M. Tech. (CSE) – 2021 Curriculum

Course Code	Semester – I	Credits
CS5101	Mathematical Foundations for Computer Science	4
CS5102	Advanced Data Structures and Algorithms	3
CS5103	Advanced Operating Systems	3
	Elective -I	3
	Elective -II	3
CS5104	Seminar	2
CS5105	Advanced Programming Laboratory	2
CS5106	Advanced Operating Systems Laboratory	2
	Total Credits	22

Course Code	Semester - II	Credits
CS5151	Machine Learning	3
CS5152	Internet of Things	3
CS5153	Advanced Computer Architecture	3
	Elective -III	3
	Elective –IV	3
CS5154	Comprehensive Viva-Voce	2
CS5155	Machine Learning Laboratory	2
CS5156	Internet of Things Laboratory	2
	Total Credits	21

Course Code	Semester - III	Credits
CS6101	Project Work Phase – I	12
	Total Credits	12

Course Code	Semester - IV	Credits
CS6151	Project Work Phase – II	12
	Total Credits	12

Summary:

Branch	I Sem	II Sem	III Sem	IV Sem	Total
CSE	22	21	12	12	67

Electives:

Course Code	Electives	Credits
Semester I Electives		
CS5111	Business Analytics	3
CS5112	Advanced Network Principles and Protocols	3
CS5113	Design and Analysis of Parallel Algorithms	3
CS5114	Software Quality Assurance	3
CS5115	Principles of Cryptography	3
CS5116	Cloud Computing Technologies	3
CS5117	Malware Analysis	3
CS5118	Open Source Programming	3
CS5119	Optimization Algorithms	3
CS5120	Service Oriented Architecture and Web Security	3
Semester II Electives		
CS5121	Distributed Systems	3
CS5122	Wireless Sensor Networks	3
CS5123	Reconfigurable Computing	3
CS5124	Malware Analysis	3
CS5125	Information Retrieval Techniques	3
CS5126	Biometric Security	3
CS5127	Social Network Analysis	3
CS5128	Natural Language Processing	3
CS5129	Digital Forensics	3
CS5130	Mobile and Pervasive Computing	3

FIRST SEMESTER

Course Code	:	**CS5101**
Course Title	:	**Mathematical Foundations for Computer Science**
Number of Credits	:	**4-0-0-4**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Recognize the fundamental methods of predicate logic and the associated theorems.
CO2	Solve complex problems using linear algebra.
CO3	Analyze the distribution of data and generate statistical information.
CO4	Use graph theory for solving real world problems.
CO5	Evaluate graphs for finding solutions for matching and hall marriage problems.

Course Content:

Introduction: Functional Logic: Proposition Logic, Resolution Proof system, Predicate logic. Congruences, Fermat's theorem, Euler function, Chinese remainder theorem.

Linear Algebra: Groups, homomorphism theorems, cosets and normal subgroups, Lagrange's theorem, Ring. Field. Linear algebra: Vector Space, Basis, Matrices and Linear Transformations, Eigen values, Orthogonality.

Probability: Counting, Probability, Discrete random variable, Continuous random variable, Moment generating function, Markov's inequality, Chebyshev's inequality, The geometric and binomial distributions, The tail of the binomial distribution.

Graph Theory: Graphs, Euler tours, planar graphs, Hamiltonian graphs, Euler's formula, applications of Kuratowski's theorem.

Graph Applications: Graph colouring, chromatic polynomials, trees, weighted trees, the max-flow min-cut theorem. Matching, halls marriage problem. Independent set, Dominating set, Vertex cover, clique.

Text Books:

1. Kenneth H.Rosen, "Discrete Mathematics and its Applications", McGraw Hill, Seventh Edition, 2012 (Indian Adaptation by Kamala Krithivasan, IIT Madras).
2. I.N. Herstein, "Topics in Algebra.", JOHN Wiley and SONS. 1990.

Reference Books:

1. Sheldon M. Ross, "Introduction to Probability Models", Elsevier.
2. G. Chartrand and P. Zhang, "Introduction to Graph Theory", McGraw-Hill Companies.

Course Code	:	**CS5102**
Course Title	:	**Advanced Data Structures and Algorithms**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Compare algorithmic techniques such as brute force, greedy, and divide and conquer.
CO2	Explain various heap data structures.
CO3	Differentiate height balanced trees and perform operations on them.
CO4	Apply advanced tree structures to solve real world problems.
CO5	Develop geometric algorithms to detect map overlays.

Course Content:

Analysis Of Algorithms: Review of order of growth of functions, recurrences, probability distributions, Average case analysis of algorithms, Randomized Algorithms – Analysis - NP – Complete and NP – Hard Problems – Amortized Analysis

Heaps: Min Heap – Min-max Heaps – Leftist heaps – Skew leftist heaps – Binomial Heaps – Lazy binomial heaps – Fibonacci Heaps.

Trees: AVL Trees – Red-Black Trees – Splay Trees - B trees - Multi-way search trees – Tries

Advanced Tree Structures: Point – trees – Quad trees - K-d trees – TV- trees – Segment trees – Static and Dynamic

Geometric Algorithms: Geometric algorithms – line segment intersection – Map overlay detection – Voronoi diagram

Text Books:

1. H. S. Wilf, “Algorithms and complexity”, Prentice hall.
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, “Fundamentals of Computer Algorithms”, 2nd Edition, University Press, 2010.

Reference Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, “Introduction to Algorithms”, Prentice hall.
2. Jon Kleinberg, Eva Tardos, “Algorithm Design”, Pearson, 2006.

Course Code	:	**CS5103**
Course Title	:	**Advanced Operating Systems**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Examine the basic functions of operating systems.
CO2	Design system architecture and resource management in distributed environment.
CO3	Explain the concurrency control algorithms in database OS.
CO4	Analyze the architecture of mobile OS.
CO5	Outline the characteristics of real-time OS.

Course Content:

Multiprocessor Operating Systems: System Architectures- Structures of OS – OS design issues – Process synchronization – Process Scheduling and Allocation- memory management.

Distributed operating system: System Architectures- Design issues – Communication models – clock synchronization – Distributed mutual exclusion – Distributed Deadlock detection. Distributed File system – Distributed shared memory – Distributed scheduling.

Database operating system: Requirements of Database OS – Transaction process model – Synchronization primitives - Concurrency control algorithms

Mobile operating system: ARM and Intel architectures - Power Management - Mobile OS Architectures - Underlying OS - Kernel structure and native level programming - Runtime issues- Approaches to power management

Real-time operating system: Basic Model of Real Time Systems - Characteristics- Applications of Real Time Systems –Real Time Task Scheduling - Handling Resource Sharing

Text Books:

1. M Singhal and NG Shivaratri, “Advanced Concepts in Operating Systems”, Tata McGraw Hill Inc, 2001.
2. Rajib Mall, “Real-Time Systems: Theory and Practice”, Pearson Education India, 2006.

Reference Books:

1. Source Wikipedia, “Mobile Operating Systems”, General Books LLC, 2010.
2. A S Tanenbaum, “Distributed Operating Systems”, Pearson Education Asia, 2001.

Course Code	:	**CS5105**
Course Title	:	**Advanced Programming Laboratory**
Number of Credits	:	**0-0-3-2**
Prerequisites (Course code)	:	**CS5102**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Apply algorithmic techniques such as brute force, greedy, and divide and conquer.
CO2	Demonstrate various heap data structure.
CO3	Draw height balanced trees for the given problem and perform operations in them.
CO4	Apply advanced tree structures to solve real world problems.
CO5	Experiment tries data structure for string processing.

