School of Computer Science and Engineering
Department of Computer Science & Engineering
B.Tech Syllabus– 2019 Onwards

III SEMESTER

EO2001: ECONOMICS [3 0 0 3]

Introduction: Definition, nature and scope of economics, introduction to micro and macroeconomics; Microeconomics: Consumer behaviour, cardinal and ordinal approaches of utility, law of diminishing marginal utility, theory of demand and supply, law of demand, exceptions to the law of demand, change in demand and change in quantity demanded, elasticity of demand and supply, Indifference curve, properties, consumer equilibrium, Price and income effect; Production: Law of production, production function, SR and LR production function, law of returns, Isoquant curve, characteristics, Isocost, producer's equilibrium; Cost and revenue analysis: Cost concepts, short run and long- run cost curves, TR,AR,MR; Various market situations: Characteristics and types, Break-even analysis; Macro Economics: National Income, Monetary and Fiscal Policies, Inflation, demand and supply of money, consumption function and business cycle.

References:

1. H.L Ahuja, *Macroeconomics Theory and Policy*, (20e) S. Chand Publication.
2. Peterson H C et.al., *Managerial Economics*, (9e), Pearson, 2012.
3. P L Mehta, *Managerial Economics*, Sultan Chand & Sons, New Delhi, 2012.
4. G J Tuesen & H G Tuesen, *Engineering Economics*, PHI, New Delhi, 2008.
5. J. L. Riggs, D. D. Bedworth, S. U. Randhawa, *Engineering Economics*, Tata McGraw Hill, 2018.

MA2101: ENGINEERING MATHEMATICS III [2 1 0 3]

Boolean Algebra: Partial ordering relations, Poset, Lattices, Basic Properties of Lattices. Distributive and complemented lattices, Boolean lattices, and Boolean Algebra. Propositional and Predicate Calculus: Well-formed formula, connectives, quantifications, Inference theory of propositional and predicate calculus. Elementary configuration: Permutations and Combinations, Generating function, Principle of inclusion and exclusion Partitions, compositions. Ordering of permutations: Lexicographical and Fikes. Graph theory: Basic definitions, Degree, regular graphs, Eulerian and Hamiltonian graphs, Trees and Properties, Center, radius and diameter of a graph, Rooted and binary trees, Matrices associated with graphs, Algorithms for finding shortest path, Algorithm. Group theory: Semi groups, Monoids, Groups subgroups, Normal Subgroups, Cosets, Lagrange's Theorem, Cyclic groups.

References:

1. C. L. Liu, *Elements of Discrete Mathematics, (2e)*, Mc Graw Hill, New Delhi, 2007.
2. J. P. Trembaly and R. Manohar, *Discrete Mathematics Structures with application to computer science*, Tata Mc Graw Hill, 2012.
3. E. S. Page and L. B. Wilson, *An Introduction to Computational Combinatorics*, Cambridge Univ. Press, 1979.
4. N. Deo, *Graph theory with Applications to computer science*, PHI, 2012.

CS2101: DATA COMMUNICATIONS [3 1 0 4]

Introduction: Data communications, Networks, Network types, Standards. Network Protocols: Introduction, Need for protocol architecture, OSI Model, TCP/IP protocol architecture. Data Transmission: Concepts and terminology, Analog and digital data transmission, Transmission impairments, Channel capacity, Transmission Media. Signal Encoding Techniques: Analog and digital Signals, Digital-to-digital conversion: Line coding schemes, Block coding, scrambling, Analog-To-Digital Conversion: Pulse code modulation, Delta modulation. Digital Data Communication Techniques: asynchronous and synchronous transmission, Types of errors, Error detection, Error correction, Line configurations. Data Link Layer: Introduction, Flow control, Error control, High-level

data link control. Multiplexing and Spread Spectrum: Frequency-division multiplexing, Time-division multiplexing, Code-division multiple access, Space division multiplexing, Spread Spectrum. Media Access Control (MAC): Random access, Aloha, Carrier sense multiple access (CSMA), CSMA with collision detection, CSMA with collision avoidance, Code-division multiple access. Wired LANs (Ethernet)

References:

1. B. Forouzan, *Data Communication & Networking,* (5e), McGraw Hill Education, 2013.
2. W. Stallings, *Data and Computer Communications*, (10e), Pearson Education,2018.

CS2102: COMPUTER SYSTEM ARCHITECTURE [3 1 0 4]

Digital Logic Circuits: Logic Gates, Boolean algebra, Map Simplification, Combinational Circuits, Flip-Flops, Sequential Circuits. Digital Components: Integrated Circuits, Decoders, Multiplexers, Registers, Shift Registers, Binary Counters, Memory Unit. Basic Structure of Computers: Computer Types, Functional Units, Basic Operational Concepts, Software, Performance. Machine Instructions and Programs: Numbers, Arithmetic Operations and Characters, Memory Locations and Addresses, Instructions and Instruction Sequencing, Addressing Modes, Assembly Language, Additional Instructions, Encoding of Machine Instructions. Arithmetic: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, Signed Operand Multiplication, Fast Multiplication, Integer Division, Floating Point Numbers and Operations.

References:

1. M. Morris Mano, *Computer System Architecture*, (3e), Pearson, 2017.
2. C. Hamacher, Z. Vranesic, S. Zaky, *Computer Organization and Embedded Systems*, (6e), McGraw Hill, 2012.
3. J. P. Hayes, *Computer Architecture and Organization*, (3e), McGraw Hill TMH, 2012.

CS2103: DATA STRUCTURES & ALGORITHMS [3 1 0 4]

Introduction: algorithm specification; Performance analysis: time and space complexity, asymptotic notation; C concepts: pointers, functions, arrays, passing arrays to functions through pointers, dynamic memory allocation, bubble sort , insertion sort , selection sort, structures, arrays of structures, passing structures to functions; List: ADT, array and its types, implementation, operations, linked list and its types, implementation and operations; Stack: ADT, implementations using array and linked list, operations and its applications; Queue: ADT, implementations using array and linked list, operations and its applications; Tree: terminologies, different types, representation of binary tree using array and linked structure, binary search tree, different operations (recursive and non-recursive), heap, heap sort, priority queue, AVL trees, B-tree; Graph: Introduction, representation, operations and applications; Searching techniques and hashing.

References:

1. A. S. Tannenbaum, J. Augenstein, *Data Structures using C*, Pearson India, 2018.
2. E. Horowitz, S. Sahni, *Fundamentals of Data Structures in C*, (2e), Universities Press, 2008.
3. A. Forouzan, R. F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning, 2006.

CS2104: OBJECT ORIENTED PROGRAMMING [3 1 0 4]

Introduction: Objects, Classes, Encapsulation, Polymorphism, Inheritance; Java Basics: Compilation and Execution of a Java program, Java Compiler and Interpreter, Data Types in Java; Class Definition and Object Creation: Instance-Fields/Attributes, Methods, Access Modifiers, Constructors, Object vs Class Variables; Role of static and final keywords in Java, Type Conversion and Promotion; Polymorphic Forms: Method Overloading, Objects as Parameters and return types; Input-Output : Reading Input and Output in Java; Object Class in Java : String form of an Object via toString() method, Object equality method; Arrays and Strings in Java: 1-D Arrays, 2-D and Multi-dimensional arrays, Variable Size array, Dynamic Arrays using Array Lists, Strings in Java via String, StringBuilder and StringTokenizer classes; Inheritance in Java: Extending classes, abstract classes, final classes, Method Overriding, Runtime Polymorphism, Inner Classes – static and non-static nested Classes, Local Classes; Inheritance via Interfaces: class vs interface, defining interfaces, implementing multiple inheritance; Comparator and Comparable interfaces, Iterators and List Iterators, Linked Lists; Exception Handling: Exceptions, Defining and Creating Exceptions, Use of Exceptions in Real Life Problems; Package in Java: Defining and Creating Packages, importing packages; Garbage Collector: Role, definition, explicit call; Multithreading: Thread class, Runnable interface, thread life cycle, synchronization, thread priority, creating and running threads.

References:

1. Herbert Schildt, *Java : The Complete Reference*, (12e), McGraw Hill, 2022.
2. E Balagurusamy, *Programming with Java*, (6e), McGraw Hill, 2019.
3. Vishwajeet Barbudhe, *Object Oriented Programming Through Java*, (1e), 2020.

CS2130: DATA STRUCTURES & ALGORITHMS LAB [0 0 2 1]

Implementation of array operations: insertion, deletion, linear search and binary search, matrix operation. Implementation of singly, doubly and circular linked lists: inserting, deleting, and inverting a linked list, Polynomial addition, subtraction and sparse matrix implementation by linked list, Josephus problem. Stacks and Queues: adding, deleting elements. Circular Queue: Adding & deleting elements, conversion of infix to postfix and Evaluation of postfix expressions using stacks & queues, Implementation of stacks & queues using linked lists. Recursive and Non-recursive traversal of Trees: Threaded binary tree traversal, BST and AVL tree implementation. Implementation of sorting and searching algorithms: bubble sort, Insertion sort, selection sort, quick sort, heap sort, merge sort, radix sort, Hash table implementation.

References:

1. A. S. Tannenbaum, J. Augenstein, *Data Structures using C*, Pearson India, 2018.
2. E. Horowitz, S. Sahni, *Fundamentals of Data Structures in C*, (2e), Universities Press, 2008.
3. A. Forouzan, R. F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning, 2006.

CS2131: OBJECT ORIENTED PROGRAMMING LAB [0 0 2 1]

Introduction to object-oriented programming language: Basic programming construct, flow control, loops, data type and arrays. Introduction to classes and object: creating class and object, using object to access class members, declaring method in class, recursion, argument passing and returning, declaring constructor, constructor overloading and method overloading. Input-output: Basic technique for input and output, type casting, file handling. Inheritance: creating base class and derive class, use of different access modifier, overriding base class methods, creating abstract classes/interfaces. Exception handling: try catch construct, creating own exception, raising exception. Multi thread programming: creating and running thread, stopping thread, use of wait, inter thread communication.

References:

1. H. Schildt, *The Complete Reference Java*, (10e), Oracle Press, 2018.
2. C. Horstmann, *Core Java Volume I—Fundamentals*, (10e), Prentice Hall, 2006.
3. H. Schildt, *The Complete Reference C++*, (4e), Mcgraw Hill, 2003.

IV SEMESTER

BB0025: VALUE, ETHICS & GOVERNANCE [2 0 0 2]

Relevance of Value Education in day-to-day life. Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life. Relevance of Personality, Attitude, Behaviour, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*. Governance: Understanding of Public and Private sector Governance systems; Courts & CAG. Public Sector Governance: Need, relevance, stakeholders. Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance. Projects on PPP mode-relevance & prospects. CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line. Suggestive Case Studies: Uphar Theatre Tragedy- Engineering Ethics, Bhopal Gas Tragedy- Operational Engineering Ethics, Satyam Case- FinancialReporting Ethics, Enron Case- Business Ethics, Navin Modi Case- Financial Fraudulence.

References:

1. Professional Module of ICSI.
2. Ghosh B.N., *Business Ethics & Corporate Governance*, (1e) McGraw Hill, 2011.
3. Mandal S.K., *Ethics in Business & Corporate Governance*, (2e), McGraw Hill, 2012.
4. Ray C.K., *Corporate Governance, Value & Ethics*, Vaya Education of India, 2012.
5. Chatterjee Abha, *Professional Ethics*, (2e) Oxford Publications.

MA2201: Engineering Mathematics IV [2 1 0 3]

Basic Set theory, Axioms of probability, Sample space, conditional probability, total probability theorem, Baye's theorem. One dimensional and two-dimensional random variables, mean and variance, properties, Chebyschev's inequality, correlation coefficient, Distributions, Binomial, Poisson, Normal and Chi-square. Functions of random variables: One dimensional and Two dimensional, F & T distributions, Moment generating functions, Sampling theory, Central limit theorem, Point estimation, MLE, Interval estimation, Test of Hypothesis: significance level, certain best tests; Chi square test.

References:

1. P. L. Meyer, *Introduction to probability and Statistical Applications*, (2e), Oxford and IBH publishing, 1980.
2. Miller, Freund and Johnson, *Probability and Statistics for Engineers*, (8e), PHI, 2011.
3. Hogg and Craig, *Introduction to mathematical statistics*, (6e), Pearson education, 2012.
4. S. M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier, 2010.

CS2201: OPERATING SYSTEMS [3 1 0 4]

Introduction: Definition of operating systems, Single and multi-processor systems, Operating system services, System commands and system calls, Interrupt, System boot, Operating system structure, Types of OS, Multi-user, Multitasking, Embedded, Real-time, Network, Distributed. Process and Thread: Process concept, Operations on processes, Inter-process communication, UNIX pipes, Multithreading, Multithreaded models, Programs using PThread. Process Scheduling: Basic concepts, Scheduling criteria, Scheduling algorithms. Synchronization: Critical section problem, Dekker's algorithm, Peterson solution, Synchronization hardware, Semaphores, Classical problems of synchronization, Deadlock, Methods for handling deadlock- prevention, avoidance, detection, and recovery. Memory Management: Address binding, Logical vs Physical address space, Swapping, Contiguous memory allocation, Paging, Structure of Page Table, Segmentation, Demand Paging, Page Replacement Policies, Allocation of Frames, Thrashing. File System Interface and Implementation: File Concept, Access Methods, Directory and Disk Structure, File System Mounting, File System Structure, File System Implementation, Allocation Methods, Free Space Management. Disk Management: Disk Scheduling Algorithms, Disk Management, Swap Space Management. Case Studies: Linux, Windows, iOS, Android.

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References:

1. Silberschatz, P. B. Galvin, G. Gagne, *Operating System Concepts*, (9e), Wiley, 2014.
2. A.S. Tanenbaum, H. Bos, *Modern Operating Systems*, (4e), Pearson, 2015.
3. W. Stallings, *Operating Systems: Internals and Design Principles*, (9e), Pearson, 2018.

