Syllabus

for

2-Years M. Tech. in Computer Science and Engineering

Effective from 2019-2020 Academic Session

Department of Computer Science and Engineering
National Institute of Technology Sikkim
South Sikkim - 737 139

First Semester

CS 21101	Advanced Data Structures and Algorithms	3-0-0	3

Module 1[10L]: Introduction to Data Structures: Link lists: Single, doubly and Circular linked list, Stack and Queue, Binary search tree (BST): Insertion and deletion of nodes in BSTs, Querying a BST (finding max, min or a given node). **AVL Tree** (all Rotations). Asymptotic notations. **Hashing –** Direct-address tables, open addressing, hash functions. **Amortized Cost Analysis**: Aggregate Analysis, Accounting Method, and Potential Method.

Module 2 [10L]: Multi-way Search Trees: B Tree, B+ Trees. **Red-Black Trees**: Insertion and all Rotations, deletion and all Rotations, Complexity Analysis of all operations, Comparison between AVL tree and RB tree, When to use what? **Binary heap, Binomial Heaps:** insertion and deletion of elements, finding maximum and minimum element. **Fibonacci Heaps:** insertion and deletion of elements, finding maximum and minimum element.

Module 3 [10L]: Greedy Algorithm: The idea. Example problems – fractional knapsack problem, activity selection problems**. Divide and Conquer Algorithms**: Master Theorem, Maximum sum subarray, Strassen's Matrix multiplication. **Dynamic Programming:** rod cutting, coin change, matrix-chain multiplication, longest common subsequence. **Overview of Backtracking:** N-queen problem.

Module 4 [10L]: Universal Turing Machine**,** NP-Hard and NP complete problems: The Cook-Levin Theorem, The Class P and NP, Reducibility and NP-completeness, Independent Set (IS) problem, Hamiltonian Path problem, 3-Color (Graph coloring with 3 colors) problem and their proof of NP-Completeness. **Approximation algorithms:** Introduction, Approximation algorithm for The Vertex Cover Problem, Travelling salesman problem (TSP), knapsack, bin packing. **Computational Geometry:** Line segments and determine whether any pair of segments intersects. Plane Sweep Techniques with its applications, Convex Hull problem (Extreme point algorithm, incremental algorithm, divide & conquer approach).

Books:

1. E. Horowitz, S. Sahni and S. Anderson-Freed, Fundamental of data Structure in C, W.HFreen Co.
2. A. V Aho, J. D Ullman and J. E Hopcroft, Data Structures and Algorithms, Addison Wesley.
3. S. Lipschutz, Data Structures, Schaum's Outlines Series, TMH.
4. Aaron M. Tenenbaum, Y. Langsam, Moshe J. Augenstein, Data Structures Using C.
5. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, MIT Press.
6. E. Horowitz, S. Sahni and S. Rajasekeran, Computer Algoritms, Silicon Press

CS 21102	Computational Mathematics	3-0-0	3

Module 1[5L]: Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains.

Module 2[5L]: Random samples, sampling distributions of estimators**,** Methods of Moments and Maximum Likelihood**.**

Module 3[8L]: Statistical inference**,** Introduction to multivariate statistical models: regression and classification problems, principal components analysis**,** The problem of overfitting model assessment.

Module 4[8L]: Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems.

Module 5[8L]: Applications in CSE: Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

Module 6[6L]: Recent Trands in various distribution functions in mathmatical field of computer science for varying fields like bioinformatics, soft computing, and computer vision.

Books:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley

Second Semester

CS 21103	Advanced Computer Networks	3-0-0	3

Module 1[10L]: Review of Networking Concepts. MAC layer issues: MAC protocols for high-speed LANS, MANs, wireless LANs and mobile networks, VLAN. Fast access technologies, Ethernet 802.3, ARP, IP addressing and Sub-netting, NAT and PAT, Variable Length Subnet Masking, CIDR

Module 2 [10L]: End to End protocols (10) TCP connection establishment and termination, Sliding window concepts, other issues: wraparound, silly window syndrome, Nagle's algorithm, adaptive retransmission, TCP extensions. Congestion and flow control, Queuing theory, TCP flavors: Tahoe, Reno, New-Reno, TCP-SACK, TCP-RED and TCP-Vegas. Transport protocol for real time (RTP), Quality of service: Integrated Services, Differentiated services, TCP extensions for high-speed networks, transaction-oriented applications.

Module 3 [10L]: Routing and Multicast. Structure of internet: Autonomous systems, Intra-domain routing: OSPF and RIP, Inter-domain routing: BGP. Multicasting: Group Management (IGMP), Internet scale multicasting: Reverse path broadcast, MOSPF, DVMPRP, PIM. IPv6: Why IPv6, basic protocol, extensions and options, support for QoS, security, neighbour discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6, 6bone. IP Multicasting, wide area multicasting, reliable multicast. Routing layer issues, ISPs and peering, BGP, IGP, Traffic Engineering, Routing mechanisms: Queue management, packet scheduling. MPLS, VPNs

Module 4 [10L]: Peer to peer and overlay networks. Concept of overlays, Unstructured Overlays: overlay networks, Internet traffic modelling, P2P Network, Gnutella, Concepts of Distributed Hash Table, Structured Overlays: Chord, CAN, Pastry.

Books:

1. Computer Networks: A Systems Approach, by Peterson and Davie, 5th Ed. Morgan Kauffman, 2011
2. Computer Networking: Top Down Approach, by Kurose and Ross, 6th Ed. Pearson, 2011

Reading List:

1. V. Paxson. "End-to-end Internet packet dynamics," in IEEE/ACM Transactions on Networking, Vol. 7, No 3, June, 1999.
2. W. Stevens, "TCP Slow Start, Congestion Avoidance, Fast Retransmit, and Fast Recovery Algorithms," RFC2001.3. K. Fall and S. Floyd, "Simulation-based comparison of Tahoe, Reno, and SACK TCP," Computer Communication Review, vol. 26, pp. 5--21, July 1996.
3. L. Brakmo and L. Peterson, "TCP Vegas: End-to-End Congestion Avoidance on a Global Internet," IEEE Journal on Selected Areas in Communications, 13(8), October 1995, 1465--1480.
4. Stoica, I., Morris, R., Karger, D., Kaashoek, F., Balakrishnan, H.: Chord: A scalable peer-to-peer lookup service for Internet applications.
5. Rowstron, A., Druschel, P.: Pastry: Scalable, decentralized object location and routing for large-scale peer to peer system

CS 22102	Advanced Topics in Database Management Systems	3-0-0	3

Module 1 [15L]: Review of DBMS concepts

Formal review of relational database, Applications of DBMS, FDs Implication, Closure and its correctness, 3NF and BCNF, Minimal Cover of Functional Dependency, Decomposition and synthesis approaches, Review of relational algebra and SQL, Basics of query processing. Dependency preservation, Lossless join decomposition, Multi-values dependency, 4NF, Join dependency.

Module 2[10L]: Transactions, Serializability and Concurrency Control

Concurrent executions, Serializability view and conflict serializability, Recoverability, Lock based protocols, Timestamp based protocols, Validation based protocols, Deadlock handling, Insert and delete operations, Failure classification, Recovery and atomicity, Log based recovery, Shadow paging, Buffer management, Remote backup systems.

Module 3[10L]:

Distributed Databases [5L]

Homogeneous and heterogeneous databases, Distributed transactions, Commit protocols, Concurrency control in distributed databases.

Hashing and Indexing, Inverted Index, Query Optimization [5L].

Module 4[5L]: Advanced Data Types and Advanced applications

Time in databases, Spatial and geographic databases, Multimedia databases, Knowledge discovery and data mining, Data mining functionalities, Classification of data mining systems, Data warehousing concepts, Slicing, Dicing schemas.

Books:

1. Fundamentals of Database Systems by Ramez Elmasri, Shamkant B. Navathe, Elmasri, PEARSON
2. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, Database System Concepts 6th Ed, McGraw Hill, 2010.
3. R. Ramakrishnan, J. Gehrke, Database Management Systems, McGraw Hill, 2004
4. J. Gray and A. Reuter, Transaction Processing, Concepts and Techniques, Morgan Kauffman, 1994.
5. J. D. Ullman, Principles of Database Systems, Galgotia
6. Han, J. and Kamber, M., “Data Mining: Concepts and Techniques”, 2nd Ed., Morgan

List of Elective Subjects

CS2*111	Software Project Management	3-0-0	3

Module 1[9L]: Definition – components of SPM – challenges and opportunities – tools and techniques – managing human resource and technical resource – costing and pricing of projects – training and development – project management techniques

Module 2[9L]: Monitoring & measurement of SW development – cost, size and time metrics – methods and tools for metrics , Classifying software measures, determining what to measure, applying the framework, Software measurement validation .

