

**School of Computer and Systems Sciences
Jawaharlal Nehru University
New Delhi-110067**

**MCA 2-Years Course Structure and Syllabus)
(From Admissions in Academic Year 2020-21 Onwards)**

Course Structure

The MCA programme would be a four semester programme with minimum 72 credits.

MCA (Semester-I)			
Course	Credits	Type	
Programming in C CS-401	2	Core	Bridge Course for students with B.Sc./ B.Com./ B.A. degree (Non-Computer Science/Non-IT) with Mathematics at 10+2 Level or at Graduation Level.
Computer Fundamentals CS-402	2	Core	
Data Structures CS-403	4	Core	
Discrete Mathematics CS-404	4	Core	
Computer Architecture CS-405	4	Core	
Numerical Methods CS-406	4	Core	

MCA (Semester-II)		
Course	Credits	Type
Database Management Systems CS-407	4	Core
Computer Networks CS-408	4	Core
Design and Analysis of Algorithms CS-409	4	Core
Object Oriented Programming CS-410	4	Core
Artificial Intelligence CS-411	4	Core
Operating Systems CS-412	4	Core

MCA (Semester-III)		
Course	Credits	Type
Software Engineering CS-413	4	Core
Theoretical Computer Science CS-414	4	Core
Elective-I	4	Elective
Elective-II	4	Elective
Elective-III	4	Elective
Elective-IV	4	Elective

MCA (Semester-IV)		
Course	Credits	Type
Project CS-460	8	Core

Elective-I, Elective-II, Elective-III and Elective-IV would be chosen from the list of electives courses given below:

List of Elective Courses	
Microprocessors CS-434	Computer Graphics and Multimedia CS-428
Probability and Statistics CS-440	Machine Learning CS-433
Advanced Data Structure and Algorithms CS-422	Advanced Computer Architecture CS-421
Web Based Programming CS-445	Cloud Computing and IoT CS-426
Compiler Design CS-427	Wireless Networks CS-446
Parallel and Distributed Systems CS-439	Front End Design Technique CS-432
Simulation and Modeling CS-441	Data Mining and Knowledge Discovery CS-430
Mobile Communication and Computing CS-436	Big Data and Analytics CS-424
Mobile Application and Programming CS-435	Cyber Security CS-429
Blockchain Technology CS-425	Natural Language Processing CS-437
Soft Computing CS-442	Digital Image Processing and Computer Vision CS-431
Software Testing CS-443	Agile Methodology and DevOps CS-423
VLSI Design CS-444	Object Oriented Analysis and Design CS-438

SYLLABUS

SEMESTER I

1. Programming in C

An introduction to the process of program design and analysis using the C programming language. Topics to be covered include basic data types and their operators, I/O, control structures (selection, loops), arrays, string, structs and unions, dynamic memory allocation (malloc and free), pointers and pointer arithmetic, and files. Some simple sorting and searching algorithms.

Suggested Readings:

- B.W. Kernighan, Dennis M. Ritchie, The C Programming Language, PHI/Pearson
- Dromey, How to Solve it By Computer, PHI
- E Balaguruswamy, C Programming, Tata Mc Graw Hill
- Stephen G. Kochan, Programming in C, Pearson Education

2. Computer Fundamentals

Logic gates, Boolean algebra, K-map, Map simplification, **Combinational circuit Design** – Half adder, full adders, Decoders, Encoder, Magnitude Comparator, Multiplexer, Read-Only memory, PLAs; **Sequential Circuit Design** – Flip-Flops, Registers, shift registers, Counters, **Processor Logic Design** – Arithmetic circuit, logic circuit, Accumulator, Status register; **Control Logic Design** - Hard-wired control, micro-program sequencer; Digital Integrated circuits – introduction to Bipolar transistor Characteristics, RTL, DTL, I²L, TTL, ECL, MOS, CMOS.

Suggested Readings:

- Moris Mano M, Digital Logic and Computer Design, Fundamentals, PHI 2004
- Givone D D, Digital Principles and Design, Tata McGraw- Hill, 2002

3. Data Structures

Classification of Data Structures: Primitive and Non- Primitive, Linear and Nonlinear; Linear lists, Stack, Linked structures; Orthogonal lists; Multilinked Structures; Tree : Binary tree, Tree traversals, Binary Search trees; Tree deletion; Threaded binary tree; AVL trees; General ordered trees :Expression trees; Huffman trees; B-trees; B+ trees; Forest; Graphs: DFS, BFS, Shortest path algorithm; Introduction,

Fundamentals of the Analysis of Algorithm Efficiency Notion of Algorithm, Fundamentals of Algorithmic Problem Solving, Asymptotic Notations and Basic efficiency classes, Mathematical analysis of Recursive and Non-recursive algorithms. Recursion - Factorial, GCD, Fibonacci Sequence, Tower of Hanoi. Sorting and searching algorithms and their analysis; Queue: Definition, Representation, Queue Variants: Circular Queue, Priority Queue, Double Ended Queue; Applications of Queues. Programming Examples.

Suggested Readings:

- Horowitz Ellis and Sahni Sartaj, “Fundamentals of Data Structures”, W H Freeman and Co.
- Tremblay Jean-Paul and Sorenson Paul G., “An Introduction to Data Structures With Applications”, McGraw-Hill, Inc.
- Kruse Robert L., “Data Structures and Program Design”, Prentice Hall.
- Gilberg Richard F. and Forouzan Behrouz A., “Data Structures: A Pseudocode Approach with C”, Cengage Learning.
- Cormen Thomas H., “Introduction to Algorithms”, The MIT Press.