CS2202: RELATIONAL DATABASE MANAGEMENT SYSTEMS [3 1 0 4]

Introduction: DBMS Concepts, Database System Vs File System, Data Models, Schema & Instance, Schema architecture, Data independence, Data Base Languages and interfaces, Database system applications, Database users, Functions of DBA Data Modeling using the Entity Relationship Model: ER model concepts, Entities, Attributes, Relationship & types, Relationship Constraints, Extended ER-Model Concept - Generalization, Specialization and Aggregation, Transforming ER diagram into the tables. Relational Data models: Domains, Tuples, Attributes, Relations, Characteristics of relations, Keys, Key attributes of relation, Relational database, Schemas, Integrity constraints. Referential integrity, Relational Algebra and Relational Calculus, Relational algebra operators – Unary, Binary, Set Operations. Tuple oriented and domain oriented relational calculus and its operations.

SQL: Basic SQL Query, Creating Table and Views, SQL as DML, DDL and DCL, SQL Algebraic Operations, Joins, Sub-Queries, Aggregate Operations, Cursors, Dynamic SQL, Integrity Constraints in SQL, Triggers ,Data Base Design: Introduction to Normalization, Functional dependency, Normal forms, Decomposition, Armstrong's Axioms, Canonical Cover, Lossless Join & Dependency preservation Problems with null valued and dangling tuples, multivalued dependencies. Transaction Processing Concepts: Transaction Properties & States, Schedules, Serial & Concurrent Schedule, Serializability of schedules, conflict & view serializable schedule, Recoverability, Recovery from transaction failures, log-based recovery, checkpoints, Deadlock handling.

Concurrency Control Techniques: Concurrency control, Concept of Locks, Concurrency Control Protocols - Two Phase Locking Protocols, Time stamping protocols, validation-based protocol, multiple granularities, Multi version schemes, Recovery with concurrent transactions.

File Structures: File Organization, Indexing, Primary, Clustered, Secondary Indexes, Hashing, Multilevel Indexing with B-Tree, B+ Tree

References:

1. A. Silberschatz, H. F. Korth, S. Sudarshan, *Database System Concepts*, (6e), McGraw Hill, 2013.
2. R. Elmasri, S. B. Navathe, *Fundamentals of Database Systems*, (6e), Addison-Wesley, 2010.
3. R. Ramakrishnan, J. Gehrke, *Database Management Systems*, (3e), McGraw Hill, 2014.
4. I. Bayross, *SQL, PL/SQL The Programming Language of Oracle*, (4e), BPB Publications, 2010.
5. C. J. Date, *An Introduction to Database Systems*, (8e), Prentice Hall of India, 2006.

CS2203: COMPUTER ORGANIZATION [3 1 0 4]

Processor Datapath and Control: Logic Design Conventions, Building a Datapath, Implementation Schemes, Exceptions, Microprogramming. Pipelining: Overview, Pipelined Datapath, Pipelined Control, Data Hazards and Forwarding, Data Hazards and Stalls, Branch Hazards. Memory Hierarchy: Basics of Caches, Measuring and Improving Cache Performance, Virtual Memory, Address Translation. Storage and Other Peripherals: Disk Storage and Dependability, Networks, Connecting I/O Devices to Processor and Memory, Interfacing I/O Devices to the Memory, Processor, and Operating System, I/O Performance Measures, Redundant Array of Inexpensive Disks. Multicores, Multiprocessors and Clusters: Shared Memory Multiprocessors, Clusters and other Message-Passing Multiprocessors, Hardware Multithreading, SISD, MIMD, SIMD, SPMD and Vector Processors.

References:

1. D. A. Patterson, J. L. Hennessy, *Computer Organization and Design: The Hardware and Software Interface*, (5e), Elsevier, 2017.
2. J. L. Hennessy, D. A. Patterson, *Computer Architecture: A Quantitative Approach*, (6e), Morgan Kaufmann Publishers, 2019.
3. W. Stallings, *Computer Organization and Architecture –Designing for Performance*, (9e), Pearson, 2013.

CS2230: OPERATING SYSTEMS LAB [0 0 2 1]

Introduction to the command line, managing physical storage, Install and configure software, components, and services, establish network connections and control firewall restrictions, Monitor and manage running processes, Manage and secure files and file systems, administer users and groups, Review the system log files and journal for issues, troubleshoot problems and analyse systems with Red Hat Insights, remotely manage systems with SSH and the Web Console.

Install Red Hat Enterprise Linux using scalable methods, Access security files, file systems, and networks, execute shell scripting and automation techniques, manage storage devices, logical volumes, and file systems, manage security and system access, Control the boot process and system services, running containers System Calls: File and process, I/O Redirection, IPC using Pipe and Signals. PThread API: Multithreaded programs, Synchronization programs using PThreads and Semaphores, CPU Scheduling, Deadlock, Memory Management. Creating a Virtual Machine: Virtual Machine Files and Snapshots, Virtual Machine Cloning and Exporting.

References:

1. W. R. Stevens, S. A. Rago, *Advanced Programming in the UNIX Environment*, (3e), Addison Wesley, 2013.
2. S. Das, *Unix Concepts and Applications*, (4e), McGraw Hill, 2006.
3. K. A. Robbins, S. Robbins, *Unix Systems Programming: Communication, Concurrency, and Threads,* (2e), Prentice Hall, 2004
4. https://www.redhat.com/en/services/training/rh124-red-hat-system-administration-i

CS2231: RELATIONAL DATABASE MANAGEMENT SYSTEMS LAB [0 0 2 1]

Database Foundations: Introduction, Databases and Data Modelling, Refining the Data Model, Oracle SQL Developer Data Modeler, Introduction to SQL,

Database Design – Introduction, Entities and Attributes, Super/Sub Types and Business Rules, Relationship Fundamentals, UIDs and Normalization, Arcs, Hierarchies, and Recursive Modelling, Mapping, Creating Database Projects, Presenting Database Projects,

Database Programming with SQL – Introduction, SELECT, WHERE ORDER BY, and Intro to Functions, Single Row Functions, JOINs, Group Functions, Subqueries, Ensuring Quality Queries Part I, DML, DDL, Constraints, Views, Sequences and Synonyms, Privileges and Regular Expressions, TCL, Final Project, and Exam Review.

References:

1. I. Bayross, *Teach yourself SQL & PL/SQL using Oracle 8i & 9i with SQLJ*, BPB Publications, 2010.
2. A. Silberschatz, H. F. Korth, S. Sudarshan, *Database System Concepts*, (6e), McGraw Hill, 2013.
3. R. Elmasri, S. B. Navathe, *Fundamentals of Database Systems*, (6e), Addison-Wesley, 2010.

CS2232: WEB TECHNOLOGY LAB [0 0 2 1]

Fundamentals/ Basic HTML, Text formatting on Web Pages, incorporate images, creating hyperlinks, tables, and nested tables, inserting web page, Setting & modifying field properties, Validating HTML frames, and frame sets, inside browser.

Introduction, Designing with Style Sheets, Style Sheet Syntax, ID, Class Contextual Selectors, Cascading Order, Properties, Absolute and Relative Positioning, Layering Elements using Z-Index, Animating objects

JavaScript: How to develop JavaScript, variables, functions, conditions, loops, and repetition. Advance JavaScript: JavaScript and objects, JavaScript own objects, the DOM and web browser environments, forms, and validations.

PHP: Starting to script on server side, arrays, function and forms, advance PHP.

Databases: Connection to XAMPP framework, creating database, performing data and schema related operations, PHP my admin and database bugs.

References:

1. R. Nixon, *Learning PHP, MySQL & JavaScript with jQuery, CSS and HTML5*, (5e), O'Reilly Publications, 2018.
2. R. Connolly, R. Hoar, *Fundamentals of Web Development,* Pearson Education India, 2015.
3. L. Welling, L. Thomson, *PHP and MySQL Web Development*, (5e), Pearson Education, 2017.
4. N. C. Zakas, *Professional JavaScript for Web Developers*, (3e), Wrox/Wiley India, 2019.
5. D. S. Mcfarland, *JavaScript & jQuery: The Missing Manual*, (3e), O'Reilly/Shroff Publishers & Distributors Pvt Ltd, 2014.
6. Z. R. A. Boehm, *Murach's HTML5 and CSS3*, (4e), Murach's/Shroff Publishers & Distributors Pvt Ltd, 2018.

V SEMESTER

CS3101: ARTIFICIAL INTELLIGENCE AND SOFT COMPUTING [3 1 0 4]

Fundamental Concepts: Agents, environments, general model, Problem solving techniques. Search Techniques: Uninformed search, heuristic search, adversarial search and game trees, Solution of constraint satisfaction problems using search. Knowledge Representation: Propositional and predicate calculus, semantics for predicate calculus, inference rules, unification, Resolution, semantic networks, conceptual graphs/Dependency, structured representation. Learning: Inductive learning, decision tree learning. Natural language processing: introduction, parsing using context free grammars, Chomsky hierarchy, case grammar. Soft computing: Fuzzy set theory, Fuzzy sets, set-theoretic operations, membership functions, Union, intersection and complement, fuzzy rules, reasoning and interference. Neural networks: Perceptron, Back Propagation. Evolutionary techniques: genetic algorithms, Swarm Algorithm, ant colony optimization.

References:

1. S. Russell, P. Norvig, *Artificial Intelligence: A Modern Approach,* (3e) PHI, 2011.
2. E. Rich, K. Knight, S. B. Nair, *Artificial Intelligence,* (3e), Tata McGraw Hill, 2009.
3. G. F. Luger, *Artificial Intelligence-Structures and Strategies for Complex Problem Solving*, (6e), Addison-Wesley Pearson Education, 2012.

CS3102: DESIGN & ANALYSIS OF ALGORITHMS [3 1 0 4]

Introduction: Algorithm Definition and Criteria of Algorithms, Iterative and Recursive algorithms, Performance Analysis: Priori and Posteriori Analysis, Asymptotic Notations, Space Complexity, Time Complexity, Performance measurement of iterative and recursive algorithms, Solving Recurrence Relations: Substitution Method, Iterative Method, Recursive Tree Method, Master Method, Divide and Conquer: Introduction, Binary Search, Finding Maximum and Minimum, Merge Sort, Quick Sort, Randomized Quick Sort, Integer Multiplication. Graph Search Algorithm: Graph representation, Breadth First Search and Depth First Search, Greedy Strategy: Introduction, Knapsack Problem, Job Sequencing with Deadlines, Huffman Coding, Union and Find Operation (Set and Disjoint Set), Minimum Cost Spanning Tree Algorithms (Prim's and Kruskal's), Optimal Merge Patterns, Single Source Shortest Path (Dijkstra's Algorithm). Dynamic Programming: Introduction, Single Source Shortest Path (Bellman and Ford Algorithm), All Pair Shortest Path (Floyd Wrashal's Algorithm), Optimal Binary Search Trees, 0/1 Knapsack Problem, Travelling Salesperson Problem, Longest Common Subsequence, Matrix Chain Multiplication, Edit distance. Backtracking: Introduction, N-Queens Problem, Graph Colouring and Hamiltonian Cycles, Branch and Bound: Introduction, FIFO and LC Branch and Bound, 0/1 Knapsack Problem, Travelling Salesman Problem. String Matching: Naïve String Matching, Rabin Karp Algorithm, Knuth-Morris-Pratt Algorithm. Complexity Classes: NP, NP-Complete and NP-Hard Problems, Cook's Theorem, Polynomial time reductions, Satisfiability, Reduction from Satisfiability to Vertex Cover

References:

1. E. Horowitz, S. Sahni, S. Rajasekaran, *Fundamental of Computer Algorithms*, (2e), Universities Press, 2007.
2. T. H. Cormen, C. E. Leiserson, R.L. Rivest and C. Stein, *Introduction to Algorithms*, (3e), MIT press, 2009.

CS3103: AUTOMATA THEORY & COMPILER DESIGN [3 1 0 4]

Introduction: Three basic concepts – language, grammar and automata; Chomsky Hierarchy. Finite Automata: Deterministic Finite Automata (DFA) and Non Deterministic Finite Automata (NFA), Mealy and Moore machines construction and equivalence; Regular Sets and Regular Grammars: Regular Expressions, Equivalence of regular expressions and regular languages, Regular Grammar and FA, Closure properties of Regular Languages, Pumping Lemma for Regular Languages; Context Free Languages (CFL) and Grammars (CFG) : Ambiguity, Methods for Transforming Grammars, Chomsky Normal Form (CNF) and Greibach Normal Form (GNF); Push Down Automata: Nondeterministic Pushdown Automata (NPDA), Design of NPDA, Equivalence of PDA and CFLs, Closure properties and decision problems of CFLs; Introduction to Turing machine: Definition, Turing Machining as Language acceptors, Types of Turing machine, Recursively Enumerable and Recursive Languages and their closure properties, Concept of insolvability & reducibility, Halting Problem, Post correspondence Problem, Rice theorem, P and NP. Polynomial-Time reductions and NP-Completeness; Introduction to Compiler Design: Structure of a Compiler, Lexical Analysis, Recognition of Tokens.

References:

1. P. Linz, *Introduction to Formal Language and Computation*, (2e), Narosa, 2006.
2. Jeffrey D Ullman, John E Hopcroft, *Introduction to Automata Theory and Languages*, Pearson Education, 3rd Edition, 2008.
3. Michael Sipser, *Introduction to the Theory of Computation*, (3e), Cenage Publication, 2014.
4. John C. Martin, *Introduction to Languages and the Theory of Computation*, (3e), MGH, 2007.

CS3104: COMPUTER NETWORKS [3 1 0 4]

Network Layer: Network layer design issues, routing algorithms, congestion control algorithms, Quality of service, MPLS, Classfull addressing, Sub-netting, Classless addressing. Protocols: ARP & DHCP, Introduction, Packet Format, message types, IPV4 header format, fragmentation, options, checksum. ICMP: Message format, message types. Dynamic routing protocols: RIP, OSPF & BGP. Multicasting Protocol: IGMP, Introduction to IPV6. Transport Layer: Transport services, state diagram, Elements of Transport Protocols, addressing, Connection establishment, connection release, Error control and Flow Control, Multiplexing. Congestion Control: Bandwidth allocation, regulating the sending rate, UDP, TCP. Application Layer: DNS, Name space, domain resource records. Electronic Mail: SMTP, POP, IMAP, MIME, HTTP, HTTPS, SNMP. Network Security: Security Goals, Attacks, Attack prevention techniques, Firewall, IDS, DMZ, IPsec.

