

S.A ENGINEERING COLLEGE, CHENNAI – 77
(An Autonomous Institution Affiliated to Anna University)
M.E COMPUTER SCIENCE AND ENGINEERING
REGULATION-2023
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. Develop proficiency as a computer science engineer with an ability to solve a wide range of computational problems and have sustainable development in industry or any other work environment.
2. Analyze and adapt quickly to new environments and technologies, gather new information, and work on emerging technologies to solve multidisciplinary engineering problems.
3. Possess the ability to think analytically and logically to understand technical problems with computational systems for a lifelong learning which leads to pursuing research.
4. Adopt ethical practices to collaborate with team members and team leaders to build technology with cutting-edge technical solutions for computing systems
5. Strongly focus on design thinking and critical analysis to create innovative products and become entrepreneurs.

PROGRAM OUTCOMES (POs):

1. An ability to independently carry out research / investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
4. Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
5. Understand the working of current Industry trends, the new hardware architectures, the software components and design solutions for real world problems by Communicating and effectively working with professionals in various engineering fields and pursue research orientation for a lifelong professional development in computer and automation arenas.
6. Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

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CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA AND SYLLABI
SEMESTER – I

S.NO	SUBJECT CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY:								
1.	MA4101	Mathematical Foundation of Computer Science	FC	5	3	1	0	4
2.	RM4101	Research Methodologies and IPR	RMC	3	3	0	0	3
3.	CS4101	Advanced Data Structures and Algorithms	PCC	3	3	0	0	3
4.	CS4102	Advanced Database Systems	PCC	5	3	0	2	4
5.	CS4103	Network Technologies	PCC	3	3	0	0	3
6.	CS4104	High Performance Computing	PCC	3	3	0	0	3
		Audit Course-I	AC	2	2	0	0	0
PRACTICALS:								
7.	CS4105	Advanced Data Structures and Algorithms Laboratory	PCC	4	0	0	4	2
TOTAL				28	20	1	6	22

SEMESTER – II

S.NO	SUBJECT CODE	COURSE TITLE	CATEG ORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CS4201	Internet of Things	PCC	5	3	0	2	4
2.	CS4202	Advanced Operating Systems	PCC	5	3	0	2	4
3.	CS4203	Machine Learning	PCC	5	3	0	2	4
4.	CS4204	Advanced Software Engineering	PCC	3	3	0	0	3
5.		Professional Elective-I	PEC	3	3	0	0	3
6.		Professional Elective-II	PEC	3	3	0	0	3
7.		Audit Course II	AC	2	2	0	0	0
PRACTICALS								
8.	CS4205	Term Paper Writing and Seminar	EEC	2	0	0	2	1
TOTAL				28	20	0	8	22

SEMESTER-III

S.NO	SUBJECT CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CS4301	Security Practices	PCC	3	3	0	0	3
2.		Professional Elective-III	PEC	3	3	0	0	3
3.		Professional Elective-IV	PEC	5	3	0	2	4
4.		Open Elective	OEC	3	3	0	0	3
PRACTICALS								
5.	CS4302	Project Work-I	EEC	12	0	0	12	6
TOTAL				26	12	0	14	19

SEMESTER-IV

S.NO	SUBJECT CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	CS4401	Project Work-II	EEC	24	0	0	24	12
TOTAL				24	0	0	24	12

TOTAL NO. OF CREDITS: 75

**PROFESSIONAL ELECTIVES SEMESTER-II,
ELECTIVE-I**

S.NO	SUBJECT CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	CS4206	Human Computer Interaction	PEC	3	3	0	0	3
2.	CS4207	Cloud Computing Technologies	PEC	3	3	0	0	3
3.	CS4208	Foundations of Data Science	PEC	3	3	0	0	3
4.	CS4209	Wireless Communications	PEC	3	3	0	0	3
5.	CS4210	Agile Methodologies	PEC	3	3	0	0	3
6.	CS4211	Performance Analysis of Computer Systems	PEC	3	3	0	0	3
7.	CS4212	Multicore Architecture and Programming	PEC	3	3	0	0	3
8.	CS4213	Digital Image Processing	PEC	3	3	0	0	3

