

# **COURSE STRUCTURE, SYLLABUS AND SCHEME OF EXAMINATION**

**FOR**

**MASTER OF COMPUTER APPLICATION  
(MCA 2 YEAR COURSE)**

**2020-21 Onwards**



**Department of Computer Applications**  
**VBS PURVANCHAL UNIVERSITY, JAUNPUR**

**STUDY & EVALUATION SCHEME**

**MCA (Master of Computer Applications)**  
**Effective from session: 2020-2021**

**SEMESTER I**

SUB CODE	SUBJECT	L	T	P	TA/CT/TS/ESE	TOTAL
MCA-101	Fundamental of Computers & Emerging Technologies	4	0	0	30/20/50/100	150
MCA -102	Principles of Programming using C	3	1	0	30/20/50/100	150
MCA -103	Principles of Management & Communication	4	0	0	30/20/50/100	150
MCA -104	Discrete Mathematics	3	1	0	30/20/50/100	150
MCA - 105	Computer Organization & Architecture	3	1	0	30/20/50/100	150
MCA – L11	Principles of Programming Using C <b>Lab</b>	0	0	4	50/50	100
MCA – L12	Computer Organization & Architecture <b>Lab</b>	0	0	2	25/50	75
MCA – L13	Office Automation <b>Lab</b>	0	0	2	25/50	75
<b>TOTAL</b>						<b>1000</b>

**SEMESTER II**

SUB CODE	SUBJECT	L	T	P	TA/CT/TS/ESE	TOTAL
MCA-201	Theory of Automata & Formal Language	3	1	0	30/20/50/100	150
MCA -202	Object Oriented Programming	3	1	0	30/20/50/100	150
MCA -203	Operating Systems	4	0	0	30/20/50/100	150
MCA -204	Database Management Systems	4	0	0	30/20/50/100	150
MCA -205	Data Structures & Analysis of Algorithms	3	1	0	30/20/50/100	150
MCA -206	Cyber Security*	2	0	0	0/50	0
MCA-L21	Object Oriented Programming <b>Lab</b>	0	0	4	50/50	100
MCA-L22	DBMS <b>Lab</b>	0	0	2	25/50	75
MCA-L23	Data Structures & Analysis of Algorithms <b>Lab</b>	0	0	2	25/50	75
<b>TOTAL</b>						<b>1000</b>

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**SEMESTER III**

SUB CODE	SUBJECT	L	T	P	TA/CT/TS/ESE	TOTAL
MCA-301	Computer Network	3	1	0	30/20/50/100	150
MCA -302	Artificial Intelligence	4	0	0	30/20/50/100	150
MCA -303	Software Engineering	3	1	0	30/20/50/100	150
MCA -304	<b>Elective -- 1</b>	3	1	0	30/20/50/100	150
MCA -305	<b>Elective -- 2</b>	3	1	0	30/20/50/100	150
MCA -L31	Mini Project**	0	0	4	50/100	150
MCA -L32	Artificial Intelligence <b>Lab</b>	0	0	2	50/50	100

TOTAL      1000

**SEMESTER IV**

SUB CODE	SUBJECT	L	T	P	TA/CT/TS/ESE	TOTAL
MCA-401	<b>Elective -- 3</b>	4	0	0	30/20/50/100	150
MCA -402	<b>Elective -- 4</b>	4	0	0	30/20/50/100	150
MCA -403	<b>Elective -- 5</b>	4	0	0	30/20/50/100	150
MCA -L41	Major Project**	0	0	10	500	500
MCA -L42	Comprehensive Viva	4	0	0	0/50	50

TOTAL      1000

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		<b>ELECTIVE SUBJECTS</b>
<b>Elective-1</b>	11	Cryptography & Network Security
	12	Data Warehousing & Data Mining
	13	Quantum Computing
	14	Cloud Computing
<b>Elective-2</b>	21	Compiler Design
	22	Web Technology
	23	Big Data
	24	Simulation & Modeling
<b>Elective-3</b>	31	Digital Image Processing
	32	Soft Computing
	33	Pattern Recognition
	34	Data Analytics
<b>Elective-4</b>	41	Blockchain Architecture
	42	Neural Network
	43	Internet of Things
	44	Machine Learning
<b>Elective-5</b>	51	Distributed Database Systems
	52	Mobile Computing
	53	Computer Graphics and Animation
	54	Natural Language Processing

**Fundamental of Computers & Emerging Technologies****MCA 101****UNIT – I Computer Fundamentals**

Introduction: Introduction to computer system, uses, types. Data Representation: Number system and Coding Schemes (ASCII and UNICODE). Human Computer Interface: Relationship between Hardware and Software, Types of software, Operating system as user interface, utility programs. Role of Computers in: Business, Manufacturing, Mobile Computing, Public Sector, Media, Defense Services.

**UNIT – II Basics of Computer Network**

Computer Network: Definition, Goals, Structure; Broadcast and Point-To-Point Networks; Network Topology and their various Types; Types of Network: LAN, MAN, WAN; Server Based LANs & Peer-to-Peer LANs; Communications Types: Synchronous, Asynchronous; Modes of Communication: Simplex, Half Duplex, Full Duplex; Protocols and Standards.

**UNIT – III Word Processing**

Text Formatting using Word Processing tools: Use of Templates, Working with document: Editing text, Find and replace text, Formatting, spell check, Autocorrect, Autotext; Bullets and numbering, Tabs, Paragraph Formatting, Indent, Page Formatting, Header and footer, section break, footnotes, bibliography and references. Tables: Inserting, filling and formatting a table; Inserting Pictures and Video; Managing Mail Merge: including linking with Database; Printing documents Data Presentation using Presentation tools: Slides, Fonts, Drawing, Editing; Inserting: Tables, Images, texts, Symbols, Media; Design; Transition; Animation; and Slide-show.

**UNIT – IV Overview of Emerging Technologies**

Cloud Computing: Meaning, Features, & Service models – Infrastructure as a service, Advantages and disadvantages, Mobile Computing: Meaning, Business Applications of Mobile computing, Virtual reality & Augmented Reality: Meaning and applications , IOT - Internet of Things: Meaning & Application.

**UNIT V Computing Trends in Internet, Education and Research:**

Internet-role and importance, Web Server and Web clients like web browser or web app, IP addressing : Public Vs Private, Static Vs Dynamic, world wide web and related protocols, e-Library, Google Scholar.

**Reference Books:**

1. Introduction to Information Technology by ITL Education Solutions Limited, second edition.
2. ‘ O’ Level made simple “introduction to ICT resources” by Satish Jain, Shashank Jain, Shashi Singh & M. Geetha Iyer, BPB publication.
3. Computer Fundamentals fourth edition by Pradeep K. Sinha and Priti Sinha BPB Information Technology The breaking wave by Dennis Curtin Tata McGraw-hill edition
4. Computer Fundamentals by A. Goel, Pearson Education, 2010.

**Principles of Programming Using C  
MCA 102**

**UNIT – I Introduction**

Algorithm, Flowcharts, Introduction of programming languages, History of C, Basic structure of C Programming, Executing C Program

**Data Types:** Constant, variables, Identifiers, Keywords, Tokens, Declaration of Variables, Assigning values to variables.

**Operators:** Arithmetic, Relational, Logical, Assignment, Increment, Decrement operators, Condition, Bit wise operators, Arithmetic expressions.

**UNIT – II Branching & Looping**

Decision making with if, If-else, Switch Statement, GOTO statement, While loop, Do While loop, FOR Loop, Break and Continue statements.

**Array:** One dimensional array, Two dimensional array, Multidimensional array, Initializing array.

**UNIT – III Function**

Function declaration, calling a function, the form of C function, Return values and their type, No arguments, no return value, arguments but no return, recursion, Nesting of function. Pointers: Accessing address of a variable, declaring and initializing pointers, pointer expression, pointer and array, pointer and function, pointer and structure, pointer to pointer

**UNIT – IV Structure & Union**

Structure definition, giving values to members, structure initialization, Array of structure, structure within structure, Size of structure, Union definition

**UNIT – V File Handling**

Defining and opening file, closing a file, I/O operations on file. Random access to file, Error handling in file. Dynamic memory allocation: Allocating and reallocating memory, allocating memory for structure and array

**Reference Books:**

1. Programming in C: Gottfried
2. Programming in ANSI C: E. Balaguruswamy
3. Let us C : Y. Kanetkar

**Principles of Management & Communication  
MCA 103****UNIT – I Management**

Concept, Nature, Importance; Management : Art and Science, Management As a Profession, Management Vs. Administration, Management Skills, Levels of Management, Characteristics of Quality Managers. Evolution of Management: Early contributions, Taylor and Scientific Management, Fayol's Administrative Management, Bureaucracy, Hawthorne Experiments and Human Relations, Social System Approach, Decision Theory Approach. Business Ethics and Social Responsibility: Concept, Shift to Ethics, Tools of Ethics.