References:

1. B. A. Forouzan, *TCP/IP Protocol Suite*, (4e), TMH, 2010.
2. A. S. Tanenbaum, *Computer Networks*, (5e), Pearson, 2010.

CS3140: INFORMATION CODING [3 0 0 3]

Information Theory: Entropy, Characterization and related properties, Huffman codes, Shannon-Fano coding, Robustness of coding techniques, Information measure-noiseless coding, Discrete memoryless channel, Channel capacity, Fundamental theorem of information theory. Coding Theory: Error correcting codes, Minimum distance principles, Hamming bound, General binary code, Group code, Linear group code. Convolution Encoding: Algebraic structure, Gilbert bound, Threshold decoding, Threshold decoding for block codes. Cyclic binary codes: BCH codes, Generalized BCH code and decoding, Optimum codes, Concepts of non-cyclic codes. Combinatorial Designs: Definitions of BIBD, Hadamard Designs, Latin Squares, Mutually Orthogonal Latin Squares, Orthogonal Arrays. Network Coding: Fundamentals of Network Coding, Butterfly networks, Graphs and networks, Max-flow min-cut theorem, Multi-source multicast problem, Deterministic code design for network coding, Randomized network coding, Application of network coding.

References:

1. T. M. Cover, J.A. Thomas, *Elements of Information Theory*, Wiley, (2e), 2006.
2. M. Kelbert, Y. Suhov, *Information Theory and Coding by Example*, Cambridge University Press, 2013.

3. D. Stinson, *Combinatorial Designs: Constructions and Analysis*, Springer, 2003.
4. P. J. Cameron , J. H. Lint, Designs, *Graphs, Codes and their Links*, Cambridge University Press, 2010.

CS3141: CLOUD COMPUTING AND VIRTUALIZATION [2 1 0 3]

Introduction: Distributed Computing and Enabling Technologies, Cloud Fundamentals: Cloud Definition, Evolution, Architecture, Applications, deployment models, and service models. Virtualization: Issues with virtualization, virtualization technologies and architectures, Internals of virtual machine monitors/hypervisors, virtualization of data centers, and Issues with Multi-tenancy. Implementation: Study of Cloud Computing Systems like Amazon EC2 and S3, Google App Engine, and Microsoft Azure, Build Private/Hybrid Cloud using open source tools, Deployment of Web Services from Inside and Outside a Cloud Architecture. MapReduce and its extensions to Cloud Computing, HDFS, and GFS. Interoperability and Service Monitoring: Issues with interoperability, Vendor lock-in, Interoperability approaches. SLA Management, Metering Issues, and Report generation. Resource Management and Load Balancing: Distributed Management of Virtual Infrastructures, Server consolidation, Dynamic provisioning and resource management, Resource Optimization, Resource dynamic reconfiguration, Scheduling Techniques for Advance Reservation, Capacity Management to meet SLA Requirements, and Load Balancing, various load balancing techniques. Migration and Fault Tolerance: Broad Aspects of Migration into Cloud, Migration of virtual Machines and techniques. Fault Tolerance Mechanisms. Advances: Grid of Clouds, Green Cloud, Mobile Cloud Computing.

References:

1. R. Buyya, J. Broberg, A. Goscinski , *Cloud Computing Principles and Paradigms* , Wiley Publishers, 2013.
2. B. Sosinsky, *Cloud Computing Bible*, Wiley, 2011.
3. M. Miller, *Cloud Computing: Web-based Applications that change the way you work and collaborate online*, Pearson, 2008.
4. D. S. Linthicum, *Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide*, Addision Wesley Information Technology Series, 2010.
5. T. Velte, A. T. Velte, R. Elsenpeter, Cloud *Computing: A Practical Approach*, McGraw Hill, 2017.

CS3142: PREDICTIVE ANALYTICS [2 1 0 3]

Introduction: Business analytics applications and Types, Models: predictive models, descriptive models, decision models, applications, analytical techniques. Understanding Data: Data types and associated techniques, complexities of data, data preparation, pre-processing, exploratory data analysis. Principles and Techniques: Predictive modelling: Propensity models, cluster models, collaborative filtering, applications, and limitations. Statistical analysis: Univariate Statistical analysis, Multivariate Statistical analysis. Model Selection: supervised versus unsupervised methods, statistical and data mining methodology, cross-validation, overfitting, bias-variance trade-off, balancing the training dataset, establishing baseline performance. Regression Models: Measuring Performance in Regression Models - Linear Regression and Its Cousins, Non-Linear Regression Models, Regression Trees and Rule-Based Models and relevant Case Studies. Classification Models: Measuring Performance in Classification Models, Discriminant Analysis and Other Linear Classification Models, Non-Linear Classification Models, Classification Trees and Rule-Based Models, Model Evaluation Techniques. Time Series Analysis: ARMA, ARIMA, ARFIMA - Temporal mining - Box Jenkinson method, temporal reasoning, temporal constraint networks.

References:

1. Dinov, ID., *Data Science and Predictive Analytics: Biomedical and Health Applications using R*, Springer, 2018.
2. A. Bari, M. Chaouchi, T. Jung, *Predictive analytics for dummies*, (2e), Wiley, 2016.
3. Jeffrey Strickland, *Predictive analytics using R, Simulation educators*, Colorado Springs, 2015
4. Daniel T. Larose, Chantal D. Larose, *Data Mining and Predictive analytics*, (2e), Wiley, 2015.
5. Max Kuhn and Kjell Johnson*, Applied Predictive Modelling*, (1e), Springer, 2013

CS3143: SECURITY AND PRIVACY FOUNDATION [2 1 0 3]

Introduction to Security and Privacy: Definition and scope of security, Importance of cyber security in today's world, Key threats and challenges in Privacy, Security Principles, and Concepts. Confidentiality, Integrity, and Availability. Risk management and risk assessment, Defense-in-depth approach, Principle of least privilege,

Threat modeling and attack vectors, Security Policies and Procedures Access Control and Authentication: User authentication methods (passwords, multi-factor authentication), Access control models (DAC, MAC, RBAC), Identity and access management (IAM), Single sign-on (SSO) and federated identity, Security in Operating Systems and Applications, Secure configuration and hardening, Malware types and prevention, Secure coding practices, Web application security, Physical Security, Physical access controls, Security of data centers and server rooms, Environmental controls (power, HVAC).
Security Auditing and Monitoring: Log management and analysis, Security event monitoring and intrusion detection, Vulnerability scanning, and penetration testing, Security assessment and auditing methodologies.
Developing security policies: Security awareness and training, Incident response and handling, Business continuity and disaster recovery planning, Network Security, Network architecture and protocols, Firewalls and intrusion detection systems, Virtual Private Networks (VPNs), Wireless network security.
Legal and Ethical Considerations: Laws and regulations related to information security (e.g., GDPR, HIPAA), Ethical hacking and responsible disclosure, Privacy, and data protection, Emerging Trends in Information Security

References:

1. J. Sammons, M. Cross, *The basics of cyber safety: computer and mobile device safety made easy*, (1e), Elsevier, 2016.
2. Charles J. Brooks, Christopher Grow, Philip Craig, D. Short, *Cybersecurity essentials*, (1e), John Wiley & Sons, 2018
3. Charles P. Pfleeger, Shari Lawerance Pfleeger, *Analysing Computer Security*, (1e), Pearson Education India, 2011
4. Surya Prakash Tripathi, Ritendra Goyal, Praveen kumar Shukla, *Introduction to Information Security and Cyber Law*, (1e), Willey Dreamtech Press, 2014

CS3130: DESIGN & ANALYSIS OF ALGORITHMS LAB [0 0 2 1]

Sorting & Searching Algorithm: insertion sort, selection sort, binary search. Basic data structures: stacks and queues, graphs and trees, binary trees. Algorithmic paradigms: Recursion, divide-and-conquer, Merge sort, Quick sort. Greedy: Knapsack, Huffman encoding, dynamic programming, lower bounds and optimal algorithms. Heaps: Heaps, priority queues, min-max heaps, heap sort. Dynamic search structures: Binary search trees, height balancing, B-trees. Algorithms on arrays: Linear-time median finding, sorting in linear time (counting sort, radix sort, bucket sort), String matching (Rabin-Karp and Knuth-Morris-Pratt algorithms). Graph algorithms Traversal: (BFS, DFS, topological sort), Minimum spanning trees (Prim and Kruskal algorithms), shortest paths (Dijkstra's and Floyd-Warshal algorithms). Mini-Projects & Case Studies.

References:

1. E. Horowitz, S. Sahni, S. Rajasekaran, *Fundamental of Computer Algorithms*, (2e), Universities Press, 2007.
2. T. H. Cormen, C. E. Leiserson, R.L. Rivest, C. Stein, *Introduction to Algorithms*, (3e), MIT press, 2009.

CS3131: ARTIFICIAL INTELLIGENCE AND SOFT COMPUTING LAB [0 0 2 1]

AI techniques: Global and local heuristics, Crypt arithmetic, Constraint satisfaction Problem, Analysis of DFS and BFS for an application, A* Algorithm, Minimaxalgorithm, block world problem, Preposition and inference, Travelling Salesman Problem using Branch & Bound, Nearest Neighbor, Character recognition using Neural Networks, Optimization using Genetic Algorithms, Mini-Projects & Case Studies.

References:

1. Denis Rothman, *Artificial Intelligence by Example*, Packt, 2018.
2. A. K. Mackworth, D. L. Poole, *Artificial Intelligence: Foundations of Computational Agents*, (2e) Cambridge University Press, 2017.
3. I. Bratko, *PROLOG: Programming for Artificial Intelligence*, (3e), Pearson Publication, 2011.

CS3132: COMPUTER NETWORKS LAB [0 0 2 1]

Cisco Packet Tracer: Introduction to packet tracer and networking device components, Router mode, Switch/Router basic commands; designing of star topology using HUB and Switch, IP configuration of

end devices, Configuring DHCP server, Static routing, RIP, OSPF, VLAN and NAT. Network programming: Transmission control protocol and User datagram protocol. WLAN, Security: Security Threats and Vulnerabilities, Network Attacks, Network Attack Mitigation, Device Security. Network Utilities Commands: PING, NETSTAT, IPCONFIG, IFCONFIG, ARP, TRACE-ROUTE, NETSTAT, NSLOOKUP, PATHPING Network Utilities Tools: NMAP, Wireshark, Network Scanner, Case Study, Mini Project: Build a Small Network and Scale to Larger Networks, Troubleshooting Scenarios

References:

1. B. A. Forouzan, *TCP/IP Protocol Suite, (5e)*, Tata McGraw Hill, 2013.
2. A. S.Tanenbaum, *Computer Networks, (5e),* Pearson Education, 2010.

VI SEMESTER

BB0026: ORGANISATION AND MANAGEMENT [3 0 0 3]

Meaning and definition of an organization, Necessity of Organization, Principles of Organization, Formal and Informal Organizations. Management: Functions of Management, Levels of Management, Managerial Skills, Importance of Management, Models of Management, Scientific Management, Forms of Ownership, Organizational Structures, Purchasing and Marketing Management, Functions of Purchasing Department, Methods of Purchasing, Marketing, Functions of Marketing, Advertising. Introduction, Functions of Personal Management, Development of Personal Policy, Manpower Planning, Recruitment and Selection of manpower**.** Motivation – Introduction, Human needs, Maslow's Hierarchy of needs, Types of Motivation, Techniques of Motivation, Motivation Theories, McGregor's Theory, Herzberg's Hygiene Maintenance Theory. Leadership - Introduction Qualities of a good Leader, Leadership Styles, Leadership Approach, Leadership Theories. Entrepreneurship-Introduction, Entrepreneurship Development, Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship, Steps for establishing small scale unit**.** Data and Information; Need, function, and Importance of MIS; Evolution of MIS; Organizational Structure and MIS, Computers and MIS, Classification of Information Systems, Information Support for functional areas of management.

References:

1. Koontz, Harold, Cyril O'Donnell, and Heinz Weihrich, *Essentials of Management*, (1e) Tata McGraw-Hill, New Delhi, 1978.
2. Robbins, Stephen P, and Mary Coulter*, Management*, Prentice Hall, (2e) New Delhi, 1997.
3. E. S. Buffa and R. K. Sarin, *Modern Production / Operations Management*, (8e), Wiley, 1987

4. H. J. Arnold and D. C. Feldman, *Organizational Behavior*, McGraw – Hill, 1986.
5. Aswathappa K, *Human Resource and Personnel Management*, Tata McGraw Hill, 2005.
6. William Wether & Keith Davis, *Human Resource and Personnel Management*, McGraw Hill, 1986.

CS3201: SOFTWARE ENGINEERING [3 1 0 4]

Introduction: The Evolving Role of Software, The changing nature of software, Legacy software, Software Myths. Software Engineering: A Layered Technology, a Process Framework, the Capability Maturity Model Integration (CMMI), Specialized Process Models, and the Unified Process. Agile development: Agile Process Models Software Engineering Practice, Communication Practice, Planning Practices, Modeling Practices, Construction Practice, Deployment Computer–Based Systems, The System Engineering Hierarchy, Business Process Engineering: An Overview. Product Engineering: An Overview, Data Modeling Concepts, Object Oriented Analysis, Flow-Oriented Modeling, Taxonomy of Quality Attributes, Perspectives of Quality, Quality System, Software Quality Assurance, Capability Maturity Model Observation on Estimation, The Project Planning Process, Software Scope and Feasibility, Human Resources, Empirical Estimation Model, Introduction to DevOps, Cloud Computing And Virtualization, Migration to DevOps, DevOps Tools.