**SEMESTER-II,
ELECTIVE-II**

S.NO	SUBJECT CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	CS4214	High Performance Computing for Big Data	PEC	3	0	0	3	3
2.	CS4215	Information Retrieval Techniques	PEC	3	0	0	3	3
3.	CS4216	Software Quality Assurance	PEC	3	0	0	3	3
4.	CS4217	Autonomous Systems	PEC	3	0	0	3	3
5.	CS4218	Web Analytics	PEC	3	0	0	3	3
6.	CS4219	Cognitive Computing	PEC	3	0	0	3	3
7.	CS4220	Quantum Computing	PEC	3	0	0	3	3
8.	CS4221	Big Data Mining and Analytics	PEC	3	0	0	3	3

**SEMESTER-III,
ELECTIVE-III**

S.NO	SUBJECT CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	CS4303	Mobile and Pervasive Computing	PEC	3	0	0	3	3
2.	CS4304	Web Services and API Design	PEC	3	0	0	3	3
3.	CS4305	Data Visualization Techniques	PEC	3	0	0	3	3
4.	CS4306	Compiler Optimization Techniques	PEC	3	0	0	3	3
5.	CS4307	Formal Models of Software Systems	PEC	3	0	0	3	3
6.	CS4308	Robotics	PEC	3	0	0	3	3
7.	CS4309	Natural Language Processing	PEC	4	2	0	2	3
8.	CS4310	GPU Computing	PEC	3	0	0	3	3

**SEMESTER-III,
ELECTIVE-IV**

S.NO	SUBJECT CODE	COURSE TITLE	CATEGO RY	CONTACT PERIODS	L	T	P	C
1.	CS4311	Devops and Microservices	PEC	5	3	0	2	4
2.	CS4312	Mobile Application Development	PEC	5	3	0	2	4
3.	CS4313	Deep Learning	PEC	5	3	0	2	4
4.	CS4314	Blockchain Technologies	PEC	5	3	0	2	4
5.	CS4315	Embedded Software Development	PEC	5	3	0	2	4
6.	CS4316	Full Stack Web Application Development	PEC	5	3	0	2	4
7.	CS4317	Bioinformatics	PEC	5	3	0	2	4
8.	CS4318	Cyber Physical Systems	PEC	5	3	0	2	4
9.	CS4319	Mixed Reality	PEC	5	3	0	2	4

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AC4001	English for Research Paper Writing	2	0	0	0
2.	AC4002	Disaster Management	2	0	0	0
3.	AC4003	Constitution of India	2	0	0	0
4.	AC4004	நற்றமிழ் இலக்கியம்	2	0	0	0

SUMMARY

Sl. No.	NAME OF THE PROGRAMME: M.E COMPUTER SCIENCE AND ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	04	00	00	00	04
2.	PCC	15	15	03	00	33
3.	PEC	00	06	07	00	13
4.	RMC	03	00	00	00	03
5.	OEC	00	00	03	00	03
6.	EEC	00	01	06	12	19
7.	Non Credit/Audit Course			00	00	
8.	TOTAL CREDIT	23	22	19	12	75