**UNIT – II Introduction to Functions of Management Planning**

Nature, Scope, Objectives and Significance of Planning, Types of Planning, Process of Planning, Barriers to Effective Planning, Planning Premises and Forecasting, Key to Planning, Decision Making. Organizing: Concept, Organisation Theories, Forms of Organizational Structure, Combining Jobs: Departmentation, Span of Control, Delegation of Authority, Authority & Responsibility, Organisational Design.

**UNIT – III Staffing**

Concept, System Approach, Manpower Planning, Job Design, Recruitment & Selection, Training & Development, Performance Appraisal Directing: Concept, Direction and Supervision Motivation: Concept, Motivation and Performance, Theories Of Motivation, Approaches for Improving Motivation, Pay and Job Performance, Quality of Work Life, Morale Building.

**UNIT -IV Basics of Technical Communication**

Technical Communication: features; Distinction between General and Technical communication; Language as a tool of communication; Levels of communication: Interpersonal, Organizational, Mass communication; The flow of Communication: Downward, Upward, Lateral or Horizontal (Peer group); Importance of technical communication; Barriers to Communication.

**UNIT - V Forms of Technical Communication**

Business Letters: Sales and Credit letters; Letter of Enquiry; Letter of Quotation, Order, Claim and Adjustment Letters; Job application and Resumes. Official Letters: D.O. Letters; Govt. Letters, Letters to Authorities etc. Reports: Types; Significance; Structure, Style & Writing of Reports. Technical Proposal; Parts; Types; Writing of Proposal; Significance. Technical Paper, Project. Dissertation and Thesis Writing: Features, Methods & Writing.

**Reference Books:**

1. Stoner, Freeman & Gilbert Jr - Management (Prentice Hall of India, 6<sup>th</sup> Edition)
2. Koontz - Principles of Management (Tata Mc Graw Hill, 1st Edition 2008)
3. Improve Your Writing ed. V.N. Arora and Laxmi Chandra, Oxford Univ. Press, New Delhi .
4. Technical Communication – Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press 2007, New Delhi.

**Discrete Mathematics  
MCA 104****UNIT – I Set Theory**

Introduction, Combination of sets, Multi sets, ordered pairs, Set Identities.

**Relations:** Definition, Operations on relations, Properties of relations, Composite Relations, Equality of relations, Order of relations.

**Functions:** Definition, Classification of functions, Operations on functions, Recursively defined functions.

**Natural Numbers:** Introduction, Mathematical Induction, Variants of Induction, Induction with Nonzero Base cases.

**UNIT – II Algebraic Structures**

Definition, Groups, Subgroups and order, Cyclic Groups, Cosets, Lagrange's theorem, Normal Subgroups, Permutation and Symmetric groups, Group Homomorphism's, Definition and elementary properties of Rings and Fields, Integers Modulo n.

**UNIT – III Partial order sets**

Definition, Partial order sets, Combination of partial order sets, Hasse diagram.

**Lattices:** Definition, Properties of lattices – Bounded, Complemented, Modular and Complete Lattice, Morphisms of lattices.

**Boolean Algebra:** Introduction, Axioms and Theorems of Boolean algebra, Algebraic manipulation of Boolean expressions. Simplification of Boolean Functions, Karnaugh maps, Logic gates, Digital circuits and Boolean algebra. Combinational and sequential Circuits.

**UNIT – IV Propositional Logic**

Proposition, well formed formula, Truth tables, Tautology, Satisfiability, Contradiction, Algebra of proposition, Theory of Inference, Natural Deduction.

**Predicate Logic:** First order predicate, well formed formula of predicate, quantifiers, Inference theory of predicate logic.

**UNIT V Trees**

Definition, Binary tree, Binary tree traversal, Binary search tree.

**Graphs:** Definition and terminology, Representation of graphs, Multi graphs, Bipartite graphs, Planar graphs, Isomorphism and Homeomorphism of graphs, Euler and Hamiltonian paths, Graph coloring.

**Recurrence Relation & Generating function:** Recursive definition of functions, Recursive algorithms, Method of solving recurrences.

**Combinatorics:** Introduction, Counting Techniques, Pigeonhole Principle

**Reference Books:**

1. Liu and Mohapatra, "Elements of Discrete Mathematics", McGraw Hill
2. Jean Paul Trembley, R Manohar, "Discrete Mathematical Structures with Application to Computer Science", McGraw-Hill
3. YN Singh, "Discrete Mathematical Structures", Wiley India, New Delhi, First Edition, August 2010.



**Computer Organization & Architecture  
MCA 105****UNIT – I Fundamental**

Functional units of digital system and their interconnections, buses, bus architecture, types of buses and bus arbitration. Register bus and memory transfer, Processor organization, general register organization, stack organization and addressing modes, Look ahead carry adders. Multiplication: Signed operand multiplication, Booths algorithm and array multiplier. Division and logic operations. Floating point arithmetic operation, Arithmetic & logic unit design.

**UNIT – II Instructions**

Instruction types, formats, instruction cycles and sub cycles (fetch, execute etc), micro-operations, execution of a complete instruction, Hardwire and micro-programmed control: micro-programme sequencing, concept of horizontal and vertical microprogramming.

**UNIT – III Memory**

Basic concept and hierarchy, semiconductor RAM memories, 2D & 212DD memory organization. ROM memories, Cache memories: concept and design issues & performance, address mapping and replacement, Auxiliary memories: magnetic disk, magnetic tape and optical disks, Virtual memory: concept implementation.

**UNIT – IV I/O Devices**

Peripheral devices, I/O interface, I/O ports, Interrupts: interrupt hardware, types of interrupts and exceptions, Modes of Data Transfer: Programmed I/O, interrupt initiated I/O and Direct Memory Access., I/O channels and processors, Serial Communication: Synchronous & asynchronous communication, standard communication interfaces.

**UNIT V Architectural Classification**

Architectural Classification Schemes, Flynn's & Feng's Classification, Performance Metrics and Measures, Speedup Performance Laws, Pipelining and Memory Hierarchy Basic and Intermediate Concepts, Linear and Nonlinear Pipeline Processors, Optimization of Cache Performance.

**Reference Books:**

1. Patterson, "Computer Organization and Design" Elsevier Pub. 2009
2. William Stalling, "Computer Organization", PHI
3. M. Morris Mano, "Computer System Architecture", Pearson Learning
4. Miles Murdocca, Vincent Heuring "Computer Architecture and Organisation: An Integrated Approach" 2nd Edition
5. Kai Hwang, "Advance Computer Architecture", TMH
6. Vravice, Hamacher & Zaky, "Computer Organization", TMH
7. John P Hays, "Computer Organization", McGraw Hill
8. Tannenbaum, "Structured Computer Organization", PHI
9. P Pal Chaudhry, "Computer Organization & Design" PHI
10. Dezso and Sima, "Advanced Computer Architecture", Pearson

**Theory of Automata & Formal Language  
MCA 201****UNIT – I Introduction**

Alphabets, Strings and Languages; Automata and Grammars, Deterministic finite Automata (DFA)-Formal Definition, Simplified notation: State transition graph, Transition table, Language of DFA, Nondeterministic finite Automata (NFA), NFA with epsilon transition, Language of NFA, Equivalence of NFA and DFA, Minimization of Finite Automata, Distinguishing one string from other, Myhill-Nerode Theorem

**UNIT – II Regular Expression**

Definition, Operators of regular expression and their precedence, Algebraic laws for Regular expressions, Kleen's Theorem, Regular expression to FA, DFA to Regular expression, Arden Theorem, Non Regular Languages, Pumping Lemma for regular Languages . Application of Pumping Lemma, Closure properties of Regular Languages, Decision properties of Regular Languages, FA with output: Moore and Mealy machine, Equivalence of Moore and Mealy Machine, Applications and Limitation of FA.

**UNIT – III Context free grammar (CFG) and Context Free Languages (CFL)**

Definition, Examples, Derivation, Derivation trees, Ambiguity in Grammar, Inherent ambiguity, Ambiguous to Unambiguous CFG, Useless symbols, Simplification of CFGs, Normal forms for CFGs: CNF and GNF, Closure proper ties of CFLs, Decision Properties of CFLs: Emptiness, Finiteness and Membership, Pumping lemma for CFLs.

**UNIT – IV Push Down Automata (PDA)**

Description and definition, Instantaneous Description, Language of PDA, Acceptance by Final state, Acceptance by empty stack, Deterministic PDA, Equivalence of PDA and CFG, CFG to PDA and PDA to CFG, Two stack PDA.

**UNIT V Turing machines (TM)**

Basic model, definition and representation, Instantaneous Description, Language acceptance by TM, Variants of Turing Machine, TM as Computer of Integer functions, Universal TM, Church's Thesis, Recursive and recursively enumerable languages, Halting problem, Introduction to Undecidability, Undecidable problems about TMs. Post correspondence problem (PCP), Modified PCP, Introduction to recursive function theory.