4. Discrete Mathematics

Sets, Relations, Functions, Logic operators, truth tables, normal forms, Propositional and predicate calculus, Boolean Algebra, Euclidean algorithms, Fibonacci numbers, Congruence and equivalence relation, Groups, Subgroups, semi-group, monoids, Error detecting & correcting codes; permutation & combination, pigeon hole principle, Principle of inclusion and exclusion, Ordinary and exponential generating functions, Recurrence relation; trees, graphs, bipartite graphs, planar & dual BFS & DFS algorithms, Flyod’s and Dijkstra shortest path algorithms, Kruskal & Prism’s algorithms for minimum cost spanning tree; Regular expression, Finite state machine, Grammars.

Suggested Readings:

- Tremblay and Manohar, Discrete Mathematical Structures, Tata McGraw Hill
- Maggard, Thomson, Discrete Mathematics, 1 st Edition
- Semyour Lipschutz, Varsha Pati “Discrete Mathematics”, IInd Edition Schaum’s Series TMH
- Kolman, Busby and Ross, “Discrete Mathematical Structures”: Prentice Hall India, Edition 3
- C.L. Liu, Elements of Discrete Structures. 6. Rosen, Discrete Mathematics and application.

5. Computer Architecture

Data representation – number system, two’s complement, Arithmetic operations using 2’s and 1’s complements, floating-point representation and arithmetic operations; Register Transfer and Micro-operations, instruction codes and formats, addressing modes, timing and control signal generation, instruction cycles, memory reference instructions, Input out instructions; Central Processing unit – stack organization, Data transfer and manipulation, program control; Pipeline and vector Processing–Arithmetic and Instruction Pipeline, vector operations, array processors; Input output organization –I/O verses memory bus, Isolated verses memory mapped I/O, Priority interrupts, DMA, I/O processors; Memory Organization– RAM, ROM, Associative memory, Cache memory, memory management hardware.

Suggested Readings:

- Morris Mano, Computer System Architecture Pearson Education, 2012
- David A. Patterson, John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, Morgan Kaufmann, 2009
- William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson Education, 2007
- Behrooz Parhami Computer Architectures: From Microprocessors to Supercomputers, , Oxford, 2005.

6. Numerical Methods

Data representation – Fixed-point numbers, Floating-point numbers, Finite data representation; Propagation of error, Root finding' Newton's methods, Fixed-point iteration, Ill-behaved root finding problems, Interpolation, divided differences, Spline functions, Approximation of functions – Chebyshev polynomial; Numerical integration and differentiation – Trapezoidal and Simpson rules, Gaussian numerical integration, Solution of systems of linear equations – matrices equation, method of triangular matrices, Gaussian elimination with pivoting, Jacobson and Gauss Seidel; Ordinary Differential equations – Euler method, Runge-Kutta methods, Multi-step method, System of differential equations.

Suggested Readings:

- M.K. Jain, SRK Iyengar and R.K.Jain, Numerical Methods for Scientific and Engineering Computation
- S.C. Chopra and Raymond P. Canale, Numerical Methods for Engineers
- Sastry, Introductory Methods of Numerical Analysis by
- E.W. Cheney and D.R.Kincaid,. Numerical Analysis

SEMESTER II

1. Data Base Management Systems

Introduction; Database Architecture; Database Analysis: Entity Relationship Model, Database Design: Relational Model, Integrity Constraints, Functional, Transitive, Multivalued and Join Dependency; Normalization: 1NF, 2NF, 3NF, BCNF, 4NF, 5NF; Lossless Join Decomposition and Dependency Preservation; Canonical Cover; Query Languages: Relational Algebra, Tuple and Domain Relational Calculus, SQL: DDL, DQL, DML, DCL; Transaction Processing, Concurrency Control and Recovery Techniques; Advances in Database Systems and Technologies.

Suggested Readings:

- Silberschatz, A., Korth, H.F., Sudarshan, S., Database System Concepts, McGraw-Hill International Edition, 2006 (5 th Edition)
- Elmasri, R., Navathe, S.B., Fundamentals of Database Systems, Fourth Edition, Pearson Education,
- Desai, B.C., An Introduction to Database Systems, Galgotia Publications,
- Date, C.J., An Introduction to Database Systems, Pearson Education, 7 th Edition
- Garcia-Molina, H., Ullman, J.D., Widom, J., Database Systems: The Complete Book, Pearson Education, 2002

2. Computer Networks

Overview of Computer Network; Data Communication – Analog and digital communications, signal and data, Channel characteristics, Nyquist theorem, Shannon's formula, modulations, encoding schemes; Error Detection – VRC, LRC, CRC, Checksum; Transmission media; Multi-channel communication – multiplexing techniques, Multiple access techniques; Switching techniques – Telephone systems, ATM; Queuing Models – little's theorem, Poisson Process, Markov Chain model, M/M/1, M/M/S/K, M/G/1 queues; ALOHA systems; Local Area Networks – CSMA/CD, Token Ring, Token Bus, FDDI, Routing – spanning tree, Bellman-Ford, Dijkstra algorithms, Distance vector and link state routing; IP protocol-fragmentation, reassembly; Transport Protocol – stop-and-wait, Sliding window protocols, congestion control, TCP, UDP; Application Protocols – FTP, Email.

Suggested Readings:

- Andrew S. Tanenbaum, Computer Networks, Fourth Edition, Pearson Education,
- Behrouz A. Ferouzan, Data Communications and Networking, 2nd edition, TMH,
- Alberto Leon-Garcia and Indra Widjaja, Communication Networks, 2 nd Ed, Tata McGraw-Hill,
- William Stallings, Data and computer Communications, 7 th Edition, Pearson Education,

3. Design and Analysis of Algorithms

Some efficient algorithms; Algorithm analysis: worst case and average case analysis, Recurrences and asymptotics; Algorithm design: divide-and-conquer, branch-and-bound, backtracking, dynamic programming, greedy methods; Efficient data structures, amortized analysis, NP completeness; Additional topics: graph problems, string searching, parallel computing, low level techniques for efficient programming.