MA4101	MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE	L	T	P	C
		3	1	0	4
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> To encourage students to develop a working knowledge of the central ideas of Linear Algebra. To enable students to understand the concepts of Probability and Random Variables. To apply the small / large sample tests through Tests of hypothesis. Be familiar with the most fundamental Graph Theory topics and results To construct automata for any given pattern and find its equivalent regular expressions. 					
UNIT I	LINEAR ALGEBRA				12
Vector spaces – norms – Inner Products – Eigenvalues using QR transformations – QR factorization – generalized eigenvectors – Canonical forms – singular value decomposition and applications – pseudo inverse – least square approximations.					
UNIT II	PROBABILITY AND RANDOM VARIABLES				12
Probability – Axioms of probability – Conditional probability – Baye’s theorem – Random variables – Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.					
UNIT III	TESTING OF HYPOTHESIS				12
Sampling distributions – Type I and Type II errors – Small and Large samples – Tests based on Normal, t, Chi square and F distributions for testing of mean, variance and proportions – Tests for independence of attributes and goodness of fit.					
UNIT IV	TREES AND CONNECTIVITY				12
Graphs – Introduction – Isomorphism – Sub graphs – Walks, Paths, Circuits –Connectedness – Components Trees – Properties of trees – Distance and centers in tree-Spanning trees – Fundamental circuits – Spanning trees in a weighted graph – cut sets – Properties of cut set– Fundamental circuits and cut sets – Connectivity and separability.					
UNIT V	FINITE STATE AUTOMATA				12
Finite State Automata-Deterministic Finite State Automata(DFA), Non Deterministic Finite State Automata (NFA)-Equivalence of DFA and NFA-Equivalence of NFA and Regular Languages.					
TOTAL: 60 PERIODS					
COURSE OUTCOMES:					
At the end of the course, students will be able to					
<ul style="list-style-type: none"> Apply the concepts of Linear Algebra to solve practical problems. Use the ideas of probability and random variables in solving engineering problems. Use statistical tests in testing hypotheses on data. Write precise and accurate mathematical definitions of objects in graph theory and Use mathematical definitions to identify and construct examples and to distinguish examples from non- examples Construct automata, regular expression for any pattern 					
TEXT BOOK AND REFERENCES:					
<ol style="list-style-type: none"> Bronson, R.,”Matrix Operation” Schaum’s outline series, Tata McGraw Hill, New York, 2011. Oliver C. Ibe, “Fundamentals of Applied probability and Random Processes”, Academic Press, Boston, 2014. Johnson R. A. and Gupta C.B., “Miller and Freund’s Probability and Statistics for Engineers”, Pearson India Education, Asia, 9th Edition, New Delhi, 2017. 					

RM4101	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • Identify an appropriate research problem in their research domain • Understand the preparation of a well-structured research paper and scientific presentations without violating professional ethics • Understand the Data Analysis and Interpretation • Understand the law of Patent and copyrights • Understand the adequate knowledge on Patent rights and to know the new developments in IPR. 					
UNIT I	RESEARCH DESIGN				9
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.					
UNIT II	DATA COLLECTION AND SOURCES				9
Effective literature studies approaches, analysis Plagiarism, Effective technical writing, how to write report, Paper Developing a Research Proposal, a presentation and assessment by a review committee, Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.					
UNIT III	DATA ANALYSIS AND REPORTING				9
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation. Data Analysis using Software Package-SPSS and R.					
UNIT IV	INTELLECTUAL PROPERTY RIGHTS				9
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Biodiversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.					
UNIT V	PATENTS				9
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents. New Developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs..					
TOTAL : 45 PERIODS					

COURSE OUTCOMES:

At the end of the course, students will be able to

- Ability to understand research problem formulation.
- Ability to understand the way of doing Literature review and to write proposal in an effective way
- Ability to understand the data collection, data analysis, data presentation and statistical software.
- Ability to understand the nature of Intellectual Property Rights, Patenting process and IPR in national and international level collaborations
- Ability to understand about Patent rights, Patent systems and new developments in IPR

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013
5. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’.
6. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.

CS4101	ADVANCED DATA STRUCTURES AND ALGORITHMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the usage of algorithms in computing
- To learn and use hierarchical data structures and its operations
- To learn the usage of graphs and its applications
- To select and design data structures and algorithms that is appropriate for problems
- To study about NP Completeness of problems

UNIT I	ROLE OF ALGORITHMS IN COMPUTING & COMPLEXITY ANALYSIS	9
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Algorithms – Algorithms as a Technology -Time and Space complexity of algorithms- Asymptotic analysis-Average and worst-case analysis-Asymptotic notation-Importance of efficient algorithms- Program performance measurement - Recurrences: The Substitution Method – The Recursion-Tree Method- Data structures and algorithms

UNIT II	HIERARCHICAL DATA STRUCTURES	9
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Binary Search Trees: Basics – Querying a Binary search tree – Insertion and Deletion- Red Black trees: Properties of Red-Black Trees – Rotations – Insertion – Deletion -B-Trees: Definition of B - trees – Basic operations on B-Trees – Deleting a key from a B-Tree- Heap – Heap Implementation – Disjoint Sets - Fibonacci Heaps: structure – Mergeable-heap operations- Decreasing a key and deleting a node-Bounding the maximum degree