Module 3[9L]: Quality in SW development – quality assurance – quality standards and certifications – the process and issues in obtaining certifications – the benefits and implications for the organization and its customers – change management.

Module 4[9L]: The risk issues in SW development and implementation – identification of risks – resolving and avoiding risks – tools and methods for identifying risk management, SPM Tools & case study on SPM.

Books:

1. Software Engineering: A Practitioner's Approach by Pressman, MGH, 8th Ed.
2. Software Engineering Project Management by Richard H. Thayer, John Wiley & Sons, 2nd edition.
3. Software Project Management by Royce, Walker, Pearson Education.
4. Software Project Management in Practice by Pankaj Jalote, Pearson Education Inc.
5. Software Project Management by Kelker, S. A., Prentice Hall.

CS2*112	Software Testing	3-0-0	3

Module 1[9L]: Software Verification and Validation- Introduction, Verification, Method of Verification, Validation, Level of Validation, Principle of testing, context of testing in producing software, White Box testing- Definition, Static testing, Structural testing, and Black box testing.

Module 2[9L]: Integration Testing- Scenario Testing, Defect bash, System and acceptance testing- functional, non-functional testing, Performance testing- methodology, tools & Process. Other Important type of testing's used in IT Industry: Regression Testing, Internationalization Testing, Enabling testing, Locale Testing, Language testing, Localization testing, Ad-hoc testing- Overview, Buddy testing, Pair Testing, Exploratory Testing, Iterative testing Agile and Extreme Testing.

Module 3[9L]: Testing of object-oriented systems: Introduction, Primer on object–oriented software's and Differences in object oriented testing. Usability and Accessibility Testing. Test planning, Test Management, Test Process and reporting,

Module 4[9L]: Software Test Automation- Scope of Automation, Design and Architecture of automation, Process Model for Automation, Test metrics and measurement- Type of Metrics, Project Metrics, Productivity Metrics, Progress Metrics, Release Metrics.

Books:

1. Software testing: Principles and Practice by Srinivasan D., Gopalswami R. Pearson Education.
2. Software Testing: Principles by M G Limaye Tata McGraw Hill.
3. Software Engineering by Sommerville Pearson Education.
4. Software Engineering – a practitioner approach by Roger Pressman, 7e, Tata McGraw Hill.
5. Software Testing by Yogesh Singh, TMH

CS2*113	Software Architecture	3-0-0	3

Module 1[6L]: Creation of the Software Architecture, Viewpoint Considerations of the Software Architect & Terminology, Views and Viewpoints Application, Software Architecture Principles, System Structures, Patterns and Anti-Patterns Research Assignment.

Module 2[6L]: Software Construction: Application Development and Visualization, Requirements Validation, Programming Patterns, Selecting the Right Development Methodology, Software Construction, Technology Platforms

Module 3[6L]: Components, Frameworks and Tools: Client Programming and User Experience (UX), Selection of Infrastructure Components, Client, Server and Storage Technologies, Modeling, Workflow, Creation of a Generic Architecture, Database Programming, Database Design and Considerations

Module 4[6L]: Service Network : Asynchronous and Synchronous Distributed Computing, SOA, Applying SOA Principles, Messaging, XML and B2B, Application and Service Management, Connecting the Sum of the Parts

Module 5[6L]: Architectural Process, Methods and Artifacts: Modeling, Applying Design Patterns, Capture and Trace of Software Architecture, Code Quality Analysis, Design Patterns Selection and Application.

Module 6[6L]: Architecture Throughout the Lifecycle: Software Architecture Governance, Working with other Architects, Application Service Transition, SDLC - What it means to the Software Architect, Formal Release Policy, Professional Growth and Mentoring.

Books:

1. Software Architecture in Practice, Len Bass, Paul Clements, Rick Kazman.
2. Documenting Software Architectures: Views and Beyond Paul Clements, Felix Bachmann, Len Bass, David Garlen, James Ivers, Reed Little, Robert Nord, Judith Stafford.

CS2*114	Software Modeling and Design	3-0-0	3

Module 1[8]: Overview of Traditional Software Process Models; Software Requirements and Design Principles, Requirements Analysis, Elicitation and Specification, Effective Modular Design.

Module 2[8]: Agile Software Process: Agile Manifesto, Plan Driven Approach vs Agile Development Process; Agile Methods: Extreme Programming (XP), Adaptive Software Development, Scrum, Crystal, FDD, Lean and DSDM, Agile Practices: Extreme Programming, Continuous Delivery, Refactoring, Working with Legacy Code, Test-Driven Development.

Module 3[8]: Software Configuration Management (SCM): The SCM process, Software Risk Management: Software risks; Software Risk: Risk identification, assessing risk impact, Risk mitigation, monitoring and refinement.

Module 4[8]: Software Quality: Attributes; Specifications; Standards; Assurance and Reliability; Quality through the Lifecycle; ISO/IEC 12207; Quality Management Systems, ISO 9000; Quality Achievement; Quality Control; Quality Preservation; Process Improvement, ISO/IEC 15504 and CMMI.

Module 5[8]: Software Metrics, Process, Product and Project Metrics; Software Measurement; Metrics for Software Quality; Software Project Estimation; Empirical Estimation Model.

Books:

1. R.S. Pressman, Software Engineering - A Practitioner's Approach, McGraw Hill, 7th Edition.
2. Ian Sommerville, "Software Engineering", 9th Edition, Pearson Education, Inc., publishing as Addison-Wesley, 2011

CS2*115	Computer Graphics	3-0-0	3

Module 1[9L]: Introduction and organization of an interactive graphics system, Graphics hardware and display devices; Basic raster graphics algorithms for drawing primitives; Scan conversion; Region filling; Anti-aliasing.

Module 2[9L]: Coordinate Systems - representations, homogenous coordinates, object, camera, world, and screen coordinate system, changing coordinate systems. Transformations - affine transformations, translation, rotation, scaling in homogenous coordinates, matrix representations and their applications. Viewing and Hidden Surface Removal - its importance in rendering, z buffer algorithm, clipping, culling.

Module 3[9L]: Projections - orthographic and perspective projection. Lighting and Shading - light sources, normal computation, reflection models, flat and smooth shading, Introduction to Textures and Mapping - Rendering Techniques - slicing, volume rendering, iso-surface extraction, ray casting, multi resolution representations for large data rendering.

Module 4[9L]: Introduction to Curves Surfaces (Bezier, splines) and Meshes - structured and unstructured, video games and computer animation, GUI: concepts of window programming, open GL programming in Windows / Linux environments.

Books:

1. D. Hearn and M. P. Baker, Computer Graphics, McGraw Hill
2. Z. Xiang and R. A. Plastock, Shaum's Outline of Computer Graphics, McGraw Hill

CS2*116	Computer Vision	3-0-0	3

Module 1 [9L]: Introduction and overview, pinhole cameras, radiometry terminology. Sources, shadows and shading: Local shading models- point, line and area sources; photometric stereo. Color: Physics of color; human color perception, Representing color; A model for image color; surface color from image color.

Module 2 [9L]: Linear filters: Linear filters and convolution; shift invariant linear systems-discrete convolution, continuous convolution, edge effects in discrete convolution; Spatial frequency and fourier transforms; Sampling and aliasing; filters as templates; Normalized correlations and finding patterns. Edge detection: Noise; estimating derivatives; detecting edges. Texture: Representing texture; Analysis using oriented pyramid; Applications; Shape from texture. The geometry and views: Two views.

Module 3 [9L]: Stereopsis: Reconstruction; human stereo; Binocular fusion; using color camera.

Module 4 [9L]: Segmentation by clustering: Human vision, applications, segmentation by graph theoretic clustering. Segmentation by fitting a model, Hough transform; fitting lines, fitting curves.

Books:

1. David A Forsynth and Jean Ponce, Computer Vision- A modern approach, Pearson education series, 2003.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, Digital image processing and computer vision, Cengage learning, 2008.
3. Schalkoff R. J., Digital Image Processing and Computer Vision, John Wiley, 2004.

CS2*117	Pattern Recognition	3-0-0	3

Module 1[9L]: Introduction: Machine Perception, Pattern Recognition Systems, The Design Cycle, Learning and Adaptation. Bay's Decision Theory: Bayes Decision Theory, Minimum Error rate Classification, Classifiers, Discriminant functions and Decision Surfaces, Normal Density, Discriminant functions for the Normal Density, Bayes Decision Theory for Discrete features

Module 2[9L]: Maximum Likelihood and Bayesian Parameter Estimation: Maximum

Likelihood Estimation, Bayesian Estimation, Bayesian Parameter Estimation, Gaussian Case and General Theory.Hidden Markov models; Non Parametric Techniques: Density Estimation, Parzen Windows, K- Nearest Neighbor Estimation, Nearest Neighbour rule, Metrics and Nearest Neighbour Classification, Fuzzy Classification, *k*-Means Clustering, Self-Organizing Maps.