References:

1. R. Pressman, *Software Engineering: A Practitioners Approach*, (8e), McGraw Hill Pubs, 2019.
2. M. Walls, *Building a Dev Ops Culture*, O'Reilly Publications, 2013.
3. J. Joyner*, Dev Ops for Beginners, Dev Ops Software Development Method guide for software developers and IT professionals,* Mihails Konoplovs, 2015*.*

CS3202: INFORMATION SYSTEMS SECURITY [3 1 0 4]

Introduction: Basic objectives of cryptography, Secret-key and public-key cryptography, One-way trapdoor one-way functions, Cryptanalysis, Attack models, Classical cryptography. Block ciphers: Modes of operation, DES and its variants, AES, Linear and differential cryptanalysis. Message digest: Properties of hash functions, MD2, MD5 and SHA-1, Keyed hash functions, Attacks on hash functions. Pseudorandom Number Generation Intractable problems: Integer factorization problem, RSA problem, Modular square root problem, Discrete logarithm problem, Diffie-Hellman problem, known algorithms for solving the intractable problems. Public-key encryption: RSA, EIGamal scheme, Elliptic and hyperelliptic curve cryptography, Side channel attacks, Diffie-Hellman and MQV key exchange. Digital signatures: RSA, DSA and NR signature schemes, blind and undeniable signatures. Entity authentication: Passwords, Challenge-response algorithms, Zero-knowledge protocols Transport-Level Security: Web Security Issues, Secure Sockets Layer (SSL), Transport Layer Security (TLS), Electronic Mail Security, Pretty Good Privacy (PGP), IP Security: IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange.

References:

1. B. A. Forouzan, D. Mukhopadhyay, *Cryptography and Network Security*, (2e), Mc-Graw Hill, 2008.
2. W. Stallings, *Cryptography and Network Security: Principles and Practice*, (5e), Prentice Hall, 2010.
3. J. Pieprzyk, T. Hardjono, J. Seberry, *Fundamentals of Computer Security*, Springer International Edition, 2003.
4. A. J. Menezes, P. C. V. Oorschot, S. A. Vanstone, *Handbook of Applied Cryptography*, CRC Press.

CS3203: DATA SCIENCE AND MACHINE LEARNING [3 0 0 3]

Data Science: Descriptive Statistics, Probability Distribution, regression analysis, ANOVA. Machine Learning: Goals, Applications of ML, developing a learning system, training data, concept representation, function approximation. Decision Tree Learning: Representing concepts as decision trees, Recursive induction of decision trees, best splitting attribute, entropy, information gain., Occam's razor, Overfitting, noisy data, and pruning. Artificial Neural Networks: Neurons and biological motivation. Linear threshold units, Perceptron, representational limitation and gradient descent training, Multilayer networks and backpropagation. Hidden layers and constructing intermediate, distributed representations, Overfitting, learning network structure, recurrent networks. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing. Support Vector Machines: Maximum margin linear separators. Kernels for learning non-linear functions. Bayesian Learning: Probability theory and Bayes rule. Naive Bayes learning algorithm, Logistic regression, Bayes nets and Markov nets for representing dependencies. Instance-Based Learning: k-Nearest-neighbor algorithm, Case-based learning,

Relevance feedback and Rocchio algorithm. Naive Bayes for text. Clustering and Unsupervised Learning: Hierarchical Agglomerative Clustering, k-means partitioned clustering, expectation maximization (EM) for soft clustering. Ensemble Learning: Bagging, boosting, and Decorate. Active learning with ensembles.

References:

1. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning with applications in R,* Springer, 2013.
2. J. Han, M. Kamber, J. Pei, *Data Mining concepts and techniques, (2e),* Morgan Kaufmann- Elsevier, 2011.
3. T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning*, (2e), Springer, 2009.
4. K. Murphy, *Machine Learning: A Probabilistic Perspective,* MIT Press, 2012.
5. T. M. Mitchell, *Machine Learning*, (Indian Edition), MacGraw Hill, 2017.
6. C. Bishop, *Neural Networks for Pattern Recognition*, Oxford University Press, 2019

CS3240: PRINCIPLES OF SECURE PROGRAMMING [3 0 0 3]

Introduction of IT application and data security: Security goals, Secure system design, Secure design principles, Secure Software Development Lifecycle (SDLC), Phases of the SDLC and security considerations at each phase, Secure coding practices and guidelines, Code review and vulnerability scanning, Security testing methodologies (e.g., static analysis, dynamic analysis)

Web Application Security: Common web application vulnerabilities (e.g., injection attacks, XSS, CSRF), Input validation and output encoding, Session management, and cookie security, Web application firewalls (WAF), Secure APIs and Web Services, and Web service security (e.g., SOAP, REST)

Identity and Access Management (IAM): IAM principles and components, User authentication and authorization mechanisms, Single Sign-On (SSO), and federation.

References:

1. N. Daswani, C. Kern, A. Kesavan, *Foundations of Security, What Every Programmer Needs to Know*, Apress, 2007.
2. J. C. Foster, V. T. Liu, *Writing Security Tools and Exploits*, Syngress Publishing, 2006.
3. J. Ericson, *Hacking: The Art of Exploitation*, (2e), No Starch Press, 2008.
4. C. Anley, J. Heasman, F. Linder, G. Richarte, *The Shellcoder's Handbook: Discovering and Exploiting Security Holes*, (2e), Addison-Wiley, 2011.

CS3241: CLOUD INFRASTRUCTURE AND SERVICES [3 0 0 3]

Introduction: Clouds and Cloud Computing: Basic Concepts, Types of Services, deployment models. Classic Data Center (CDC): DBMS concepts, CDC drawbacks, CDC Management and case studies. Virtualized Data Center (VDC): Compute virtualization overview, Compute virtualization techniques, Virtual Machines, VM Resource management techniques, Virtual Infrastructure Requirements. Storage: Storage virtualization overview, Virtual Machine Storage, Virtual provisioning and automated storage tiering. Networking: VDC networking overview, VDC networking components, VLAN and VSAN technologies. Business Continuity in VDC, Fault tolerance mechanism in VDC. Cloud Security: Access control and identity management in Cloud, Governance, risk, and compliance, Security best practices for Cloud, Cloud Migration. Issues in Cloud Development: Migration etc.

References:

1. B. Jackson, K. Saurabh, *Cloud Computing*, (2e), Wiley India, 2012.
2. V. Joysula, M. Orr, G. Page, *Cloud Computing: Automating the Virtualized Data Center*, Cisco Press, 2012.
3. R. K. Buyya, *Cloud Computing: Principles and Paradigms*, Wiley Press, 2011.
4. M. Miller, *Cloud Computing*, (8e), Que Publishers, 2008.
5. Course materials from *EMC² Education Services.*

CS3242: IMAGE PROCESSING AND PATTERN ANALYSIS [2 1 0 3]

Image representation and properties: image processing and computer vision, image processing steps, image digitization, digital image properties, metrics, histograms, entropy, sampling and quantization, image file formats, basic relationships between pixels, physics of color, human perception, color spaces, image sensing and acquisition, monochromatic and color camera. image enhancements: grayscale transformations, brightness interpolation, histogram processing, using arithmetic/logic operations, smoothing spatial filters, sharpening spatial filters, canny edge detection, detection of corners (interest points). mathematical transforms: linearity, convolution, linear integral transform, Fourier transform, DFT, DCT, wavelet transform, SVD, PCA, smoothing frequency-domain filters, sharpening frequency domain filters. Data structure for image analysis: matrices, chains, topological data structures, relational structures, pyramid, quadtree. image restoration: various noise models, image restoration using spatial domain filtering. estimating the degradation function, inverse filtering, wiener filtering. image segmentation and representation: grey level features, edges and lines, similarity, correlation, thresholding, template matching, edge-based segmentation, region-based segmentation, representation scheme, evaluation issues, mean shift segmentation, graph cut segmentation. shape representation and description: contour-based Analysis, Connected Component Analysis, chain code, b-spline representation, region-based, moments, convex hull. image understanding: scale invariant feature transform (SIFT), histograms of oriented gradient (HOG), image morphology, dilation and erosion, skeleton.

References:

1. M. Sonka, V, Hlavac, R. Boyle, *Image Processing, Analysis and Machine Vision*, (4e), Cengage Learning India, 2015.
2. S. Jayaraman, S. Esakkirajan, T Veerakumar, *Digital Image Processing*, (2e), Tata McGraw Hill Education, 2020.
3. R. C. Gonzalez, R. E. Woods, *Digital Image Processing*, (4e), Pearson Education, 2018.
4. Prateek Joshi, *OpenCV with Python by Example*, (1e) PACKT Publishing, 2018.
5. R. C. Gonzalez, R. E. Woods, S. Eddins, *Digital Image Processing using MATLAB*, (2e), Pearson Education, 2017.

CS3230: SOFTWARE ENGINEERING LAB [0 0 2 1]

Introduction: Agile development: Agile Process Models Software, Communication Practice, Planning Practices, Modeling Practices, Construction Practice, Deployment of Computer–Based Systems, The System Engineering Hierarchy. Business Process Engineering: An Overview, Product Engineering: An Overview, Data Modeling Concepts, Object Oriented Analysis, Flow-Oriented Modeling, Taxonomy of Quality Attributes, Perspectives of Quality, Quality System, Software Quality Assurance, Capability Maturity Model Observation on Estimation using Projects, The Project Planning Process, Software Scope and Feasibility, Human Resources, Empirical Estimation Model ,Introduction To DevOps, Cloud Computing And Virtualization, Migration to DevOps, DevOps Tools, All above will be facilitated using Software Projects assigned to the students.

References:

1. R. Pressman, *Software Engineering: A Practitioners Approach*, (8e), McGrawHill Pubs, 2019.
2. M. Walls, *Building a Dev Ops Culture*, O'Reilly Publications, 2013.
3. J. Joyner*, Dev Ops for Beginners, Dev Ops Software Development Method guide for software developers and IT professionals,* Mihails Konoplovs, 2015.

CS3231: INFORMATION SYSTEMS SECURITY LAB [0 0 2 1]

Substitution and Transposition Cipher Implementation: Caesar Cipher, Playfair Cipher, Hill Cipher, Vigenere Cipher, Rail fence. Symmetric and Asymmetric Cipher Implementation: DES, RSA, Diffie-Hellman, MD5, SHA-1. Signature Schemes Implementation: Digital Signature Standard, GnuPG API. Demonstration of secure data storage: Setup of honey pot and monitoring on network using KF sensors. Installation of rootkits. Wireless audit on an access point or a router, WEP and WPA (Net Stumbler). Intrusion detection system using snort.

References:

1. B. A. Forouzan, D. Mukhopadhyay, Cryptography and Network Security, (2e), Mc-Graw Hill, 2008.
2. W. Stallings, Cryptography and Network Security: Principles and Practice, (5e), Prentice Hall, 2010.
3. J. Pieprzyk, T. Hardjono, J. Seberry, Fundamentals of Computer Security, Springer, 2003.

CS3270: MINOR PROJECT [0 0 6 3]

In this course student has to select a project work based on a topic of interest. Periodically the supervisor will evaluate the implementation. This work, started in sixth semester of which, the student will be evaluated internally and externally.

VII SEMESTER

CS4140: CYBER SECURITY [3 0 0 3]

Introduction to cyber security: Computer Security, threats, harm, vulnerabilities, controls, Authentication, Access Control and Cryptography, Web User Side, Browser Attacks, Web Attacks Targeting Users, Email Attacks. Security in operating system and networks: Security in Operating Systems, Security in the Design of Operating Systems, Rootkit, Network security attack, Threats to Network Communications, Wireless Network Security, Denial of Service, Distributed Denial-of Service. Security Countermeasures: Cryptography in Network Security, Firewalls, Intrusion Detection and Prevention Systems, Network Management, Databases, Security Requirements of Databases Reliability and Integrity, Database Disclosure, Data Mining and Big Data. Privacy in Cyberspace: Privacy Concepts, Privacy Principles and Policies, Authentication and Privacy, Data Mining, Privacy on the Web, Email Security. Cyber Policies: Policies to mitigate cyber risks, Reducing Supply Chain Risks, Mitigate Risks through Human Resource Development, Information sharing Implementing a Cyber security framework, Digital Signature.

References:

1. M.S. Merkov, J. Breithaupt, *Information Security: Principles & Practices*, (2e), Pearson, 2014.
2. C.P. Pfleeger, S.L. Pfleeger, J. Margulies, *Security in Computing*, (5e), Pearson, 2015.
3. V. Sood, *Cyber Laws Simplified*, (2e) McGraw Hill, 2017.
4. N. Godbole, *Information Systems Security*, (2e), Wiley, 2017.

CS4141: DIGITAL FORENSICS & CYBER CRIMES [2 1 0 3]

Introduction to Computer Forensics: Computer crimes, evidence, extraction, preservation, overview of hardware and operating systems, structure of storage media/devices, uncovering attacks that evade detection by event viewer, task manager, and other Windows GUI tools, data acquisition, disk imaging, recovering swap files, temporary and cache files. Computer Forensic tools: Encase, Helix, FTK, Autopsy, Sleuth kit Forensic Browser, FIRE, Found stone Forensic ToolKit, WinHex, Linux and other open source tools. Mobile and Network Forensics: Collecting and analyzing network-based evidence, reconstructing web browsing, email activity, and windows registry changes, intrusion detection, tracking offenders, Mobile Network Technology, Investigations, Collecting Evidence, Interpretation of Digital Evidence on Mobile Network. Software Reverse Engineering: Defend against software targets for viruses, worms and other malware, improving third-party software library, identifying hostile codes-buffer overflow, provision of unexpected inputs. Computer crime and Legal issues: Intellectual property, privacy issues, Criminal Justice system for forensic, audit/investigative situations and digital crime scene, investigative procedure/standards for extraction, preservation, and deposition of legal evidence in a court of law.

References:

1. C. Altheide, H. Carvey, *Digital Forensics with Open Source Tools*, Syngress, 2011.
2. M.T. Britz, *Computer Forensics and Cyber Crime: An Introduction*, (3e), Kindle Edition, 2013.
3. S. Davidoff, J. Ham, *Network Forensics: Tracking Hackers through Cyberspace*, Prentice Hall, 2012.
4. B. Nelson, A. Phillips, F. Enfinger, C. Steua, *Guide to Computer Forensics and Investigations*, Thomson, (4e), 2009.