UNIT III	GRAPHS	9
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Elementary Graph Algorithms: Representations of Graphs – Breadth-First Search – Depth-First Search – Topological Sort – Strongly Connected Components- Minimum Spanning Trees: Growing a Minimum Spanning Tree – Kruskal and Prim- Single-Source Shortest Paths: The Bellman-Ford algorithm – Single-Source Shortest paths in Directed Acyclic Graphs – Dijkstra’s Algorithm; Dynamic Programming - All-Pairs Shortest Paths: Shortest Paths and Matrix Multiplication – The Floyd-Warshall Algorithm

UNIT IV	ALGORITHM DESIGN TECHNIQUES	9
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Dynamic Programming: Matrix-Chain Multiplication – Elements of Dynamic Programming – Longest Common Subsequence- Greedy Algorithms: – Elements of the Greedy Strategy- An Activity-Selection Problem - Huffman Coding.

UNIT V	NP COMPLETE AND NP HARD	9
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NP-Completeness: Polynomial Time – Polynomial-Time Verification – NP- Completeness and Reducibility – NP-Completeness Proofs – NP-Complete Problems

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- Design data structures and algorithms to solve computing problems.
- Choose and implement efficient data structures and apply them to solve problems.
- Design algorithms using graph structure and various string-matching algorithms to solve real-life problems
- Design one’s own algorithm for an unknown problem.
- Apply suitable design strategy for problem solving.

REFERENCES:

1. S.Sridhar,” Design and Analysis of Algorithms”, Oxford University Press, 1st Edition,2014
2. Adam Drozdex, “Data Structures and algorithms in C++”, Cengage Learning, 4th Edition, 2013.
3. T.H. Cormen, C.E.Leiserson, R.L. Rivest and C.Stein, "Introduction to Algorithms", Prentice Hall of India, 3rd Edition, 2012.
4. Mark Allen Weiss, “Data Structures and Algorithms in C++”, Pearson Education, 3rd Edition, 2009.
5. E. Horowitz, S. Sahni and S. Rajasekaran, “Fundamentals of Computer Algorithms”, University Press, 2nd Edition, 2008
6. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, “Data Structures and Algorithms”, Pearson Education, Reprint 2006.

CS4102	ADVANCED DATABASE SYSTEMS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- Describe the fundamental elements of relational database management systems
- Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
- Understand query processing in a distributed database system
- Understand the basics of XML and create well-formed and valid XML documents.
- Distinguish the different types of NoSQL databases
- To understand the different models involved in database security and their applications in real time world to protect the database and information associated with them

UNIT I	RELATIONAL DATA MODEL	15
Entity Relationship Model – Relational Data Model – Mapping Entity Relationship Model to Relational Model – Relational Algebra – Structured Query Language – Database Normalization.		
Suggested Activities: Data Definition Language <ul style="list-style-type: none"> ● Create, Alter and Drop ● Enforce Primary Key, Foreign Key, Check, Unique and Not Null Constraints ● Creating Views Data Manipulation Language <ul style="list-style-type: none"> ● Insert, Delete, Update ● Cartesian Product, Equi Join, Left Outer Join, Right Outer Join and Full Outer Join ● Aggregate Functions ● Set Operations ● Nested Queries Transaction Control Language Commit, Rollback and Save Points		
UNIT II	DISTRIBUTED DATABASES, ACTIVE DATABASES AND OPEN DATABASE CONNECTIVITY	15
Distributed Database Architecture – Distributed Data Storage – Distributed Transactions – Distributed Query Processing – Distributed Transaction Management – Event Condition Action Model – Design and Implementation Issues for Active Databases – Open Database Connectivity		
Suggested Activities: <ul style="list-style-type: none"> ● Distributed Database Design and Implementation ● Row Level and Statement Level Triggers ● Accessing a Relational Database using PHP, Python and R 		
UNIT III	XML DATABASES	15
Structured, Semi structured, and Unstructured Data – XML Hierarchical Data Model – XML Documents – Document Type Definition – XML Schema – XML Documents and Databases – XML Querying – XPath – XQuery		
Suggested Activities: <ul style="list-style-type: none"> ● Creating XML Documents, Document Type Definition and XML Schema ● Using a Relational Database to store the XML documents as text ● Using a Relational Database to store the XML documents as data elements ● Creating or publishing customized XML documents from pre-existing relational databases ● Extracting XML Documents from Relational Databases XML Querying 		