Module 3[9L]: Linear Discriminant Functions: Linear Discriminant Functions and Decision Surfaces, Generalized Discriminant Functions, The two-category linearly separable case, Minimizing the perceptron criterion function, relaxation procedures, non- separable behaviour, Minimum Squared- Error procedures. Support vector machines, Algorithm-independent machine learning-Bias and Variance, Bootstrapping-Adaboost Algorithm, Boosting, Bagging

Module 4[9L]: Multi-Layer Neural Networks: Feed-forward Operation, Classification, Back – propagation Algorithm, Error Surfaces, Back-propagation as Feature mapping, Radial Basis Function Networks, Decision trees: Axis-parallel, Oblique, Impuritymeasures; Graphical Model,

Books:

1 R. O. Duda, P. E. Hart and D. G. Stork, Pattern classification, John Wiley & Sons, 2002.
2 C. M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.
3 V. N. Vapnik, The Nature of Statistical Learning Theory, Springer, 2000.
4 N. Cristianini and J. Shawe-Taylor, An Introduction to Support Vector Machines, Cambridge University Press, 2000.

CS2*118	Compiler Design	3-0-0	3

Module 1 [9L]: Introduction to Compiling**:** Compilers – Analysis of the source program – Phases of a compiler – Cousins of the Compiler – Grouping of Phases – Compiler construction tools – Lexical Analysis – Role of Lexical Analyzer – Input Buffering – Specification of Tokens.

Module 2 [9L]: Syntax Analysis**:** Role of the parser –Writing Grammars –Context-Free Grammars – Top Down parsing – Recursive Descent Parsing – Predictive Parsing – Bottom-up parsing – Shift Reduce Parsing – Operator Precedent Parsing – LR Parsers – SLR Parser – Canonical LR Parser – LALR Parser.

Module 3 [9L]: Intermediate code generation: Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples);
Introduction– Principal Sources of Optimization – Optimization of basic Blocks – DAG representation of Basic Blocks - Introduction to Global Data Flow Analysis

Module 4 [9L]: Runtime Environments – Source Language issues – Storage Organization – Storage Allocation strategies – Access to non-local names – Parameter Passing, Error detection and recovery. Code Optimization: Introduction, basic & flow graph. Peephole optimization

Books:

1. Aho, Sethi and Ullman, Compiler Principles, Techniques and Tools, Pearson Education.
2. Holub, Compiler Design in C, PHI.

CS2*119	Web Programming	3-0-0	3

Module 1 [9L]: Internet and its architecture, Client Server Networking - Creating an Internet Client, Application Protocols and http, Presentation aspects html, CSS and Java script, Creating a web server, Serving Dynamic Content- CGI – overview of technologies like PHP – applets – JSP. Implementation

Module 2[9L]: Web server architecture, Programming threads in C, Shared memory synchronization, Performance measurement and workload models. Comparison using existing benchmarks.

Module 3[9L]: Web development frameworks – Detailed study of one open source web framework - Ruby Scripting, Ruby on rails – Design, Implementation and Maintenance aspects.

Module 4[9L]: Service Oriented Architecture – SOAP. Web 2.0 technologies. – AJAX. Development using Web2.0 technologies. Introduction to semantic web.

Books:

1. Dave Thomas, with Chad Fowler and Andy Hunt. Programming Ruby: The Pragmatic Programmer's Guide (3/e), Pragmatic Programmers, May 2008.
2. Balachander Krishnamurthy and Jennifer Rexford. Web Protocols and Practice: HTTP/1.1, Networking Protocols, Caching, and Traffic Measurement (1/e), Addison Wesley Professional, 2001

CS2*120	VLSI Design	3-0-0	3

Module 1 [9L]: Introduction: Introduction to IC Technology – MOS, PMOS, NMOS, CMOS & BiCMOS, Basic Electrical Properties: Basic Electrical Properties of MOS and BiCMOS Circuits: IdsVds relationships, MOS transistor threshold Voltage, gm, gds, Figure of merit ωo; Pass transistor, NMOS Inverter, Various pull ups, CMOS Inverter analysis and design, Bi-CMOS Inverters.

Module 2 [9L]: VLSI Circuit Design Processes: VLSI Design Flow, MOS Layers, Stick Diagrams, Design. Rules and Layout, 2 µm CMOS Design rules for wires, Contacts and Transistors Layout Diagrams for NMOS and CMOS Inverters and Gates, Scaling of MOS circuits.

Module 3[9L]: Gate Level Design: Logic Gates and Other complex gates, Switch logic, Alternate gate circuits, Time delays, Driving large capacitive loads, Wiring capacitance, Fan – in, Fan – out, Choice of layers.

Module 4 [9L]: Data Path Subsystems: Subsystem Design, Shifters, Adders, ALUs, Multipliers, Parity generators, Comparators, Zero/One Detectors, Counters. Array Subsystems: SRAM, DRAM, ROM, Serial Access Memories. **Programmable Logic Devices:** PLAs, FPGAs, CPLDs, Standard Cells, Programmable Array Logic, Design Approach, Parameters

influencing low power design. CMOS Testing: CMOS Testing, Need for testing, Test Principles, Design Strategies for test, Chip level Test Techniques.

Books:

1. Essentials of VLSI circuits and systems – Kamran Eshraghian, Eshraghian Dougles and A. Pucknell, PHI, 2005 Edition
2. CMOS VLSI Design – A Circuits and Systems Perspective, Neil H. E Weste, David Harris, Ayan Banerjee, 3rd Ed, Pearson, 2009.
3. CMOS logic circuit Design – John .P. Uyemura, Springer, 2007.
4. Modern VLSI Design – Wayne Wolf, Pearson Education, 3rd Edition, 1997.

CS2*121	Embedded System	3-0-0	3

Module 1[8L]: INTRODUCTION TO EMBEDDED SYSTEMS

Embedded system model – embedded standards – block diagrams – powering the hardware - embedded board using von Neuman model. EMBEDDED processors: ISA architecture models – application specific ISA models – general purpose ISA models – instruction level parallelism.

Module 2[7L]: REAL-TIME ENVIRONMENT 9 Hours

Real-time computer system requirements – classification of real time systems – simplicity – global time – internal and external clock synchronization – real time model. Real – time communication – temporal relations – dependability.

Module 3[7L]: REAL-TIME OPERATING SYSTEMS 9 Hours

Real –time communication – event triggered – rate constrained – time triggered. Inter component communication – task management – dual role of time – inter task interactions – process input/output – agreement protocols – error detection.

Module 4[7L]: SYSTEM DESIGN 9 Hours

Scheduling problem - static & dynamic scheduling – system design – validation – time–triggered architecture.

Module 5[7L]: CASE STUDY ON PROGRAMMING EMBEDDED SYSTEMS 9 Hours

Building the blinking LED program-eCos Examples-Embedded linux examples-Extending functionality-optimization techniques.

Books:

3. Embedded system architecture by Tammy Noergaard, 2nd Edition , Elsevier, 2012
4. Real–Time systems – Design Principles for distributed Embedded Applications by Hermann Kopetz, 2nd Edition, Springer 2011
5. Programming Embedded Systems-With C and GNU Development Tools by Michael Barr, Anthony Massa, 2nd Edition, O'Reilly Media, 2009.
6. Embedded Systems – Architecture Programming and Design by Raj Kamal, Tata McGraw Hill, 2nd Edition, 2011.

CS2*122	Real Time Systems	3-0-0	3

Module 1[10L]: Introduction to Real-time systems, Issues in Real-time Systems, Real-time System Components, Classification of Real-time systems and Real-time tasks. Misconceptions about real-time computing. Real-time System requirements: Speed, Predictability, reliability, adaptability. Specification of timing constraints

Module 2[10L]: Real-time scheduling: Requirements and Issues, Terminology, modeling, Introduction static and dynamic scheduling schemes, cyclic scheduling, priority driven scheduling of periodic tasks, schedulability tests.

Module 3[10L]: Aperiodic task scheduling: fixed priority server/non-server based scheduling algorithms. Practical factors/overheads.

Module 4[10L]: Task Synchronization: Need and priority inversion problem, Priority Inheritance protocol, priority ceiling protocol and stack-based priority ceiling protocol for fixed priority preemptive system. Introduction to multiprocessor real-time systems, problems and issues. An overview of a real-time operating system.

Books

1. J.W.S.Liu: Real-Time Systems, Pearson Education Asia.
2. Rajib Mall, "Real-Time Systems: Theory and Practice," Pearson, 2008.
3. S.T.Lavi, A.K.Agrawala: Real-time system Design, McGraw Hill.
4. P.A.Laplante: Real-time Systems Design and Analysis, An Engineer's Handbook, IEEE Press.
5. P.D.Laurence, K.Mauch: Real-time Microcomputer System Design, An Introduction, McGraw Hill.
6. Krishna and Shin, "Real-Time Systems," Tata McGraw Hill. 1999.