CS4142: CLOUD COMPUTING APPLICATIONS [3 0 0 3]

Cloud Based Applications: Introduction, Contrast traditional software development and development for the cloud. Public v private cloud apps. Understanding Cloud ecosystems – what is SaaS/PaaS, popular APIs, mobile; Desktop and Application: Cloud Application Architectures, Desktop virtualization, Application virtualization, Web Application design, Cloud app, Benefits of cloud apps, cloud API, Cloud apps vs. web apps, Cloud apps vs. desktop apps, Testing of cloud apps; Designing Code for the cloud: Class and Method design to make best use of the Cloud infrastructure; Web Browsers and the Presentation Layer- Understanding Web browsers attributes and differences. Building blocks of the presentation layer: HTML, HTML5, CSS, Silverlight, and Flash. Web Development Techniques and Frameworks: Building Ajax controls, introduction to JavaScript using jQuery, working with JSON, XML, REST. Application development Frameworks e.g. Ruby on Rails, .Net, Java API's or JSF; Deployment Environments – Platform As A Service (PAAS),Amazon, vmForce, Google App Engine, Azure, Heroku, AppForce; Cloud Application Performance Management: Managing applications in the cloud, cloud application migration, Resource vs. application performance , Private and public instances, Topology discovery, First generation CAPM tools and problems, Second generation CAPM tools and advantages, Cloud application performance components, Agents and applications, Internet as part of the infrastructure, Hosted SaaS CAPM advantages, Root cause analysis challenges, case studies.

References:

1. G. Reese, *Cloud Application Architectures*, O'Reilly Media, Inc, 2009.
2. E. Pace, D. Betts, S. Densmore, R. Dunn, M. Narumoto, *Developing Applications for the Cloud on the Microsoft Windows Azure Platform*, Microsoft Press, 2010.
3. V. Joysula, M. Orr, G. Page, *Cloud Computing: Automating the Virtualized Data Center*, Cisco Press, 2012.
4. Mei- Ling Liu, *Distributed Computing: Principles and Application*, Pearson, Education, Inc. New Delhi. 2004

CS4143: CLOUD SECURITY AND PRIVACY [3 0 0 3]

Introduction: Cloud Computing Defined, The SaaS, PaaS and IaaS (SPI) Framework for Cloud Computing, Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise. Security: Infrastructure Security: Network, Host and Application. Data Security and Storage: Aspects and Mitigation, Provider Data and Its Security. Identity and Access Management (IAM): Trust Boundaries, IAM Challenges, Definitions, Architecture and Practices, IAM Standards and Protocols for Cloud Services, Cloud Authorization Management. Security Management: Security Management Standards, Security Management in the Cloud, Availability Management: SaaS Availability Management, PaaS Availability Management, IaaS Availability Management, Access Control, Security Vulnerability, Patch, and Configuration Management. Privacy: Privacy Standards, Data Life Cycle, Key Privacy Concerns in the Cloud, Legal and Regulatory Implications. Cloud Morphing: Shaping the Future of Cloud Computing Security and Auditing the Cloud for Compliance. Audit and Compliance: Internal Policy Compliance, Governance, Risk, and Compliance, Illustrative Control Objectives for Cloud Computing, Incremental CSP-Specific Control Objectives, Additional Key Management Control Objectives, Control Considerations for CSP Users, Regulatory/External Compliance Cloud Security Alliance, Auditing the Cloud for Compliance.

References:

1. S. Pearson , G. Yee , *Privacy and Security for Cloud Computing*, Springer, 2013.
2. T. Mather, Subra Kumaraswamy, Shahed Latif, *Cloud Security and Privacy*, O'Reilly Media, 2009.
3. B. Halpert, *Auditing Cloud Computing: A Security and Privacy Guide*, Wiley, 2011.
4. K. Saurabh, *Cloud Computing*, (2e), Wiley, 2012.

CS4159: DATA VISUALIZATION TECHNIQUES [2 1 0 3]

Visualization: Visual Representation of Data, Gestalt Principles, Information Overloads. Creating Visual Representations: Visualization Reference Model, Visual Mapping, Visual Analytics, Design of Visualization Applications. Classification of Visualization Systems: Interaction and Visualization Techniques, Visualization of One, Two and Multi-Dimensional Data, Text, and Text Documents. Visualization of Groups: Trees, Graphs, Clusters, Networks, Software, Metaphorical Visualization. Visualization of Volumetric Data: Vector Fields, Processes and Simulations, Visualization of Maps, Geographic Information, GIS systems, Collaborative Visualizations, Evaluating Visualizations. Recent

Trends in Various Perception Techniques: Various Visualization Techniques, Data Structures used in Data Visualization.

Reference:

1. Stephanie D. H. Evergreen, *Effective Data Visualization the Right Chart for the Right Data*, (2e), 2019
2. Tamara Munzner, *Visualization Analysis and Design*, (1e), A K Peters Visualization Series, CRC Press, 2014
3. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data II: A Practical Guide to Data Visualization, Advanced Data Mining Methods, and Applications*, John Wiley & Sons Publication, (1e), 2011.

CS4160: FUNDAMENTALS OF BIG DATA [2 1 0 3]

Introduction: introduction to big data, definition, need and evolution of BDA, Applications of Big Data. Analyzing big data: Sources of big data, Characteristics of Big Data (4 V's), Drivers of BDA, Structured vs. Unstructured data, Data Marts, Differences between traditional DWDM and BDA. Data Processing: Data Wrangling, Data Munging, Data Jujitsu. Statistics for Model Building and Evaluation: Statistics in the Analytic Lifecycle, Hypothesis Testing, Difference of means. Hadoop Framework: Introduction to Hadoop, HDFS - Hadoop Distributed File system, Map Reduce Programming, Pig. ETL & Batch Processing with Hadoop: ETL & Data Warehousing, Ingesting data into Big Data Platforms using Apache Sqoop & Flume, Big Data Analytics using Apache Hive, NoSQL databases for Big Data Storage Applications (HBase), Workflow management for Hadoop using Oozie Spark: Introduction to Spark, SparkSQL, MLLib: Regression, Clustering & Classification using Spark MLLib.

Reference:

1. J. Thompson, S. P. Rogers, Analytics: *How to Win with Intelligence*, Technics, LLC Publications, 2017.
2. A. Jorgensen, J. Rowland-Jones, J. Welch, *Microsoft Big Data Solutions*, Wiley, 2014.

B. Schmarzo, *Big Data: Understanding How Data Powers Big Business*, Wiley, 2013

CS4144: INFORMATION RETRIEVAL [3 0 0 3]

Introduction to IR: IR Concepts, Boolean Retrievals- An Example Information Retrieval Problem, A First Take at Building an Inverted Index, Processing Boolean Queries. The Term Vocabulary and Postings Lists: Document Delineation and Character Sequence Decoding, Determining the Vocabulary of Terms. Dictionaries and Tolerant Retrieval: Search Structures for Dictionaries, Wildcard Queries, Spelling Correction, Phonetic Correction. Index Construction: Hardware Basics Blocked Sort-Based Indexing. Scoring, Term Weighting and the Vector Space Model: Parametric and Zone Indexes, Term Frequency and Weighting, The Vector Space Model for Scoring. Evaluation in Information Retrieval: Information Retrieval System Evaluation, Standard Test Collections, Evaluation of Unranked Retrieval Sets,

Evaluation of Ranked Retrieval Results. XML Retrieval: Basic XML Concepts, Challenges in XML Retrieval, A Vector Space Model for XML Retrieval, Evaluation of XML Retrieval, Text-Centric vs. Data-Centric XML Retrieval. Web Search Basics: Web Characteristics, Advertising as the Economic Model, The Search User Experience, Index Size and Estimation, Near-Duplicates and Shingling. Web Crawling and Indexes: Overview, Crawling, Distributing Indexes, Connectivity Servers. Link Analysis: The Web as a Graph, Page Rank, Hubs, and Authorities.

References:

1. C. Manning, P. Raghavan, H. Schütze, *Introduction to Information Retrieval*, Cambridge University Press, 2009.
2. R. Baeza-Yate, B. Ribeiro-Neto, *Modern Information Retrieval*, (2e), Addison Wesley, 2012.
3. S. Chakrabarti, *Mining the Web: discovering knowledge from hypertext data*, (2e), Morgan Kaufmann, 2002.
4. D. A. Grossman, O. Frieder, *Information Retrieval: Algorithms, and Heuristics*, (2e), Springer, 2004.

CS4145: COMPUTER GRAPHICS & MULTIMEDIA [3 0 0 3]

Basics of Computer Graphics: Pixel, Frame buffer, Application of computer graphics. Graphic Display Devices: Cathode Ray Tube, Light emitting diode, DVST, Random and Raster Scan displays. Scan Conversion: Line Generation using digital differential analyzer (DDA), bresenham's Algorithm, Circle generation algorithm, Ellipse generation algorithm, Polygon generation and filling algorithms. Two Dimensional Transformations: Introduction, homogeneous representation of points, basic transformation like Translation, Rotation, Scaling, Reflection, Shear. Clipping and Windowing: Cohen Sutherland Algorithm, liang Barsky algorithm, Sutherland Hodgman Algorithm. Three-dimensional transformation: Translation, Rotation, Scaling and Reflection. Projection: Introduction, Types of projection. Hidden Surface elimination: Depth comparison, Back face detection algorithm, Painter's Algorithm, Z-Buffer Algorithm. Basic Illumination Model: Diffuse reflection, Specular reflection, Phong and Gouraud shading. Introduction to Multimedia: Concepts and uses, hypertext and hypermedia, image, video and audio standards, text compression algorithm. Animation: types, techniques, key frame animation, utility, morphing.

References:

1. D. Hearn, M. P. Baker, *Computer Graphics with OpenGL*, (4e), Pearson Education, 2014.
2. R. Steinmetz, K. Nahrstedt, *Multimedia Systems*, Springer, 2004
3. J. F. Hughes, J. D. Foley, *Computer graphics Principles and Practice*, (3e), Pearson Education, 2014.
4. R. Steinmetz, K. Nahrstedt, *Multimedia Fundamentals: Media Coding and Content Processing*, (2e), Pearson Education, 2004

CS4146: USER INTERFACE DESIGN [3 0 0 3]

Introductory Panel: UI Design and Why it Matters, Introduction to the Specialization, Courses, and Capstone, User Interface Hall of Fame / Shame, Case Study 1: UI Disasters, including GPS fails, Case Study 2: Corporate Value: Citibank AT, Case Study 3: Microsoft Office 2007 Ribbon, Case Study 4: International Children's Digital Library, Case Study 5: Taxes and Tickets, Case Study 6: AirBnB vs. Couch Surfing, UI Design Process, Design Process Introduction Designing to Address a Problem w/o Solution Ideas Designing for a known solution direction9m Designing to iterate on/improve an existing solution, Common Elements Usability Engineering and Task-Centered Approaches, Use Cases, Personas, Tasks, and Scenarios, Intro to Design-Centered Approaches, Design-Centered Methods & When They Work Best, Short- and long-term memory, attention, Perception and visualization, hierarchy Mistakes, Errors, and Slips, Conceptual models, The Gulf of Execution and the Gulf of Evaluation, Design Principles: Visibility, Feedback, Mappings, Constraints, interacting beyond individuals (social psychology), High-Level Models: Distributed Cognition, Activity Theory, Situated Action, Intro to UI Design: Psychology and Human Factors: Shortcuts to Understanding Your User

References:

1. Norman, A. Donald, *The Design of Everyday Things*. MIT Press, 2014.
2. https://www.coursera.org/specializations/user-interface-design#courses

CS4147: DIGITAL IMAGE PROCESSING [3 0 0 3]

Introduction to image processing: steps in image processing, Image file formats, Basic relationships between pixels, Colour Models. Image Enhancement and Restoration: Image histogram, Spatial domain enhancement, point operations, Log transformation, Power-law transformation. Frequency domain enhancement: introduction to image transforms, Fourier transform, 2D-DFT. Restoration: Noise models, Restoration using Inverse filtering and Wiener filtering. Image Coding and Compression: Lossless compression, Lossy compression, JPEG, MPEG. Image Segmentation and Representation: Grey level features, edges and lines, similarity, correlation, template matching, edge detection using templates, Representation scheme, boundary descriptors, regional descriptors, Image Morphology. Biometric Authentication, Object Detection.

References:

1. K. R. Castleman, Digital Image Processing, (2e), Pearson Education, 2011.
2. R. C. Gonzalez, R. E. Woods, Digital Image Processing, (4e), Pearson Education, 2018.
3. A. K. Jain, Fundamentals of *Digital Image Processing*, Pearson Education, Reprint 2015.
4. S. Jayaraman, S. Esakkirajan, T Veerakumar, *Digital Image Processing*, Tata McGraw Hill Education, 2009.
5. R. C. Gonzalez, R. E. Woods, S. Eddins, *Digital Image Processing using MATLAB*, (2e), Pearson Education.
6. A. McAndrew*, Introduction to Image processing using MATLAB*, Cengage Learning Publisher, 2007.
7. Prateek Joshi, *OpenCV with Python by Example*, (1e) PACKT Publishing, 2018.

CS4148: INTERNET OF THINGS [3 0 0 3]

Introduction: Analog and digital signals, serial communication, RF, and sensors; Introduction to JSON/XML. Programming on Development Boards: Understanding of the board, tool chain and development environment setup; Sensors and Actuators: Understanding and using analog, digital, SPI, UART, I2C. Nodes and communication protocols: Understanding usage of nodes and gateways for sensor communication and external communication, RF, Zigbee, BT, WI-FI, GSM. IoT Cloud Platform, Cloud using Web Services, Cloud Computing Services for Sensor Management, Python Script; Data Analytics: Mongo DB, Map Reduce, Using cloud APIs for analytics, Visualization, NVD3, Mobile interfacing.