UNIT IV	NOSQL DATABASES AND BIG DATA STORAGE SYSTEMS	15
NoSQL – Categories of NoSQL Systems – CAP Theorem – Document-Based NoSQL Systems and MongoDB – MongoDB Data Model – MongoDB Distributed Systems Characteristics – NoSQL Key-Value Stores – DynamoDB Overview – Voldemort Key-Value Distributed Data Store – Wide Column NoSQL Systems – Hbase Data Model – Hbase Crud Operations – Hbase Storage and Distributed System Concepts – NoSQL Graph Databases and Neo4j – Cypher Query Language of Neo4j – Big Data – MapReduce – Hadoop – YARN		
Suggested Activities: <ul style="list-style-type: none"> ● Creating Databases using MongoDB, DynamoDB, Voldemort Key-Value Distributed Data Store Hbase and Neo4j. Writing simple queries to access databases created using MongoDB, DynamoDB, Voldemort Key-Value Distributed Data Store Hbase and Neo4j		
UNIT V	DATABASE SECURITY	15
Database Security Issues – Discretionary Access Control Based on Granting and Revoking Privileges – Mandatory Access Control and Role-Based Access Control for Multilevel Security – SQL Injection – Statistical Database Security – Flow Control – Encryption and Public Key Infrastructures – Preserving Data Privacy – Challenges to Maintaining Database Security – Database Survivability – Oracle Label-Based Security.		
Suggested Activities: Implementing Access Control in Relational Databases		
TOTAL: 75 PERIODS		
COURSE OUTCOMES: At the end of the course, the students will be able to <ul style="list-style-type: none"> ● Convert the ER-model to relational tables, populate relational databases and formulate SQL queries on data. ● Understand and write well-formed XML documents ● Be able to apply methods and techniques for distributed query processing. ● Design and Implement secure database systems. ● Use the data control, definition, and manipulation languages of the NoSQL databases. 		
REFERENCES: <ol style="list-style-type: none"> 1. R. Elmasri, S.B. Navathe, “Fundamentals of Database Systems”, Seventh Edition, Pearson Education 2016. 2. Henry F. Korth, Abraham Silberschatz, S. Sudharshan, “Database System Concepts”, Seventh Edition, McGraw Hill, 2019. 3. C.J.Date, A.Kannan, S.Swamynathan, “An Introduction to Database Systems, Eighth Edition, Pearson Education, 2006 4. Raghu Ramakrishnan , Johannes Gehrke “Database Management Systems”, Fourth Edition, McGraw Hill Education, 2015. 5. Harrison, Guy, “Next Generation Databases, NoSQL and Big Data” , First Edition, Apress publishers, 2015 6. Thomas Cannolly and Carolyn Begg, “Database Systems, A Practical Approach to Design, Implementation and Management”, Sixth Edition, Pearson Education, 2015. 		