Course Content:

Implement the following data structures using C++ / Java / Python

- Min-max heap
- Leftist
- Binomial heap
- Fibonacci heap
- AVL tree
- Red Black tree
- B tree
- Tries

Course Code	:	**CS5106**
Course Title	:	**Advanced Operating Systems Laboratory**
Number of Credits	:	**0-0-3-2**
Prerequisites (Course code)	:	**CS5103**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Practice the various basic functions of Linux operating systems.
CO2	Experiment Inter Process Communication in Linux system.
CO3	Implement deadlock handling algorithms and concurrency control algorithms.
CO4	Compare different mobile operating systems.
CO5	Illustrate the features of Real-time OS.

Course Content:

Implement process scheduling algorithms

Exercises using Linux tools – Grep, awk, tr

Exercises using Linux ICORE and system calls

Exercises on deadlock and concurrency control algorithms

Comparative study of different Mobile operating system

Study of Real-time operating system

SECOND SEMESTER

Course Code	:	**CS5151**
Course Title	:	**Machine Learning**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Identify the need and use of Machine learning.
CO2	Employ the mathematical foundation and their approaches of regression models.
CO3	Relate the ensemble models and their run time complexity.
CO4	Summarize fundamental concepts of deep learning.
CO5	Apply reinforcement learning techniques for the given problem.

Course Content:

Introduction: Learning-Types of learning –Machine Learning – Designing Learning System – Perspectives and Issues in Machine Learning – Types of Machine learning: supervised learning, unsupervised learning and reinforcement learning – The machine learning process – Formal learning model – Bias complexity trade off – The Runtime of Learning.

Regression: Geometric Intuition of Logistic Regression – Weight Vector – L2 Regularization – Overfitting and Underfitting – Probabilistic Interpretation – Gaussian Naïve Bayes – Loss Minimization Interpretation– Hyper Parameter Search – Grid Search and Random Search – Real World Cases – Linear Regression Geometric Intuition – Mathematical Formulation – Real world Cases.

Ensemble Models: Ensembles – Bagging Institution– Random Forest and their Construction – Bias and Variance Trade off – Train and Runtime Complexity – Boosting Institution – Residuals, Loss Function and Gradients – Gradient Boosting – Regularization by Shrinkage – Train and Runtime Complexity – Stacking Models – Cascading Classifiers.

Deep Learning: Challenges Motivating Deep Learning – MP Neuron, Perceptron – Sigmoid Neuron, Gradient Decent– Cross Entropy –Feed Forward Neural Network – Back Propagation – Activation Functions and Initialization Methods – Regularization Methods – Overfitting and regularization – Convolution Neural Networks – CNN Architecture – CNN Visualization– Batch Normalization and dropout.

Reinforcement Learning: Recent Advances in Reinforcement Learning – Model Based RL: Bayesian Approaches to Reinforcement Learning – Data-efficient Reinforcement Learning – Learning with off-line data – Temporal Difference Learning – RL and Planning.

Text Books:

1. Tom Mitchell, “Machine Learning”, McGraw-Hill, 1997.

2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016.

Reference Books:

1. Bishop. C M, “Pattern Recognition and Machine Learning”, Springer, 2006.
2. T. Hastie, R. Tibshirani and J. Friedman, “The Elements of Statistical Learning”, Springer, 2011.

Course Code	:	**CS5152**
Course Title	:	**Internet of things**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Choose the architecture and protocols of IoT for the given problem
CO2	Develop IoT system using Arduino and Raspberry Pi with Python.
CO3	Set up the connection between the IoT system and cloud environment.
CO4	Analyze the tools and techniques of big data analytics for IoT.
CO5	Design and operate IoT in industry environment.

Course Content:

Fundamentals of IoT

Definition, Characteristics, IoT network architecture and design-Comparision,simplified architecture, Core IoT functional stack, IoT data management and compute stack. Smart Objects: The "Things" in IoT, IoT access technologies, IP as the IoT network layer, Application protocols for IoT.

IoT System Development

IoT system building blocks-Arduino–types, board details, Arduino tool chain, programming structure, IDE programming-Raspberry Pi-Interfaces and Raspberry Pi with Python programming-Implementing IoT concepts with python, Implementation of IoT with Raspberry Pi, different IoT tools, developing applications through IoT tools, developing sensor based application through embedded system platform, connecting to the cloud.

IoT in Cloud

Introduction to cloud storage models and communication APIs – Web application framework – Designing a web API – Web services – IoT device management, Challenges introduced by 5G in IoT Middleware (Technological Requirements of 5G Systems - Perspectives and a Middleware approach toward 5G (COMPaaS Middleware) – Resource management in IoT, Application Protocols.

Big data analytics for IoT

Introduction to Data analytics for IoT, Big data analytics tools and technology- Massively parallel processing databases, NoSQL databases, Hadoop, YARN, Hadoop ecosystem, Apache Kafka, Lambda architecture, Edge streaming analytics, Network analytics.

Industrial IoT (IIoT)

Industry 4.0 – comparison, IIoT - Smart devices and products - Smart logistics - Support system for Industry 4.0 - Cyber-physical systems requirements - Data as a new resource for organizations -Trends of industrial big data and predictive analytics for smart business-Architecture of Industry 4.0, IoT in various industry applications, Research aspects in IoT: Role of AI in IoT applications, Securing IoT- block chain for IoT security.

Text Books:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", 1st edition, Cisco Press, 2017.
2. Adeel Javed, "Building Arduino Projects for the Internet of Things: Experiments with Real-World Applications", 1st Edition, Apress, 2016.

Reference Books:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.

Course Code	:	**CS5153**
Course Title	:	**Advanced Computer Architecture**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Core**

Course outcomes: At the end of the course, the student will be able to:

CO1	Summarize the basic and intermediate concepts of pipelining.
CO2	Apply instruction level parallelism for the given problem.
CO3	Differentiate between data-level and thread-level parallelism.
CO4	Analyze and compare the various cache optimization techniques.
CO5	Evaluate the efficiency of an I/O system.

Course Content:

Fundamentals of Computer Design Defining: Computer Architecture – Trends in Technology – Trends in Power in Integrated Circuits – Trends in Cost – Dependability – Measuring, Reporting and Summarizing Performance – Quantitative Principles of Computer Design – Basic and Intermediate concepts of pipelining – Pipeline Hazards – Pipelining Implementation issues.

Instruction-Level Parallelism and Its Exploitation: Instruction-Level Parallelism-Concepts and Challenges – Basic Compiler Techniques for Exposing ILP – Reducing Branch Costs with Prediction – Overcoming Data Hazards with Dynamic Scheduling – Dynamic Scheduling: Algorithm and Examples – Hardware-Based Speculation – Exploiting ILP Using Multiple Issue and Static Scheduling – Exploiting ILP Using Dynamic Scheduling, Multiple Issue and Speculation – Studies of the Limitations of ILP – Limitations on ILP for Realizable Processors – Hardware versus Software Speculation – Using ILP Support to Exploit Thread-Level Parallelism

Data-Level and Thread-Level Parallelism: Vector Architecture – SIMD Instruction Set Extensions for Multimedia – Graphics Processing Units – Detecting and Enhancing Loop-Level Parallelism – Centralized Shared-Memory Architectures – Performance of Shared-Memory Multiprocessors – Distributed Shared Memory and Directory Based Coherence – Basics of Synchronization – Models of Memory Consistency – Programming Models and Workloads for Warehouse- Scale Computers – Computer Architecture of Warehouse-Scale Computers – Physical Infrastructure and Costs of Warehouse-Scale Computers- Domain-Specific Architecture – Introduction- Guidelines for DSAs - Example Domains - Cross-Cutting Issues- CPUs Versus GPUs Versus DNN Accelerators.