References:

1. V. Madisetti, A. Bahga, *Internet of Things: A Hands-On- Approach*, VPT, 2014.
2. R. Buyya, A. V. Dastjerdi*, Internet of Things Principles and Paradigms*, 2016.
3. H. Geng, *Internet of Things Principles and Data Analytics Handbook*, Wiley, 2017.
4. P. Raj, A. C. Raman, *The Internet of Things Enabling Technologies, Platforms, and Use Cases*, CRC Press, 2017.

CS4149: BIG DATA ANALYTICS [2 1 0 3]

INTRODUCTION: Introduction to big data, definition, need and evolution of BDA, Applications of Big Data. Analysing big data: Sources of big data, Characteristics of Big Data (4 V's), Drivers of BDA, Structured vs. Unstructured data, Data Marts, Differences between traditional DWDM and BDA. Data Processing: Data Wrangling, Data Munging, Data Jujitsu. Data Visualisation: Why to visualize data. Data Analytics Life Cycle. Advanced Analytics Algorithms: Introduction using R – Theory and Methods Overview: K-means clustering, Association Rules, Linear Regression, Logistic Regression, Naïve Bayesian Classifiers, Decision Trees, Time Series Analysis, Text Analytics; Statistics for Model Building and Evaluation: Statistics in the Analytic Lifecycle, Hypothesis Testing, Difference of means. Hadoop Framework: Introduction to Hadoop, HDFS - Hadoop Distributed File system, Map Reduce Programming, Pig. ETL & Batch Processing with Hadoop: ETL & Data Warehousing, Ingesting data into Big Data Platforms using Apache Sqoop & Flume, Big Data Analytics using Apache Hive, NoSQL databases for Big Data Storage Applications (HBase), Workflow management for Hadoop using Oozie Spark: Introduction to Spark, SparkSQL, MLLib: Regression, Clustering & Classification using Spark MLLib.

References:

1. B. Schmarzo, *Big Data: Understanding How Data Powers Big Business*, Wiley.2013
2. A. Jorgensen, J. Rowland-Jones, J. Welch, *Microsoft Big Data Solutions*, Wiley.,2014

3. J. Thompson, S. P. Rogers, Analytics: *How to Win with Intelligence, Technics*, LLC Publications, 2017

CS4150: SOFTWARE DEFINED NETWORKS [3 0 0 3]

Overview, Central Control, Active Networks, Network Virtualization, From FORCES to Ethane: Control Plane Evolution, The Road to SDN, Tutorial: Setup Vagrant/Mininet Course VM Setup, Mininet Topologies and Mininet Python API, Control/Data Separation, Opportunities in Various Domains, Challenges in Separating the Data and Control Planes Routing, Control Platform, The 4D Network Architecture, The Control Plane, Overview of SDN Controllers, Customizing SDN Control (Part 1: Switching), Customizing SDN Control (Part 2: Firewalls), Commercial-Grade Controllers: ODL, Commercial-Grade Controllers: Ryu Virtualization, Applications of Virtual Networking, Network Virtualization with Mininet, Slicing Network Control, Virtualization in Multi-Tenant Datacenters Network Functions Virtualization, Docker and Containerization, Networking in Docker Programmable Data Planes, Making Software Faster: Route Bricks, Programmable Hardware Overview Programmable Chipsets: RMT, High-Level Programming Languages: P4, P4 Examples, Intermediate Representations: NetASM Motivation for "Northbound APIs" and SDN Programming Languages, Frenetic: A Programming Language for SDNs, Composing SDN Policies, Pyretic: A Language for Composing SDN Policies, Kinetic: Event-Based SDN Control, Data Centers, Internet Exchange Points, Wide-Area Backbone Networks, Home Networks.

References:

1. T. D. Nadeau, K. Gray, SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies, (1e) O'Reilly Media, 2013.
2. P. Goransson, C. Black, Software Defined Networks: A Comprehensive Approach, (2e) Morgan Kaufmann, 2016.
3. F. Hu, Network Innovation through Open Flow and SDN: Principles and Design, CRC Press, 2014.
4. V. Tiwari, SDN and Open Flow for Beginners, Amazon Digital Services, Inc., ASIN, 2013.
5. S Subramanian, Software Defined Networking with OpenStack, Packt Publishing, 2016.
6. https://www.coursera.org/learn/sdn

CS4151: DEEP NEURAL NETWORK [3 0 0 3]

Introduction of Deep Learning, Basics of Machine Learning, Neural Network, Activation function,Gradient Descent, Stochastic Gradient Descent, backpropagation, Deep Convolution Neural network: convolution operation, ReLU Layer, Pooling Layer, Flattening, fully connected layer, softmax and cross entropy, Recurrent Neural network: Vanishing Gradient Problem, LSTMs, LSTM variations, Self- organizing Map (SOM), K-means clustering, Boltzmann Machine, Energy-based Models, Contrastive Divergence, Deep Belief Networks, autoencoders, training of auto encode, over complete hidden layers, sparse autoencoders, denoising autoencoders, contractive autoencoders, stacked autoencoders, deep autoencoders.

References:

1. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning,* MIT Press 2016.
2. S. Haykin, *Neural Networks and Learning Machines*, (3e), PHI, 2008.

CS4152: SOCIAL NETWORK ANALYSIS [2 0 1 3]

Introduction to Social Web: Nodes, Edges and Network measures, Describing Nodes and Edges, Describing Networks, Layouts. Visualizing Network features: The role of Tie Strength, Measuring Tie Strength, Tie Strength and Network Structure, Tie Strength and Network Propagation, Link Prediction, Entity Resolution. Link Prediction: Case Study Friend recommendation. Communities: Introduction, Communities in Context, Quality Functions. Algorithms: Clustering-based, Newman and Girvan- Divisive clustering, Newman-Modularity maximization, Clauset-Greedy optimization of modularity, Louvain Method-Hierarchical clustering, Agglomerative clustering, Falkowski(DENGRAPH)-Density-based clustering, Nikolaev-Entropy centrality-based clustering, Clique-based Methods for Overlapping Community Detection, Palla- Clique percolation method, Lancichinetti-Fitness function, Du-Kernels-based clustering, Shen-Agglomerative hierarchical clustering, Evans-Line graph, clique graph, Label Propagation-based Community Detection. Introduction to Social Influence: Influence Related Statistics, Social Similarity and Influence, Homophile, Existential Test for Social Influence, Influence and Actions, Influence and Interaction, Influence Maximization in Viral Marketing.

References:

1. J. Goldbeck, *Analyzing the Social Web,* Morgan Kaufmann Publications, 2013.
2. C. C. Aggarwal, *Social Network Data Analytics*, Springer Publications, 2011.
3. J. Scott, *Social Network Analysis*, (3e), SAGE Publications Limited, 2013.
4. J. Goldman, *Facebook Cookbook*, O'Reilly, 2009.
5. S. Kumar, F. Morstatter, H. Liu, *Twitter Data Analytics*, Springer Publications, 2013.

CS4153: SOFTWARE TESTING [3 0 0 3]

Introduction and concept learning: Basic definitions, Testing axioms, Purpose of Software Testing, Software Testing Principles, The Tester's Role in a Software Development Organization, Origins of Defects, Cost of defects, Defect Classes, Defect Prevention strategies, Defect Repository, Strategies for Software Testing, Testing Activities, Mistakes, Faults & Failures, Verification and Formal Methods, Planning for Verification and Validation. White-Box Testing: Test Adequacy Criteria, Static Testing, Structural Testing, Code Complexity Testing, Mutation Testing, Data Flow Testing. Black-Box Testing: Test Case Design Criteria, Requirement Based Testing, Positive and Negative Testing, Boundary Value Analysis, Equivalence Partitioning State Based Testing, Domain Testing. Functional Testing: Test Plan, Test Management, Test Execution and Reporting, Test Specialist Skills, Tester's Workbench and Tool Categories, Debugging, Test Bed, Traceability and Testability, Attributes of Testable Requirements, Test Matrix, Types of Testing Documentation, Verification Testing, Validation Testing, Integration Testing, System and Acceptance Testing, GUI Testing, Regression Testing, Selection, Minimization and Prioritization of Test Cases for Regression Testing, Creating Test Cases from Requirements and Use cases, Test Design. Test Automation: Software test automation – skill needed for automation – scope of automation – design and architecture for automation – requirements for a test tool – challenges in automation – Test metrics and measurements – project, progress and productivity metrics.

References:

1. W. E. Perry, *Effective Methods for Software Testing*, John Wiley, and Sons, 2000.
2. R. Patton, *Software Testing,* Sams Publishing, 2005.
3. A. P. Mathur*, Foundations of Software Testing*, Pearson Education, 2013.
4. J. L. Mitchell, R. Black, *Advanced Software Testing*—Vol. 3, Rocky Nook, 2015.

CS4154: LINUX SYSTEM AND SHELL PROGRAMMING [3 0 0 3]

Fundamentals: Processes in Linux, I/O system calls, select and poll functions, Filters and redirection, Linux file system navigation, Directory access, File system implementation, Hard links, and symbolic links. Asynchronous Events: Manipulating signal masks and signal sets, Catching, and ignoring signals, Waiting for signals. Inter-Process Communication: Sockets, Remote procedure calls, Network file system. Concurrency: POSIX thread attributes, Synchronization functions, Mutex locks, Condition variables, Signal handling and threads. Character Device Driver Development: Driver concepts, Writing character drivers, Interrupt handling, Interfacing with hardware. Shell Scripting: Loops, Conditional statements, Command line arguments, test command, expr command. Advanced Scripting Techniques: Providing command line options to scripts, exporting variables, Arrays, Remote shell execution, connecting to MySQL using shell, Essential system administration.

References:

1. W. R. Stevens, S. A. Rago, *Advanced Programming in the UNIX Environment*, (3e), Addison-Wesley, 2013.
2. R. Love, *Linux System Programming: Talking Directly to the Kernel and C Library*, O'Reilly, 2007.
3. S. Das, *Unix Concepts and Applications*, (4e), McGraw Hill, 2006.
2. W. R. Stevens, B. Fenner, *UNIX Network Programming, Volume 1: The Sockets Networking API,* (3e), Pearson, 2003.
3. K. A. Robbins, S. Robbins, *Unix Systems Programming: Communication, Concurrency, and Threads,* (2e), Prentice Hall, 2004.

CS4155: WIRELESS SENSOR & ADHOC NETWORK [3 0 0 3]

Introduction: Wireless Ad Hoc Networks- Part- I Introduction: Wireless Ad Hoc Networks- Part- II Self-organizing Behavior of Wireless Ad Hoc Networks, Cooperation in Mobile Ad Hoc Networks- Part- I Cooperation in Mobile Ad Hoc Networks- Part- II MAC Protocols in MANETs- Part- I MAC Protocols in

MANETs- Part- II Routing in MANETs- Part- I, Routing in MANETs- Part- II Routing in MANETs- Part- III Multicasting in MANETs, Mobility Models for MANETs Transport Protocols for MANETs- Part- I Transport Protocols for MANETs- Part- II, Opportunistic Mobile Networks- Part- I, Opportunistic Mobile Networks- Part- II, Opportunistic Mobile Networks- Part- III, UAV Networks- Part- I UAV Networks- Part- II UAV Networks- Part- III Introduction: Wireless Sensor Networks- Part- I Introduction: Wireless Sensor Networks- Part- II WSN Coverage & Placement- Part-I Topology Management in Wireless Sensor Network Mobile Wireless Sensor Networks Mobile Wireless Sensor Networks Medium Access Control in Wireless Networks- Part-I, Medium Access Control in Wireless Networks- Part-II Routing in Wireless Sensor Networks- Part- I Routing in Wireless Sensor Networks- Part- II Congestion and Flow Control- Part- I Congestion and Flow Control- Part- II Underwater Sensor Networks- Part- I Underwater Sensor Networks- Part- II, Underwater Sensor Networks- Part- III, Underwater Sensor Networks- Part- IV, Security of Wireless Sensor Networks- Part- I Security of Wireless Sensor Networks- Part- II Hardware Design of Sensor Node

References:

1. S. K. Sarkar, T G Basavaraju, C Puttamadappa, Ad Hoc Mobile Wireless Networks: Principles, Protocols, and Applications, (2e), CRC Press, 2016.
2. C. D. Morais Cordeiro, D. P. Agrawal, Ad Hoc and Sensor Networks: Theory and Applications, (2e), World Scientific Publishing, 2011.
3. H. Karl, A. Willing, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, 2007.
4. R. Jurdak, Wireless Ad Hoc and Sensor Networks: A Cross-Layer Design Perspective, Springer Publications, 2007.
5. S R Murthy, B. S. Manoj, Ad Hoc Wireless Networks Architectures and Protocols, Pearson Education, 2008.
6. https://nptel.ac.in/courses/106105160

CS4156: MOBILE COMPUTING [3 0 0 3]

Overview of Cellular Systems and evolution 2g/3G/4G/5G Cellular Concepts – Frequency reuse, Cochannel and Adjacent channel Interference, C/I, Hando , Blocking, Erlang Capacity Wireless propagation Part 1 - Link budget, Free-space path loss, Noise figure of receiver Wireless propagation Part II - Multipath fading, Shadowing, Fading margin, Shadowing margin, Antenna Diversity Wireless Channel Capacity MIMO CDMA Part I CDMA Part II OFDM and LTE Part I OFDM and LTE Part II Large Scale Propagation effects and Channel Models.

References:

1. W. Stallings, Wireless Communications and Networks, (2e) Pearson Education, 2018.
2. J. Schiller, Mobile Communications, (2e), Pearson Education, 2009.
3. K. Garg, Mobile Computing: Theory and Practice, (1e) Pearson Education India, 2010.
4. https://nptel.ac.in/courses/106106147

CS4157: NATURAL LANGUAGE PROCESSING [3 0 0 3]

Introduction: Ambiguity and uncertainty in language, processing paradigms, phases in natural language processing. Text representation in computers: encoding schemes. Linguistics resources: Introduction to corpus, elements in balanced corpus, WordNet, VerbNet. Part of Speech tagging: Stochastic POS tagging, HMM, Transformation based tagging (TBL), handling of unknown words, named entities, multi word expressions. Natural language grammars: lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, context free grammar, spoken language syntax. Parsing- unification, probabilistic parsing, tree-bank. Semantics: meaning representation, semantic analysis, lexical semantics. Word Sense Disambiguation: selection restriction, machine learning approaches, dictionary based approaches. Discourse: Reference resolution, constraints on co-reference, algorithm for pronoun resolution, text coherence, discourse structure. Real time Applications of NLP: text to speech, text summarization, information retrieval, sentiment analysis, machine translation.