CS4103	NETWORK TECHNOLOGIES	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • To understand the basic concepts of networks • To explore various technologies in the wireless domain • To study about 4G and 5G cellular networks • To learn about Network Function Virtualization • To understand the paradigm of Software defined networks 					
UNIT I	NETWORKING CONCEPTS				9
Peer To Peer Vs Client-Server Networks. Network Devices. Network Terminology. Network Speeds. Network throughput, delay. Osi Model. Packets, Frames, And Headers. Collision And Broadcast Domains. LAN Vs WAN. Network Adapter. Hub. Switch. Router. Firewall, IP addressing.					
UNIT II	WIRELESS NETWORKS				9
Wireless access techniques- IEEE 802.11a, 802.11g, 802.11e, 802.11n/ac/ay/ba/be, QoS – Bluetooth – Protocol Stack – Security – Profiles – zigbee					
UNIT III	MOBILE DATA NETWORKS				9
4G Networks and Composite Radio Environment – Protocol Boosters – Hybrid 4G Wireless Networks Protocols – Green Wireless Networks – Physical Layer and Multiple Access – Channel Modelling for 4G – Concepts of 5G – channel access –air interface -Cognitive Radio- spectrum management – C-RAN architecture - Vehicular communications-protocol – Network slicing – MIMO, mmWave, Introduction to 6G.					
UNIT IV	SOFTWARE DEFINED NETWORKS				9
SDN Architecture. Characteristics of Software-Defined Networking. SDN- and NFV-Related Standards. SDN Data Plane. Data Plane Functions. Data Plane Protocols. OpenFlow Logical Network Device. Flow Table Structure. Flow Table Pipeline. The Use of Multiple Tables. Group Table. OpenFlow Protocol. SDN Control Plane Architecture. Control Plane Functions. Southbound Interface. Northbound Interface. Routing. ITU-T Model. OpenDaylight. OpenDaylight Architecture. OpenDaylight Helium. SDN Application Plane Architecture. Northbound Interface. Network Services Abstraction Layer. Network Applications. User Interface					
UNIT V	NETWORK FUNCTIONS VIRTUALIZATION				9
Motivation-Virtual Machines –NFV benefits-requirements – architecture- NFV Infrastructure - Virtualized Network Functions - NFV Management and Orchestration- NFV Use Cases- NFV and SDN –Network virtualization – VLAN and VPN					
					TOTAL: 45 PERIODS

COURSE OUTCOMES:**At the end of the course, the students will be able to**

- Explain basic networking concepts
- Compare different wireless networking protocols
- Describe the developments in each generation of mobile data networks
- Explain and develop SDN based applications
- Explain the concepts of network function virtualization

SUGGESTED ACTIVITIES:

1. Execute various network utilities such as tracert, pathping, ipconfig
2. Implement the Software Defined Networking using Mininet
3. Implement routing in Mininet
4. Install a virtual machine and study network virtualization
5. Simulate various network topologies in Network Simulator

REFERENCES:

1. James Bernstein, “Networking made Easy”, 2018. (UNIT I)
2. HoudaLabiod, Costantino de Santis, HossamAfifi “Wi-Fi, Bluetooth, Zigbee and WiMax”, Springer 2007 (UNIT 2)
3. Erik Dahlman, Stefan Parkvall, Johan Skold, 4G: LTE/LTE-Advanced for Mobile Broadband, Academic Press, 2013 (UNIT 3)
4. Saad Z. Asif “5G Mobile Communications Concepts and Technologies” CRC press – 2019 (UNIT 3)
5. William Stallings “Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud” 1st Edition, Pearson Education, 2016.(Unit 4 and 5)
6. Thomas D.Nadeau and Ken Gray, SDN – Software Defined Networks, O’Reilly Publishers, 2013.
7. Guy Pujolle, “Software Networks”, Second Edition, Wiley-ISTE, 2020.

CS4104	HIGH PERFORMANCE COMPUTING	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> ● To understand the need for multi-core processors, and their architecture. ● To understand the challenges in parallel and multithreaded programming. ● To learn about the various parallel programming paradigms, ● To develop multicore programs and design parallel solutions 					
UNIT I	HIGH PERFORMANCE COMPUTING ARCHITECTURE				9
Introduction - Key properties-Flynn’s Taxonomy– SIMD and MIMD systems – Vector and Pipelining- Multiprocessors– Shared Memory Multiprocessors-Massively Parallel processors-Commodity .Clusters-Performance issues– Heterogeneous Computer Structures					
UNIT II	PARALLEL ALGORITHMS AND CHALLENGES				9
Fork-join – Divide and Conquer - Halo Exchange – Cannon’s Algorithm-Performance – Scalability – Synchronization and data sharing – Data races – deadlocks and live locks– communication between threads (condition variables, signals, message queues and pipes).					
UNIT III	SHARED MEMORY PROGRAMMING WITH Open MP				9