Memory Hierarchy Design Cache: Performance – Six Basic Cache Optimizations – Virtual Memory – Protection and Examples of Virtual Memory – Ten Advanced Optimizations of Cache Performance – Memory Technology and Optimizations –

Protection: Virtual Memory and Virtual Machines – The Design of Memory Hierarchies

Storage Systems and Case Studies: Advanced Topics in Disk Storage – Definition and Examples of Real Faults and Failures – I/O Performance, Reliability Measures and Benchmarks – Designing and Evaluating an I/O System – The Internet Archive Cluster Case Studies / Lab Exercises: INTEL i3, i5, i7 processor Cores, NVIDIA GPUs, AMD, ARM processor Cores – Simulators – GEM5, CACTI, SIMICS, Multi2sim and INTEL Software development tools.

Text Books:

1. David.A. Patterson, John L.Hennessy, "Computer Architecture: A Quantitative approach", Elsevier, 6th Edition 2019.
2. K.Hwang, Naresh Jotwani, "Advanced Computer Architecture, Parallelism, Scalability, Programmability", Tata McGraw Hill, 2nd Edition 2010.

Reference Books:

1. Peter S. Pacheco, "An Introduction to Parallel Programming", 1st Edition, Morgan Kaufmann Publishers, 2011.
2. Jason Sanders and Edward Kandrot, "An Introduction to General-Purpose GPU Programming", 1st Edition, Addison-Wesley Professional, 2011, ISBN-13: 9780131387683

Course Code	:	**CS5155**
Course Title	:	**Machine Learning Laboratory**
Number of Credits	:	**0-0-3-2**
Prerequisites (Course code)	:	**CS5151**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Implement and analyze the performance of supervised and unsupervised learning algorithms.
CO2	Evaluate the performance of Regression models in terms of different evaluation measures.
CO3	Apply the concept of bagging and boosting.
CO4	Classify the given text using deep learning.
CO5	Design the Feed forward and Convolution Neural Networks in deep learning environment using real world dataset.

Course Content:

Implement the following algorithms

- Supervised and unsupervised learning algorithms using benchmark datasets.
- Logistic regression based on grid search and random search.
- Linear regression.
- Bagging and various Boosting models.
- Binary text classification using deep learning environment.
- Feed Forward Networks and Convolutional Neural networks.

Course Code	:	**CS5156**
Course Title	:	**Internet of Things Lab**
Number of Credits	:	**0-0-3-2**
Prerequisites (Course code)	:	**CS5152**
Course Type	:	**ELR**

Course outcomes: At the end of the course, the student will be able to:

CO1	Practice Arduino IDE.
CO2	Develop sketches to measure the property of different sensors.
CO3	Implement RFID and MQTT protocol using Arduino.
CO4	Experiment with the pin structure of Raspberry Pi.
CO5	Analyze sensor data in Cayenne/ThingSpeak cloud using Rasberry Pi and Tinkercad.

Course Content:

Study different types of Arduino, prototyping, analog and digital inputs and outputs.

Install IDE of Arduino.

Develop sketches to do simple experiments using Arduino board

Study and Implement RFID, NFC using Arduino.

Study and implement MQTT protocol using Arduino.

Study and install Raspbian and Configure Raspberry Pi

Experiments using Raspberry Pi

Study and implement Zigbee Protocol using Arduino / Raspberry Pi.

Experiment on connectivity of Raspberry Pi with existing system components.

Send the sensor data privately to the cloud.

ELECTIVES

Course Code	:	**CS5111**
Course Title	:	**Business Analytics**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Understand the basic concepts of business analytics.
CO2	Evaluate the various descriptive analytics techniques involved in business analytics.
CO3	Apply the various predictive analytics techniques to real world problems.
CO4	Compare the linear and non-linear optimization techniques of prescriptive analytics.
CO5	Employ the decision analysis for real-world applications of business analytics.

Course Content:

Introduction: Business View of Information Technology Applications – Evolution of Business Analytics– Key Purpose of using IT in Business – Descriptive, Predictive, and Prescriptive Analytics - Data for Business Analytics – Models in Business Analytics – Problem Solving with Analytics.

Descriptive Analytics: Data Visualization – Descriptive Statistics – Frequency Distributions and Histograms – Descriptive Statistical Measures – Statistical Test – Understanding Hypothesis and t-Test – Statistics in PivotTables – Sampling and Estimation – Estimating Population Parameters – Sampling Distributions – Interval Estimates – Using Confidence Intervals for Decision Making – Prediction Intervals – Statistical Inference.

Predictive Analytics: Trendlines and Regression Analysis – Modeling Relationships and Trends in Data– Simple Linear Regression– Residual Analysis and Regression Assumptions– Multiple Linear Regression– Regression with Categorical Independent Variables – Forecasting Techniques – Forecasting Models for Time Series with a Linear Trend – Spreadsheet Modeling and Analysis – Simulation and Risk Analysis– Random Sampling from Probability Distributions – Monte Carlo Simulation.

Prescriptive Analytics: Linear Optimization – Developing Linear Optimization Models– Solving Linear Optimization Models – Applications of Linear Optimization – Integer and Nonlinear Optimization – Models with Binary Variables – Nonlinear Optimization Models – Non-Smooth Optimization – Optimization Analytics – Models with Bounded Variables.

Making Decisions: Decision Analysis – Formulating Decision Problems – Decision Strategies without Outcome Probabilities – Decision Strategies with Outcome Probabilities – Utility and Decision Making – Emerging Analytics – Application of Business Analytics – Retail Analytics – Marketing Analytics – Financial Analytics – Healthcare Analytics –

Supply Chain Analytics.

Text Books:

1. James R. Evans, “Business Analytics, 3rd Edition”, Pearson, 2020.
2. R.N. Prasad and Seema Acharya, “Fundamentals of Business Analytics”, Wiley, Second Edition, 2016.

Reference Books:

1. Ger Koole, “An Introduction to Business Analytics”, Lulu.com, 2019.
2. Sahil Raj, “Business Analytics”, Cengage, 1st edition, May 2015.

Course Code	:	**CS5112**
Course Title	:	**Advanced Network Principles and Protocols**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Summarize the different layers of TCP/IP protocol stack.
CO2	Explain the working principle of different protocols of network layer.
CO3	Apply networking concepts to real life problems.
CO4	Compare TCP and UDP.
CO5	Employ application layer protocol for effective communication.

Course Content:

Introduction: Introduction to Networks - Application of Networks - Architecture Topology Switching - SLIP, PPP -ALOHA protocols, CSMA/CD, IEEE 802.3, 802.4, 802.5

Network Layer: Network Layer Issues- Routing, Congestion control- Internetworking - Issues, Address Learning Bridges, Spanning tree, Source routing, Bridges, Routers, Gateway.

Network Protocol: Network Protocol- IP datagram - hop by hop routing, ARP, RARP, DHCP -Subnet Addressing, Address Masking, ICMP, RIP, RIPV2, OSPF, DNS, LAN and WAN Multicast.

Transport Layer: Transport Layer- Design issues, Connection Management, Transmission Control Protocol (TCP), User Datagram Protocol (UDP).

Application Layer: Application Layer Protocol- Telnet - TFTP - FTP - SMTP - Ping Finger, Bootstrap Network Time Protocol- SNMP.

Text Books:

1. Andrew S. Tanenbaum and David J. Wetherall, "Computer Networks", 5th Edition, Electivearson, 2011.
2. William Stallings, "Data and Computer Communications", 9th Edition, Pearson, 2011.

Reference Books:

1. W Richard Stevens and G. Gabrani, "TCP/IP Illustrated - Volume I, The protocols", Pearson Education, 2009.
2. Eiji Oki, Roberto Rojas-Cessa, Christian Vogt, "Advanced Internet Protocols, Services and Applications", John Wiley and Sons Ltd, 2012**.**

Course Code	:	**CS5113**
Course Title	:	**Design and Analysis of Parallel Algorithms**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Explain the algorithms for array processors.
CO2	Develop searching algorithms for various kinds of models.
CO3	Apply efficient sorting operation on different models.
CO4	Solve linear and nonlinear equations using PRAM models.
CO5	Construct graph and find solutions to real world problems.

