,9,10),2(excluding section 22), 3, 4 (excluding section 36), 5.

Reference Book :

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.

15 MMCC 202 Numerical Analysis (3-0-0)

Module –I (10 Hours)

Solution of equations in one and two variables: Mullers method, for two variables; fixed pt iteration, Newton's method.

Interpolation; Hermite, cubic spline and piecewise interpolation .,Natural cubic splines, B. Splines

Numerical differentiation; first order derivative, higher order derivative, Richardson Extrapolation.

Module -II :(10 Hours)

Numerical integration; Romberg integration, Gaussian Quadrature (2-pt,3-pt,4-pt),asymptotic error formula and their applications , Newton- Cotes rules..

Numerical solution to ODE; Taylor's series methods ,Adaptive Runge - Kutta method, predictor- corrector method, convergence and stability theory for multistep methods,

Module -III: (10 Hours)

Matrix eigen value problem; power method ,shifted power method, inverse power ,RQ-method, error and stability results.

Numerical solution to partial differential equations; parabolic ,elliptic ,Hyperbolic equations using finite difference method.

Text Book :

1. Numerical Analysis: Richard L. Burden.(chapter – 3,4,5,6,7)
2. An introduction to Numerical Analysis : by Kendall E. Atkinson,Wiley

Reference Books :

1. Advanced numerical methods ,L.V. Fusset

2. Numerical methods for Scientific and Engineering Computation , M.k.Jain,S.R.K.Iyengar.

3. Numerical methods for Engineers by Chapra & Canale , TMH

15 MMCC 203 Complex Analyses (3-1-0)

Module-I (14 Hours)

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, analytic function ,Power series representation of analytic functions, Cauchy-Riemann equation , analytic function as mapping and its Mobius transformation.

Module-II (14 Hours)

Complex integration: Zeros of analytic function, entire function, 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.

Module-III (12Hours)

Classification of singularity, Poles ,absolute convergence, 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. A Text book of Complex variable: by M.L Khanna (Meerut Publication)
2. Complex Analysis by Alhfors, TMH.
3. Complex Variable; Theory & Application : Kasana , PHI

15 MMCC 204 Linear Algebra (3-0-0)

Module-I (10-hours)

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-hours)

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-hours)

Eigen values and eigenvectors, Diagonalisation of a Matrix, Difference equations and powers A^k, Markov Matrices, Differential equations and e^{At}, stability of differential equation, 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.

Reference

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.

15 MMCF 207 Computer Network (3-1-0)

Module – I(14 Hrs)

Overview of Data Communications and Networking. Physical Layer : Analog and Digital, Analog Signals, Digital Signals, Analog versus Digital, Data Rate Limits, Transmission Impairment, More about signals. Digital Transmission: Line coding, Block coding, Sampling, Transmission mode. Analog Transmission: Modulation of Digital Data; Telephone modems, modulation of Analog signals. Multiplexing : FDM , WDM , TDM , Over view of OSI Model .

Module –II (13 Hrs)

Data Link Layer Error Detection and correction: Types of Errors, Detection, Error Correction Data Link Control and Protocols: Flow and Error Control, Stop-and-wait ARQ. Go-Back-N ARQ, Selective Repeat ARQ, HDLC. Point-to –Point Access: PPP Point –to- Point Protocol, PPP Stack, Multiple Access and Random Access.

Module – III (13 Hrs)

Network Layer: Host to Host Delivery: Internetworking, addressing and Routing Network Layer Protocols: ARP, IPV4, ICMP, IPV6 ad ICMPV6 Transport Layer: Process to Process Delivery: UDP; TCP congestion control and Quality of service.

Application Layer :

Client Server Model, Socket Interface, Domain Name System (DNS): Electronic Mail (SMTP) and file transfer (FTP) ,HTTP

Text Books:

1. Data Communications and Networking: Behrouz A. Forouzan, Tata McGraw-Hill, 4th Ed

2. Computer Networks: A. S. Tannenbum, D. Wetherall, Prentice Hall, Imprint of Pearson 5th Ed

Reference Book :

1. Computer Networks:A system Approach:Larry L, Peterson and Bruce S. Davie,Elsevier, 4th Ed
2. Computer Networks: Natalia Olifer, Victor Olifer, Willey India .