References:

1. D. Jurafsky, J. H. Martin, *Speech, and Language Processing,* (2e), Pearson Education, 2009.
2. T. Siddiqui, U. S. Tiwary, *Natural language processing and Information retrieval*, Oxford University Press, 2008.

CS4158: COMPUTER VISION [3 0 0 3]

Introduction to computer vision and its applications, Geometric Image Features: Differential Geometry, Contour Geometry, analytical image features: Euclidean geometry, Geometric Camera Parameters, Calibration methods, Image formation, Liner Filtering: Linear filters and convolution, shift invariant linear systems, spatial frequency and Fourier transforms, Image transformations and Colour models, Edge Detection methods (Laplacian detectors and Canny edge detector), Points and patches, Harris corner detector, Histogram of Gradients, Difference of Gaussian detector, SIFT, Colour and Texture, Feature based alignment, least squares and RANSAC, Camera models, Camera calibration, Stereo vision, Stereo correspondence, Epipolar geometry Optical flow, Lucas Kanade method, KLT tracking method, Mean shift method, Dense motion estimation, Support Vector Machines, Face detection and recognition, Bag of words, Deep convolution neural network.

References:

1. R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer 2011.
2. D. A. Forsyth, J. Ponce, *Computer Vision: A Modern Approach*, (2e), PHI learning, 2012
3. J. E. Solem, *Programming Computer Vision with Python,* O'Reilly, 2012.

CS4161: ADVANCED DATA STRUCTURES [2 0 1 3]

Dictionaries: Definition, Dictionary Abstract Data Type, Implementation of Dictionaries. Hashing: Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing. Skip Lists: Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists. Splay Trees: Splaying, Search and Update Operations on Splay Trees, Amortized Analysis of Splaying. Text Processing: String Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem. Computational Geometry: One Dimensional Range Searching, Two-Dimensional Range Searching, constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quad trees, k-D Trees.

References:

1.M. A. Weiss, *Data Structures and Algorithm Analysis in C*++, (2e), Pearson, 2004.
2.T. H. Cormen, C. E. Leiserson, R.L.Rivest, and C. Stein, I*ntroduction to Algorithms*, (3e), MIT press, 2010.

3. M T Goodrich, R. Tamassia*, Algorithm Design*, John Wiley, 2002.

CS4162: BLOCKCHAIN TECHNOLOGIES [3 0 0 3]

Introduction and concept learning: Introduction to Blockchain, Building blocks of Blockchain, Industry Applications of Blockchain, Types of Blockchain, History of Centralized Services, Trust and Vulnerability. Types of Trust model; Introduction to Cryptography: Hashing, Data Integrity, Merkle Trees, Symmetric Key Cryptography, Public Key Cryptography, Digital Signatures, Application of Cryptography to Blockchain; Mining and consensus: Mining, Proof of Work, Proof of Stake, Byzantine Fault Tolerance, Proof of Authority and Proof of Elapsed Time; Bitcoin versus Cryptocurrencies versus Blockchain: Transaction, Wallet, Distributed Ledger Technology (DLT), Fork, Ethereum: Ethereum Virtual Machine (EVM), Wallet for Ethereum, Solidity, Smart Contracts, Introducing WEB 3.0, Hyperledger, Coinbase's API; Regulation and Anonymity: Initial Coin Offerings (ICO), Securities and Exchange Commission (SEC) ruling, Anonymity: Zcash, Monero, Anti Money Laundering, Case study: Use of blockchain in different areas such as healthcare, finance, supply chain.

References:

1. I. Bashir, *Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained*, (2e), Packt Publication, 2018.

2. M. Grincalaitis, *Mastering Ethereum: Implement advanced blockchain applications using Ethereum-supported tools, services, and protocols*, (1e), Packt Publishing, 2019
3. B. Hill, S. Chopra, P. Valencourt, *Blockchain Quick Reference: A guide to exploring decentralized Blockchain application development*, Packt Publication, 2018.
4. A. T. Norman, *Blockchain Technology Explained: The Ultimate Beginner's Guide*, Create Space Independent Publishing, 2017.

CS4163: EXPLAINABLE ARTIFICIAL INTELLIGENCE [3 0 0 3]

Introduction to XAI, Type of XAI, The importance of XAI, Interpretability and Explainability, Historical perspective on AI and XAI interpretability, Applications of XAI, Techniques for Model Interpretability, Pre-model Interpretability and Explainability, Exploratory Data Analysis, Feature Engineering and Explainability, Partial dependence plots, LIME, SHAP values, ELI5, Skater, Decision Tree-Based techniques, Rule-Based techniques, Ensemble-Based techniques, Example-Based techniques, Explainable Deep Learning, Post-Hoc Interpretability, and Explanations, Interpretable vs. Explainable algorithms, Visualization of Model Outputs, Confusion matrices, ROC curves, Other visualization techniques, Ethics and Fairness in AI, Bias in AI, Fairness metrics, Mitigating bias in AI models, XAI: Challenges and Future, XAI in medical decision system, Hands-on Programming Assignments, Implementing model interpretability techniques using Python, Visualizing model outputs, Evaluating fairness and Ethics of AI Models, Project Work, Students will work on a project to apply the ideas acquired in the course to a real-world scenario.

References:

1. Christoph Molnar, *Interpretable machine learning*. Lulu.com, 2020
2. Imoize, Agbotiname Lucky, Jude Hemanth, Dinh-Thuan Do, and Samarendra Nath Sur, eds. *Explainable Artificial Intelligence in Medical Decision Support Systems*. IET, 2022

CS4164: ADVANCE COMPILER DESIGN [3 0 0 3]

Introduction: Language Processors, The Structure of a Compiler. Lexical Analysis: Role of the Lexical Analyzer, Input Buffering, Specifications and Recognition of Tokens, Design of Lexical Analyzer Generator, LEX. Syntax Analysis: Introduction, Writing a Grammar, Parser Generator YACC, Top Down Parsing: Recursive Descent Parsing, LL(1) parsing. Introduction to Bottom up parsing: Operator precedence parsing, LR (0), SLR, LALR and CLR(1) parsing. Syntax-Directed Translation: Syntax-Directed Definitions, Application of Syntax- Directed Translation. Intermediate Code Generation: Variants of Syntax Trees, Three Address Codes, Type checking, Control Flow and Back Patching. Runtime Environment: Storage Organization, Stack Allocation and Heap Management. Code Generation and Optimization: Issues in code generation, data and control flow, peephole optimization, register allocation, Machine independent optimization techniques.

References:

1. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, *Compilers Principles, Techniques and Tools*, (2e), Pearson Education, 2010.
2. Kenneth C. Louden, *Compiler Construction - Principles and Practice*, (1e), Thomson, 2007.
3. John R. Levine, Tony Manson, Doug Brown, *LEX & YACC*, (2e), O Reilly Media, 2012.

CS4170: INDUSTRIAL TRAINING [0 0 2 1]

In this course the student, undergo in reputed Private / Public Sector / Government organization / companies as industrial training for minimum 45 days to be undergone by the student in the summer vacation of the VI semester.

Outcome of this course:

- To expose students to the 'real' working environment and be acquainted with the organization structure, business operations and administrative functions.
- To have hands-on experience in the students' related field so that they can relate and reinforce what has been taught at the university.
- To promote cooperation and to develop synergetic collaboration between industry and the university in promoting a knowledgeable society & to set the stage for future recruitment by potential employers.

CS4270: MAJOR PROJECT [0 0 24 12]

In this course student has to select a project work based on a topic of interest. Periodically the supervisor will evaluate the implementation. This work, started in eighth semester of which, the student will be evaluated internally and externally.

Outcome of the course:

- Investigating professional topics, including ethical, legal and security issues, related to computing projects.
- Design and develop the software with Software Engineering practices and standards
- Apply prior knowledge to design and implement solutions for computational problems while considering numerous realistic restraints.

OPEN ELECTIVES

CS0001: FOG DATA SCIENCE FOR ENGINEERS [3 0 0 3]

Introduction to R: variables and data types in R, data frames, recasting and joining of data frames, arithmetic, logic, and matrix operations in R. Advanced programming in R: Functions, control structures, data visualization in R and basic graphics. Linear Algebra for Data Science: Solving linear equations, distance, hyperplanes and half spaces, Eigenvalues, Eigenvectors, Statistical Modelling, Random variables, probability functions, sample statistics, hypothesis testing. Optimization for data science: Unconstrained multivariate optimization, gradient descent, multivariate optimization with equality and inequality constraints. Introduction to Data Science: Solving data analysis problems, Predictive modelling, linear regression, model assessment, cross validation, classification, logistic regression, KNN, K-mean clustering, implementation in R.

References:

1. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning with applications in R*, Springer, 2013.
2. J. Han, M. Kamber, J. Pei, *Data Mining concepts and techniques*, (2e), Morgan Kaufmann-Elsevier, 2011.
3. https://nptel.ac.in/courses/106/106/106106179/

CS0002: PROGRAMMING, DATA STRUCTURES AND ALGORITHMS USING PYTHON [3 0 0 3]

Introduction: Introduction to programming, algorithms, and data structures via gcd, Downloading and installing Python, gcd in Python: variables, operations, control flow - assignments, conditionals, loops, functions. Python: Types, expressions, strings, lists, tuples. Python memory model: Names, mutable and immutable values. List operations: slices etc., Binary search. Inductive function definitions: numerical and structural induction. Elementary inductive sorting: selection and insertion sort, In-place sorting. Basic algorithmic analysis: input size, asymptotic, complexity, O() notation, Arrays vs lists, Merge sort, Quicksort, Stable sorting, Dictionaries. More on Python functions: optional arguments, default values, Passing functions as arguments, Higher-order functions on lists: map, list comprehension. Exception handling: Basic input/output, Handling files, String processing. Backtracking: N Queens, recording all

solutions. Scope in Python: local, global, nonlocal names, Nested functions. Data structures: stack, queue, Heaps, Abstract datatypes, Classes, and objects in Python. "Linked" lists: find, insert, delete. Binary search trees: find, insert, delete, Height-balanced binary search trees. Efficient evaluation of recursive definitions: memorization. Dynamic programming: examples. Other programming languages: C and manual memory management. Other programming paradigms: functional programming.

References:

1. M. T. Goodrich, R. Tamassia, M. H. Golwasser, *Data Structures and Algorithms in Python*, Wiley, 2021.
2. R. Thareja, *Python Programming: Using Problem Solving Approach,* Oxford university Press, 2017.
3. https://swayam.gov.in/nd1_noc20_cs70/preview

CS0003: DATA STRUCTURE AND ALGORITHMS USING JAVA [3 0 0 3]

Introduction to Arrays: 1D array, list, and vector, 2D matrices and tables of objects, Java implementation of 1D and 2D arrays and its operations. Linked lists: Linked lists and its various operations, stack and queue, Java implementation of linked lists, stack, and queue. Binary trees: Representation and operations. Variations of binary tree: Binary search tree, Height balanced search tree, Heap tree, Java implementation of binary trees and its variations. Graph: Structure, representation and operations, Java implementations of graph data structures. Algorithms (Part-I): Searching and sorting algorithms, Java implementation of Part-I algorithms. Algorithms (Part-II): Greedy algorithms, shortest path algorithms, Java implementation of Part-II algorithms.

References:

1. M. T. Goodrich, R. Tamassia, *Data Structures and Algorithms in Java* (4e), Wiley, 2021.
2. N. Karumachi, *Data Structures and Algorithms Made Easy in JAVA: Data Structure and Algorithmic Puzzles*, Careermonk, 2018.
3. https://swayam.gov.in/nd1_noc20_cs85/preview

CS0004: THE JOY OF COMPUTING USING PYTHON [3 0 0 3]

Motivation for Computing, Introduction to Programming, Variables and Expressions: Design your own calculator. Loops and Conditionals: Hopscotch once again, Lists, Tuples and Conditionals: Lets go on a trip. Abstraction Everywhere: Apps in your phone. Counting Candies: Crowd to the rescue. Birthday Paradox: Find your twin. Google Translate: Speak in any Language. Currency Converter: Count your foreign trip expenses Monte Hall: 3 doors and a twist. Sorting: Arrange the books.

References:

1. M. T. Goodrich, R. Tamassia, M. H. Golwasser, *Data Structures and Algorithms in Python*, Wiley, 2021.
2. R. Thareja, *Python Programming: Using Problem Solving Approach*, Oxford University Press, 2017.
3. https://nptel.ac.in/courses/106/106/106106182/

CS0005: FUNDAMENTALS OF DATABASES [3 0 0 3]

Introduction: Database-System Applications, Relational Databases, Database Design, Data Storage and Querying, Transaction Management, Database Architecture. File Management System: Indexing and Hashing. Relational Algebra: Algebra, Tuple Calculus, Domain Calculus. SQL: Data Definition Language, Data manipulation language, SQL Data Types and Schemas, Integrity Constraints, Basic Structure of SQL Queries, Set Operations, Aggregate Functions, Null Values, Nested Sub-queries, Correlated queries. Join: Inner, Outer, Left, Right and Natural. The Entity-Relationship Model: Constraints, Entity-Relationship Diagrams, Entity-Relationship Design Issues, Weak Entity Sets, Extended E-R Features. Normalization: Normal Forms, BCNF.