Course Content:

Structures and algorithms for array processors: SIMD Array Processors, Interconnection networks, Parallel algorithms for Array processors. Multiprocessor architecture-and Interconnection networks-multiprocessor control algorithms- parallel algorithms for multiprocessors.

Selection – broadcast- all sums- parallel selection. Searching a random sequence, sorted sequence on PRAM models, Tree and Mesh.

Merging – A network for merging – merging on PRAM models. Sorting on a linear array, EREW, CREW and CRCW SIMD models, MIMD Enumeration sort.

Matrix operations- Transposition, Matrix by matrix multiplication, matrix by vector multiplication. Numerical problems- solving systems of linear equations, finding roots of non linear equations on PRAM models.

Graphs – Connected components- dense graphs- sparse graphs. Minimum spanning tree-Solli's algorithm, Biconnected components, Ear decomposition, Directed graphs.

Text Books:

1. Kai Wang and Briggs, "Computer Architecture and Parallel Processing", McGraw Hill, 1985.

Reference Books:

1. S. G. Akl, "Design and Analysis of Parallel Algorithms", Prentice Hall Inc., 1992.

Course Code	:	**CS5114**
Course Title	:	**Software Quality Assurance**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Utilize the concepts in software development life cycle.
CO2	Apply software testing strategies to assure the quality of software.
CO3	Assess the quality of software infrastructure components.
CO4	Perceive software quality management components and design software quality metrics..
CO5	Adopt software quality assurance standards for certification and assessment.

Course Content:

Introduction: Defining Software Quality -Software Quality factors - Components of software quality assurance- pre project software quality components- Contract Review - Development and Quality Plans

SQA Components In The Project Life Cycle: Integrating Quality Activities in the Project Life Cycle – Reviews - Software Testing – Strategies - Software Testing – Implementation - Assuring the Quality of Software Maintenance - Assuring The Quality of External Participants' Parts - Case Tools and their Affect on Software Quality.

Software Quality Infrastructure Components: Procedures and Work Instructions - Supporting Quality Devices - Staff Training Instructing and Certification - Preventive and Corrective Actions - Configuration Management - Documentation and Quality Records Controls.

Software Quality Management Components: Management Components Software Quality - Project Progress Control- Components, Internal and External Participants, Progress control regimes, Computerized tools, Software Quality Metrics – Objective, Classification, Process and Product Metrics, Implementation and Limitation of Software Metrics - Software Quality Costs – Objective, Classification Model of cost, Extended Model and Applications

Standards- Certification And Assessment: SQA Standards - ISO 9001 Certification - Software Process Assessment. Organizing for Quality Assurance -Management and its Role in Quality Assurance - The Software Quality Assurance Unit - SQA Trustees and Committees

Text Books:

1. Daniel Galin, “Software Quality Assurance: From Theory to Implementation”, Pearson

Addison-Wesley, 2012.
2. Allen Gilles, “Software quality: Theory and management”, International Thomson, Computer press, 1997.

Reference Books:

1. Stephen H.Kan, “Metrics and models in software quality Engineering”, Addison – Wesley, 1955.
2. Jeff Tian, “Software Quality Engineering: Testing, Quality Assurance, and Quantifiable”, Wiley, 2005.

Course Code	:	**CS5115**
Course Title	:	**Principles of Cryptography**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Summarize the concepts of number theory.
CO2	Identify simple provable security proofs for cryptographic schemes.
CO3	Design and implement cryptographic protocols.
CO4	Implement digital signatures using Schnorr signature scheme.
CO5	Implement block chain technology and bitcoin.

Course Content:

Number Theory: Review of number theory, group, ring and finite fields, quadratic residues, Legendre symbol, Jacobi symbol, Probability, Probability, Discrete random variable, Continuous random variable, Markov's inequality, Chebyshev's inequality, normal distribution, the geometric and binomial distributions.

Formal Notions of Attacks: Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model.

Public Key Cryptography: Public key cryptography, probabilistic encryption, homomorphic encryption, Elliptic curve cryptosystems, Cryptographic hash functions.

Digital Signatures: Digital signatures and the notion of existential unforgability under chosen message attacks. Schnorr signature scheme. Zero Knowledge Proofs and Protocols,

Blockchain Technology: Blockchain technology, Consensus algorithm, Incentives and proof of work, Smart contract, Bitcoin.

Text Books:

1. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2014.
2. Jonathan Katz and Yehuda Lindell, "Introduction to Modern Cryptography", 2nd edition, CRC Press, 2015.
3. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies", 2016.

Reference Books:

1. Koblitz, N., "Course on Number Theory and Cryptography", Springer Verlag, 1986.

2. Menezes, A, et.al., “Handbook of Applied Cryptography”, CRC Press, 1996.
3. Thomas Koshy, “Elementary Number Theory with applications”, Elsevier.

Course Code	:	**CS5116**
Course Title	:	**Cloud Computing Technologies**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Summarize the various centralized and distributed computing systems.
CO2	Identify the architecture and various service models of cloud computing.
CO3	Design a cloud with security, privacy, and interoperability.
CO4	Evaluate appropriate cloud computing solutions and recommendations according to the applications used.
CO5	Develop cloud programs on different software environments.

Course Content:

History of Centralized and Distributed Computing - Overview of Distributed Computing, Cluster computing, Grid computing. Technologies for Network based systems- SOA – Hardware- MultiCore Systems – GPGPU- Data Storage

Cloud issues and challenges - Properties - Characteristics - Service models, Deployment models- Virtualization – Virtual Machines – Hypervisor Types – Resource Virtualization: Server, Storage, Network

Service models - Infrastructure as a Service (IaaS) - Platform as a Service (PaaS) - Software as a Service (SaaS) - Anything as a service (XaaS) – Service Management

Cloud Access: authentication, authorization and accounting - Cloud Provenance and meta-data - Cloud Reliability and fault-tolerance - Cloud Security, privacy, policy and compliance- Cloud federation, interoperability and standards.

Cloud Programming and Software Environments –Programming on Amazon AWS and Microsoft Azure – Programming support of Google App Engine – Docker Architecture and Components –Docker Interfaces – Docker Orchestration - Emerging Cloud Software Environment.

Text Books:

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, "Distributed and cloud computing from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier – 2012.
2. Barrie Sosinsky, "Cloud Computing Bible", John Wiley and Sons, 2010.

Reference Books:

1. Tim Mather, Subra Kumaraswamy, and Shahed Latif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance”, O'Reilly 2009
2. James Turnbul, “The Docker Book: Containerization Is the New Virtualization”, e-book, 2015.

Course Code	:	**CS5117**
Course Title	:	**Malware Analysis**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Examine basic static and dynamic analysis of a system.
CO2	Apply reverse engineering for advanced dynamic analysis.
CO3	Analyze windows programs for monitoring malware behaviour.
CO4	Evaluate countermeasures for anti-analysis and anti-disassembly.
CO5	Implement Rootkit techniques for kernel debugging.