15 MMCF 208 Designs and Analysis of Algorithm (3-0-0)

Module- I: (10 Hours)

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 Hours)

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 Hours)

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.

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,

3.Fundamentals of Algorithm-by Horowitz & Sahani, 2nd Edition, Universities Press.

4.Algorithms By Sanjay Dasgupta, Umesh Vazirani – McGraw-Hill Education

5.Algorithm Design – Goodrich, Tamassia, Wiley India.

15 MMCF 251 DAA LAB(0-0-3)

1. Using a stack of characters, convert an infix string to postfix string.(1 class)

2. Implement insertion, deletion, searching of a BST. (1 class)

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.

8. Write down a program to find out a solution for 0 / 1 Knapsack problem.

9. Using dynamic programming implement LCS.

10. (a) Find out the solution to the N-Queen problem. (b) Implement back tracking using game trees.

15 MMCC 251 NUMERICAL ANALYSIS LAB(0-0-3)

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 fit a nth degree polynomial of the form $y = \sum_{i=0}^{n} c_i x^i$ for a given data by the method of least square.
3. Write a computer oriented algorithm & the corresponding C Program to find the smallest positive root using fixed point iteration method.
4. Write a computer oriented algorithm & the corresponding C Program to find the smallest positive root using Newton- Raphson method.
5. Write a computer oriented algorithm & the corresponding C Program to find the solution of the system of linear equations using Gauss Seidel Method.
6. 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.
7. Write a computer oriented algorithm & the corresponding C Program to find the derivative at the initial point using Newton 's Forward Difference Method.
8. Write a computer oriented algorithm & the corresponding C Program to find the derivative at the final point using Newton 's Backward Difference Method.
9. Write a computer oriented algorithm & the corresponding C Program to integrate Numerically using Trapezoidal & Simpson's Rule.
10. Write a computer oriented algorithm & the corresponding C Program to integrate Numerically using Gauss Quadrature Rule.
11. 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.

15 MMCC – 301 FUNCTIONAL ANALYSES (3-1-0)

MODULE-I (14 Hours)

Normed spaces, continuity of linear maps, Hahn-Banach theorems, Banach spaces.

Uniform bounded principle, Application-Divergencce of Fourier Series of Continuous Functions, closed graph theorem, open mapping theorem, bounded inverse theorem, Spectrum bounded Operator.

MODULE-II (13 Hours)

Duals and transposes, duals of $L^p[a,b]$ and $C[a,b]$.

Inner product spaces, orthonormal sets, approximation and optimization, projections, Riesz representation theorem.

MODULE-III (13 Hours)

Bounded operators and adjoints on a Hilbert space, normal, unitary and self adjoint operators.

Text book :

1. B. V. Limaye : Functional Analysis (2nd Edition)- New Age International Limited.

Chapter-2 (5-8), chapter-3 (9-12), chapter-4 (13,14), chapter-6 (21-24), chapter-7 (25,26)

2. G. BACHMAN, L. NARICI, Functional Analysis, Academic Press

Reference book :

1) Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons (Asia), pvt.ltd., 2006.
2) John B. Conway, A course in Functional Analysis, 2nd edition, Springer verlag, 2006

15 MMCC – 302 MATRIX ALGEBRA (3-1-0)

MODULE-1 (12)

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-2 (13)

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-3 (15)

Eigen values and Eigen vectors, 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 Ch 1.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

15 MMCC-303 PROBABILITY THEORY (3-1-0)

Module : I (14 Hours)

Random Variables and Distribution
Random Variable and some important Distributions **;** The Exponential Distribution ; The Reliability, Failure Density and Hazard Function ; Functions of a Random Variable ; Jointly Distributed Random Variables ; Order Statistics ; Distribution of Sums ; Functions of Normal Random Variables.
Expectation
Moments ; Expectation of Functions of More Than One Random Variable ; Inequalities and Limit Theorems.