Suggested Readings:

- T Cormen, C Leiserson, R Rivest, C Stein, Introduction to Algorithms, PHI.
- V. Aho, J. Hopcraft, J. Ulmann, The Design and Analysis of Computer Algorithms, Addison Wesley.
- E Horowitz, S Sahni, S Rajasekaran, Fundamentals of Computer Algorithms, Universities Press
- S. Basse, A. V. Gelder, Computer Algorithms: Introduction to Design and Analysis, Pearson Education Asia Pvt. Ltd.

4. Object Oriented Programming

The Key Attributes of Object-Oriented Programming, The Java Development Kit, The Java Class Libraries. Java's Primitive Types, Literals, The Scope and Lifetime of Variables, operators, Shorthand Assignments, Type conversion in Assignments, Using Cast. Control Statements, Classes, Objects and Methods, Controlling Access to Class Members, Pass Objects to Methods, Method Overloading, Overloading Constructors, Recursion, Inheritance Basics, Member Access and Inheritance, Constructors and Inheritance, Using super to Call Superclass constructors.

Suggested Readings:

- H.M. Deitel, P.J. Deitel, Java : how to program, Fifth edition, Prentice Hall Publication.
- Herbert Schildt, The Java 2: Complete Reference, Fourth edition, TMH.

5. Artificial Intelligence

Overview of AI; Problem solving; various search strategies, Game playing: MinMax, Alpha-Beta pruning; Introduction to logic programming, inference mechanisms; Knowledge representation: Logic, rules, semantics, frames, Conceptual dependency; Uncertain knowledge and reasoning; Hill Climbing, Simulated Annealing, Best First Search: Graphs, Heuristic Functions, A* Algorithm, AND –OR graphs, AO* Algorithm. Expert systems.

Suggested Readings:

- Rich and Knight, Artificial Intelligence, Tata McGraw-Hill.
- Russell and Norvig, Artificial Intelligence: A Modern Approach (3rd Edition), Prentice Hall.
- Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann Publishers, Inc.
- Winston, Artificial Intelligence, Addison Wesley.

6. Operating Systems

Overview, Computer System Structures, Operating System Structures, Process and Process Scheduling, CPU scheduling, Process Synchronization, Semaphores, Monitors, Deadlock and methods of deadlock handling, Address Space, Paging, Segmentation, Virtual Memory, Page Replacement Algorithms, File and Directory Concepts, Access Methods, File System Allocation methods, Secondary Storage Scheduling and Management, Protection, Security

Suggested Readings:

- Silberschatz, P. Galvin and G. Gagne, Operating System Concepts, 9th Edition
- William Stallings, Operating Systems: Internals and Design Principles, 7th Edition

SEMESTER III

1. Software Engineering

Introduction, Software Product and Process, Software Process Models, Requirements Engineering, Requirements Analysis –Data Flow Diagram, Requirement Specification, Requirement Validation; Design- Concepts, Coupling, Cohesion, Mapping Analysis to Design, User Interface Design, Structure Charts, Coding Principles, Coding Standards and Guidelines, Software Testing Techniques and Strategies, Software Debugging, Software Project Metrics and Estimation Techniques – Empirical, Heuristic and Analytical Techniques, Software Quality Assurance, CASE Tools, Software Maintenance and Reengineering.

Suggested Readings:

- Pressman, R., Software Engineering – A Practitioner’s approach, Sixth Edition, McGrawHill International Edition.
- Sommerville, I., Software Engineering, Sixth Edition, Pearson Education.
- Ghezzi, C., Jazayeri, M., Mandrioli, D., Fundamentals of Software Engineering, Second Edition, Pearson Education.
- Jalote, P., An Integrated Approach to Software Engineering, Second Edition, Narosa Publishing House.

2. Theoretical Computer Science

Mathematical reasoning; logic; methods of proof; sets, relations, function; induction principle, Grammars, Chomskian hierarchy of languages and their properties; Finite state machines, Kleen’s theorem, Moore and Mealy models; Pushdown automata; Turing machine; Recursive and recursively enumerable sets models, recursive functions; Halting problem, Church’s thesis.

Suggested Readings:

- Linz, Peter, An introduction to Formal Languages and Automata, Narosa Publishing House, 2007
- Lewis, H.R., and Papadimitriou, C.H., Elements of Theory of Computation, Pearson Education, 2002
- Hofcroft, J.E., and Ullman, J.D., Introduction to Automata Theory, Languages and Computation, Narosa Publishing house 2008
- Krithivasan, Kamala, Introduction to Automata Theory, Languages and Computation, Pearson Education, 2009
- Martin, J.C., Introduction to Languages and Theory of Computation, Tata McGraw-Hill Publication, 3e, 2007

Elective Courses

1. Microprocessors

Basic Microprocessor architecture, bus structure and memory maps, memory systems for microprocessor, hardware and software interrupts, I/O systems Introduction to Intel family of microprocessor, 8085/8086 microprocessor - architecture, Instruction set, programming.

Suggested Readings:

- Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Wiley Eastern Limited, 2002
- Barry B. Brey, C.R.Sharma, The Intel Microprocessors: Architecture, Programming and Interfacing, Pearson Education, 2005
- Sunil Mathur, Microprocessor 8086: Architecture, Programming and Interfacing, PHI, 2011
- Douglas V. Hall, Microprocessor and Interfacing, McGraw Hill Company, 2005.