Course Content:

Introduction to malware, Basic static and dynamic analysis, Overview of windows file format, PEView.exe, Patching binaries, Disassembly (objdump, IDA Pro)

Introduction to IDA, Introduction to reverse engineering, Extended reverse engineering using GDB and IDA, Advanced dynamic analysis - debugging tools and concepts

Malware behavior - malicious activities and techniques, Analyzing windows programs – WinAPI, Handles, Networking, COM, Data encoding

Malware countermeasures, Covert launching and execution, Anti analysis- anti disassembly, VM, Debugging, Packers – packing and unpacking

Kernel basics, Windows kernelAPI, Windows drivers, Kernel debugging, Rootkit techniques- Hooking, Patching, Kernel object manipulation, Rootkit anti-forensics, Covert analysis

Text Books:

1. Michael Sikorski and Andrew Honig, “Practical Malware Analysis”, No Starch Press, 2012.
2. Jamie Butler and Greg Hoglund, “Rootkits: Subverting the Windows Kernel”, Addison-Wesley, 2005.

Reference Books:

1. Dang, Gazet,Bachaalany, “Practical Reverse Engineering”, Wiley, 2014.
2. Reverend Bill Blunden, “The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System”, Second Edition, Jones and Bartlett, 2012.

Course Code	:	**CS5118**
Course Title	:	**Open source programming**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Develop shell programs in Linux operating system.
CO2	Apply PHP functions for solving problems.
CO3	Create web applications for retrieving data from web databases.
CO4	Build programs in PERL, TCL and Python.
CO5	Identify security threats and build secure web applications.

Course Content:

Introduction: Introduction to open source programming languages: advantages and drawbacks - threats and vulnerabilities - Introduction to shell programming. Operating System – Linux.

PHP: PHP Language Basics- Functions - calling a function- variable function - anonymous function, Strings – cleaning- encoding and escaping- comparing strings. Arrays – storing data in arrays extracting multiple values- traversing- sorting arrays. Objects – creation – introspection serialization. Web Techniques – processing forms and maintaining state.

Web Database Applications: Three-tier architecture - Introduction to Object oriented programming with PHP 5. Database basics: MYSQL - querying web databases - writing to web databases - validation with Javascript - Form based authentication - protecting data on the web.

PERL, TCL and PYTHON: PERL: Numbers and Strings- Control Statements- Lists and Arrays- Files- Pattern matching Hashes- Functions. Introduction to TCL/TK - Introduction to Python.

Security in Web Applications: Recognizing web application security threats: Code Grinder - Building functional and secure web applications - Security problems with JavaScript - vulnerable CGI scripts - Code Auditing and Reverse Engineering - types of security used in applications.

Text Books:

1. Kevin Tatroe, Peter MacIntyre, Rasmus Lerdorf, “Programming PHP”, Third Edition, O’Reilly Media, 2013.

Reference Books:

1. Research Papers published in IEEE, ACM, Elsevier publishers, etc.

Course Code	:	**CS5119**
Course Title	:	**Optimization Algorithms**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Discuss the basic concepts of optimization algorithms.
CO2	Analyze the mathematical inference of linear optimization.
CO3	Apply the various swarm intelligence and bio-inspired optimization algorithms for finding solutions to a problem.
CO4	Implement the convex optimization algorithms.
CO5	Explain the different multi-objective optimization algorithms.

Course Content:

Introduction: Historical Review– Optimization Problem– Modeling of the Optimization Problem – Solution with the Graphical Method – Convexity – Gradient Vector, Directional Derivative, and Hessian Matrix – Linear and Quadratic Approximations – 1-D Optimization Algorithms – Solution Techniques – Comparison of Solution Methods.

Linear Optimization: Variants of linear programming problem – Linear convex objective function – Large scale optimization – Delayed column generation – The cutting stock problem – Danzig-wolfe decomposition – Stochastic Programming and Benders Decomposition – Complexity of linear programming – Modelling languages for linear optimization – Dynamic programming – Approximation algorithm – Local search – Simulated Annealing – Complexity Theory.

Swarm Intelligence and Bio-Inspired optimization Algorithms: Optimization Problems– Analysis of Swarm Intelligence Based Algorithms for Constrained Optimization – Swarm Intelligence–Based Optimization Algorithms – Lévy Flights and Global Optimization – Particle Swarm Optimization – Bat Algorithm – Cuckoo Search Algorithm – Whale Optimization Algorithm – Opportunities and Challenges of Integrating Bio-Inspired Optimization.

Convex Optimization Algorithms: Iterative Descent Algorithms – Approximation Methods – Sub gradient Methods – Proximal Algorithms – Basic Theory of Proximal Algorithms – Dual Proximal Algorithms – Proximal Algorithms with Linearization – Alternating Direction Methods of Multipliers – Proximal Gradient Methods – Coordinate Descent Methods.

Multi objective Optimization: Classical Methods – Evolutionary Algorithms – Non-Elitist Multi-Objective Evolutionary Algorithms – Elitist Multi-Objective Evolutionary Algorithms – Constrained Multi-Objective Evolutionary Algorithms – Salient Issues of

Multi-Objective Evolutionary Algorithms – Applications of Multi-Objective Evolutionary Algorithms.

Text Books:

1. Dimitri P. Bertsekas, “Convex Optimization Algorithms”, Athena Scientific, 2015.
2. Dimitris Bertsimas and John N. Tsitsiklis, “Introduction to Linear Optimization”, Athena Scientific,1997.

Reference Books:

1. Kalyanmoy Deb, “Multi-Objective Optimization using Evolutionary Algorithms”, Wiley, 2001.
2. Xin-She Yang, “Swarm Intelligence and Bio-Inspired Computation”, 1st Edition, Elsevier, 2013.

Course Code	:	**CS5120**
Course Title	:	**Service Oriented Architecture and Web Security**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Evaluate web service architecture and XML technologies.
CO2	Develop web applications using web services.
CO3	Summarize the basics of cryptography.
CO4	Apply cryptographic hash functions for authentication.
CO5	Implement security mechanism at different layers of network.

Course Content:

Web Service Architecture: Web Service Architecture, XML Technologies, Service Description: WSDL, Service Discovery: UDDI, Service Transport, Security Considerations

Web Services Technologies: Web Services Technologies - JAX-RPC, JAX-WS. Service Orchestration and Choreography – Composition Standards - Service Oriented Analysis and Design, BPEL

Basics of Cryptography: Basics of Cryptography, Symmetric key Encipherment, Asymmetric key Encipherment

Integrity and Authentication: Message Integrity and authentication, Cryptographic hash functions, Digital signature, Entity authentication, Key management

Security: Security at the application layer, Transport layer, Network layer, Principles in Practice and System Security

Text Books:

1. Thomas Erl, "Service Oriented Architecture: Concepts, Technology, and Design", Pearson Education, 2005.
2. Behrouz A. Forouzan, "Cryptography and Network Security", McGraw-Hill, Inc. New York, NY, USA, 2008.

Reference Books:

1. B V Kumar, S V Subramanya, "Web Services: An Introduction", Tata McGRAW Hill, 2008.
2. Bryan Sullivan; Vincent Liu, "Web Application Security", Publisher: McGraw-Hill, 2011.

Course Code	:	**CS5121**
Course Title	:	**Distributed Systems**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Discuss the architecture and various models of a distributed system.
CO2	Evaluate protocols for various distributed systems.
CO3	Analyze issues related to operating system in distributed file system.
CO4	Devise concurrency control algorithms in distributed transactions.
CO5	Differentiate between asynchronous and synchronous network models.

Course Content:

Basic Concepts Distributed systems: Definition -Examples - Resource sharing and the Web Challenges -System models -Architecture and fundamental models. Networking: Inter process communication - External data representation and marshalling – Client-server and Group communication.

Distributed Objects and Process Distributed objects and remote invocation, Communication between distributed objects, Remote procedure call, Events and notifications. Distributed Operating System: Architecture - Protection - Processes and Threads – Communication and invocation. Security techniques: Cryptographic algorithms – Access control – Digital signatures – Cryptography pragmatics, Needham-Schroeder, Kerberos, Securing electronics transaction, IEEE802.11 WiFi.