**Reference Books:**

1. Hopcroft, Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education.
2. KLP Mishra and N. Chandrasekaran, "Theory of Computer Science: Automata, Languages and Computation", PHI Learning Private Limited, Delhi India.
3. Peter Linz, "An Introduction to Formal Language and Automata", Narosa Publishing house.
4. YN Singh "Mathematical Foundation of Computer Science", New Age International.
5. Malviya, AK "Theory of Computation and Application", BPaperback Publications
6. Papadimitrou, C. and Lewis, CL, "Elements of the Theory of Computation", Pearson Publication.

**Object Oriented Programming****MCA 202****UNIT – I Introduction to OOPs and Java Fundamentals**

Object Oriented Programming – Abstraction – objects and classes – Encapsulation- Inheritance – Polymorphism- OOP in Java – Characteristics of Java – The Java Environment – Java Source File Structure – Compilation. Fundamental Programming Structures in Java – Defining classes in Java – constructors, methods -access specifiers – static members -Comments, Data Types, Variables, Operators, Control Flow, Arrays , Packages – JavaDoc comments.

**UNIT – II Inheritance and Interfaces**

Inheritance – Super classes- sub classes –Protected members – constructors in sub classes- the Object class – abstract classes and methods- final methods and classes – Interfaces – defining an interface, implementing interface, differences between classes and interfaces and extending interfaces – Object cloning -inner classes, ArrayLists – Strings

**UNIT – III Exception Handling and I/O**

Exceptions – exception hierarchy – throw and catching exceptions – built-in exceptions, creating own exceptions, Stack Trace Elements. Input / Output Basics – Streams – Byte streams and Character streams – Reading and Writing Console – Reading and Writing Files

**UNIT – IV Multithreading and Generic Programming**

Differences between multi-threading and multitasking, thread life cycle, creating threads, synchronizing threads, Inter-thread communication, daemon threads, thread groups. Generic Programming – Generic classes – generic methods – Bounded Types – Restrictions and Limitations.

**UNIT V Event Driven Programming**

Graphics programming – Frame – Components – working with 2D shapes – Using color, fonts, and images – Basics of event handling – event handlers – adapter classes – actions – mouse events – AWT event hierarchy – Introduction to Swing – layout management – Swing Components – Text Fields , Text Areas – Buttons- Check Boxes – Radio Buttons – Lists- choices- Scrollbars – Windows –Menus – Dialog Boxes

**Reference Books:**

1. Paul Deitel, Harvey Deitel, —Java SE 8 for programmers, 3rd Edition, Pearson, 2015.
2. Steven Holzner, —Java 2 Black book, Dreamtech press, 2011.
3. Timothy Budd, —Understanding Object-oriented programming with Javal, Updated Edition, Pearson Education, 2000.

**Operating Systems  
MCA 203****UNIT-I Operating System Concepts**

OS definition and services; Types and features: batch systems, multiprogramming, multitasking, parallel systems, distributed systems, real-time systems, timesharing systems, PC systems; System Calls types, System Programs

**UNIT – II Process vs. Thread**

Process states, process control block; Inter process communication; Process Synchronization: Classical problems of synchronization; CPU Scheduling: Criteria; Algorithms: FCFS, SJF, Priority, Round- Critical section problem and solution criteria, Semaphores.

**UNIT – III Memory Management**

Paging and Segmentation approaches, virtual memory, Demand Paging and Page Replacement algorithms; Deadlocks: necessary conditions, prevention, avoidance and recovery, banker's algorithm.

**UNIT – IV File Management**

File system Structure, allocation methods: Contiguous allocation, Linked allocation, indexed allocation free space management: Bit vector, linked list, grouping, counting; Directory implementation: Linear List, Hash table. Device Management: Disk structure, Disk scheduling: Selecting Disk Scheduling algorithm.

**UNIT V UNIX**

Essential commands and utilities, Unix files, directory structure, file security, pipe, filter, Bourne shell programming features, systems calls classification and basics (reg. file manipulation, process, signal and IPC); Linux: System components, Process management, scheduling, memory management, Networking software layers, Security, various editors, I/O devices, IPC.

**Reference Books:**

1. Operating System Concepts by Silberschatz and Galvin; Addison Wesley
2. Distributed Operating Systems by Andrew S. Tannenbaum; Pearson Education
3. UNIX Concepts and Applications by Sumitabha Das; Tata MC-Graw Hill
4. Ekta Walia, Khanna Publishing House, Operating System Concepts

**Database Management Systems  
MCA 204****UNIT – I Introduction**

The Evolution of Database Systems- Overview of a Database Management System- Outline of Database-System Studies-The Entity- RELATIONSHIP DATA MODEL: Elements of the E/R Model-Design Principles-The Modelling of Constraints-Weak Entity Sets

**UNIT – II The Relational Data Model & Algebra**

Basics of the Relational Model-From E/R Diagrams to Relational Designs Converting Subclass Structures to Relations Functional Dependencies-Rules About Functional Dependencies-Design of Relational Database Schemas - Multivalued Dependencies. RELATIONAL ALGEBRA: Relational Operations-Extended Operators of Relational Algebra- Constraints on Relations

**UNIT – III SQL**

Simple Queries in SQL-Sub queries-Full-Relation Operations-Database Modifications-Defining a Relation Schema-View Definitions- Constraints and Triggers: Keys and Foreign Keys-Constraints on Attributes and Tuples Modification of Constraints-Schema-Level Constraints and Triggers -Java Database Connectivity- Security and User Authorization in SQL

**UNIT – IV Index Structure, Query Processing**

Index Structures: Indexes on Sequential Files-Secondary Indexes-B-Trees-Hash Tables-Bitmap Indexes. QUERY EXECUTION: Physical-Query-Plan Operators-One-Pass, two-pass & index based Algorithms, Buffer Management, Parallel Algorithms-Estimating the Cost of Operations-Cost-Based Plan Selection -Order for Joins-Physical- QueryPlan

**UNIT V - Failure Recovery and Concurrency Control**

Issues and Models for Resilient Operation -Undo/Redo Logging-Protecting against Media Failures Concurrency Control: Serial and Serializable Schedules-Conflict Serializability-Enforcing Serializability by Locks-Locking Systems with Several Lock Modes-Concurrency Control by Timestamps, validation. Transaction Management: Serializability and Recoverability-View Serializability-Resolving Deadlocks-Distributed Databases: Commit and Lock

**Reference Books:**

1. Hector Garcia-Molina, Jeff Ullman, and Jennifer Widom, “Database Systems: The Complete Book”, Pearson Education, Second Edition, 2008.
2. Silberschatz, H. Korth and Sudarshan S., “Database System Concepts”, 6th Edition, McGraw-Hill International, 2010.
3. Elmasri R. and Shamakant B.Navathe, “Fundamentals of Database Systems”, 6th Edition, AddisonWesley , 2011.

**Data Structures & Analysis of Algorithms  
MCA 205****UNIT – I: Data Structures Basics**

Structure and Problem Solving, Data structures, Data structure Operations, Algorithm: complexity, Time- space tradeoff. Linked List: Introduction, Linked lists, Representation of linked lists in Memory, Traversing a linked list, Searching a linked list, Memory allocation and Garbage collection, insertion into linked list, Deletion from a linked list, Types of linked list.

**UNIT – II: Stack and Queue**

Introduction, Array Representation of Stack, Linked List Representation of stack, Application of stack, Queue, Array Representation of Queue, Linked List Representation of Queue. Trees: Definitions and Concepts, Operations on Binary Trees, Representation of binary tree, Conversion of General Trees to Binary Trees, Tree Traversal. Graphs: Matrix Representation of Graphs, List Structures, Other Representations of Graphs, Breadth First Search, Depth First Search, Spanning Trees. Directed Graphs Types of Directed Graphs. Applications of Graphs: Topological Sorting, Shortest-Path Algorithms – Weighted Shortest Paths – Dijkstra’s Algorithm, Minimum spanning tree- Prim’s Algorithm, Introduction to NP-Completeness.

**UNIT – III: Searching and Sorting Techniques**

Bubble sort, Merge sort, Selection sort, Heap sort, Insertion Sort. Searching Techniques: Sequential Searching, Binary Searching, Search Trees. Elementary Algorithms: Notation for Expressing Algorithms; Example of an Algorithm; Problems and Instances; Characteristics of an Algorithm; Building Blocks of Algorithms; Procedure and Recursion – Procedure, Recursion; Outline of Algorithms; Specification Methods for Algorithms.

**UNIT - IV: Mathematical Functions and Notations Functions and Notations**

Modular Arithmetic / Mod Function; Mathematical Expectation in Average Case Analysis; Efficiency of an Algorithm; Well Known Asymptotic Functions and Notations; Analysis of Algorithms – Simple Examples; Well Known Sorting Algorithms – Insertion sort, Bubble sort, Selection sort, Shell sort, Heap sort.

**UNIT V: Divide and Conquer Divide and Conquer Strategy**

Binary Search; Max. And Min.; Merge sort; Quick sort. Greedy Method, Strategy; Optimistic Storage on Tapes; Knapsack Problem; Job Sequencing with Deadlines; Single Source Shortlist Paths, Dynamic Programming Strategy; Multistage Graphs; All Pair Shortest Paths; Travelling Salesman Problems. Backtracking Strategy, 8-Queens Problem, Sum of Subsets.