2. Computer Graphics and Multimedia

Graphics devices – random scan and Raster-scan; Bresenahm’s circle drawing algorithm, generation of ellipses, Curve drawing, Bezier and B-spline curves, **2-D graphics**: polar coordinates, parametric functions, vectors, matrices operations; Transformation – homogeneous coordinate systems, translation, scaling, rotation, mirror reflection, parametric representation of a line segment; **3-D graphics**: transformation- right handed coordinate system with vertical y-axis, matrices for translation, scaling rotation around axis, Parallel Projection – front and side views, Oblique view, Multimedia Fundamentals, Multimedia Building Blocks: Text, Graphics, video capturing, Sound capturing, editing, Multimedia & the Internet

Suggested Readings:

- J.D. Foley, A. Van Dam, J.F. Hughes and S.K. Feiner, Computer Graphics: Principles and Practice, Second Edition, Addison Wesley
- D. Hearn and P. M. Baker, Computer Graphics, Prentice Hall of India, Second Edition
- Rogers, Procedural Elements of Computer Graphics, Second Edition, TMG
- Rogers and Adams, Mathematical Elements of Computer Graphics, Second Edition, TMG
- Li , Ze - Nian, Fundamentals of Multimedia, ISBN: 0130618721, Prentice-Hall, 2004.
- Ramesh Yerraballi, Multimedia Systems Concepts Standards and Practice, PHI, 2004.

3. Probability and Statistics

Probability – Axioms, Conditional probability, Bayes Theorem, random variables, Discrete RV – Binomial, geometric Poisson; Continuous RV – Uniform, Exponential, Gamma, Normal, Expectation, Mean and Variance, Jointly distributed RVs, Co-variance, Sums of RVs, Central Limit Theorem, Moment generating functions, Sample Distribution, Inference concerning mean, Statistical inference-Parameter estimation, Maximum likelihood estimation, Hypothesis testing, Curve fitting, Methods of least Squares, Curvilinear Multiple regression.

Suggested Readings:

- Ross, S., A First Course in Probability, Sixth Edition, Pearson Education
- Ross, S., Introduction to Probability Models, Eight Edition, Elsevier, 2003
- Trivedi, K.S., Probability and Statistics with Reliability, Queueing and Computer Science Applications, Second Edition, Wiley, 2002
- R. Nelson, “Probability, Stochastic Processes and Queuing Theory”, Springer, 1995

4. Machine Learning

An overview of Machine learning; Inductive learning, ID3, C4.5; Learning Concepts and rules from Examples; Learning by analogy; Learning from observation and discovery; Learning by experimentation. Learning by training Neural Networks; Genetic Based Machine Learning (GBML) Learning Classifier Systems (LCS), Genetic Programming.; Analytical learning; Reinforcement learning. Applications to KDD.

Suggested Readings:

- T. M. Mitchell, "Machine Learning", Mcgraw Hill, 1997
- R. S. Mitchalski, J. G. Carhonell and T. M. Mitchell, "Machine Learning- An Artificial Intelligence Approach", Vol I - IV, Springer-Verlag, 1980
- H. Adeli and S. L. Hung, "Machine Learning- Neural Networks, Genetic algorithms and Fuzzy Systems", John Wiley and Sons, 1995
- T. Hastie, J. Friedman and R. Tibshirani, "Elements of Statistical Learning", Springer, 2000 Com

5. Advanced Data Structure and Algorithms

Review of basic data structures, Dynamic data structures: 2-3 trees, Redblack trees, Binomial and Fibonacci heaps, Splay trees, Linking and Cutting trees, Network flows: preflow-push algorithms, max flow algorithm, and scaling algorithms. Theory of Complexity: P, NP and NP-Complete complexity classes, NP- Hard and NP-Complete Problems, A few NP-Completeness proofs. Approximation Algorithms: Introduction, Combinatorial Optimization, approximation factor, Polynomial Time Approximation Scheme (PTAS), Fully Polynomial Time Approximation Scheme (FPTAS) , Approximation algorithms for vertex cover, set cover, TSP, knapsack, bin packing, subset-sum problem etc. Analysis of the expected time complexity of the algorithms. Probabilistic Algorithms & Randomized Algorithms: Numerical probabilistic algorithms, Las Vegas and Monte Carlo algorithms, Game-theoretic techniques, Applications on graph problems, Parallel Algorithms: Introduction, Models, speedup and efficiency, Some basic techniques, Examples from graph theory, sorting, Parallel sorting networks. Parallel algorithms and their parallel time and processors complexity.

Suggested Readings:

- T Cormen, C Leiserson, R Rivest, C Stein, Introduction to Algorithms, PHI
- Vijay Vazirani, Approximation Algorithms, Springer-Verlag, ISBN: 3-540-65367-8, Published: a. 2001
- D. Williamson and D. Shmoys, The Design of Approximation Algorithms, Cambridge a. University Press, 2011
- T Cormen, C Leiserson, R Rivest, C Stein, Introduction to Algorithms, PHI.
- Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 1995

6. Advanced Computer Architecture

Register Transfer and Micro operations:. Register Transfer language, Register transfer, Bus and Memory Transfer, Arithmetic Micro operations, Logic Micro operations, Shift Micro operations and Arithmetic logic shift unit. Instruction codes, Computer Registers, Computer Instructions, Timing and Control, Design of Accumulator logic, Machine Language, Assembly Language, Programming Arithmetic and Logic Operations, Subroutines, Micro programmed Control: Control Memory, Address Sequencing, Micro program Example, Design of Control Unit. RISC. Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction, Pipeline, RISC Pipeline. Computer Arithmetic: Addition and Subtraction, Multiplication, algorithms, Division Algorithms, Floating point arithmetic operations, decimal arithmetic unit, and decimal arithmetic operations.