Operating System Issues Distributed file systems - Name services, Domain name system, Directory and discovery services, Peer to peer systems, Napster file sharing system, Peer to peer middle ware routing overlays – Clocks, Events and process states. Clock Synchronization: Logical clocks - Global states. Distributed debugging. Distributed mutual exclusion: Elections. Multicast communication.

Distributed Transaction Processing: Transactions: Nested transactions - Locks - Optimistic concurrency control – Time Stamp ordering- Flat and nested distributed transactions - Atomic commit protocols - Concurrency control in distributed transactions – Distributed deadlocks – Transaction recover. Overview of replication, Distributed shared memory and Web services.

Distributed Algorithms: Synchronous network model: Algorithms - leader election - maximal independent set. Asynchronous system model: I/O automata - operations on automata – fairness – shared memory model. Mutual exclusion: model - stronger conditions – lockout –free mutual exclusion algorithms. Asynchronous network model: Algorithms – leader election in a ring and an arbitrary network.

Text Books:

1. George Coulouris, Jean Dollimore and Tim Kindberg, “Distributed Systems Concepts and Design”, Fifth Edition, Pearson Education, 2011.
2. Andrew S. Tanenbaum, Maartenvan Steen, “Distributed Systems Principles and Paradigms”, Second Edition (Reprint), Pearson Education, 2013.

Reference Books:

1. Nancy A. Lynch, “Distributed Algorithms”, Hardcourt Asia Pvt. Ltd., Morgan Kaufmann, 1996**.**
2. Research Papers published in IEEE, ACM, and Elsevier publishers

Course Code	:	**CS5122**
Course Title	:	**Wireless Sensor Networks**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Identify the characteristics of wireless sensor network.
CO2	Evaluate various critical parameters in deploying a wireless sensor network.
CO3	Analyze the issues in designing MAC protocols.
CO4	Discuss the issues in designing routing protocols.
CO5	Notify the challenges in providing Quality of Service.

Course Content:

Introduction: Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet.

Introduction to Adhoc/sensor networks: Introduction to adhoc/sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering.

MAC Protocols: MAC Protocols, Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.

Routing Protocols: Routing Protocols, Issues in designing a routing protocol, classification of routing protocols, table-driven, on- demand, hybrid, flooding, hierarchical, and power aware routing protocols

QoS and Energy Management: QoS and Energy Management, Issues and Challenges in providing QoS, classifications, MAC, network layer solutions, QoS frameworks, need for energy management, classification, battery, transmission power, and system power management schemes.

Text Books:

1. C. Siva Ram Murthy, and B. S. Manoj, “AdHoc Wireless networks”, Pearson Education, 2008.

2. Feng Zhao and Leonides Guibas, “Wireless sensor networks”, Elsevier publication - 2004.

Reference Books:

1. Jochen Schiller, “Mobile Communications”, Pearson Education, 2nd Edition, 2003.
2. William Stallings, “Wireless Communications and Networks”, Pearson Education, 2004.

Course Code	:	**CS5123**
Course Title	:	**Reconfigurable Computing**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Identify the need for reconfigurable architectures.
CO2	Explain the salient features of different reconfigurable architectures.
CO3	Discuss the architecture of FPGAs.
CO4	Build mapping designs to reconfigurable platforms.
CO5	Develop applications using FPGAs.

Course Content:

Device Architecture: General Purpose Computing Vs Reconfigurable Computing – Simple Programmable Logic Devices – Complex Programmable Logic Devices – FPGAs – Device Architecture - Case Studies.

Reconfigurable Computing Architectures and Systems: Reconfigurable Processing Fabric Architectures – RPF Integration into Traditional Computing Systems – Reconfigurable Computing Systems – Case Studies – Reconfiguration Management.

Programming Reconfigurable Systems: Compute Models - Programming FPGA Applications in HDL – Compiling C for Spatial Computing – Operating System Support for Reconfigurable Computing.

Mapping Designs To Reconfigurable Platforms: The Design Flow - Technology Mapping – FPGA Placement and Routing – Configuration Bitstream Generation – Case Studies with Appropriate Tools.

Application Development With FPGAs: Case Studies of FPGA Applications – System on a Programmable Chip (SoPC) Designs.

Text Books:

1. Christophe Bobda, "Introduction to Reconfigurable Computing – Architectures, Algorithms and Applications", Springer, 2010.
2. Maya B. Gokhale and Paul S. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", Springer, 2005.

Reference Books:

1. Nicole Hemsoth, Timothy Prickett, "FPGA Frontiers: New Applications in Reconfigurable Computing", Morgan, Next Platform, 2017.
2. Joao Cardoso (Editor), Michael Hübne, "Reconfigurable Computing: From FPGAs to Hardware/Software Codesign", Springer, 2011.

Course Code	:	**CS5124**
Course Title	:	**Biomedical Image Processing and Analysis**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Examine the difficulties in acquiring biomedical images.
CO2	Apply enhancement techniques to make the image suitable for analysis.
CO3	Identify affected region in the image for segmentation.
CO4	Analyze shape and texture of the image.
CO5	Explain the methods of image reconstruction from projections.

Course Content:

Introduction: Nature of Biomedical images, Objectives of biomedical image analysis, Difficulties in biomedical image acquisition and analysis. Characterization of artifacts, filtering, applications: multiframe averaging in confocal microscopy and noise reduction in nuclear medicine imaging.

Enhancement: Digital Subtraction Angiography, Dual-energy and energy-subtraction X-ray Imaging, Temporal Subtraction, Application: Contrast Enhancement of Mammograms

Detection of Region of Interest: Segmentation and Region growing – Detection of calcifications by multitolerance region growing and linear prediction error.Fuzzy-set-based Region Growing to detect breast tumors. Application: Detection of Spinal Canal, Detection of the breast boundary in mammograms, Detection of pectoral muscle in mammograms.

Analysis of shape and texture: Representation of shapes and contours, Shape factors, fractional concavity, analysis of spicularity, Applications: shape analysis of calcifications and breast masses and tumors. Texture in Biomedical images, model for the generation of texture, Statistical analysis of texture, Law's measures, fractal analysis, audification and sonification of texture in images

Image reconstruction from projections: Radon transform, Methods for generating projection data, Transmission tomography, Reflection tomography, Emission tomography, Magnetic resonance imaging, Fourier slice theorem, Back-projection theorem. Reconstruction techniques for CT (filtered back projection) and MRI (using the FFT), Application: Analysis of the tumor in neuroblastoma.

Text Books:

1. Rangaraj M. Rangayyan, "Biomedical image analysis", CRC Press, 2004.
2. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing" , Pearson Education, 4th edition, 2018.

Reference Books:

1. John L. Semmlow, Benjamin Griffel, “Biosignal and Medical Image Processing”, 3rd Ed, CRC Press, 2014.
2. B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose, “Medical Physics and Biomedical Engineering”, CRC Press, 1998.

Course Code	:	**CS5125**
Course Title	:	**Information Retrieval Techniques**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Utilize an open source search engine framework and explore its capabilities.
CO2	Interpret documents in different ways and discuss its effect on similarity calculations.
CO3	Implement supervised and unsupervised algorithms for text classification.
CO4	Explain search engine architecture and develop search algorithms.
CO5	Apply parallel and distribution methods for information retrieval from the given document, audio or image files.

Course Content:

Introduction Information Retrieval – Early Developments – The IR Problem – The User's Task – Information versus Data Retrieval - The IR System – The Software Architecture of the IR System – The Retrieval and Ranking Processes - The Web – The e-Publishing Era – How the web changed Search – Practical Issues on the Web – How People Search – Search Interfaces Today – Visualization in Search Interfaces.