CS2*123	Deep Learning	3-0-0	3

Module 1[9L] Introduction to Deep Learning: Why Deep Learning? What is a neural network? Three reasons to go Deep, Your choice of Deep Net, An old problem: The Vanishing Gradient.

Module 2[9L] Deep Learning Models: Restricted Boltzmann Machines, Deep Belief Nets, Convolutional Networks, Recurrent Nets. **Additional Deep Learning Models**: Autoencoders, Recursive Neural Tensor Nets, Deep Learning Use Cases.

Module 3[9L] Introduction to various CNN Architectures: VGG16, VGG19, Alex Net, Google Net, ResNet, etc. **Sequence Models:** RNN, LSTM, BURT, Image captioning, visual question answering, Generative Adversarial Networks (GAN) models, Deep Reinforcement Learning and Network Visualization.

Module 4[9L] Deep Learning Platforms and Software Libraries: What is a Deep Learning Platform? H2O.ai, Dato GraphLab, What is a Deep Learning Library? CPUs, GPUs, TPUs, PyTorch, Theano, Caffe, TensorFlow, Dynamic vs Static computation graphs

Books:

1. Neural Networks and Deep Learning: A Textbook Book by Charu C. Aggarwal
2. Deep Learning: A Practitioner's Approach Book by Adam Gibson and Josh Patterson
3. Deep Learning by Aaron C. Courville, Ian Goodfellow, and Yoshua Bengio

CS2*124	Natural Language Processing	3-0-0	3

Module 1[9L]: Basic Concepts: Importance of Natural Language Processing, Ambiguity of Language, Lexical Resources, Word counts, Zipf's Law, Collocations and Concordance, An overview of Information Theory – Entropy, Joint entropy and conditional entropy, Mutual information, Noisy Channel model, Kullback-Leibler divergence, Cross entropy, The entropy of English Language, Perplexity.
Linguistic Essentials: Parts of Speech and Morphology, Phrase Structure – Phrase Structure Grammars, Arguments and Adjuncts, X' Theory, Phrase Structure Ambiguity, Semantics and Pragmatics. Corpus-based work – Tokenization, Morphology, Sentences, Markup schemas, Grammatical Tagging.

Module 2[9L]: Collocations: Frequency, Mean and Variance, Hypothesis testing: t test, Hypothesis testing of differences, Pearson's chi-square test, Likelihood ratios, Mutual Information, The notion of collocation.
n-gram Models over Sparse Data: Bins - Forming Equivalence Classes, n-gram models, Buildin n-gram models, Statistical Estimators – MLE, Laplace Law, Lidstone Law, Jeffreys-Perks Law, Held-out estimation, Cross-validation, Good-Turing estimation. Combining Estimators - Simple linear interpolation, Katz's backing-off, General linear interpolation.
Word Sense Disambiguation: Overview of Supervised and Unsupervised Learning, Pseudowords, Supervised Disambiguation, Dictionary-based Disambiguation, Unsupervised Disambiguation, Word Sense.
Lexical Acquisitions: Evaluation Measures, Verb Subcategorization, Attachment Ambiguity, Selection Preferences, Semantic Similarity.

Module 3[9L]: Part-of-Speech Tagging: Concept of Markov Models and Hidden Markov Models, Information source of Tagging, Markov Model Taggers – probabilistic model, Viterbi Algorithm, variations, Hidden Markov Model Taggers, Transformation-based Learning of tags – Transformations, The Learning Algorithm, Tagging Accuracy and uses of Taggers.
Probabilistic Parsing: Probabilistic Context Free Grammars. The probability of a string. Parsing for Disambiguation, Treebanks, Tree probabilities and Derivational probabilities, Phrase structure grammars and Dependency grammars, Evaluation, Building Parsers – Search methods, use of the Geometric Mean.

Module 4[9L]: Statistical Alignment: Text alignment, Word alignment, Statistical Machine Translation. **Clustering:** Hierarchical Clustering – Single-link and Complete-link, Group-average agglomerative, Non-hierarchical Clustering – K-means, EM Algorithm.

An overview of Information Retrieval: Common design features, Evaluation measures, Probability Ranking Principle, Vector Space Model, Term Distribution Models, Latent Semantic Indexing, Discourse segmentation.
Text Categorization: Decision Trees, Maximum Entropy Modelling, Perceptrons, k Nearest Neighbor Classification.

Books:

1. Foundation of Statistical Natural Language Processing by Christopher D. Manning

CS2*125	Internet of Things	3-0-0	3

Module 1[8L]: Overview- IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management.

Module 2[8L]: Reference Architecture- IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference ArchitectureIntroduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.

Module 3[8L]: IoT Data Link Layer & Network Layer Protocols- PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART,Z-Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP.

Module 4[8L]: Transport & Session Layer Protocols - Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT.

Module 5[8L]: Service Layer Protocols & Security: Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC 802.15.4, 6LoWPAN, RPL, Application Layer

Books:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1 st Edition, Academic Press, 2014.
2. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM – MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
4. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118- 47347-4, Willy Publications

5. Vijay Madisetti and ArshdeepBahga, “Internet of Things (A Hands-onApproach)”, 1 st Edition, VPT, 2014.

CS2*126	Mobile Computing	3-0-0	3

Module 1[9L]: INTRODUCTION: Mobile Computing – Mobile Computing Vs wireless, Networking – Mobile Computing Applications – Characteristics of Mobile computing-Structure of Mobile Computing Application. MAC Protocols – Wireless MAC Issues – Fixed, Assignment Schemes – Random Assignment Schemes – Reservation Based Schemes.

Module 2[9L]: MOBILE INTERNET PROTOCOL AND TRANSPORT LAYER: Overview of Mobile IP – Features of Mobile IP – Key Mechanism in Mobile IP – route Optimization. Overview of TCP/IP – Architecture of TCP/IP- Adaptation of TCP Window – Improvement in TCP Performance.

Module 3[9L]: MOBILE TELECOMMUNICATION SYSTEM: Global System for Mobile Communication (GSM) – General Packet Radio Service (GPRS) – Universal Mobile Telecommunication System (UMTS).
MOBILE AD-HOC NETWORKS: Ad-Hoc Basic Concepts – Characteristics – Applications – Design Issues – Routing – Essential of Traditional Routing Protocols –Popular Routing Protocols – Vehicular Ad Hoc networks (VANET) – MANET Vs VANET – Security.

Module 4[9L]: MOBILE PLATFORMS AND APPLICATIONS: Mobile Device Operating Systems – Special Constrains & Requirements – Commercial Mobile Operating Systems – Software Development Kit: iOS, Android, BlackBerry, Windows Phone – MCommerce – Structure – Pros & Cons – Mobile Payment System – Security Issues.

Books:

1. Mobile Communications by Jochen H. Schller, Second Edition, Pearson Education, New Delhi, 2007.
2. Introduction to Wireless and Mobile systems by Dharma Prakash Agarval, Qing and An Zeng, Thomson Asia Pvt Ltd, 2005.

CS2*127	Mainframe Technology	3-0-0	3

Module 1[10L]: Mainframe Applications: Characteristics of Mainframe Applications**,** Classes of Mainframe applications, Batch**,** On-line, Interactive, Inter/Intra/Extranet, Network Capabilities, Application Development, High Level Languages, Standard Utilities, Other Utilities.

Module 2[10L]: Mainframe Components: CPUs, Main Storage, Channels, Control Units, Direct Access Storage Device (DASD), Tape Devices, Printers & Card Readers, Terminals, Operating System, System Operation, Maintenance.
OS Components: Features, Virtual Storage, Swapping, Paging, Multiprogramming, Spooling, Sub-Systems, Usage Modes, Batch Processing, Time Sharing Data Sets.

Module 3[10L]: Catalogs, VTOC and DASD labels, Tape Labels, Naming Convention, Generation

Data Groups, Data Security, Archiving, Backup.

OS Processing:

Data Set Access, File Organization, Record Organization, Access Strategies, Databases: Concepts, Hierarchical Databases, Network Databases, Relational Databases.

Batch Processing: Jobs, JCL, Job Entry Subsystem (JES), Job Submission, Job Scheduling, Initiators, Job Execution, Output Processing, Scheduling Extensions, Audit Extensions, Output Extensions.

Module 4[6L]: OS TP Monitors and Tools

TP Monitors, SNA/VTAM, CICS/VS, IMS, VM/CMS, TSO

CS2*128	Fog and Edge Computing	3-0-0	3

Module 1[9L]: Fog and Edge Computing Completing the Cloud, Advantages of FEC: SCALE, How FEC Achieves, These Advantages: SCANC, Hierarchy of Fog and Edge Computing, **Addressing the Challenges in Federating Edge Resources.**

Module 2[9L]: Optimization Problems in Fog and Edge Computing, Middleware for Fog and Edge Computing: Design Issues.