Module : II (12 Hours)

Conditional Distribution & Conditional Expectation
Introduction ; Mixture Distributions ; Conditional Expectation ; Random Sums.
Stochastic Processes
Introduction ; Classification of Stochastic Processes ; The Bernoulli Process ; The Poisson Process ; Renewal Processes.

Module : III (14 Hours)

Discrete- Parameter Markov Chains
Introduction ; Computation of n-step Transition Probabilities ; State Classification and Limiting Distributions ; Distribution of Times between State Changes ; Irreducible Finite Chains with a periodic States ; Discrete- Parameter Birth-Death Processes ; Finite Markov Chains with Absorbing States : Analysis of Program Execution Time.
Continuous - Parameter Markov Chains
The Birth-Death Process, Markov Chains with Absorbing States.

Text Book :

1. Probability & Statistics with Reliability, Queuing and Computer Science Applications : Kishore S. Trivedi, PHI.

Reference Books :

1. Modern Probability Theory, B. R Bhatt,. , Wiley Eastern.
2. Introduction to Probability Theory and Mathematical Statistics, V. K. Rohatgi, , Wiley Eastern.
3. Linear Statistical Inference and Its Applications, C. R. Rao, Wiley Eastern.

15 MMCC –304 OPTIMIZATION TECHNIQUE (3-0-0)

Module-I (10 Hours)

Linear programming: Formulation of LPP, Graphical solution, Simplex method, Big M method, Two Phase method, Revised simplex method, Duality theory and its application, Dual simplex method , Sensitivity analysis in linear programming

Transportation problems: Finding an initial basic feasible solution by Northwest Corner rule, Least Cost rule, Vogel's approximation method, Degeneracy, Optimality test, MODI method, Stepping stone method.

Assignment problems: Hungarian method for solution of Assignment problems.

Module -II (10 Hours)

Integer Programming: Integer programming problem, Importance and application of Integer programming problem, Gromory cutting plane method and fractional cut method Branch and Bound algorithm for solution of integer Programming Problems .Zero one programming problem.
Game theory : Pay off, types of games, maxima minima principle ,without saddle point ,2x2 and 2xn dominance principle
Dynamic programming : Decision tree Belmain principle of optimality characteristics of DPP DPP algorithm
Simulation and Modeling : Introduction to simulation and modeling,random variable ,monte carlo techinque and monte carlo, Simulation ,generation of random variables.
Sequencing : Principle assumption n jobs through two machine,N jobs with tree machine, N jobs and k machine , 2 jobs through k machine,Decision theory making process making environment under conditions of certainty

Module -III (10 Hours)

Goal programming: Goal programming model formulation, Goal programming algorithm and modified simplex method of Goal programming.

Non-linear programming: Introduction to non-linear programming. Unconstraint optimization: Fibonacci and Golden Section Search method. Constrained optimization with equality constraint: Lagrange multiplier, Constrained optimization with inequality constraint: Kuhn-Tucker condition.

Ttext books

1. A. Ravindran, D. T. Philips, J. Solberg, *" Operations Research- Principle and Practice*", Second edition, Wiley India Pvt Ltd
2. Kalyanmoy Deb, " *Optimization for Engineering Design*", PHI Learning Pvt Ltd

Reference books:

1. **S**tephen G. Nash, A. Sofer, *" Linear and Non-linear Programming*", McGraw Hill
2. A.Ravindran, K.M.Ragsdell, G.V.Reklaitis," *Engineering Optimization*", Second edition, Wiley India Pvt. Ltd
3. H.A.Taha, A.M.Natarajan, P.Balasubramanie, A.Tamilarasi, "*Operations Research*", Eighth Edition, Pearson Education
4. F.S.Hiller, G.J.Lieberman, *" Operations Research*", Eighth Edition, Tata McDraw Hill
5. P.K.Gupta, D.S.Hira, "*Operations Research*", S.Chand and Company Ltd.
6. Kanti Swarup, P. K. Gupta, Man Mohan, "*Operations Research*", Sultan Chand and Sons.