**Reference Books:**

1. Y. Langsam, M. Augenstin and A. Tannenbaum, Data Structures using C and C++, Pearson Education Asia, 2nd Edition, 2002.
2. Ellis Horowitz, S. Sahni, D. Mehta Fundamentals of Data Structures in C++, Galgotia Book Source, New Delhi.
3. Design and Analysis of Computer Algorithms, Aho, Pearson Education Pub.
4. Fundamentals of Computer Algorithms by Horowitz and Sahani, Galgotia

**Cyber Security  
MCA 206****UNIT – I Introduction to Information Systems**

Types of information Systems, Development of Information Systems, Introduction to information security, Need for Information security, Threats to Information Systems, Information Assurance, Cyber Security, and Security Risk Analysis.

**UNIT – II Security**

Application security (Database, E-mail and Internet), Data Security Considerations-Backups, Archival Storage and Disposal of Data, Security Technology-Firewall and VPNs, Intrusion Detection, Access Control.

Security Threats -Viruses, Worms, Trojan Horse, Bombs, Trapdoors, Spoofs, E-mail viruses, Macro viruses, Malicious Software, Network and Denial of Services Attack, Security Threats to E-Commerce- Electronic Payment System, e-Cash, Credit/Debit Cards. Digital Signature, public Key Cryptography.

**UNIT – III Development of Secure Information System**

Developing Secure Information Systems, Application Development Security, Information Security Governance & Risk Management, Security Architecture & Design Security Issues in Hardware, Data Storage & Downloadable Devices, Physical Security of IT Assets, Access Control, CCTV and intrusion Detection Systems, Backup Security Measures.

**UNIT – IV Security Policies**

Why Policies should be developed, WWW policies, Email Security policies, Policy Review Process-Corporate policies-Sample Security Policies, Publishing and Notification Requirement of the Policies.

**UNIT V Information Security Standards**

ISO, IT Act, Copyright Act, Patent Law, IPR. Cyber Laws in India; IT Act 2000 Provisions, Intellectual Property Law: Copy Right Law, Software License, Semiconductor Law and Patent Law.

**Reference Books:**

1. Charles P. Pfleeger, Shari Lawerance Pfleeger, “Analysing Computer Security”, Pearson Education India.
2. V.K. Pachghare, “Cryptography and information Security”, PHI Learning Private Limited, Delhi India.
3. Dr. Surya Prakash Tripathi, Ritendra Goyal, Praveen kumar Shukla ,“Introduction to Information Security and Cyber Law” Willey Dreamtech Press.
4. Schou, Shoemaker, “Information Assurance for the Enterprise”, Tata McGraw Hill.
5. CHANDER, HARISH, “Cyber Laws And It Protection”, PHI Learning Private Limited, Delhi, India

**Computer Network  
MCA 301**

**UNIT – I Data Communications**

Data communication Components – Data representation and Data flow – Networks – Types of Connections – Topologies – Protocols and Standards – OSI model – Transmission Media – LAN –Wired LANs, Wireless LANs, Connecting LANs, Virtual LANs.

**UNIT – II Data Link Layer**

Error Detection and Error Correction – Introduction–Block coding–Hamming Distance – CRC–Flow Control and Error control – Stop and Wait – Go back – N ARQ – Selective Repeat ARQ – Sliding Window – Piggybacking – Random Access – CSMA/CD, CDMA/CA.

**UNIT – III Network Layer**

Switching–Logical addressing – IPV4 – IPV6–Address mapping–ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols.

**UNIT – IV Transport Layer**

Process to Process Delivery – User Datagram Protocol – Transmission Control Protocol – SCTP – Congestion Control with Examples.

**UNIT - V Application Layer**

Domain Name Space – DDNS – TELNET – EMAIL – File transfer WWW – HTTP – SNMP – Cryptography – Basic concepts.

**Reference Books:**

1. Behrouz A. Forouzan, “Data communication and Networking”, Tata McGraw–Hill, Fourth Edition, 2011.
2. Larry L.Peterson, Peter S. Davie, “Computer Networks”, Elsevier, Fifth Edition, 2012.
3. William Stallings, “Data and Computer Communication”, Eighth Edition, Pearson Education, 2007.
4. James F. Kurose, Keith W. Ross, “Computer Networking: A Top–Down Approach Featuring the Internet”, Pearson Education, 2005.



**Artificial Intelligence  
MCA 302****UNIT-I Introduction**

Introduction to Artificial Intelligence, Foundations and History of Artificial Intelligence, Applications of Artificial Intelligence, Intelligent Agents, Structure of Intelligent Agents. Computer vision, Natural Language Possessing.

**UNIT-II Introduction to Search**

Searching for solutions, Uniformed search strategies, Informed search strategies, Local search algorithms and optimistic problems, Adversarial Search, Search for games, Alpha - Beta pruning.

**UNIT-III Knowledge Representation & Reasoning**

Propositional logic, Theory of first order logic, Inference in First order logic, Forward & Backward chaining, Resolution, Probabilistic reasoning, Utility theory, Hidden Markov Models (HMM), Bayesian Networks.

**UNIT-IV Machine Learning**

Supervised and unsupervised learning, Decision trees, Statistical learning models, Learning with complete data - Naive Bayes models, Learning with hidden data - EM algorithm, Reinforcement learning,

**UNIT-V Pattern Recognition**

Introduction, Design principles of pattern recognition system, Statistical Pattern recognition, Parameter estimation methods - Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA), Classification Techniques – Nearest Neighbour (NN) Rule, Bayes Classifier, Support Vector Machine (SVM), K – means clustering.

**Reference Books:**

1. Stuart Russell, Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education
2. Elaine Rich and Kevin Knight, “Artificial Intelligence”, McGraw-Hill
3. E Charniak and D McDermott, “Introduction to Artificial Intelligence”, Pearson Education
4. Dan W. Patterson, “Artificial Intelligence and Expert Systems”, Prentice Hall of India

**Software Engineering  
MCA 303****UNIT – I Introduction**

Introduction to Software Engineering, Software Components, Software Characteristics, Software Crisis, Software Engineering Processes, Similarity and Differences from Conventional Engineering Processes, Software Quality Attributes. Software Development Life Cycle (SDLC) Models: Water Fall Model, Prototype Model, Spiral Model, Evolutionary Development Models, Iterative Enhancement Models.

**UNIT – II Software Requirement Specifications (SRS)**

Requirement Engineering Process: Elicitation, Analysis, Documentation, Review and Management of User Needs, Feasibility Study, Information Modeling, Data Flow Diagrams, Entity Relationship Diagrams, Decision Tables, SRS Document, IEEE Standards for SRS.

**Software Quality Assurance (SQA):** Verification and Validation, SQA Plans, Software Quality Frameworks, ISO 9000 Models, SEI-CMM Model.

**UNIT – III Software Design**

Basic Concept of Software Design, Architectural Design, Low Level Design: Modularization, Design Structure Charts, Pseudo Codes, Flow Charts, Coupling and Cohesion Measures, Design Strategies: Function Oriented Design, Object Oriented Design, Top-Down and Bottom-Up Design. Software Measurement and Metrics: Various Size Oriented Measures: Halestead's Software Science, Function Point (FP) Based Measures, Cyclomatic Complexity Measures: Control Flow Graphs.

**UNIT – IV Software Testing**

Testing Objectives, Unit Testing, Integration Testing, Acceptance Testing, Regression Testing, Testing for Functionality and Testing for Performance, Top-Down and Bottom-Up Testing Strategies: Test Drivers and Test Stubs, Structural Testing (White Box Testing), Functional Testing (Black Box Testing), Test Data Suit Preparation, Alpha and Beta Testing of Products.

Static Testing Strategies: Formal Technical Reviews (Peer Reviews), Walk Through, Code Inspection, Compliance with Design and Coding Standards.

**UNIT V Software Maintenance and Software Project Management**

Software as an Evolutionary Entity, Need for Maintenance, Categories of Maintenance: Preventive, Corrective and Perfective Maintenance, Cost of Maintenance, Software Re-Engineering, Reverse Engineering. Software Configuration Management Activities, Change Control Process, Software Version Control, An Overview of CASE Tools. Estimation of Various Parameters such as Cost, Efforts, Schedule/Duration, Constructive Cost Models (COCOMO), Resource Allocation Models, Software Risk Analysis and Management.

**Reference Books:**

1. RS Pressman, Software Engineering: A Practitioners Approach, McGraw Hill.
2. Pankaj Jalote, Software Engineering, Wiley
3. Rajib Mall, Fundamentals of Software Engineering, PHI Publication.
4. KK Aggarwal and Yogesh Singh, Software Engineering, New Age International Publishers.