Module 3[9L]: Data Management in Fog Computing.

Module 4[9L]: Applications and Issues.

Books:

1. Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama.

CS2*129	Search Engine Optimization	3-0-0	3

Module 1[6L]: Basics for SEO: What is Domain? Basic Knowledge of World Wide Web, Difference between Portal and Search Engines, What is SEO, Types of SEO Techniques, Black hat techniques, White Hat techniques, How Search Engine works.

Module 2[5L]: SEO Research & Analysis, Market Research, Keyword Research and Analysis, Keyword opportunity, Competitors Website Analysis, SWOT Analysis of Website, How to Choose Best Keywords, Tools available for Keyword Research.

Module 3[5L]: Website Design SEO Guidelines: Content Research, Content Guidelines, Content Optimization, Design & Layout, XML Sitemap / URL List Sitemap.

Module 4[5L]: On-page Optimization: The Page Title, Meta Descriptions & Meta Keywords, Headings, Bold Text, Domain Names & Suggestions, Canonical Tag, Meta Tags, Images and Alt Text, Internal Link Building, The Sitemap, Invisible Text, Server and Hosting Check, Robots Meta Tag, Doorway Pages, 301 Redirects, 404 Error, Duplicate content.

Module 5[5L]: Off-page Optimization: Page Rank, Link Popularity, Link Building in Detail, Directory Submission, Social Bookmark Submission, Blog Submission, Articles, Links Exchange, Reciprocal Linking, Posting to Forums, Submission to Search Engine, RSS Feeds Submissions, Press Release Submissions, Forum Link Building, Competitor Link Analysis.

Module 6[5L]: Analytics: Google Analytics, Installing Google Analytics, How to Study Google Analytics, Interpreting Bars & Figures, How Google Analytics can Help SEO, Advanced Reporting, Webmaster Central & Bing/Yahoo, Open Site Explorer, Website Analysis using various SEO Tools available.

Module 7[5L]: SEO Tools and Reporting: Keyword Density Analyzer Tools, Google Tools, Yahoo / Bing Tools, Rich Snippet Text Tools, Comparison Tools, Link Popularity Tools, Search Engines Tools, Site Tools, Miscellaneous Tools, Google analysis, Tracking and Reporting, Reports Submission, Securing Ranks.

Books:

1. Search Engine Optimization For Flash by Perkins
2. Website Optimization by King

CS2*130	Information Retrieval Techniques and Evaluation	3-0-0	3

Module 1[9L]: Introduction: Basic IR system structure; Retrieval techniques: Boolean retrieval, term-vocabulary, postings-lists, Dictionaries, Entropy of information calculations.

Module 2[9L]: Inverted indices: Preprocessing steps, tokenization, stemming, stop word removal, term weighting; Index Compression: Data Compression Techniques, Huffman Coding, Arithmetic Coding, compressing posting lists.

Module 3[9L]: Models: vector space model, probabilistic model, language models; Evaluation: standard test collection, concept of relevance, precision-recall based metrics, reciprocal rank, DCG; Relevance feedback and query expansion: Rocchio algorithm;Text classification : Naïve Bayes; Text clustering: Flat Clustering, Hierarchical Clustering; XML Retrieval: Basic concepts, Challenges, Evaluation.

Module 4[9L]: Web search: Structure of Web, web graph, Hidden Web, User intent, Web crawl. Link Analysis: Web as a graph, Page Rank, Hubs and Authorities; Sentiment analysis of social networking, Question Answering, Collaborative Searching.

Books:

1. Introduction to Information Retrieval by Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Cambridge University Press. 2008.

CS2*131	Virtual Reality	3-0-0	3

Module 1[8L]: Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environments requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark, 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden

Surface Removal, Realism-Stereographic image.

Module 2[8L]: Geometric Modeling: Introduction – From 2D to 3D – 3D space curves – 3D boundary representation, Geometrical Transformations: Introduction, Frames of reference, Modeling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection, Generic VR system: Introduction, virtual environment, Computer environment, VR Technology, Model of interaction, VR Systems.

Module 3[8L]: Virtual Environment: Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Non-linear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system, Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

Module 4[8L]: VR Hardware and Software: Human factors: Introduction, the eye, the ear, the somatic senses, VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems, VR Software: Introduction, Modeling virtual world, Physical simulation, VR toolkits, Introduction to VRML

Module 5[4L]: VR Applications: Introduction, Engineering, Entertainment, Science, Training
The Future: Virtual environment, modes of interaction

Books:
1. Virtual Reality Systems by John Vince, Pearson Education Asia, 2007.

References:
1. Visualizations of Virtual Reality by Adams, Tata McGraw Hill, 2000.
2. Virtual Reality Technology by Grigore C. Burdea, Philippe Coiffet, Wiley Inter Science, 2nd Edition, 2006.
3. Understanding Virtual Reality: Interface, Application and Design by William R. Sherman, Alan B. Craig, Morgan Kaufmann, 2008.

CS2*132	Bioinformatics	3-0-0	3

Module 1[9L]: Molecular Biology and Biological Chemistry: The Genetic Material, Gene structure and Information Content, Protein Structure and Function, The Nature of Chemical Bonds, Molecular Biology Tools – Biomolecular Operations. C-value Paradox, Reassociation Kinetics.
Data Searches and Pairwise Alignments: Dot Plots, Simple Alignments, Gaps – Simple Gap Penalties, Origination and length penalties. Scoring Matrices. Needleman-Wunsch Algorithm. Global and Local Alignment – Semiglobal alignments, Smith-Waterman Algorithm. Database Searches – BLAST, FASTA, Alignment scores and statistical significance of database searches. Multiple Sequence Alignments.

Module 2[9L]: Substitution Patterns: Patterns of Substitutions within Genes, Estimating Substitution Numbers, Variations in Evolutionary Rates between Genes. Molecular Clocks.
Distance-based Methods of Phylogenetics: Molecular Phylogenetics, Phylogenetic Trees – tree

reconstruction, rooted and unrooted trees, gene vs species trees, character and distance data. Distance Matrix Methods – UPGMA, Estimation of branch lengths, Transformed distance method, Neighbor's relation method, Neighbor-joining methods. Maximum Likelihood Approaches. Multiple Sequence Alignments.

Module 3[9L]: Character-based Methods of Phylogenetics: Parsimony – Informative and Uninformative sites, Unweighted and Weighted Parsimony. Inferred Ancestral Sequences. Strategies for Faster Searches. Consensus Trees. Tree Confidence – Bootstrapping, Parametric Tests, Comparison of Phylogenetic Methods, Molecular Phylogenetics.
Genomic and Gene Recognition – Prokaryotic Genomes, Prokaryotic Gene Structure. GC Content in Prokaryotic Genomes. Prokaryotic Gene Density. Eukaryotic Genomes. Eukaryotic Gene Structure. Open Reading Frames – Introns and exons. GC Content in Eukaryotic Genomes – CpG islands, Isochores, Codon usage bias. Gene Expression. Transposition. Repetitive Elements. Eukaryotic Gene Density.

Module 4[9L]: Protein and RNA Structure Prediction: Amino Acids, Polypeptide Composition, Secondary Structure – Backbone flexibility, Accuracy of predictions, Chou-Fasman and GOR methods. Tertiary and Quaternary Structure – Hydrophobicity, Desulfide bonds, Active structures. Algorithms for Modeling Protein Folding – Lattice models, Off-lattice models, Energy fuctions and optimizations. Structure Prediction – Comparative modeling, Reverse protein folding.
Proteomics: From Genomes to Proteomes. Protein Classification – Enzyme nomenclature, Families and superfamilies, Folds. Experimental Techniques – 2D electrophoresis, Mass spectrometry, Protein microarrays. Inhibitors and Drug Design. Ligand Screening. X-Ray Crystal Structures. NMR Structures. Empirical Methods and Prediction Techniques. Post-translational Modification Prediction.

Books:
1. Fundamental Concepts of Bioinformatics, Krane, Raymer.

CS2*133	Quantum Computing	3-0-0	3

Module 1[8L]: Overview of Quantum Computing: Quantum bits – single qubit and multi-qubit systems. Measurements, Quantum Circuits, Bell states, Quantum Teleportation. Quantum Algorithms - Classical computations on quantum computer, Quantum parallelism, Deutsch's Algorithm, Deutsch-Jozsa Algorithm. Experimental Approach - Stern-Gerlach Experiment. Quantum Information.