ELECTIVE –I (3-0-0)

STATISTICS (3-0-0)

MODULE:-I(12 Hours)

Random Sampling ,some important statistics ,sampling distributions , sampling distributions of Means, sampling distribution of S^2 , t distribution , F distribution.Classical Methods of Estimations , estimating mean of a single Sample, standard Error of a point estimate, prediction intervals ,Tolerance limits , Estimating the difference between Two means of Two samples , Paired observations ,Estimating a proportion and variance of a single sample , Estimating the difference between two proportions of two samples, Estimating the ratio of Two variances, Maximum likelihood Estimations .

MODULE:-II(10 Hours)

Statistical Hypothesis ,Testing of Statistical Hypothesis, one and two tailed test, Use of P – values for decision making in testing hypothesis, Test concerning a single mean when variance is known and unknown ,Confidence interval & relationship to Confidence interval estimations, Two Samples : Test on Two means , Test on single proportions, test on two proportions, one and two sample tests concerning variances, Goodness of Fit test, test for independence .

Introduction to Linear regression , The simple Linear regression models, Least square & Fitted models , properties of least square Estimators , inference concerning the regression coefficients , prediction , choice of regression models ,analysis of Variances approach, , simple linear regression case study, Correlation

MODULE:-III(8 Hours)

Multiple Linear regression and certain nonlinear regression model: Introduction, estimating the coefficients, Linear regression models using matrices, properties of least square Estimators ,inferences in multiple linear regression, choice of fitted model through hypothesis testing,Special case of Orthogonality, special nonlinear models for non ideal conditions ,potential misconceptions and hazards .

TEXT BOOK :-

1. R.E.Walpole, R.H.Myers,S.l.Myers. Probability and Statistics for Engineers & Scientists, 8th edition, Pearson Education

Chapters:8,9,10,11,12,

REFERENCE BOOK:

1. Rohatgi, V. K. Introduction to theory of probability and Mathematical Statistics (John Wiley & Sons)
2. Wilks, S. S. Mathematical Statistics (John Wiley)
3. Gupta & kapoor :- Mathematical Statistics
4. Taylor, H. M. and Karlin, S. (1984) An Introduction to Stochastic Modelling. (Academic Press)
4. Bhat B.R. :Stochastic Models: Analysis and Applications (New Age Internationals)
5. Morrison, D.F.(1990) Multivariate Statistical Methods (McGraw Hill Co.)(3rd ed.)

ELECTIVE – II (3-0-0)

PARALLEL AND DISTRIBUTED COMPUTING (3-0-0)

Module - I (12 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 (12 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 (16 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 s.

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.
3. Advanced Computer Architecture: Parallelism, Scalability, Programmability, Kai **Hwang**, McGraw-Hill.

Reference Books :

1. Distributed Computing: Principles and Applications ,Mei-Ling **Liu**, 2004, Pearson Education, Inc. New Delhi.

Introduction to Distributed Algorithms ,Gerard **Tel**, Second edition, 2002, Cambridge University Press / Foundation Books India, New Delhi.

15 MMCC 351 Optimization Lab (0-0-3)

1. Introduction to linear programming problem , solving lpp by mat lab(Introduction)
2. Solve various simplex problem using mat lab Function
3. Solve Transportation and assignment problem using ,Any suitable simulator
4. Compare. between Transportation ,Assignment problem by Using mat lab
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 mat lab
8. Introduction to Non linear Programming by any suitable simulator
9. Iterative method for optimization problem by any suitable simulator
10. Application of non linear programming using Mat lab

15 MMCC 352 MatLab (0-0-3)

1. Introduction to statistical problem by mat lab.
2. Finding Correlation ,Regression by the use of mat lab.
3. T- test , Chi square test by using mat lab.
4. Testing of hypothesis, confidence interval by using mat lab.
5. Statistical validation of various types of data by using mat lab.
6. Design and modeling of Binomial and Poisson distribution by mat lab.
7. Generation of random numbers , by any simulator.
8. Simple integration by random numbers ,mat lab implementation.
9. Finding 1^{st},2^{nd} moments by using mat lab.
10. General statistical application in validation of medical related data.