Suggested Readings:

- Morris Mano, Computer System Architecture Pearson Education, 2012
- David A. Patterson, John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, Morgan Kaufmann, 2009
- William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson Education, 2007
- Behrooz Parhami Computer Architectures: From Microprocessors to Supercomputers, Oxford, 2005.

7. Web-Based Programming

Word Wide Web – introduction, Client-Server model, Web servers, Browser Interface, Browser architecture, optional clients, caching in web browser, Search engines, optimization of search engines, CGI interface; Hypertext – HTML, DHTML, HTTP; Scripting languages – JSP, ASP; Web Programming- Java language, Java Swings, Java Beans, Applets, Servlets, RMI, Java utilities.

Suggested Readings:

- Comer D.E, Computer Networks, Internet and applications, 3rd 2004.
- Crouch, Web programming with ASP and COM , Pearson Education
- Jon Duckett, Beginning Web Programming with HTML, XHTML, and CSS, Wiley Publication

8. Cloud Computing and IoT

Cloud Computing Fundamentals, Types of cloud, Cloud services: Benefits and challenges of cloud computing, Cluster Computing, Grid Computing, Grid Computing Versus Cloud Computing, Key Characteristics of Cloud Models, Cloud Services and File System, Virtualization: Virtualization of CPU, Memory, I/O Devices, Virtualization for Data-center Automation. IoT and Digitization, IoT Challenges, IoT Network Architecture and Design, Smart Objects: Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, Introduction to Arduino, Fundamentals of Arduino Programming, Introduction to RaspberryPi.

Suggested Readings:

- Kai Hwang, Geoffrey Fox, Jack Dongarra, Distributed and Cloud Computing, Elsevier, 2012.
- Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, Mastering Cloud Computing, TMH, 2013.
- Dan C. Marinescu, Cloud Computing: Theory and Practice, Elsevier, 2013.
- Samuel Greengard, The Internet of Things, MIT Press, 2015
- Peter Waher, Learning Internet of Things, Packt Publishing, 2015
- Dirk Slama, Frank Puhlmann, Jim Morrish , Enterprise IOT, O'Reilly Publishers, 2015

9. Compiler Design

Overview of a Compiler; Lexical Analyzer; Syntax Analysis: PDA, NPDA, Construction of Top-down and Bottom-up parsers from CFG, Recursive descent parser, LL(1) parser, Operator precedence parser, LR parsers; Semantic Analysis : SDTS, Intermediate Code generation ;Code Optimization : The principle sources of optimization, Optimization of basic blocks, Loops in flow graphs, Introduction to global data-flow analysis.

Suggested Readings:

- Aho , Ulman, Sethi, Compiler: Principles, techniques and tools, Pearson education
- Kenneth C. Loudon , Compiler Construction Principles and Practice, , Thompson
- Cooper and Linda, Engineering a Compiler-, Elsevier.
- John R. Levine, Tony Mason, Doug Brown, lex and yacc , O'reilly

10. Wireless Networks

Introduction to Wireless Networks, Wireless Transmission, Modulation techniques - analog modulation and digital modulation, Spread Spectrum technology e.g. Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS), Wireless Medium Access Control: Space Division Multiple Access (SDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). Cellular system fundamentals, GSM architecture and GSM –TDMA/ FDMA, Handover in GSM system, High Speed Circuit Switched Data (HSCSD) and Universal Mobile Telecommunication System (UMTS) architecture and radio interface. IEEE 802.11 architecture, WiMAX (Worldwide Interoperability for Microwave Access). Mobility and Mobile IP, TCP Over wireless networks, Mobile TCP. HSPA+, LTE (Long Term Evolution) and 4G, and 5G technology. Wireless security, and QoS in Wireless. Mobile Ad Hoc Networks (MANET's): Properties and applications of MANET, MANET routing algorithms, and energy management in MANETS. Some important protocols of WSN.

Suggested Readings:

- Rappaport, Wireless communications: principal and practice , Pearson ed.
- Matthew S. Gast, 802.11 wireless networks, o'reilly
- Andrea Goldsmith ,Wireless communication , cambridge university press ed .
- Feng Zhao, Leonidas Guibas, “ Wireless Sensor Network”,Elsevier,
- Kazem, Sohrawy, Daniel Minoli, Taieb Zanti, “Wireless Sensor Network: Technology, Protocols and Application”, John Wiley and Sons.
- Carlos d. M and D P Agrawal, “Ad Hoc and Sensor networks: Theory and Applications”, worldscientific.

11. Parallel and Distributed Systems

Parallel systems – Hardware, SIMD, MISD, MIMD, Multiprocessor systems, Parallel algorithms, Shared memory, message-passing, and data parallel programming, Shared memory multiprocessors, cache coherence, and memory consistency, Scalable multiprocessors, interconnection network design, and directory-based cache coherence protocols, Performance issues, simulation, and benchmarks, Multiprocessor real-time scheduling, Latency tolerance, techniques, Single chip multiprocessors, Distributed systems – hardware and software concepts, Client-server model; Communication – Lower-level protocols, transport protocols, higher level protocols, RMI Remote Object Invocation, Message oriented communication, Stream oriented communication; Synchronization – Clock synchronization, logical Clock, Election Algorithms, Mutual exclusion, distributed transactions; Consistency and Replication – Dat centric and client centric consistency, distribution protocols, consistency protocols; Fault tolerance, Security, Distributed object-based systems, Distributed file systems.

Suggested Readings:

- Kai Hwang , Advanced Computer Architecture, TMH, 2011
- M.R. Bhujade, Parallel Computing, New Age International Publications, 2011
- Andrew S. Tanenbaum Tanenbaum, Distributed System, Pearson Education, 2002
- Nancy A. Bynch, Distributed Algorithms, Morgan Kaufmann, 1996.