References:

1. R. Elmasri, S. B. Navathe, *Fundamentals of Database Systems,* (6e), Addison-Wesley, 2010.

2. R. Ramakrishnan, J. Gehrke, *Database Management Systems,* (3e), McGraw Hill, 2014
3. https://nptel.ac.in/courses/106106220

CS0006: FUNDAMENTALS OF CRYPTOGRAPHY [3 0 0 3]

Introduction: Basic objectives of cryptography, Secret-key and public-key cryptography, Cryptanalysis, Attack models, Classical cryptography. Block ciphers: Modes of operation, DES and its variants, AES, Linear and differential cryptanalysis. Message digest: Properties of hash functions, SHA-512, Keyed hash functions, Attacks on hash functions. Public-key parameters: Modular arithmetic, Primality testing, Chinese remainder theorem, Modular square roots, Finite fields. Public-key encryption: RSA, Rabin and EIGamal schemes, Elliptic and hyper-elliptic curve cryptography, Diffie-Hellman key exchange. Digital signatures: RSA, DSA and NR signature schemes, blind and undeniable signatures.

References:

1. W. Stallings, *Cryptography and Network Security: Principles and Practice*, (6e), Prentice Hall, 2014.
2. B. A. Forouzan, D. Mukhopadhyay, *Cryptography and Network Security*, (2e), Mc-Graw Hill, 2008.
3. https://nptel.ac.in/courses/106106221

CS0007: PRINCIPLES OF PROGRAMMING LANGUAGES [3 0 0 3]

Preliminary Concepts: Concepts of programming languages. Syntax and Semantics: general Problem of describing Syntax and Semantics. Data types: Primitive, character, user defined, array, associative record, union, pointer, and reference types. Expressions and Statements: Assignment Statements, Control Structures. Subprograms and Blocks: Fundamentals of sub-programs, Scope of lifetime of variables, static and dynamic scope, design issues of sub-programs and operations. Abstract Data types: Abstractions and encapsulation, introductions to data abstraction, design issues, language examples. Concurrency: Subprogram level concurrency, semaphores, monitors, massage passing, Java threads, C# threads. Exception handling: Exceptions, exception Propagation, Exception handler in Ada, C++, and Java. Logic Programming Language: Introduction and overview of logic programming.

References:

1. R. W. Sebesta, *Concepts of Programming Languages*, (10e), Pearson Education, 2008
2. D. A. Watt, *Programming Language Design Concepts*, Wiley, (2e), 2007.
3. B. Tucker, R. E. Noonan, *Programming Languages*, (2e), TMH, 2007.
4. K. C. Louden, *Programming Languages*, (2e), Thomson, 2003.
5. T. W. Pratt, M. V. Zelkowitz, T. V. Gopal, *Programming Languages: Design and Implementation,* (4e), PHI, 2006.
6. https://nptel.ac.in/courses/106102067

CS0008: PRINCIPLES OF SOFTWARE DESIGN [3 0 0 3]

Design fundamentals: Nature of Design process objectives, Building Modules, Constructs, Design qualities, assessing the design, Design viewpoints for software. Design Practices: Analysis on design requirements and designing with quality factors, coupling, cohesion and cognitive dimensions, measure quality attributes and assessment. Design strategies and Methodologies: Design strategies Top down and bottom up, Organizational methods and design, Jackson Structural programming, Jackson system development. Design Models: Object-based design and Structured System Analysis and Structured design method Traditional approach to design-SADT organizational design practices-SSADM and design for real time systems. Software Architecture: Introduction- Software Architecture- Definition Prospects- State of Art-Architectural Styles-Pipes and Filters-Layered Systems-Repositories-Process Control, Other familiar Architecture Heterogeneous Architectures. Software Architecture patterns: Introduction to design pattern Architectural design and Mapping–Description of various Architectural design patterns.

References:

1. D. Budgen, *Software Design* (2e), Addison Wesley, Pearson Education, 2012
2. H. Zhu, *Software Design Methodology from Principles to Architectural Styles* (1e), Elsevier, 2011.
3. R.S. Pressman, *Software Engineering (*5e), McGraw Hill Inc., 2015.

4. B. Hughes et al., *Software Project Management* (6e), McGraw Hill, 2017.
5. https://nptel.ac.in/courses/106105182

CS0009: FUNDAMENTALS OF INTERNET OF THINGS [3 0 0 3]

IOT Fundamentals: What is the IoT and why is it important? Elements of an IoT ecosystem, Technology drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues, sensors, and actuators. Basics of IoT networking: Connectivity technologies, Sensor networks, UAV networks, Machine to machine communication. Interoperability in IoT: Introduction to Arduino and Raspberry Pi. Implementation of IoT: Software Defined IoT Networking, Cloud Computing Case Studies, Sensor Cloud, Fog Computing. Case Studies of IoT: Smart homes and Smart Cities, connected vehicles, Smart Grid, Healthcare IoT.

References:

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy, *Introduction to IoT*, Cambridge University Press, 2021.
2. Adrian McEwen, Hakim Cassimally, *Designing the Internet of Things*, Wiley publication, 1st Edition, November 2013.
3. Honbo Zhou, *The Internet of Things in the Cloud: A Middleware Perspective*, CRC Press, 2012.
4. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), *Architecting the Internet of Things*, Springer, 2011.
5. Olivier Hersent, David Boswarthick, Omar Elloumi, The *Internet of Things – Key applications and Protocols*, Wiley, 2012.
6. https://onlinecourses.nptel.ac.in/noc22_cs53/preview

CS0010: PRINCIPLES OF MACHINE LEARNING [3 0 0 3]

Introduction to Artificial Intelligence: Foundations, scope, problems. Problem-solving through Searching: forward and backward, state-space, blind, heuristic, problem-reduction, minimax. Supervised Learning: Process for feature selection, over-parameterization and the curse of dimensionality, regularization, cross validation. Classification: operation of classifiers, regression as a classifier, metrics used to evaluate classifiers, SVM, Naïve Bayes, KNN. Regression: operation of regression models, prediction and forecasting, metrics used to evaluate regression models. Neural networks: Feed forward NN, Feed backward NN, Convolutional Neural network. Unsupervised Learning: K-mean clustering. Algorithmic Learning Theory and Applications: Mistake bound model, PAC Model.

References:

1. G. F. Luger, W. A. Stubblefield, *Artificial Intelligence - Structures and Strategies for Complex Problem Solving*. (5e), Addison Wesley, 2005.
2. P Baldi, S Brunak, *Bioinformatics: A Machine Learning Approach,* (2e) MIT Press, 2002.
3. T. M. Mitchell, *Machine Learning*, McGraw-Hill Education, 2017.
4. Y Abu-Mostafa, M. Magdon-Ismail, H.T. Lin, H-T*. Learning from Data*. AML Book, 2012.
5. https://nptel.ac.in/courses/106106139

CS0051: HTML, CSS, AND JAVASCRIPT FOR WEB DEVELOPERS [3 0 0 3]

Introduction to HTML5, introduction to CSS3, Coding the static restaurant site, introduction to JavaScript, using JavaScript to build web applications.

References:

1. R. Connolly, R. Hoar, *Fundamentals of Web Development*, Pearson Education India, 2015.
2. R. Nixon, *Learning PHP, MySQL & JavaScript with jQuery, CSS and HTML5*, (5e), O'Reilly Publications, 2018.
3. N. C. Zakas, *Professional JavaScript for Web Developers*, (3e), Wrox/Wiley India, 2019.
4. https://www.coursera.org/learn/html-css-javascript-for-web-developers, https://www.coursera.org/learn/duke-programming-web

CS0052: NETWORKING AND SECURITY IN IOS APPLICATIONS [3 0 0 3]

Introduction, Using Secure Web APIs: an Instagram Case Study, Push notifications, securely storing data on the iOS platform called Core Data.

References:

1. Academy, *Json for Beginners: Your Guide to Easily Learn Json in 7 Days,* Zaccheus Entertainment, 2017.
2. N. C. Zakas, *Professional JavaScript for Web Developers,* (3e), Wrox/Wiley India, 2019.
3. https://www.coursera.org/learn/security, https://www.coursera.org/learn/managing-network-cybersecurity

CS0053: FUNDAMENTALS OF IOT SECURITY [3 0 0 3]

Basic Concepts: Fundamentals, Architecture of IoTs, IoT Security Requirements, IoT Privacy Preservation Issues. Attack Models: Attacks to Sensors in IoTs, Attacks to RFIDs in IoTs, Attacks to Network Functions in IoTs, Attacks to Back-end Systems. Security Services: Security in Front-end Sensors and Equipment, Prevent Unauthorized Access to Sensor Data, M2M Security, RFID Security, Cyber-Physical Object Security, Hardware Security, Front-end System Privacy Protection. Networking Function Security: IoT Networking Protocols, Secure IoT Lower Layers, Secure IoT Higher Layers, Secure Communication Links in IoTs. Back-end Security: Secure Resource Management, Secure IoT Databases. Security Products: Existing Testbed on Security and Privacy of IoTs, Commercialized Products.

References:

1. F. HU, *Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations,* CRC Press, First Edition, 2016.
2. Russell, Brian and Drew Van Duren, *Practical Internet of Things Security*, Packt Publishing, First Edition, 2016.
3. O. Whitehouse, *Security of Things: An Implementers' Guide to Cyber-Security for Internet of Things Devices and Beyond*, NCC Group, First Edition, 2014.
4. https://www.coursera.org/lecture/aws-iot-developing-and-deploying-an-internet-of-things/iot-security-oGiF6 https://www.coursera.org/learn/iot-cyber-secrity

CS0054: ENTERPRISE RESOURCE PLANNING [3 0 0 3]

ERP Overview: ERP Components, ERP Benefits. Business Process Reengineering (BPA): BPA life cycle, BPA components. Data warehousing, Datamining, Supply chain Management; ERP: evolution, a Manufacturing Perspective, ERP Module, ERP Market, ERP implementation life cycle, Options of various paradigms, Identification of suitable platforms. SDLC/SSAD: Role of SDLC/SSAD, Object oriented architecture. ERP Implementation: introduction, pre-evaluation screening, package evaluation, project planning phase, Gap analysis, Hidden costs, Major Vendors, Consultant Employees, Human Resource. ERP & E-Commerce: Future Directives- in ERP, ERP and Internet, Critical Factors guiding selection and evaluation of ERP, Strategies for its successful implementation, Impediments, and initiatives to achieve success, Critical success and failure factors, Integrating of ERP into organizational culture. Using ERP tool: Case study of a system using SAP or ORACLE or open-source ERP.

References:

1. S. R. Magal, J. Word, Integrated Business Processes with ERP Systems, (2e), John Wiley & Sons, 2011.
2. M. Sumner, Enterprise Resource Planning, Pearson Education, (2e), 2006.
3. E. Monk, B. Wagner, Concepts in Enterprise Resource Planning, (3e), Thomson Course Technology, 2006.
4. https://www.coursera.org/lecture/advanced-manufacturing-enterprise/enterprise-resource-planning-erp-MAUTK

CS0080: INTRODUCTION TO DATA SCIENCE USING R [3 0 0 3]

Introduction to statistics with R, Introduction to probability and data, Introduction to data: Data basics, Observational studies & experiments, Sampling and sources of bias, Experiment design, Introduction to R studio, Exploratory data analysis and Introduction to inference, Exploring Numerical Data: Visualizing Numerical Data, Measure of Center, Measure of Spread, Robust Statistics, Transforming Data, Exploring Categorical Data: Exploring Categorical Variable, Introduction to Inference, Introduction to Probability, Defining probability: Introduction, Disjoint Event + General addition rule, Independence, Disjoint vs Independence, Conditional Probability: Introduction, Probability trees, Bayesian Inference, Unit-4: Probability Distribution, The normal distribution: Introduction, Evaluating the normal distribution, Working with normal distribution, Binomial distribution: Normal Approximation to binomial: Working with binomial distribution, Data analysis project

References:

1. David Diez, Mine C., Christopher D Barr, *OpenIntro Statistics*, (4e), 2019
2. Garrett Grolemund, *Hands-on programming with R: Write your own functions and simulations*. O'Reilly Media Inc, 2014
3 Kenneth Baclawski, *Introduction to Probability with R*, CRC Press, 2008.

CS0081: Robotic Process Automation [3 0 0 3]

Programming concept basic & Recap: Data types, loops statements, conditional statements, switch case. Introduction to Robotic Process Automation (RPA): scopes and techniques of automation, What can RPA do, RPA components and various RPA platforms, The future of automation, What Processes can be Automated, Types of Bots, Applications and Benefits of RPA, Introduction to UiPath as RPA platform, UiPath Studio, UiPath robot, and UiPath Orchestrator. RPA basics: Types of Projects in RPA- Sequence, Flowcharts, and State machines. Variables, Arguments, Data Types and Control flow: flow chart activities and sequences activities. Data Manipulation: Text Manipulation, Data Manipulation, Scalar variables, collections, and Data Tables. Recording Introduction: Basic and Desktop Recording, Web Recording, Input/Output Methods, Screen Scraping, Data Scraping, Scrapping Using OCR. Selectors: Defining and Assessing Selectors, Customization, Debugging, Dynamic Selectors, Partial Selectors, RPA Challenge. Image, Text and introduction of Citrix Automation. Excel Data Tables & PDF: Data Tables in RPA, Excel and Data Table basics, Data Manipulation in excel, Extracting Data from PDF, Extracting a single piece of data, Anchors. Email Automation: Incoming Email automation, Sending Email automation. Debugging and Exception Handling: Common exceptions and ways to tackle them, Strategies for solving issues, Catching errors. Deploying and Maintaining the Bot: Introduction to Orchestrator, control the bots, connecting a Robot to Server, Deploy the Robot to Server, Publishing and managing updates. Capstone Project.

References:

1. Alok Mani Tripathi, *Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool–UiPath*, Packt Publishing Ltd, 2018.
2. Richard Murdoch, *Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks & Become an RPA Consultant*. Richard Murdoch & RPA Ultra, 2018
3. Lim Mei Ying, *Robotic Process Automation with Blue Prism Quick Start Guide: Create software robots and automate business processes*, (1e), Packt Publishing, 2018
4. Gerardus Blokdyk, *RPA Robotic Process Automation*, (2e), 5Starcook, 2018
5. Kelly Wibbenmeyer, *The Simple Implementation Guide to Robotic Process Automation (RPA): How to Best Implement Rpa in an Organization*, iUniverse, 2018