15 MMCF 407 THEORY OF COMPUTATION (3-1-0)

Module – I : (12 Hours)
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 (14 Hours)

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 : (14 Hours)
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
3.Theory of computation by Saradhi Varma, Scitech Publication

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.

15 MMCC 401 DIFFERENTIAL GEOMETRY (3-1-0)

Module – I : (14 Hours)Tensors

Tensor and their transformation laws, Tensor algebra, Contraction,
Quotient law, Reciprocal tensors, Kronecker delta, Symmetric and skew- symmetric tensors, Metric tensor, Riemannian space, Christoffel symbols and their transformation laws, Covariant differentiation of a tensor, Riemannian curvature tensor and its properties, Bianchi identities, Ricci-tensor, Scalar curvature, Einstein space.

Module – II : (12 Hours)Curves in Space

Parametric representation of curves, Helix , Curvilinear coordinates in E_3. Tangent and first curvature vector, Frenet formulas for curves in space, Frenet formulas for curve in $E_{n.}$ Intrinsic differentiation, Parallel vector fields, Geodesic.

Module – III : (14 Hours)Surfaces

Parametric representation of a surface, Tangent and Normal vector field on a surface, The first and second fundamental tensor, Geodesic curvature of a surface curve, The third fundamental form, Gaussian curvature , Isometry of surfaces, Developable surfaces, Weingarten formula, Equation of Gauss and Codazzi , Principal curvature, Normal curvature, Meusnier's theorem.

Text Book :

1. Tensor Calculas and Application to Geometry and Mechanics :
   (chapter-II and III) – I.S.SOKOLNIKOFF.

2. An Introduction to Differential Geometry:
   (chapter – I,II,III,V and VI) - T.J. WILMORE.

References Book :

1. Vector and Tensor Analysis : Lass, H, Mc Graw Hill
2. Tensor Analysis : Shanti Narayan, Academic Publishers
3. Differential Geometry : Weather burn, C.E.
4. Tenser Calculus - BARY SPAIN, Dover Publication
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ELECTIVE – III (3-0-0)

COMPUTATIONAL FINANCE(3-0-0)

Module-I(14 Hr.)

Stochastic process: Markov process, Wiener process, Geometric Brownian Motion, Ito Integral, Ito's Lemma.

Basic concepts of financial- Stock options, Forward and Futures, Speculation, Hedging, put-call parity, Principle of non-arbitrage pricing, Computation of volatility.

Module-II(14 Hr.)

Derivation of black- scholes differential equation and Black-scholes Option Pricing formula, Greeks and Hedging strategies.

Module-III(12 Hr.)

Finite difference methods for partial differential equations-finite difference approximation to derivatives, Explicit and implicit and methods for parabolic equations, Iterative methods for solution of a system of linear algebraioc equations, Two dimensional Parabolic equations- alternating – directimplicit method, Convergence, Stability and Consistency of finite difference schemes.

Text Book :

1 .J. BAX and G. Chacko-Financial Derivatives : Pricing, Application and Mathematics-Cambridge Univ. Press, 2004.

2. G. D. Smith : Numerical Solution of Partial Differential Equations, Oxford University Press.

References Book :

1. P. Wilmott : Qualitative Finance-John Wiley, 2000.

2. P. Copinsui and T. Zastawrian : Mathematics for Finance-an Introduction to Financial Engineering, Springer Verlag.

3. J. C. Hull : Options, Futures and others Derivatives-PHI, 2003

15 MMCC 451SEMINAR 4 CREDIT
15 MMCC452 PROJECT 10 CREDIT