## ELECTIVE - 1

### E-11 - Cryptography & Network Security

#### **UNIT-I Introduction**

Security attacks, services and mechanism, introduction to cryptography. Conventional Encryption: Conventional encryption model, classical encryption techniques- substitution ciphers and transposition ciphers, cryptanalysis, stereography, stream and block ciphers. Modern Block Ciphers: Block ciphers principals, Shannon's theory of confusion and diffusion, fiestal structure, data encryption standard(DES), strength of DES, differential and linear crypt analysis of DES, block cipher modes of operations, triple DES, IDEA encryption and decryption, strength of IDEA, confidentiality using conventional encryption, traffic confidentiality, key distribution, random number generation.

#### **UNIT-II Introduction to Graph**

Ring and field, prime and relative prime numbers, modular arithmetic, Fermat's and Euler's theorem, primality testing, Euclid's Algorithm, Chinese Remainder theorem, discrete logarithms. Principals of public key crypto systems, RSA algorithm, security of RSA, key management, Diffle-Hellman key exchange algorithm, introductory idea of Elliptic curve cryptography, Elganel encryption.

#### **UNIT-III Message Authentication and Hash Function**

Authentication requirements, authentication functions, message authentication code, hash functions, birthday attacks, security of hash functions and MACS, MD5 message digest algorithm, Secure hash algorithm(SHA). Digital Signatures: Digital Signatures, authentication protocols, digital signature standards (DSS), proof of digital signature algorithm.

#### **UNIT-IV Authentication Applications**

Kerberos and X.509, directory authentication service, electronic mail security pretty good privacy (PGP), S/MIME.

#### **UNIT-V IP Security**

Architecture, Authentication header, Encapsulating security payloads, combining security associations, key management. Web Security: Secure socket layer and transport layer security, secure electronic transaction (SET). System Security: Intruders, Viruses and related threads, firewall design principals, trusted systems.

#### **Reference Books:**

1. William Stallings, "Cryptography and Network Security: Principals and Practice", Pearson Education.
2. Behrouz A. Frouzan: Cryptography and Network Security, Tata McGraw Hill
3. C K Shyamala, N Harini, Dr. T.R.Padmnabhan Cryptography and Security, Wiley
4. Bruce Schiener, "Applied Cryptography". John Wiley & Sons
5. V.K. Jain, Cryptography and Network Security, Khanna Publishing House
6. Bernard Menezes," Network Security and Cryptography", Cengage Learning. 6. Atul Kahate, "Cryptography and Network Security", Tata McGraw Hill

## **ELECTIVE - 1**

### **E-12 – Data Warehousing & Data Mining**

#### **UNIT – I Data Warehousing**

Overview, Definition, Data Warehousing Components, Building a Data Warehouse, Warehouse Database, Mapping the Data Warehouse to a Multiprocessor Architecture, Difference between Database System and Data Warehouse, Multi Dimensional Data Model, Data Cubes, Stars, Snow Flakes, Fact Constellations, Concept hierarchy, Process Architecture, 3 Tier Architecture, Data Marting.

#### **UNIT – II Data Warehouse Process and Technology**

Warehousing Strategy, Warehouse Management and Support Processes, Warehouse Planning and Implementation, Hardware and Operating Systems for Data Warehousing, Client/Server Computing Model & Data Warehousing. Parallel Processors & Cluster Systems, Distributed DBMS implementations, Warehousing Software, Warehouse Schema Design, Data Extraction, Cleanup & Transformation Tools, Warehouse Metadata

#### **UNIT – III Data Mining**

Overview, Definition & Functionalities, Data Processing, Form of Data Preprocessing, Data Cleaning: Missing Values, Noisy Data, (Binning, Clustering, Regression, Computer and Human inspection), Inconsistent Data, Data Integration and Transformation. Data Reduction:-Data Cube Aggregation, Dimensionality reduction, Data Compression, Numerosity Red

#### **UNIT- IV Data Mining Techniques**

Classification: Definition, Data Generalization, Analytical Characterization, Analysis of attribute relevance, Mining Class comparisons, Statistical measures in large Databases, Statistical-Based Algorithms, Distance-Based Algorithms, Decision Tree-Based Algorithms. Clustering: Introduction, Similarity and Distance Measures, Hierarchical and Partitional Algorithms. Hierarchical Clustering- CURE and Chameleon. Density Based Methods-DBSCAN, OPTICS. Grid Based Methods- STING, CLIQUE. Model Based Method –Statistical Approach, Association rules: Introduction, Large Itemsets, Basic Algorithms, Parallel and Distributed Algorithms, Neural Network approach.

#### **UNIT - V Data Visualization and Overall Perspective**

Aggregation, Historical information, Query Facility, OLAP function and Tools. OLAP Servers, ROLAP, MOLAP, HOLAP, Data Mining interface, Security, Backup and Recovery, Tuning Data Warehouse, Testing Data Warehouse. Warehousing applications and Recent Trends: Types of Warehousing Applications, Web Mining, Spatial Mining and Temporal Mining.

#### **Reference Books:**

1. Alex Berson, Stephen J. Smith “Data Warehousing, Data-Mining & OLAP”, TMH
2. Mark Humphries, Michael W. Hawkins, Michelle C. Dy, “ Data Warehousing: Architecture and Implementation”, Pearson
3. Margaret H. Dunham, S. Sridhar, ”Data Mining: Introductory and Advanced Topics” Pearson Education
4. Arun K. Pujari, “Data Mining Techniques” Universities Press
5. Pieter Adriaans, Dolf Zantinge, “Data-Mining”, Pearson Education

## ELECTIVE - 1

### E-13 – Quantum Computing

#### UNIT-1 Introduction to Quantum Computation

Quantum bits, Bloch sphere representation of a qubit, multiple qubits.

#### UNIT-2 Background Mathematics and Physics

Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis.

#### UNIT-3 Quantum Circuits

Single qubit gates, multiple qubit gates, design of quantum circuits.

#### UNIT-4 Quantum Information and Cryptography

Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem.

#### UNIT-5 Quantum Algorithms

Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search.

**Noise and error correction:** Graph states and codes, Quantum error correction, fault-tolerant computation.

#### Reference Books:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press.2002
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific. 2004
3. Pittenger A. O., An Introduction to Quantum Computing Algorithms

## ELECTIVE - 1

### E-14 – Cloud Computing

#### UNIT-I Introduction

Cloud-definition, benefits, usage scenarios, History of Cloud Computing - Cloud Architecture - Types of Clouds - Business models around Clouds – Major Players in Cloud Computing- issues in Clouds - Eucalyptus - Nimbus - Open Nebula, Cloud Sim.

#### UNIT-II Cloud Services

Types of Cloud services: Software as a Service-Platform as a Service –Infrastructure as a Service -Database as a Service - Monitoring as a Service –Communication as services. Service providers- Google, Amazon, Microsoft Azure, IBM, Sales force.

#### UNIT-III Collaborating Using Cloud Services

Email Communication over the Cloud - CRM Management – Project Management-Event Management - Task Management – Calendar - Schedules - Word Processing – Presentation – Spreadsheet - Databases – Desktop - Social Networks and Groupware.

#### UNIT-IV Virtualization for Cloud

Need for Virtualization – Pros and cons of Virtualization – Types of Virtualization – System Vim, Process VM, Virtual Machine monitor – Virtual machine properties -

Interpretation and binary translation, HLL VM - supervisors – Xen, KVM, VMware, Virtual Box, Hyper-V.

### **UNIT-V Security, Standards and Applications**

Security in Clouds: Cloud security challenges – Software as a Service Security, Common Standards: The Open Cloud Consortium – The Distributed management Task Force – Standards for application Developers – Standards for Messaging – Standards for Security, End user access to cloud computing, Mobile Internet devices and the cloud.

### **Reference Books:**

1. David E.Y. Sarna Implementing and Developing Cloud Application, CRC press 2011.
2. Lee Badger, Tim Grance, Robert Patt-Corner, Jeff Voas, NIST, Draft cloud computing synopsis and recommendation, May 2011.
3. Anthony T Velte, Toby J Velte, Robert Elsenpeter, Cloud Computing : A Practical Approach, Tata McGraw-Hill 2010.
4. Haley Beard, Best Practices for Managing and Measuring Processes for On-demand Computing, Applications and Data Centers in the Cloud with SLAs, Emereo Pty Limited, July 2008.
5. G.J.Popek, R.P. Goldberg, Formal requirements for virtualizable third generation Architectures, Communications of the ACM, No.7 Vol.17, July 1974
6. John Rittinghouse & James Ransome, Cloud Computing, Implementation, Management and Strategy, CRC Press, 2010.