12. Front End Design Technique

Introduction to the specific HTML5 tags: header, footer, aside, section, nav, figure. W3C validation and fixing problems with HTMLBlock and inline HTML tags. Browser compatibility issues with HTML5 tags and workarounds. CSSClasses, IDs, styling HTML tags, external stylesheets. Understanding selectors: Universal selector, Descendant combinatory, Child combinatory, General sibling combinatory, adjacent sibling combinatory, Attribute selector, Pseudo-class, Pseudo-element. Inheritance and functioning. Positioning web pages.

Suggested Readings:

- Goldberg, Internet and world wide web – How to Program, 5th Edition, Deitel & Deitel, Pearson Education,2011.
- Patrick Carey, New Perspectives on HTML, CSS, and XML, Comprehensive, 4th Edition, 2013 PHI
- Hans Bergsten, Java Server Pages, SPD O'Reilly
- Chris Bates, Web Programming, building internet applications, 2nd edition, WILEY Dreamtech

13. Simulation and Modeling

Advantages and disadvantages of simulation systems, Components of system, Discrete and continuous systems, Examples – Simulation of queuing and inventory systems, concepts in discrete-event simulation; Simulation software – GPSS, CSIM, Simulation Packages; Statistical models in simulation; Queuing models – long run measures of performance, steady-state behaviour, M/M/1, M/M/C/∞/∞, M/M/C/N/∞,

M/M/C/K/K; Pseudo random numbers, random variate generation, Inverse transform technique, Acceptance – rejection technique, Analysis of simulation data, Verification and validation of simulation models, Output analysis for single model, Simulation of computer systems.

Suggested Readings:

- Raj Jain, Art of Computer Systems Performance Analysis, John Wiley and Sons, Inc, 1991.
- Sheldon M. Ross, Simulation, 4 th Ed., Elsevier 2008,
- Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, 3 rd Ed. Tata McGraw-Hill, 2003
- Geofeerey Gordon, System Simulation, 2 nd Ed., PHI, 1987.
- J Banks, J. S. Carson II, B. L. Nelson, D. M. Nicol, 2010, Discrete Events System Simulation, 5 th Edition, Prentice Hall.
- R. Y. Rubinstein, D. P. Kroese, 2008, Simulation and the Monte Carlo Method, 2 nd Edition, Wiley Series in Probability and Statistics, Wiley.
- J. R. Thompson, 2000, Simulation A Modeler’s Approach, Wiley Series in Probability and Statistics, Wiley.

14. Data Mining and Knowledge Discovery

Introduction to Data Mining and knowledge discovery in databases (KDD); Data understanding, preparation and pre-processing; Data warehousing, Online analytical processing; Mining frequent patterns, association rules, and correlation, Techniques – Apriori, FP-Growth; Classification: Building decision tree – Information theory and Gini index, Overfitting and pruning, Naïve Bayes method, Estimating prediction accuracy; Cluster Analysis: Partition based clustering – K-Means, Hierarchical based clustering – Agglomerative and Divisive; Density based clustering – DBSCAN; Web mining: Web content mining, Web structure mining and Web usage mining.

Suggested Readings:

- Han, J. and Kamber, M., Data Mining: Concepts and Techniques, Morgan Kaufmann, 2007
- Witten, I.H. and Frank, E., Data mining: Practical Tools and Techniques with Java Implementations, Morgan Kaufmann 1999
- Tan, P-N, V. Kumar, V. and Steinbach, M.: Introduction to Data Mining, Pearson, 2007
- Hand, D. and Mannila, H. and Smyth, P. Principles of Data Mining, Indian reprint, PHI 2004

15. Mobile Communication and Computing

Introduction of Mobile Computing: History, Types, Benefits. Propagation Modes, Wireless Architecture and its types, Cellular system, Hexagonal geometry cell and concept of frequency reuse, Channel Assignment Strategies. GSM:-Channel allocation, call routing Architecture, network aspects, frequency allocation, security, Handoffs Techniques .GPRS: network operation, data services, Applications. Mobile IP, IP packet delivery, Agent Discovery, Registration, Tunneling and encapsulation, Route optimization, IP Handoff. Indirect TCP, Snoop TCP, Mobile TCP. WAP, WAP applications, WAP Architecture, WAP Protocol Stack. Introduction to 4G.

Suggested Readings:

- Jochen Schiller, Mobile Communications, Second Edition, PHI/Pearson Education, 2003.
- Raj Kamal, Mobile Computing, Oxford University Press, 2019
- Rappaport Theodore S., Wireless Communications: Principal and Practice, Pearson Education, 2010.
- Matthew s. Gast, 802.11 Wireless Networks, O’reilly, 2011

16. Mobile Application and Programming

Introduction to Android: The Android Platform, Android SDK, Eclipse Installation, Android Installation, Building you First Android application, Understanding Anatomy of Android Application, Android

Manifest file. Android Application Design Essentials: Anatomy of an Android applications, Android terminologies, Application Context, Activities, Services, Intents, Receiving and Broadcasting Intents, Android Manifest File and its common settings, Using Intent Filter, Permissions.

Android User Interface Design Essentials: User Interface Screen elements, Designing User Interfaces with Layouts, Drawing and Working with Animation. Testing Android applications, Publishing Android application, Using Android preferences, Managing Application resources in a hierarchy, working with different types of resources. Using Common Android APIs: Using Android Data and Storage APIs, Managing data using Sqlite, Sharing Data between Applications with Content Providers, Using Android Networking APIs, Using Android Web APIs, Using Android Telephony APIs, Deploying Android Application to the World.