Module 2[8L]: Overview of Linear Algebra and Quantum Mechanics: Bases, Linear Operators, Pauli Matrices, Inner products, Adjoints and Hermitian Operators, Tensor Products. Operator functions. The commutator and anti-commutator, Polar and singular value decomposition.
Postulates of Quantum Mechanics: State Space, Evolution, Quantum Measurement, Distinguishing Quantum States, Projective and POVM Measurements, Phase, Composite Systems. Superdense coding. Density Operator – Ensembles of quantum states, General

properties, Reduced Density operators. Schmidt Decomposition and Purifications. EPR and Bell inequality.

Module 3[10L]: Quantum Circuits: Single qubit operations, Controlled operations, Measurement, Universal Quantum Gates, Quantum Circuit model of Computation, Quantum System Simulation – Quantum Simulation Algorithm.
Quantum Search Algorithm: Grover's Search Algorithm – oracle, geometric visualization, performance. Quantum Search as a Quantum Simulation. Quantum Counting. Speeding up the solutions of NP-complete problems. Quantum Search of an unstructured database, optimality, Black Box Algorithm Limits.

Module 4[10L]: Physical Realization of Quantum Computers: Conditions for Quantum Computation, Harmonic oscillator, Optical Photon, Optical Cavity Quantum Electrodynamics, Ion Traps, Nuclear Magnetic Resonance. Current trends in implementation –Quantum hardware designed by D-Wave, IBM QX.
Quantum Error Correction, Quantum Information Theory,-Quantum Cryptography.

Books:
1. Quantum Computation and Quantum Information, Nielsen, Chuang

CS2*134	Nature-Inspired Computing	3-0-0	3

Module 1 [9L]: Introduction, Some Nature Inspired Solutions, Characteristics of Nature not existing in Traditional Computing, Traditional Computing vs Biological Computing.

Module 2 [9L]: Computations in Nature: Social Insects, Immune System, Evolving Population, Brain etc.

Module 3 [9L]: Evolutionary Intelligence, Collective Intelligence, Social Natural Intelligence. Genetic Algorithm, Ant Colony Optimizations, Bees Algorithm, Bat Algorithm, Paddy Field Algorithm, Cuckoo Search Algorithm, Fire-fly Algorithm etc.

Module 4 [9L]: Recent topics in nature inspired computing.

Books:
1. Nature Inspired Algorithm for Optimization by Raymond Chiong, Springer.
2. Nature Inspired Optimization Algorithms by Xin-She yang, Elsevier.
3. Nature Inspired Metaheuristics Algorithms by Xin-She yang, Luniver Press

CS2*135	Information Theory and Coding	3-0-0	3

Module 1 [9L]: Probability Theory Review, Entropy, Mutual Information, Random Sources, Stochastic Process, Markov Sources, Discrete Finite State Stationary Markov Sources, Entropy

Rate, Conditional Entropy

Module 2 [9L]: Noise less coding, Shannon's first fundamental theorem, Discrete memory less channel, Mutual information, Sources with finite memory, Markov sources, Shannon's second fundamental theorem on coding, Huffman coding, Lempel – Ziv algorithm, Shannon-Fano algorithm.

Module 3 [9L]: Error detecting codes, Hamming distance, Error correcting codes, Repitition codes, Linear block codes, binary cyclic codes, BCH codes, Reed-Soleman codes, Golay codes. Convolution Coding: Code tree, state diagram, Trellis diagram, Maximum-Likelihood decoding ,Viterbi's algorithm, Sequential decoding.

Module 4 [9L]: Network Information theory, Information Theoretic Security, Perfect Secrecy, Shannon's Theorem, Perfectly Secret Codes, Introduction to Computational Security and Pseudo Random Sources

Books:

1. Elements of Information Theory by T.M Gover, J.M Thomos, Wiley , Edition 2nd
2. Digital Communications by Haykins S, Wiley
3. Information Theory, Inference and Learning Algorithms by D. J. Mackay, Cambridge University Press ,Edition 2002
4. Digital Communications by J G Proakis, Mc Graw Hill.
5. Computer Vision by Ballard and C.M.Brown, Prentice Hall, Englewood Cliffs
6. Coding and Information Theory by Roman, S. New York: Springer-Verlag, 1992

CS2*136	Wireless Network Security	3-0-0	3

Module 1 [10L]: Threats and Security Goals, Network Security Analysis, Information Security Measures, Important Terms relating to Communication Security; Challenges of Broadcast Communication, Security Requirements for Broadcast Applications; Broadcast Network Requirements, IPv-4 vs IPv6,

Module 2 [10L]: The wireless Local Area Network (WLAN): Wireless Transmission Media, WLAN Products and Standards, 802.11 security, IEEE 802.11b/n/g.., Securing WLANs, Countermeasures;
Wireless Application Protocol (WAP): Comparison of the TCP/IP with mobile TCP/IP, OSI and WAP Models, WAP Security Architecture, Marginal Security;
Secure Wireless and Mobile Communications: Security aspects of mobile communications: Security in WLANs, Mobile WANs, Mobile Internet Communications, Wireless Transport Layer Security.

Module 3 [10L]: Bluetooth Technology: Basic specifications, Design specifications, Security architecture, Authentication and encryptions;
Voice over Internet Protocol (VoIP): The Buzz around VoIP, VoIP standards, The rise of VoIP

Technology, Technical Issues and Voice network security.

Module 4 [10L]: Hardware Perspectives for End-to-End Security (E2E) in Wireless Applications: Communication - Client-Server versus Peer-to-Peer, Circuit-Switched versus Packet-Switched or Frame-Switched, Unicast versus Broadcast/anycast, LAN-Based versus Wireless-Based Communications,
Transmission Medium, Transmission Nature, Advanced Mobile Phone Services, Internet Telephony, Time Division Multiple Access, GSM, Wideband and narrowband CDMA

Books:

1. Mobile and wireless network security and privacy by S.K. Makki, P. Reiher, K. Makki, N. Pissinou and S. Makki, Springer.
2. Wireless Security: Models, Threats and Solutions by R. Nichols and P. Lekkas, McGrawhill, 2010

CS2*137	Public Key Infrastructure and Trust Management	3-0-0	3

Module 1 [9L]: Asymmetric key cryptography: RSA cryptosystem, RABIN Cryptosystem ElGamal Cryptosystem, message Integrity & Authentication; Random Oracle model, message authentication, Cryptographic hash functions; MD hash families, Whirlpool, SHA-512

Module 2[9L]: Digital Signature; Process and services, attacks on digital signatures, Digital Signature Schemes; Digital certificates and PKIs; Different PKIs: PGP (Pretty Good Privacy): Web of trust, applications; X.509: X.500, Certification Authority (CA), Registration Authority (RA), Root-CA, X.509 Protocols, Simple PKI (SPKI)

Module 3[9L]: Entity Authentication; Passwords and Challenge Response, zero-knowledge and bio-metrics, Key management; security key distribution, Kerberos, Symmetric Key agreement, Public Key Distribution and Hi-jacking, Issues of revocation, Anonymity and Privacy Smartcard integration with PKIs, Trust management systems,

Module 4[9L]: Email Security, PGP and S-MIME, Cloud security through PKI, Application in e-commerce, e-business, e-payment, e-health and mobile applications.

Books:

1. Cryptography and Network Security by Behrouz Forouzan and D. Mukhopadhyay
2. Public Key Infrastructure Overview by Joel Weise, Sun Blue Prints

CS2*138	Advanced Topics in Cyber Security	3-0-0	3

Module 1 [9L]: Introduction
Overview of Public Key Cryptography, Symmetric Cryptography, Digital Signature, Encryption/Decryption Algorithms, Public Key Infrastructure, Internet Key Exchange Protocol

Module 2 [9L]: Elliptic Curve Cryptography
Different types of elliptic curves recommended by NIST and their characteristics, elliptic curve

operations, computational hardness's of elliptic curve (ECDLP, ECFP, CDHP, DDHP), elliptic curve digital signature algorithm (ECDSA), elliptic curve Diffie-Hellman protocol, elliptic curve PKI, Security protocols in real life applications (research articles).

Module 3 [9L]: Identity Based Cryptography
Zero knowledge proof system, pairing based cryptography, bilinear mapping, chosen cipher text security models, identity-based encryption, attribute-based encryption, different access control models.

Module 4 [9L]: Attribute Based Encryption
Preliminary quantum mechanics, Quantum algorithms, Mathematical models of quantum computation, their relationships to each other, and to physical systems; Quantum error correcting codes; Quantum cryptography, Quantum fault tolerance.

Books:

1. Cryptography: Theory and Practice by Douglas Stinson
2. Oded Goldreich, "Foundation of Cryptography"
3. Matthieu Bloch and Joao Barros, "Physical-Layer Security"
4. Michael Nielsen and Isaac Chuang, "Quantum Computation and Quantum Information"

CS2*139	Cyber Forensics	3-0-0	3

Module 1 [9L]: Computer forensics fundamentals, Benefits of forensics, Computer crimes, Computer forensics evidence and courts, Legal concerns and private issues. Understanding digital and cloud forensics.