## **ELECTIVE - 2**

### **E-21 – Compiler Design**

#### **UNIT – I Compilers: Grammars & Automata**

Languages – Grammars – Types of grammars – Context free grammar - regular expression - Recognizing of patterns - finite automation (deterministic & non deterministic) Conversion of NDFA to DFA - Conversion of regular expression of NDFA – Thompson’s construction- minimization of NDFA –Derivation - parse tree – ambiguity

#### **UNIT – II Lexical Analysis**

Lexical analysis- handles - token specification - design of lexical analysis (LEX) - Automatic generation of lexical analyzer - input buffering - A language for specifying lexical analyzers - implementation of lexical analyzer

#### **UNIT – III Syntax Analysis**

PARSING: Definition - role of parsers - top down parsing - bottom-up parsing - Left recursion - left factoring - Handle pruning , Shift reduce parsing - operator precedence parsing – FIRST- FOLLOW- LEADING- TRAILING- Predictive parsing - recursive descent parsing. LR parsing – LR (0) items - SLR parsing – Canonical LR - LALR parsing - generation of LALR - Ambiguous grammars - error recovery

#### **UNIT – IV Syntax Directed Translation**

Intermediate Languages - prefix - postfix - Quadruple - triple - indirect triples – syntax tree- Evaluation of expression - three-address code- Synthesized attributes – Inherited attributes – Conversion of Assignment statements- Boolean expressions –Backpatching - Declaration - CASE statements.

## **UNIT V Code Optimization**

Local optimization- Loop Optimization techniques – DAG – Dominators- Flow graphs – Storage allocations- Peephole optimization – Issues in Code Generation.

### **Reference Books:**

1. Alfred V Aho , Jeffery D Ullman , Ravi Sethi, " Compilers , Principles techniques and tools ", Pearson Education 2011
2. Raghavan V., “Principles of Compiler Design”, Tata McGraw Hill Education Pvt. Ltd., 2010.
3. David Galles, “Modern Compiler Design”, Pearson Education, Reprint 2012.
4. Dasaradh Ramaiah. K., “Introduction to Automata and Compiler Design”, PHI, 2011

## **ELECTIVE - 2**

### **E-22 – Web Technology**

#### **UNIT – I Introduction & Web Design**

Introduction: Concept of WWW, Internet and WWW, HTTP Protocol: Request and Response, Web browser and Web servers, Features of Web 2.0

Web Design: Concepts of effective web design, Web design issues including Browser, Bandwidth and Cache, Display resolution, Look and Feel of the Website, Page Layout and linking, User centric design, Sitemap, Planning and publishing website, Designing effective navigation.

#### **UNIT – II Html & Style Sheets**

HTML: Basics of HTML, formatting and fonts, commenting code, color, hyperlink, lists, tables, images, forms, XHTML, Meta tags, Character entities, frames and frame sets, Browser architecture and Web site structure. Overview and features of HTML 5

Style sheets : Need for CSS, introduction to CSS, basic syntax and structure, using CSS, background images, colors and properties, manipulating texts, using fonts, borders and boxes, margins, padding lists, positioning using CSS, CSS2, Overview and features of CSS3

#### **UNIT – III Javascript & Xml**

JavaScript : Client side scripting with JavaScript, variables, functions, conditions, loops and repetition, Pop up boxes, Advance JavaScript: JavaScript and objects, JavaScript own objects, the DOM and web browser environments, Manipulation using DOM, forms and validations, DHTML : Combining HTML, CSS and JavaScript, Events and buttons

XML: Introduction to XML, uses of XML, simple XML, XML key components, DTD and Schemas, Using XML with application. Transforming XML using XSL and XSLT

#### **UNIT – IV PHP**

PHP : Introduction and basic syntax of PHP, decision and looping with examples, PHP and HTML, Arrays, Functions, Browser control and detection, string, Form processing, Files, Advance Features: Cookies and Sessions, Object Oriented Programming with PHP

#### **UNIT V MYSQL**

PHP and MySQL : Basic commands with PHP examples, Connection to server, creating database, selecting a database, listing database, listing table names, creating a table,

inserting data, altering tables, queries, deleting database, deleting data and tables, PHP myadmin and database bugs

**Reference Books:**

1. Developing Web Applications, Ralph Moseley and M. T. Savaliya, Wiley-India
2. Web Technologies, Black Book, Dreamtech Press
3. HTML 5, Black Book, Dreamtech Press
4. Web Design, Joel Sklar, Cengage Learning
5. Developing Web Applications in PHP and AJAX, Harwani, McGraw Hill
6. Internet and World Wide Web How to program, P.J. Deitel & H.M. Deitel, Pearson

**ELECTIVE - 2**  
**E-23 – Big Data**

**UNIT-I Understanding Big Data**

What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data ,credit risk management, big data and algorithmic trading, big data and HealthCare, big data in medicine, advertising and big data, big data technologies, Introduction to Hadoop, open source technologies, cloud and big data mobile business intelligence, Crowd sourcing Analytics ,inter and trans firewall analytics

**UNIT-II NoSQL Data Management**

Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schema less databases ,materialized views, distribution models ,sharing , masters slave replication , peer-peer replication , sharing and replication , consistency , relaxing consistency , version stamps , map reduce , partitioning and combining , composing map-reduce calculations

**UNIT-III Basics of Hadoop**

Data format, analyzing data with Hadoop, scaling out , Hadoop streaming , Hadoop pipes , design of Hadoop distributed file system (HDFS) , HDFS concepts , Java interface , data flow ,Hadoop I/O , data integrity , oppression ,serialization , Avro file-based data structures

**UNIT-IV Map Reduce Applications**

Map Reduce workflows, UNIT tests with MR UNIT, test data and local tests – anatomy of Map Reduce job run , classic Map-reduce , YARN , failures in classic Map-reduce and YARN , job scheduling , shuffle and sort , task execution , MapReduce types , input formats , output formats

**UNIT-V Hadoop Related Tools**

HBase, data model and implementations, Hbase clients, Hbase examples – praxis. Cassandra, cassandra data model, cassandra examples ,cassandra clients , Hadoop integration.Pig , Grunt , pig data model , Pig Latin , developing and testing PigLatin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation – HiveQL queries



### **Reference Books:**

1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
3. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
4. V.K. Jain, Big Data & Hadoop, Khanna Publishing House Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
5. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
6. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.

## **ELECTIVE - 2**

### **E-24 – Simulation & Modeling**

#### **UNIT-I Introduction**

System definition and components, stochastic activities, continuous and discrete systems, system modeling, types of models, static and dynamic physical models, static and dynamic mathematical models, full corporate model, types of system study.

#### **UNIT-II Simulation**

System simulation, why & when to simulate, nature and techniques of simulation, comparison of simulation and analytical methods, types of system simulation, real time simulation, hybrid simulation, simulation of pure-pursuit problem, single server queuing system and an inventory problem, Monte-Carlo simulation, Distributed Lag models, Cobweb model.

#### **UNIT-III Simulation of Continuous Systems**

Analog vs. digital Simulation, Simulation of water reservoir system, Simulation of a servo system, simulation of an autopilot, Discrete system simulation, fixed time-step vs. even to even model, generation of random numbers, test for randomness, Monte-Carlo computation vs. stochastic simulation.

#### **UNIT-IV System Dynamics**

Exponential growth models, exponential decay models, modified exponential growth models, logistic curves, generalization of growth models, system dynamic diagrams, Introduction to SIMSCRIPT: Program, system concepts, origination, and statements, defining the telephone system model.

#### **UNIT-V Simulation of PERT Networks**

Critical path computation, uncertainties in activity duration, resource allocation and consideration. Simulation languages and software, continuous and discrete simulation languages, expression-based languages, object-oriented simulation, general purpose vs. application - oriented simulation packages, CSMP-III, MODSIM-III.

### **Reference Books:**

1. Geoffrey Gordon, "System Simulation", PHI
2. Jerry Banks, John S. C Barry L. Nelson David M. Nicol, "Discrete Event System Simulation", Pearson Education
3. V P Singh, "System Modeling and simulation", New Age International.

## ELECTIVE - 3

### E-31 – Digital Image Processing

#### UNIT-I Introduction and Fundamentals

Motivation and Perspective, Applications, Components of Image Processing System, Element of Visual Perception, A Simple Image Model, Sampling and Quantization.

**Image Enhancement in Frequency Domain: Fourier** Transform and the Frequency Domain, Basis of Filtering in Frequency Domain, Filters – Low-pass, High-pass; Correspondence Between Filtering in Spatial and Frequency Domain; Smoothing Frequency Domain Filters – Gaussian Low pass Filters; Sharpening Frequency Domain Filters – Gaussian High pass Filters; Homomorphic Filtering.

#### UNIT-II Image Enhancement in Spatial Domain

Introduction; Basic Gray Level Functions – Piecewise-Linear Transformation Functions: Contrast Stretching; Histogram Specification; Histogram Equalization; Local Enhancement; Enhancement using Arithmetic/Logic Operations – Image Subtraction, Image Averaging; Basics of Spatial Filtering; Smoothing – Mean filter, Ordered Statistic Filter; Sharpening – The Laplacian.

#### UNIT-III Image Restoration

A Model of Restoration Process, Noise Models, Restoration in the presence of Noise Only-Spatial Filtering – Mean Filters: Arithmetic Mean filter, Geometric Mean Filter, Order Statistic Filters – Median Filter, Max and Min filters; Periodic Noise Reduction by Frequency Domain Filtering – Band pass Filters; Minimum Mean-square Error Restoration.