Modeling and Retrieval Evaluation IR models – Classic Information Retrieval – Alternative Set Theoretic Models – Alternative Algebraic Models – Alternative Probabilistic Models – Other Models – Hypertext Models – Web based Models – Retrieval Evaluation – Cranfield Paradigm – Retrieval Metrics – Reference Collections – User-based Evaluation – Relevance Feedback and Query Expansion – Explicit Relevance Feedback – Clicks – Implicit Feedback Through Local Analysis – Global Analysis – Documents: Languages and Properties – Queries: Languages and Properties.

Text Classification, Indexing and Searching A Characterization of Text Classification – Unsupervised Algorithms – Supervised Algorithms – Feature Selection or Dimensionality Reduction – Evaluation metrics – Organizing the classes – Indexing and Searching – Inverted Indexes –Signature Files – Suffix Trees and Suffix Arrays – Sequential Searching – Multi-dimensional Indexing.

Web Retrieval and Web Crawling Web – Search Engine Architectures – Search Engine Ranking – Managing Web Data – Search Engine User Interaction – Browsing – Applications of a Web Crawler – Taxonomy – Architecture and Implementation – Scheduling Algorithms – Evaluation - Structured Text Retrieval.

Types of IR and Applications Parallel and Distributed IR –Data Partitioning – Parallel IR – Cluster-based IR – Distributed IR - Multimedia Information Retrieval – Challenges –

Content Based Image Retrieval – Audio and Music Retrieval – Retrieving and Browsing Video – Fusion Models – Segmentation –Compression - Enterprise Search –Tasks – Architecture of Enterprise Search Systems – Enterprise Search Evaluation - Library Systems – Digital Libraries

Text Books:

1. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, "Modern Information Retrieval: The Concepts and Technology behind Search", Second Edition, ACM Press Books, 2011.
2. Stefan Buettcher, Charles L. A. Clarke and Gordon V. Cormack, "Information Retrieval:Implementing and Evaluating Search Engines", The MIT Press, 2010.

Reference Books:

2. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008.
3. Bruce Croft, Donald Metzler and Trevor Strohman, "Search Engines: Information Retrieval in Practice", First Edition, Addison Wesley, 2009.

Course Code	:	**CS5126**
Course Title	:	**Biometric security**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Discuss basic principles of biometric systems.
CO2	Analyze the strengths and weaknesses of physiological biometric technologies.
CO3	Apply various technical descriptions of handprint and DNA biometrics.
CO4	Identify the signature and voice biometric systems.
CO5	Assess multi factor biometrics with passwords.

Course Content:

Introduction- Biometrics, benefits of biometrics over traditional authentication systems - benefits of biometrics in identification systems-selecting a biometric for a system – Applications - Key biometric terms and processes - biometric matching methods -Accuracy in biometric systems.

Physiological Biometric Technologies: Fingerprints - Technical description – characteristics - Competing technologies - strengths – weaknesses – deployment - Facial scan - Technical description - characteristics - weaknesses-deployment - Iris scan - Technical description – characteristics - strengths – weaknesses – deployment.

Advanced technologies: Retina vascular pattern- Technical description – characteristics - strengths – weaknesses – deployment - Hand scan - Technical description-characteristics - strengths – weaknesses deployment – DNA biometrics. Behavioral Biometric Technologies: Handprint Biometrics - DNA Biometrics.

Signature and voice technology: Handwriting - Technical description – classification – keyboard / keystroke dynamics- Voice – data acquisition - feature extraction - characteristics - strengths – weaknesses-deployment.

Multi-modal biometrics and security: Limitations of unimodal systems, multibiometric scenarios, levels of fusion, system design, score fusion techniques, score normalization, user-specific parameters, and soft biometrics. Two-factor authentication with passwords - tickets and tokens – executive decision - implementation plan.

Text Books:

1. Samir Nanavathi, Michel Thieme, and Raj Nanavathi, “Biometrics -Identity verification

in a network", 1st Edition, Wiley Eastern, 2002.
2. John Chirillo and Scott Blaul, "Implementing Biometric Security", 1st Edition, Wiley Eastern Publication, 2005.

Reference Books:

1. John Berger, "Biometrics for Network Security", 1st Edition, Prentice Hall, 2004.
2. J. Wayman, A.K. Jain, D. Maltoni, and D. Maio (Eds.), "Biometric Systems: Technology, Design and Performance Evaluation", Springer, 2004.

Course Code	:	**CS5127**
Course Title	:	**Social Network Analysis**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Describe the fundamental concept of semantic web.
CO2	Apply ontology based knowledge representation for semantic web.
CO3	Design mining algorithms for identifying patterns of social media data.
CO4	Perform extraction analysis to identify evolutionary web communities.
CO5	Employ various recommendation methodologies for real world applications.

Course Content:

Introduction: Introduction to Semantic Web: Limitations of current Web – Development of Semantic Web – Emergence of the Social Web. Social Network analysis: Development of Social Network Analysis – Key concepts and measures in network analysis

Modelling, Aggregating And Knowledge Representation: Ontology and their role in the Semantic Web: Ontology-based knowledge Representation – Ontology languages for the Semantic Web: Resource Description Framework – Web Ontology Language – Modelling and aggregating social network data: State-of-the-art in network data representation – Ontological representation of social individuals – Ontological representation of social relationships – Aggregating and reasoning with social network data – Advanced representations.

Algorithms And Techniques: Association Rule Mining, Supervised Learning, Unsupervised Learning, Semi-supervised Learning, Markov models, K-Nearest Neighbouring, Content-based Recommendation, Collaborative Filtering Recommendation, Social Network Analysis, Detecting Community Structure in Networks, the Evolution of Social Networks

Extracting And Analyzing Web Social Networks: Extracting Evolution of Web Community from a Series of Web Archive, Temporal Analysis on Semantic Graph using Three-Way Tensor, Decomposition, Analysis of Communities and Their Evolutions in Dynamic Networks.

Web Mining And Recommendation Systems: User-based and Item-based Collaborative Filtering Recommender Systems, Hybrid User-based and Item-based Web Recommendation System, User Profiling for Web Recommendation Based on PLSA and LDA Model, Combing Long-Term Web Achieves and Logs for Web Query Recommendation

Text Books:

1. Peter Mika, “Social networks and the Semantic Web”, Springer, 2007.
2. Guandong Xu,Yanchun Zhang, and Lin Li, “Web Mining and Social Networking Techniques and Applications”, Springer.

Reference Books:

1. Borko Furht, “Handbook of Social Network Technologies and Applications”, 1st Edition, Springer, 2010.
2. Guandong Xu ,Yanchun Zhang and Lin Li, “Web Mining and Social Networking – Techniques and applications”, First Edition Springer, 2011.

Course Code	:	**CS5128**
Course Title	:	**Natural Language Processing**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Identify the different linguistic components of natural language.
CO2	Evaluate a morphological analyser for a given natural language
CO3	Apply appropriate parsing techniques necessary for a given language.
CO4	Design new tagset and a tagger for a given natural language.
CO5	Develop applications involving natural language.