Suggested Readings:

- Lauren Darcey and Shane Conder, “Android Wireless Application Development”, Pearson Education, 2nd ed. (2011)
- Reto Meier, “Professional Android 2 Application Development”, Wiley India Pvt Ltd2.
- Mark L Murphy, “Beginning Android”, Wiley India Pvt Ltd3.R3. Android Application Development All in one for Dummies by Barry Burd, Edition:

17. Big Data and Analytics

Introduction to Big data, Big data Architecture, Storage Management, Database processing, Data integration, Distributed file system, MapReduce, HDFS and Hadoop, Data Analytics, Statistical and Computational predictive analysis on data, Mining Big data, Big Data Streams and Real Time Predictive Analysis, Tools and Visualization, Link Analysis, Web Analytics, Collaborative Filtering, Social Network Analysis, Issues, Challenges and Opportunities with Big Data and its Analytics.

Suggested Readings:

- Rajaraman, A., Ullman, J. D., Mining of Massive Datasets, Cambridge University Press, United Kingdom, 2012
- Bermann, .J., Principles of Big Data: Preparing, Sharing and Analyzing Complex Information, Morgan Kaufmann, 2014
- Barlow, M., Real-Time Big Data Analytics: Emerging Architecture, O Reilly, 2013
- Baesens, B., Analytics in a Big Data World, Wiley, 2016
- Bell, J., Machine Learning for Big Data, Wiley, 2016

18. Cyber Security

Cyber Security Fundamental: Basic Terminologies, Services and Mechanism, Basic Cryptography, Operating System, and the Internet. Cyber Crimes: Vulnerability, The threat, Virus, attacks, Classification, Types Cyber Crimes, Malicious Code, Exploitation, Ethical Hacking. Defence and Analysis Techniques: Cryptographic Mechanism, Authentication, Confidentiality, Integrity, Digital Signature and Key Distribution Technique, Secure Password, Secure Browsing, Antivirus, Antispyware, Firewall, IDS. Honeypot. Cyber Forensic and Law: OS Security, Database Security, Mobile Security, Wireless Security, Forensic Techniques and Cyber Law, Cyber Security Initiatives in India and World.

Suggested Readings:

19. Blockchain Technology

Introduction to Blockchain, How Blockchain works, Blockchain vs Bitcoin, Practical applications, public and private key basics, pros and cons of Blockchain, Myths about Bitcoin. Blockchain Architecture, versions, variants, use cases, Blockchain vs shared Database, Introduction to cryptocurrencies, Types, Applications, Concept of Double Spending, Hashing, Mining, Proof of work, Introduction to Merkel tree,

Privacy, Payment verification, Resolving Conflicts, Creation of Blocks, Introduction to Ethereum, Advantages and Disadvantages, Ethereum vs Bitcoin, Introduction to Smart contracts, usage, application, working principle, Law and Regulations, Case Study.

Suggested Readings:

- Lewis, Antony. *The basics of bitcoins and blockchains: an introduction to cryptocurrencies and the technology that powers them*. Mango Media Inc., 2018.
- Mahankali, Srinivas. *Blockchain: The Untold Story: From birth of Internet to future of Blockchain*. BPB Publications, 2019.
- Singhal, Bikramaditya, Gautam Dhameja, and Priyansu Sekhar Panda. *Beginning Blockchain: A Beginner's Guide to Building Blockchain Solutions*. Apress, 2018.
- Wattenhofer, Roger. *The science of the blockchain*. CreateSpace Independent Publishing Platform, 2016.

20. Natural Language Processing

General Characteristics of Natural language – ambiguity, incompleteness, imprecision; Linguistic Essentials – Part of speech, Lexicography, morphology, Phrase structure grammar, theory, Semantics and pragmatics; Grammatical frameworks – Chomsky hierarchy, X-bar theory, LFG, Unification grammar; Efficient parsing for Natural languages; Knowledge Representations – Frames, Scripts, Conceptual graphs; Statistical Techniques – Elementary Probability theory, Essential information theory; Applications of Statistical Techniques - Word Sense Disambiguation, Lexical Acquisition, Markov Model for Part-of-speech tagging, Probabilistic CFG, Probabilistic parsing, Statistical Alignment and machine translation, Clustering.

Suggested Readings:

- Jurafsky Daniel and Martin James H., *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition*, Prentice Hall.
- Manning Christopher D. and Schütze. Hinrich, *Foundations of Statistical Natural Language Processing*, MIT Press.
- Allen James, *Natural Language Understanding*, Benjamin/Cummings.
- Jelinek Frederick, *Statistical Methods for Speech Recognition*, MIT Press.
- Pang Bo and Lee Lillian, *Opinion mining and sentiment analysis*, *Foundations and Trends in Information Retrieval* 2 (1-2), pp. 1–135, 2008.

21. Digital Image Processing & Computer Vision

Introduction to digital image processing and computer vision; Digital image fundamentals; Image sensing and acquisition; Camera models; Geometric Image Transformations; Image Sampling and Quantization; Image Enhancement in the Spatial Domain: grey-level transformations, histogram processing, spatial filters; Fourier transforms and their properties; Image enhancement in the frequency domain; Image Segmentation: Edge detection, Hough Transform, Region based segmentation; Feature detection; Camera calibration; Epipolar Geometry; 3D Reconstruction; ; Object detection.

Suggested Readings:

- Rafael C. Gonzalez, Richard Eugene Woods, *Digital Image Processing* Pearson Education India, 2009.
- Anil K. Jain, *Fundamentals of Digital Image Processing*, PHI, 1989
- Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2011
- Richard Hartley and Andrew Zissermann, *Multi-view Geometry in Computer Vision*, 2nd Edition
- Forsyth and Ponce, *Computer Vision: A Modern Approach*, Prentice Hal

22. Soft Computing

Definition, Hard computing versus Soft computing, Need of Soft computing, Applications of Soft Computing. Neural Network: Biological and Artificial Neuron, Neural Networks, Supervised and Unsupervised Learning. Single Layer Perceptron - Multilayer Perceptron – Backpropagation Learning, Variation of Standard Back propagation Neural Network, Associative Memory, Adaptive Resonance theory and Self Organizing Map, Support Vector Machines; Fuzzy Logic: Fuzzy Sets – Properties – Membership Functions - Fuzzy Operations. Fuzzy Logic and Fuzzy Inference System, Defuzzification Method, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification; Evolutionary Computation - Genetic Algorithms (GA), Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Inversion, Convergence of GA, Bit wise operation in GA, Multi-level Optimization; Genetic programming, Hybrid Systems.