#### UNIT-IV Morphological Image Processing

Introduction, Logic Operations involving Binary Images, Dilation and Erosion, Opening and Closing, Morphological Algorithms – Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening

#### UNIT-V Registration

Introduction, Geometric Transformation – Plane to Plane transformation, Mapping, Stereo Imaging – Algorithms to Establish Correspondence, Algorithms to Recover Depth Segmentation: Introduction, Region Extraction, Pixel-Based Approach, Multi-level thresholding, Local thresholding, Region-based Approach, Edge and Line Detection: Edge Detection, Edge Operators, Pattern Fitting Approach, Edge Linking and Edge Following, Edge Elements Extraction by thresholding, Edge Detector Performance, Line Detection, Corner Detection.

#### Reference Books:

1. Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education.
2. Digital Image Processing and Computer Vision, R.J. Schalkoff. Published by: John Wiley and Sons, NY.
3. Fundamentals of Digital Image Processing, A.K. Jain. Published by Prentice Hall, Upper Saddle River, NJ.

## **ELECTIVE - 3**

### **E-32 – Soft Computing**

#### **UNIT-I Artificial Neural Networks**

Basic concepts - Single layer perception - Multilayer Perception - Supervised and Unsupervised learning – Back propagation networks - Kohonen's self organizing networks - Hopfield network.

#### **UNIT-II Fuzzy Systems**

Fuzzy sets, Fuzzy Relations and Fuzzy reasoning, Fuzzy functions - Decomposition – Fuzzy automata and languages - Fuzzy control methods - Fuzzy decision making.

#### **UNIT-III Neuro - Fuzzy Modeling**

Adaptive networks based Fuzzy interface systems - Classification and Regression Trees – Data clustering algorithms - Rule based structure identification - Neuro-Fuzzy controls – Simulated annealing – Evolutionary computation.

#### **UNIT-IV Genetic Algorithms**

Survival of the Fittest - Fitness Computations - Cross over - Mutation - Reproduction – Rank method - Rank space method.

#### **UNIT-V Application of Soft Computing**

Optimization of traveling salesman problem using Genetic Algorithm, Genetic algorithm-based Internet Search Techniques, Soft computing-based hybrid fuzzy controller, Introduction to MATLAB Environment for Soft computing Techniques.

#### **Reference Books:**

1. Sivanandam, Deepa, “Principles of Soft Computing”, Wiley
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill
3. Laurene Fausett, "Fundamentals of Neural Networks", Prentice Hall
4. D.E. Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley Wang, “Fuzzy Logic”, Springer

## **ELECTIVE - 3**

### **E-33 – Pattern Recognition**

#### **UNIT-1 Introduction**

Basics of pattern recognition, Design principles of pattern recognition system, Learning and adaptation, Pattern recognition approaches, Mathematical foundations – Linear algebra, Probability Theory, Expectation, mean and covariance, Normal distribution, multivariate normal densities, Chi squared test.

#### **UNIT-II Statistical Pattern Recognition**

Bayesian Decision Theory, Classifiers, Normal density and discriminant functions,

#### **UNIT-III Parameter Estimation Methods**

Maximum-Likelihood estimation, Bayesian Parameter estimation, Dimension reduction methods - Principal Component Analysis (PCA), Fisher Linear discriminant analysis, Expectation-maximization (EM), Hidden Markov Models (HMM), Gaussian mixture models.

#### **UNIT-IV Nonparametric Techniques**

Density Estimation, Parzen Windows, K-Nearest Neighbor Estimation, Nearest Neighbor Rule, Fuzzy classification.

## **UNIT-V Unsupervised Learning & Clustering**

Criterion functions for clustering, Clustering Techniques: Iterative square – error partitioned clustering – K means, agglomerative hierarchical clustering, Cluster validation.

### **Reference Books:**

1. Richard O. Duda, Peter E. Hart and David G. Stork, “Pattern Classification”, 2nd Edition, John Wiley, 2006.
2. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2009.
3. S. Theodoridis and K. Koutroumbas, “Pattern Recognition”, 4th Edition, Academic Press, 2009.

## **ELECTIVE - 3**

### **E-34 – Data Analytics**

#### **UNIT-I Introduction To Data Analytics**

Introduction to data analytics Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.

#### **UNIT-II Mining Data Streams**

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications – Case Studies - Real Time Sentiment Analysis- Stock Market Predictions.

#### **UNIT-III Hadoop**

History of Hadoop- the Hadoop Distributed File System – Components of Hadoop Analysing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS- Java interfaces to HDFS Basics- Developing a Map Reduce Application-How Map Reduce Works-Anatomy of a Map Reduce Job run-Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats- Map Reduce Features- Hadoop environment.

#### **UNIT-IV Frameworks**

Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM InfoSphere Insights and Streams.

#### **UNIT-V Predictive Analytics**

Simple linear regression- Multiple linear regression- Interpretation of regression coefficients. Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications.

### **Reference Books:**

1. Bill Franks, “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, John Wiley & sons, 2012.
2. Jiawei Han, Micheline Kamber “Data Mining Concepts and Techniques”, 2<sup>nd</sup> Edition, Elsevier, Reprinted 2008.
3. Da Ruan, Guoqing Chen, Etienne E.Kerre, Geert Wets, “Intelligent Data Mining”, Springer, 2007.

## **ELECTIVE - 4**

### **E-41 – Blockchain Architecture**

#### **UNIT-I Introduction to Blockchain**

Digital Money to Distributed Ledgers , Design Primitives: Protocols, Security, Consensus, Permissions, Privacy. Blockchain Architecture and Design: Basic crypto primitives: Hash, Signature,) Hashchain to Blockchain, Basic consensus mechanisms

#### **UNIT-II Consensus**

Requirements for the consensus protocols, Proof of Work (PoW), Scalability aspects of Blockchain consensus protocols Permissioned Blockchains:Design goals, Consensus protocols for Permissioned Blockchains

#### **UNIT-III Hyperledger Fabric (A)**

Decomposing the consensus process , Hyperledger fabric components, Chaincode Design and Implementation Hyperledger Fabric (B): Beyond Chaincode: fabric SDK and Front End (b) Hyperledger composer tool

#### **UNIT-IV Use case 1**

Blockchain in Financial Software and Systems (FSS): (i) Settlements, (ii) KYC, (iii) Capital markets, (iv) Insurance **Use case 2:** Blockchain in trade/supply chain: (i) Provenance of goods, visibility, trade/supply chain finance, invoice management discounting, etc

#### **UNIT-V Use case 3**

Blockchain for Government: (i) Digital identity, land records and other kinds of record keeping between government entities, (ii) public distribution system social welfare systems Blockchain Cryptography, Privacy and Security on Blockchain

#### **Reference Books:**

1. Mastering Bitcoin: Unlocking Digital Cryptocurrencies, by Andreas Antonopoulos
2. Blockchain by Melanie Swa, O'Reilly
3. Hyperledger Fabric - <https://www.hyperledger.org/projects/fabric>

## **ELECTIVE - 4**

### **E-42 – Neural Network**

#### **UNIT-I Neurocomputing and Neuroscience**

Historical notes, human Brain, neuron Mode 1, Knowledge representation, AI and NN. Learning process: Supervised and unsupervised learning, Error correction learning, competitive learning, adaptation, statistical nature of the learning process.

#### **UNIT-II Data Processing**

Scaling, normalization, Transformation (FT/FFT), principal component analysis, regression, covariance matrix, eigen values & eigen vectors. Basic Models of Artificial neurons, activation Functions, aggregation function, single neuron computation, multilayer perceptron, least mean square algorithm, gradient descent rule, nonlinearly separable problems and bench mark problems in NN.

#### **UNIT-III Multilayered Network Architecture**

Back propagation algorithm, heuristics for making BP algorithm performs better. Accelerated learning BP (like recursive least square, quick prop, RPROP algorithm), approximation properties of RBF networks and comparison with multilayer perceptron.

#### **UNIT-IV Recurrent Network**

Temporal feed-forward network, implementation with BP, self organizing map and SOM algorithm, properties of feature map and computer simulation. Principal component and Independent component analysis, application to image and signal processing.

#### **UNIT-V Complex Valued NN**

Complex valued BP, analyticity of activation function, application in 2D information processing. Complexity analysis of network models. Soft computing. Neuro-Fuzzy-genetic algorithm Integration.

#### **Reference Books:**

1. J.A. Anderson, An Introduction to Neural Networks, MIT
2. Hagen Demuth Beale, Neural Network Design, Cengage Learning
3. R.L. Harvey, Neural Network Principles, PHI
4. Kosko, Neural Network and Fuzzy Sets, PHI

### **ELECTIVE - 4**

#### **E-43 – Internet Of Things**

##### **UNIT-I M2M to IoT**

The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.