Module 2 [9L]: Understanding Computing Investigations, Understanding data recovery work station and software, Conducting and investigations.

Module 3 [9L]: Data acquisition- understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, remote network acquisition tools, other forensics acquisitions tools.

Module 4 [9L]: Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, storing digital evidence, obtaining digital hash, reviewing case.

Books:

1. Computer Forensics: Incident Response Essentials by Warren G. Kruse IIandJay G. Heiser, Addison Wesley, 2002.
2. Guide to Computer Forensics and Investigations by Nelson, B, Phillips, A, Enfinger, F, Stuart, C., 2nd ed., Thomson Course Technology, 2006, ISBN: 0-619-21706-5.
3. Computer Forensics, Computer Crime Scene Investigation by Vacca, J, 2nd Ed, Charles River Media

CS2*140	Blockchain Technology	3-0-0	3

Module 1 [9L]: Introduction: Overview of Blockchain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Blockchain, Transactions, Distributed Consensus, Public vs Private Blockchain, Understanding Cryptocurrency to Blockchain, Permissioned Model of Blockchain, Overview of Security aspects of Blockchain, Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

Module 2 [9L]: Understanding Blockchain with Cryptocurrency: Bitcoin and Blockchain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay. Working with Consensus in Bitcoin**:** Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Module 3 [9L]: Understanding Blockchain for Enterprises: Permissioned Blockchain: Permissioned model and use cases, Design issues for Permissioned blockchains, Execute contracts, State machine replication, Overview of Consensus models for permissioned blockchain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems. Enterprise application of Blockchain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Blockchain, Blockchain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Blockchain.

Module 4 [9L]: Blockchain application development: Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

Books:

1. Blockchain: Blueprint for a New Economy by Melanie Swan, O'Reilly, 2015
2. Blockchain: The Blockchain for Beginners-Guide to Blockchain Technology and Leveraging Blockchain Programming by Josh Thompsons
3. Blockchain Basics by Daniel Drescher, Apress; 1st edition, 2017

CS2*141	Software Defined Networking	3-0-0	3

Module 1[8L]: INTRODUCING SDN: SDN Origins and Evolution – Introduction – Why SDN? - Centralized and Distributed Control and Data Planes - The Genesis of SDN.

Module 2 [7L]: SDN ABSTRACTIONS

How SDN Works - The Openflow Protocol - SDN Controllers: Introduction – General Concepts - VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight - Layer 3 Centric - Plexxi - Cisco OnePK

Module 3 [7L]: PROGRAMMING SDN'S: Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing

Module 4 [7L]: SDN APPLICATIONS AND USE CASES: SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3

Module 5 [7L]: SDN'S FUTURE AND PERSPECTIVES: SDN Open Source - SDN Futures - Final Thoughts and Conclusions

Books:

1. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014
2. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013
3. Software Defined Networking with OpenFlow By SiamakAzodolmolky, Packt Publishing, 2013

CS2*142	Artificial Intelligence	3-0-0	3

Module 1 [10L]: Basic Concepts: Foundations of Artificial Intelligence – the four approaches to AI. Intelligent Agents – Agents and Environments, Rationality, Nature of Environments, Structure of Agents. **Solving Problems by Searching:** Problem-Solving Agents, Searching for Solutions, Uninformed Search Strategies, Heuristic Search Strategies, Heuristic Functions.
Beyond Classical Search: Local Search Algorithms and Optimization Problems, Local Search in Continuous Spaces, Searching with Nondeterministic Actions. Introduction to Adversarial Search.

Module 2[6L]: Logical Agents: Knowledge-Based Agents, Logic, Propositional Logic, Propositional Theorem Proving, Effective Propositional Model Checking, Agents Based on Propositional Logic.

Module 3 [7L]: Classical Planning: Definitions of Classical Planning. Algorithms for Planning as State-Space Search. Planning Graphs. Other Classical Planning Approaches. Analysis of Planning Approaches. **Planning and Acting in the Real World:** Time, Schedule and Resources, Hierarchical Planning, Planning and Acting in Nondeterministic Domains, Multi-agent Planning.
Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Reasoning with Default Information.

Module 4 [7L]: Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, Exact Inference and Approximate Inference in Bayesian Networks. Relational and First-order Probability Models. **Probabilistic Reasoning over Time:** Time and Uncertainty, Inference in

Temporal Models, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Keeping Track of Many Objects. **Making Decisions:** Making Simple Decisions – Combining Beliefs and Desires, Utility Theory, Utility Functions, Multi-attribute Utility Functions, Decision Networks, Decision-Theoretic Expert Systems. Sequential Decision Problems. Value Iteration, Policy Iteration. Partially Observable MDPs. Decisions with Multiple Agents.

Module 5[6L]: Fuzzy Logic: Crisp Sets V/s Fuzzy Sets, Fuzzy Functions, Fuzzy Logic and Fuzzy Inference Systems, Type-2 Fuzzy Sets, Intuitionistic Fuzzy Sets based sentiment Analysis.
APPLICATIONS /CASE STUDY– *Match Making for Indian Matrimony, Fuzzy Expert System for Sleep Disturbance, Fuzzy Logic based Air Conditioner, Solving Reviewer Assignment Problem using Fuzzy Functions, Time-Series Forecasting*
Rough Sets: Introduction, Indiscernibility, Set Approximations, properties of Rough Sets, Rough Membership, Reducts.
APPLICATIONS / CASE STUDY- *Development of Part of Speech Tagger for Hindi Language using Rough Sets***.**

Books:

1. Artificial Intelligence by E. Rich and K. Knight, TMH, 2nd Ed., 1992.
2. Principles of AI by N. J. Nilsson, Narosa Publ. House, 1990.

Reference:

3. Artificial Intelligence by P. H. Winston, Pearson Education, 3rd Edition, 2000
4. Fuzzy Logic with Engineering Applications by T. J.Ross, Third Edition, John Wiley.
5. Rule Based Expert Systems by M. Sasikumar, S. Ramani, Narosa Publishing House, 1994.
6. Principles of Soft Computing by Sivandandam, Deepa, Wiley Publications. 2nd Edition.

CS2*143	Parallel and Distributed Systems	3-0-0	3

Module 1 [8L]: Introduction; Need; Parallelism in uniprocessors systems; Pipeline-MIMD/SIMD, Distributed systems Versus Parallel systems, Models of distributed Systems-Happened Before and Potential Causality Model, Models based on States.

Module 2[10L]: Distributed algorithms and applications, Clock synchronization algorithms;-Logical clocks, Vector clocks, Verifying clock algorithms, Direct dependency clocks. Fault Tolerance; Fault tolerant, termination detection algorithms and leader election algorithms.

Module 3[12L]: Parallel algorithms: prefix sum computation, matrix multiplication; Ranking, Searching, Traversal and Sorting; multi-threaded programming, p-Threads. Programming models-I (data parallel, task parallel, shared memory, distributed memory- Message Passing): Message passing interface (MPI), Communication Types- Block and Non-blocking, Buffered and Non-buffered; OpenMP programming.

Module 4[10L]: Co-processors parallel systems, GPGPU, CUDA Kernels and Threads, CUDA devices memories, Blocks, Threads and indexes. OpenCL programming, CUDA vs OpenCL.

Books:

1. Introduction to Parallel Computing, by Kumar, Grama, Gupta and Karypis, Benjamin Cummings Publishing Co., 2nd Ed., 2003.
2. Parallel Programming in C with MPI and OpenMP by M. J. Quinn.
3. Program Massively Parallel Processors: A Hands on Approach by David Kirk.
4. Heterogeneous computing with OpenCL by Benedict Gaster and Lee Howes

References:

1. H. Attiya and J. Welch, Distributed Computing: Fundamentals, Simulation and Advanced Topics, McGraw Hill
2. Parallel Programming in OpenMP by Dror Mayden at all.
3. Parallel Programming with MPI by Petter S. Pacheco.
4. Using MPI: Portable Parallel Programming with the Message-Passing Interface, by William Gropp, Ewing Lusk, and Anthony Skjellum, 2nd Ed., 1999.
5. CUDA GPU Gems 3 by Hubert Nguyen.

CS2*144	Machine Learning	3-0-0	3

Module 1 [9L]: Introduction to Machine Learning: Introduction, Examples of Various Learning Paradigms, Perspectives and Issues, Version Spaces, Finite and Infinite Hypothesis Spaces, PAC Learning, VC Dimension.