Suggested Readings:

- Tettamanzi, A. and Tomassini, M., Soft Computing: Integrating Evolutionary, Neural and Fuzzy Systems, Springer, 2010
- Fausett, L. Fundamentals of Neural Networks: Architecture, Algorithms and Applications, Pearson Education India, 2004
- Goldberg, D.E., Genetic Algorithms in Search, Optimization and Machine Learning, Pearson Education, 2006
- Klir, G.J. and Yuan, B. Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall, 1995

23. Software Testing

Software Quality, Role of testing, v & v, objectives and issues of testing, Testing activities and levels, Sources of Information for Test Case Selection, White-Box and Black-Box Testing, Test Planning and Design, Monitoring and Measuring Test Execution, Test Tools and Automation, Test Team Organization and Management. Unit Testing: Concept, Static Unit Testing, Defect Prevention, Dynamic Unit Testing, Mutation Testing, Debugging. Control Flow & Data Flow Testing: Outline of CFT, CF Graph, Paths in a Control Flow Graph, Path Selection Criteria, Generating Test Input, Examples of Test Data Selection. Overview of Dynamic Data Flow Testing, Data Flow Graph, Data Flow Testing Criteria, Comparison of Testing Techniques. System Integration Testing & Test Design, System Test Planning, Automation & Execution Test Selection Guidelines for Automation, Structure of an Automated Test Case, Software Quality: Five Views of Software Quality, McCall's Quality Factors and Criteria, Quality Factors Quality Criteria, Quality Metrics, ISO 9126 Quality Characteristics, ISO 9000:2000 Software Quality Standard ISO 9000:2000

Suggested Readings:

- Jorgensen P.C., Software Testing, A Craftsman's Approach, Third Edition, Auerbach Publications, 2010
- Chauhan N., Software Testing: Principles and Practices, First Edition, Oxford University Press, 2010

24. Agile Methodology and DevOps

Introduction to Agile, Basics of Agile Process Methodology, Comparison of Agile versus conventional software development methods, Agile Methodologies: SCRUM, XP. Agile requirements, Agile architecture, Risk and quality assurance in Agile. Managing the Agile Approach Monitoring progress. Principles of Agile Testing, The agile testing quadrants, functionality testing, User Interface testing and performance testing. Introduction to Devops, Devops and Agile, Devops Tools, Continuous Integration and Continuous Delivery CI/CD: Jenkins Creating pipelines, DevOps in practice.

Suggested Readings:

- Robert C. Martin, Agile Software Development, Principles, Patterns, and Practices. Alan Apt Series (2011)
- Andrew Stellman, Jennifer Greene, Learning Agile: Understanding Scrum, XP, Lean, and Kanban, By 2015, O Reilly
- By Sricharan Vadapalli, DevOps: Continuous Delivery, Integration, and Deployment with DevOps: Dive, Packt, 2018
- Lisa Crispin, Janet Gregory, Agile Testing: A Practical Guide for Testers and Agile Teams, Pearson, 2010

25. VLSI Design

Introduction to CMOS VLSI Design; nMOS and CMOS transistor structures and process technologies, Operation of MOS transistor as a switch, Design and analysis of nMOS and CMOS inverters, common gates, latches and flip-flops, Fabrication of MOS transistors; stick diagrams, design rules and layout, Circuit characterization and performance estimation of MOS circuits. CMOS circuit and logic design. Dynamic MOS structures, Registers, counters and memory realizations using MOS logic, Design structuring; Regular structure circuits, PLAs and FSMs, system timing and clocking issues, scaling. CMOS subsystem design, Low power circuits and systems, System case studies, Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues.

Suggested Readings:

- M. Sarafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, MCGrawHill.
- N.H.E. Weste and K. Eshraghian, Principles of CMOS VLSI Design: A Systems Perspective, Person Education, India
- W. Wolf, Modern VLSI Design: Systems on Silicon, Pearson Education.
- J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Prentice Hall of India.
- P. H. Bardell, W. H. McAnney and J. Savir, Built-in Test for VLSI: Pseudorandom Techniques, Wiley Interscience.

26. Object Oriented Analysis and Design

Object oriented paradigm and principles, Modeling-Importance, Principles; Analysis model; Design model; Conceptual model of the UML; Structural Modeling – Class, Relationships, Interfaces, Type, Roles, Packages, Instance; Structural Diagrams – Class, Object; Behavioral modelling – Interactions, Use cases, Activities, State machines; Behavioral diagrams – Use case, sequence, collaboration, Activity, Statechart; Architectural modelling – Component, Deployment and corresponding diagrams.

Suggested Readings:

- Booch, G., Object Oriented Analysis and Design with Applications, The Benjamin/Cummings Publishing Company, Third Edition, 2007
- Booch, G., Rumbaugh, J. and Jacobson, I., The Unified Modeling Language: User Guide, Second Edition, 2005
- Rumbaugh, J., Jacobson, I. and Booch, G., The Unified Modeling Language: Reference Manual, Second Edition, 2005
- Jacobson, I., Booch, G. and Rumbaugh, J., The Unified Software Development Process, Pearson Education, First Edition, 1999