##### **UNIT-II M2M to IoT – A Market Perspective**

Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. M2M to IoT-An Architectural Overview Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

##### **UNIT-III M2M and IoT Technology Fundamentals**

Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management

##### **UNIT-IV IoT Architecture-State of the Art**

Introduction, State of the art, Architecture Reference Model Introduction, Reference Model and architecture, IoT reference Model

##### **UNIT-V IoT Reference Architecture**

Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control. Industrial Automation- Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, Commercial Building Automation- Introduction, Case study: phase one-commercial

building automation today, Case study: phase two- commercial building automation in the future.

**Reference Books:**

1. Vijay Madiseti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, 1stEdition, VPT, 2014.
2. Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013

**ELECTIVE - 4**

**E-44 – Machine Learning**

**UNIT-I Learning**

Types of machine learning - Supervised learning - The brain and the neurons, Linear Discriminants -Perceptron - Linear Separability -Linear Regression - Multilayer perceptron - Examples of using MLP - Back propagation of error.

**UNIT-II Classification Algorithms**

Decision trees - Constructing decision trees - Classification of regression trees - Regression example - Probability and Learning: Turning data into probabilities - Some basic statistics - Gaussian mixture models - Nearest Neighbor methods.

**UNIT-III Analysis**

The k-Means algorithm - Vector Quantization’s - Linear Discriminant Analysis - Principal component analysis - Factor Analysis - Independent component analysis - Locally Linear embedding – Isomap - Least squares optimization - Simulated annealing.

**UNIT IV Optimization Techniques**

The Genetic algorithm - Genetic operators - Genetic programming - Combining sampling with genetic programming - Markov Decision Process - Markov Chain Monte Carlo methods: sampling - Monte carlo - Proposal distribution.

**UNIT V Python for Machine Learning**

Baysean Networks - Markov Random moFields - Hidden Markov Models -Tracking methods. Python: Installation - Python for MATLAB AND R users - Code Basics - Using NumPy and MatPolitB.

**Reference Books:**

1. Kevin P. Murphy, “Machine Learning – A probabilistic Perspective”, MIT Pres, 2016.
2. Randal S, “Python Machine Learning, PACKT Publishing, 2016.

## **ELECTIVE - 5**

### **E-51 – Distributed Database Systems**

#### **UNIT-I Transaction and Schedules**

Concurrent Execution of transaction, Conflict and View Serializability, Testing for Serializability, Concepts in Recoverable and Cascade less schedules.

#### **UNIT-II Lock based protocols**

Time stamp-based protocols, Multiple Granularity and Multi version Techniques, enforcing serializability by Locks, Locking system with multiple lock modes, architecture for Locking scheduler

#### **UNIT-III Distributed Transactions Management**

Data Distribution, Fragmentation and Replication Techniques, Distributed Commit, Distributed Locking schemes, Long duration transactions, Moss Concurrency protocol.

#### **UNIT-IV Issues of Recovery**

Atomicity in Distributed Databases, Traditional recovery techniques, Log based recovery, Recovery with Concurrent Transactions, Recovery in Message passing systems, Checkpoints, Algorithms for recovery line, Concepts in Orphan and Inconsistent Messages.

#### **UNIT-V Distributed Query Processing**

Multiday Joins, Semi joins, Cost based query optimization for distributed database, Updating replicated data, protocols for Distributed Deadlock Detection, Eager and Lazy Replication Techniques

#### **Reference Books:**

1. Silberschatz, Korth and Sudershan, Database System Concept', Mc Graw Hill
2. Ramakrishna and Gehrke,' Database Management System, Mc Graw Hill
3. Ceei and Pelagatti,'Distributed Database', TMH
4. Distributed System, Munesh C. Trivedi, Khanna Publishing House

## **ELECTIVE - 5**

### **E-52 – Mobile Computing**

#### **UNIT – I Introduction**

Issues in mobile computing, overview of wireless telephony: cellular concept, GSM: air-interface, channel structure, location management: HLR-VLR, hierarchical, handoffs, channel allocation in cellular systems, CDMA, GPRS.

#### **UNIT - II Wireless Networking**

Wireless LAN Overview: MAC issues, IEEE 802.11, Blue Tooth, Wireless multiple access protocols, TCP over wireless, Wireless applications, data broadcasting, Mobile IP, WAP: Architecture, protocol stack, application environment, applications.

#### **UNIT – III Data Management Issues**

Data replication for mobile computers, adaptive clustering for mobile wireless networks, File system, disconnected operations.

#### **UNIT - IV Mobile Agents Computing**

Security and fault tolerance, transaction processing in mobile computing environment.

#### **UNIT – V Ad Hoc Networks**



Localization, MAC issues, Routing protocols, global state routing (GSR), Destination sequenced distance vector routing (DSDV), Dynamic source routing (DSR), Ad Hoc on demand distance vector routing (AODV), Temporary ordered routing algorithm (TORA), QoS in Ad Hoc Networks, applications.

**Reference Books:**

1. J. Schiller, Mobile Communications, Addison Wesley.
2. A. Mehrotra , GSM System Engineering.
3. M. V. D. Heijden, M. Taylor, Understanding WAP, Artech House.

**ELECTIVE - 5**

**E-53 – Computer Graphics and Animation**

**UNIT-I Introduction to Computer Graphics**

What is Computer Graphics, Computer Graphics Applications, Computer Graphics Hardware and software, two-dimensional Graphics Primitives: Points and Lines, Line drawing algorithms: DDA, Bresenham's Circle drawing algorithms: Using polar coordinates, Bresenham's circle drawing, mid-point circle drawing algorithm; Filled area algorithms: Scan line: Polygon filling algorithm, boundary filled algorithm.

**UNIT-II Two/Three-Dimensional Viewing**

The 2-D viewing pipeline, windows, viewports, window to view port mapping; Clipping: point, clipping line (algorithms): - 4-bit code algorithm, Sutherland-Cohen algorithm, parametric line clipping algorithm (Cyrus Beck). Polygon clipping algorithm: Sutherland-Hodgeman polygon clipping algorithm. Two dimensional transformations: transformations, translation, scaling, rotation, reflection, composite transformation. Three dimensional transformations: Three-dimensional graphics concept, Matrix representation of 3 D Transformations, Composition of 3-D transformation.

**UNIT-III Viewing in 3D**

Projections, types of projections, mathematics of planner geometric projections, coordinate systems. Hidden surface removal: Introduction to hidden surface removal. Z-buffer algorithm, scanline algorithm, area subdivision algorithm.

**UNIT-IV Representing Curves and Surfaces**

Parametric representation of curves: Bezier curves, B-Spline curves. Parametric representation of surfaces; Interpolation method. Illumination, shading, image manipulation: Illumination models, shading models for polygons, shadows, transparency. What is an image? Filtering, image processing, geometric transformation of images.

**UNIT- V Animation**

Fundamentals of computer animation, Animation Techniques. Animation and Flash Overview, Using Layer and Creating Animation

**Reference Books:**

1. Procedural Elements for Computer Graphics – David F. Rogers, 2001, T.M.H Second Edition.
2. Fundamentals of 3Dimensional Computer Graphics by Alan Watt, 1999, Addison Wesley.
3. Computer Graphics: Secrets and Solutions by Corrign John, BPB
4. M.C. Trivedi, NN Jani, Computer Graphics, Jaico Publication

## **ELECTIVE - 5**

### **E-54 – Natural Language Processing**

#### **UNIT-I Introduction**

Natural Language Understanding: The study of Language, Applications of NLP, Evaluating Language Understanding Systems, Different levels of Language Analysis, Representations and Understanding, Organization of Natural language Understanding Systems, Linguistic Background: An outline of English syntax.

#### **UNIT-II Semantics**

Introduction to semantics and knowledge representation, some applications like machine translation, database interface.

#### **UNIT-III Grammars and Parsing**

Grammars and sentence Structure, Top-Down and Bottom-Up Parsers, Transition Network Grammars, Top- Down Chart Parsing. Feature Systems and Augmented Grammars: Basic Feature system for English, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.

#### **UNIT-IV Grammars for Natural Language**

Auxiliary Verbs and Verb Phrases, Movement Phenomenon in Language, Handling questions in Context-Free Grammars. Human preferences in Parsing, Encoding uncertainty, Deterministic Parser.

#### **UNIT-V Ambiguity Resolution**

Statistical Methods, Probabilistic Language Processing, Estimating Probabilities, Part-of-Speech tagging, Obtaining Lexical Probabilities, Probabilistic Context-Free Grammars, Best First Parsing. Semantics and Logical Form, Word senses and Ambiguity, Encoding Ambiguity in Logical Form.

#### **Reference Books:**

1. Akshar Bharti, Vineet Chaitanya and Rajeev Sangal, NLP: A Paninian Perspective, Prentice Hall, New Delhi
2. James Allen, Natural Language Understanding, Pearson Education
3. D. Jurafsky, J. H. Martin, Speech and Language Processing, Pearson Education
4. L.M. Ivarasca, S. C. Shapiro, Natural Language Processing and Language Representation
5. T. Winograd, Language as a Cognitive Process, Addison-Wesley