Module 2 [9L]: Supervised Learning: Decision Trees: ID3, Classification and Regression Trees, Regression: Linear Regression, Multiple Linear Regression, Logistic Regression, Support vector machines: Linear and Non-Linear, Kernel Functions, K-Nearest Neighbors

Module 3 [9L]: Ensemble Learning: Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: *Random Forest Trees*, Boosting: *Adaboost*, Stacking.
Unsupervised Learning: Introduction to clustering, Hierarchical: *AGNES, DIANA*, Partitional: *K-means clustering, K-Mode Clustering*, Expectation Maximization, Gaussian Mixture Models.
Probabilistic Learning: Bayesian Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks

Module 4 [9L]: Neural Networks and Deep Learning: Perceptron, Multilayer Perceptron, Representational limitation and gradient descent training. Multilayer networks and back propagation. Hidden layers and constructing intermediate, distributed representations. Over fitting, learning network structure, recurrent networks.
Re-inforcement Learning: Q-Learning**.**

Books:

1 Introduction to Machine Learning by Ethem Alpaydin, MIT Press, PHI, 3rd Edition 2014.
2 Applied Machine Learning by M. Gopal, TMH.
3 Machine Learning by Tom Mitchell, McGraw Hill, 3rd Edition,1997.
4 Foundations of Machine Learning by Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, MIT Press, 2012.
5 Artificial Intelligence and Machine Learning by Vinod Chandra and Anand Harindra, PHI**.**
6 Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, The MIT Press, 2012.

7 Data Mining –Concepts and Techniques by Jiawei Han and Micheline Kambers and Jian Pei, 3rd edition, Morgan Kaufman Publications, 2012.

CS2*145	Cloud Computing	3-0-0	3

Module 1 [9L]: Introduction

Definition of Cloud Computing: Defining a Cloud, Cloud Types – NIST model, Cloud Cube model, Deployment models, Service models, Cloud Reference model, Characteristics of Cloud Computing, Benefits and advantages of Cloud Computing; Cloud Architecture: A brief introduction on Infrastructure, Platforms, Virtual Appliances, Communication Protocols, Applications, Connecting to the Cloud by Clients; Services and Applications by Type: IaaS, PaaS, SaaS, IDaaS and CaaS.

Module 2 [9L]: Use of Platforms in Cloud Computing

Concepts of Abstraction and Virtualization: Virtualization technologies, Load Balancing and Virtualization, Hypervisors, Machine Imaging, Porting of applications in the Cloud; Concepts of Platform as a Service; Use of PaaS Application frameworks; Use of Google, Amazon and Microsoft Web Services;

Module 3 [9L]: Cloud Infrastructure

Cloud Management: Features of network management systems, Monitoring of an entire cloud computing deployment stack – an overview with mention of some products, Lifecycle management of cloud services (six stages of lifecycle); Cloud Security: Cloud security concerns, Security boundary, Security service boundary, Overview of security mapping, Security of data, Identity management.

Module 4 [9L]: Concepts of Services and Applications

Service Oriented Architecture: Basic concepts of message-based transactions, Protocol stack for an SOA architecture, Event-driven SOA, Enterprise Service Bus, Service catalogs; Applications in the Cloud: Concepts of cloud transactions, functionality mapping, Application attributes, Cloud service attributes, System abstraction and Cloud Bursting, Applications and Cloud APIs; Cloud-based Storage: Cloud storage definition – Manned and Unmanned; Webmail Services: Cloud mail services including Google Gmail, Mail2Web, Windows Live Hotmail, Yahoo mail.

Books:

1. Cloud Computing Bible by B. Sosinsky, Wiley India
2. Mastering Cloud Computing by R. Buyya, C. Vecchiola and S. T. Selvi, McGraw Hill
3. Cloud computing: A practical approach by A. T. Velte, TMH
4. Cloud Computing by Miller, Pearson
5. Building applications in cloud: Concept, Patterns and Projects by Moyer, Pearson

CS2*146	Image Processing	3-0-0	3

Module 1[9L]: Introduction

Background; Digital Image Representation; Fundamental steps in Image Processing; Elements of Digital Image Processing; Digital Image Formation: A Simple Image Model, Geometric Model-Basic Transformation (Translation, Scaling, Rotation), Perspective Projection, Sampling & Quantization - Uniform & Non uniform; Mathematical Preliminaries: Neighbor of pixels, Connectivity, Relations, Equivalence & Transitive Closure, Distance Measures, Arithmetic/Logic Operations, Fourier Transformation, Properties of The Two Dimensional Fourier Transform, Discrete Fourier Transform, Discrete Cosine & Sine Transform.

Module 2[9L]: Image Enhancement
Spatial Domain Method, Frequency Domain Method, Contrast Enhancement -Linear & Nonlinear Stretching, Histogram Processing; Smoothing - Image Averaging, Mean Filter, Low-pass Filtering; Image Sharpening. High-pass Filtering, High-boost Filtering, Derivative Filtering, Homomorphic Filtering; Enhancement in the frequency domain - Low and high pass filtering.

Module 3[9L]: Image Restoration
Degradation Model, Discrete Formulation, Algebraic Approach to Restoration - Unconstrained & Constrained; Constrained Least Square Restoration, Restoration by Homomorphic Filtering, Geometric Transformation - Spatial Transformation, Gray Level Interpolation.

Module 4[9L]: Image Segmentation
Point Detection, Line Detection, Edge detection, Combined detection, Edge Linking & Boundary Detection - Local Processing, Global Processing via The Hough Transform; Thresholding - Foundation, Simple Global Thresholding, Optimal Thresholding; Region Oriented Segmentation - Basic Formulation, Region Growing by Pixel Aggregation, Region Splitting & Merging.

Books:

1. Digital Image Processing by Gonzalves, Pearson.
2. Digital Image Processing by Jahne, Springer.
3. Digital Image Processing & Analysis by Chanda & Majumder, PHI.
4. Fundamentals of Digital Image Processing by Jain, PHI.

CS2*147	Cryptography and Network Security	3-0-0	3

Module 1 [9L]: Algebra: Group, cyclic group, cyclic subgroup, field, probability. Number Theory: Fermat's theorem, Cauchy's theorem, Chinese remainder theorem, primality testing algorithm, Euclid's algorithm for integers, quadratic residues, Legendre symbol, Jacobi symbol etc.

Module 2 [9L]: Cryptography and cryptanalysis, Classical Cryptography, substitution cipher, different type of attack: CMA, CPA, CCA etc. Shannon perfect secrecy, OTP, Pseudo random bit generators, stream ciphers andRC4.

Module 3 [9L]: Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis; One-way function, Trapdoor one-way function, Public key cryptography, RSA cryptosystem, Diffie-Hellman key exchange algorithm, Elgamal Cryptosystem; Cryptographic hash functions, Secure hash algorithm, Message authentication,

digital signature, RSA digital signature, Elgamal digital signature.

Module 4 [9L]: IKE and IPSec; SSL/TLS; E-mail Security and PGP.

Books:

1 Cryptography and Network Security by Behrouz A. Forouzan and Debdeep Mukhopadhyay, Second edition, Tata McGraw Hill, 2011.
2 Cryptography and Network Security Principles and practice by W. Stallings, 5/e, Pearson EducationAsia, 2012.
3 Cryptography: Theory and Practice by Stinson. D., third edition, Chapman & Hall/CRC, 2010.
4 Elementary Number Theory with applications by Thomas Koshy, Elsevier India, 2005.

CS2*148	Data Analytics	3-0-0	3

Module 1 [9L]: Analysis of unstructured data, recommender system, Spark, R, R-HADOOP. **Descriptive Statistics:** Introduction to the course**,** Descriptive Statistics, Probability Distributions.

Module 2 [9L]: Introduction to Hadoop Distributed File System, The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization.

Module 3 [9L]: Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.

Module 4 [9L]: Collaborative Filtering, Social networking analysis. **Inferential Statistics:** Inferential Statistics through hypothesis tests, Permutation & Randomization Test. **Regression & ANOVA:** Regression, ANOVA(Analysis of Variance).

Books:

1. Hadoop: The Definitive Guide by Tom White, Third Edit on, O'reily Media, 2012.
2. Big Data Analytics by Seema Acharya, Subhasini Chellappan, Wiley 2015.
3. Intelligent Data Analysis by Michael Berthold, David J. Hand, Springer, 2007.

Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses by Michael Mineli, Michele Chambers, Ambiga Dhiraj, Wiley Publications, 2013.

CS2*149	Research Methodology	3-0-0	3

Module 1[6L]: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Module 2[4L]: Effective literature studies approaches, analysis Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Module 3[10L]Statistical Methods of Analysis
Descriptive Statistics: Mean, Median, Mode, Range, Standard Deviation, regression and correlation analysis. Inferential Statistics: Estimation of parameters, Hypothesis, Types of Hypothesis, Testing of Hypothesis, Test of Normality, Introduction to Parametric and Non Parametric tests. Test of significance: t-test, chi square test, ANOVA(1-way, 2-way), Repeated Measures ANOVA, ANCOVA, α-correction

Module 4[10L]: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5[4L]: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6[6L]: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

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