Course Content:

Morphology And Part-Of-Speech Processing: Introduction –Regular Expressions and Automata-Non-Deterministic FSAs. Transducers –English Morphology-Finite-State Morphological Parsing -Porter Stemmer -Tokenization-Detection and Correction of Spelling Errors. N-grams –Perplexity -Smoothing -Interpolation -Backoff . Part-of-Speech Tagging –English Word Classes -Tagsets -Rule-Based -HMM -Transformation-Based Tagging -Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models

Speech Processing: Phonetics –Articulatory Phonetics -Phonological Categories -Acoustic Phonetics and Signals -Speech Synthesis–Text Normalization –Phonetic and Acoustic Analysis -Diphone Waveform synthesis –Evaluation-Automatic Speech Recognition – Architecture -Hidden Markov Model to Speech -MFCC vectors -Acoustic Likelihood Computation -Evaluation. Triphones –Discriminative Training -Modeling Variation. Computational Phonology- Finite-State Phonology –Computational Optimality Theory - Syllabification -Learning Phonology and Morphology

Syntax Analysis: Finite-State and Context-Free Grammars -Dependency Grammars. Syntactic Parsing – Ambiguity -Dynamic Programming Parsing Methods –CKY-Earley and Chart Parsing-Partial Parsing-Evaluation. Statistical Parsing – Probabilistic Context-Free Grammars –Probabilistic CKY Parsing of PCFGs –Probabilistic Lexicalized CFGs – Collins Parser – Shallow parsers – Dependency parsing

Semantic and Pragmatic Interpretation: Representation of Meaning –Desirable Properties -Computational Semantics -Word Senses -Relations Between Senses –WordNet -Event Participants-Proposition Bank -Frame Net -–Metaphor. Computational Lexical Semantics –Word Sense Disambiguation-Supervised Word Sense Disambiguation - Dictionary and Thesaurus Methods-Word Similarity -Minimally Supervised WSD -

Hyponymy and Other Word Relations -Semantic Role Labeling -Unsupervised Sense Disambiguation. Computational Discourse -Discourse Segmentation - Unsupervised Discourse -Segmentation -Text Coherence -Reference Resolution –Phenomena –Features and algorithms -Pronominal Anaphora Resolution

Applications: Information Extraction –Named Entity Recognition -Relation Detection and Classification –Temporal and Event Processing -Template-Filling -Biomedical Information Extraction. Question Answering and Summarization - Information Retrieval -Factoid Question Answering -Summarization -Single and Multi-Document Summarization - Focused Summarization -Evaluation. Dialog and Conversational Agents –Properties of Human Conversations -Basic Dialogue Systems

Text Books:

1. Jurafsky and Martin, “Speech and Language Processing”, Pearson Prentice Hall, Second Edition, 2008.
2. Christopher D. Manning and Hinrich Schütze, “Foundations of Statistical Natural Language Processing”, MIT Press, 1999.

Reference Books:

1. Stevan Bird, “Natural Language Processing with Python”, Shroff, 2009.
2. James Allen, “Natural Language Understanding”, Addison Wesley, Second Edition, 2007.

Course Code	:	**CS5129**
Course Title	:	**Digital Forensics**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Explain the stages of forensic process.
CO2	Analyze online forensics using social network analysis.
CO3	Apply database forensics to recover relevant information.
CO4	Perform forensics to recover digital evidence or data from a mobile device.
CO5	Employ various analysis techniques on gadgets.

Course Content:

Introduction: Introduction to legal issues, context, and digital forensics; Stages of Forensic: acquisition or imaging of exhibits, analysis and reporting standards.

Computer forensics. Network forensics: monitoring and analysis of Computer Networks, Social Network analysis for Online Forensics.

Database forensics: forensic study of databases and their metadata. Investigative use of database contents, log files and in-RAM data in order to build a time-line or recover relevant information.

Mobile device forensics: recovery of digital evidence or data from a mobile device.
Media Analysis: disk structure, file systems (NTFS, EXT 2/3, HFS), and physical layer issues; Tools for digital forensics.

Analysis Techniques: keyword searches, timelines, hidden data; Application Analysis; Network Analysis; Analysis of Cell phones, PDAs, etc.; Binary Code Analysis; Evidence: collection, preservation, testimony.

Text Books:

1. Kanellis, Panagiotis, "Digital Crime and Forensic Science in Cyberspace", IGI Publishing.
2. Andrew Jones and Craig V, "Building a Digital Forensic Laboratory", 2008.
3. Marshell, Angus M., "Digital Forensics: Digital Evidence in Criminal-Investigation", Wiley Blackwell, 2008.

Reference Books:

1. Philip Craiger, Sujeet Shenoi, "Advances in Digital Forensics", Springer, 2007.
2. Paul Crowley Dave Kleiman, "CD and DVD Forensics", Syngress Publishing Inc, 2007.
3. Chris Prosise, Kevin Mandia, "Incident Response and Computer Forensics", McGraw-Hill, 2nd Edition, 2003.

Course Code	:	**CS5130**
Course Title	:	**Mobile and Pervasive Computing**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**None**
Course Type	:	**Elective**

Course outcomes: At the end of the course, the student will be able to:

CO1	Explain basic architecture and concepts of Third Generation Communication systems.
CO2	Summarize the principles of 4G Telecommunication System.
CO3	Evaluate pervasive computing and its elements.
CO4	Implement Human-Computer Interface in Pervasive environment.
CO5	Apply pervasive concepts in mobile environment.

Course Content:

Introduction: History – Wireless communications: GSM – DECT – TETRA – UMTS – IMT – 2000 – Blue tooth, WiFi, WiMAX, 3G,WATM.- Mobile IP protocols -WAP push architecture-Wml scripts and applications. Data networks – SMS – GPRS – EDGE – Hybrid Wireless100 Networks – ATM – Wireless ATM.

Overview of a Modern 4G Telecommunications System: Introduction. LTE-A System Architecture. LTE RAN. OFDM Air Interface. Evolved Packet Core. LTE Requirements. LTE-Advanced. LTE-A in Release. OFDMA – Introduction. OFDM Principles. LTE Uplink—SC-FDMA. Summary of OFDMA.

Pervasive Concepts And Elements: Technology Trend Overview - Pervasive Computing: Concepts - Challenges - Middleware - Context Awareness - Resource Management - Human–Computer Interaction - Pervasive Transaction Processing - Infrastructure and Devices - Wireless Networks - Middleware for Pervasive Computing Systems - Resource Management - User Tracking- Context Management -Service Management - Data Management - Security Management - Pervasive Computing Environments - Smart Car Space - Intelligent Campus

HCI in Pervasive Computing: Prototype for Application Migration - Prototype for Multimodalities - Human–Computer Interface in Pervasive Environments - HCI Service and Interaction Migration - ContextDriven HCI Service Selection - Interaction Service Selection Overview - User Devices - Service-Oriented Middleware Support - User History and Preference - Context Manager - Local Service Matching - Global Combination - Effective Region - User Active Scope - Service Combination Selection Algorithm

Pervasive Mobile Transactions: Pervasive Mobile Transactions - Introduction to Pervasive Transactions - Mobile Transaction Framework - Unavailable Transaction

Service - Pervasive Transaction Processing Framework - Context-Aware Pervasive Transaction Model - Context Model for Pervasive Transaction Processing - Context-Aware Pervasive Transaction Model - A Case of Pervasive Transactions - Dynamic Transaction Management - Context-Aware Transaction Coordination Mechanism - Coordination Algorithm for Pervasive Transactions - Participant Discovery - Formal Transaction Verification - Petri Net with Selective Transition.

Text Books:

1. Alan Colman, Jun Han, and Muhammad Ashad Kabir, "Pervasive Social Computing Socially-Aware Pervasive Systems and Mobile Applications", Springer, 2016.
2. Kolomvatsos, Kostas, "Intelligent Technologies and Techniques for Pervasive Computing", IGI Global, 2013.
3. Minyi Guo, Jingyu Zhou, Feilong Tang, Yao Shen, "Pervasive Computing: Concepts, Technologies and Applications", CRC Press, 2016.

Reference Books:

1. M. Bala Krishna, Jaime Lloret Mauri, "Advances in Mobile Computing and Communications: Perspectives and Emerging Trends in 5G Networks", CRC 2016.
2. J.Schiller, "Mobile Communication", Addison Wesley, 2000.
3. Juha Korhonen, "Introduction to 4G Mobile Communications", Artech House Publishers, 2014.