OpenMP Execution Model – Memory Model – Open MP Directives – Work-sharing Constructs – Library functions – Handling Data and Functional Parallelism – Handling Loops – Performance Considerations.		
UNIT IV	DISTRIBUTED MEMORY PROGRAMMING WITH MPI	9
MPI program execution – MPI constructs – libraries – MPI send and receive – Point-to-point and Collective communication – MPI derived data types– Performance evaluation		
UNIT V	PARALLEL PROGRAM DEVELOPMENT	9
Case studies – n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison		
		TOTAL: 45 PERIODS
COURSE OUTCOMES		
At the end of the course, the students should be able to		
<ul style="list-style-type: none"> ● Describe multicore architectures and identify their characteristics and challenges ● Identify the issues in programming Parallel Processors. ● Write programs using OpenMP and MPI. ● Design parallel programming solutions to common problems. ● Compare and contrast programming for serial processors and programming for parallel processors 		
REFERENCES:		
1. Peter S. Pacheco, “An Introduction to Parallel Programming, Morgan-Kauffman/Elsevier, 2021.		
2. Darryl Gove, “Multicore Application Programming for Windows, Linux, and Oracle Solaris, Pearson, 2011 (unit 2)		
3. Michael J Quinn, “Parallel programming in C with MPI and OpenMP, Tata McGraw Hill,2003.		
4. Victor Alessandrini, Shared Memory Application Programming, 1st Edition, Concepts and Strategies in Multicore Application Programming, Morgan Kaufmann, 2015.		
5. Yan Solihin, Fundamentals of Parallel Multicore Architecture, CRC Press, 2015.		

CS4105	ADVANCED DATA STRUCTURES AND ALGORITHMS LABORATORY	L	T	P	C	
		0	0	4	2	
COURSE OBJECTIVES:						
<ul style="list-style-type: none"> To acquire the knowledge of using advanced tree structures To learn the usage of heap structures To understand the usage of graph structures and spanning trees To understand the problems such as matrix chain multiplication, activity selection and Huffman coding To understand the necessary mathematical abstraction to solve problems 						
LIST OF EXPERIMENTS						
<ol style="list-style-type: none"> Implementation of recursive function for tree traversal and Fibonacci Implementation of iteration function for tree traversal and Fibonacci Implementation of Merge Sort and Quick Sort Implementation of a Binary Search Tree Red-Black Tree Implementation Heap Implementation Fibonacci Heap Implementation Graph Traversals Spanning Tree Implementation Shortest Path Algorithms (Dijkstra's algorithm, Bellman Ford Algorithm) Implementation of Matrix Chain Multiplication Activity Selection and Huffman Coding Implementation 						
HARDWARE/SOFTWARE REQUIREMENTS						
64-bit Open source Linux or its derivative						
Open Source C++ Programming tool like G++/GCC						
					TOTAL: 60 PERIODS	
REFERENCES:						
<ol style="list-style-type: none"> Lipschutz Seymour, "Data Structures Schaum's Outlines Series", Tata McGraw Hill, 3rd Edition, 2014. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, "Data Structures and Algorithms", Pearson Education, Reprint 2006 http://www.coursera.org/specializations/data-structures-algorithms http://www.tutorialspoint.com/data_structures_algorithms http://www.geeksforgeeks.org/data-structures/ 						
CS4201	INTERNET OF THINGS	L	T	P	C	
		3	0	2	4	
COURSE OBJECTIVES:						
<ul style="list-style-type: none"> To Understand the Architectural Overview of IoT To Understand the IoT Reference Architecture and Real World Design Constraints To Understand the various IoT levels To understand the basics of cloud architecture To gain experience in Raspberry PI and experiment simple IoT application on it 						
UNIT I	INTRODUCTION					15

Internet of Things- Domain Specific IoTs - IoT and M2M-Sensors for IoT Applications–Structure of IoT–IoT Map Device- IoT System Management with NETCONF-YANG		
UNIT II	IoT ARCHITECTURE, GENERATIONS AND PROTOCOLS	15
IETF architecture for IoT - IoT reference architecture -First Generation – Description & Characteristics–Advanced Generation – Description & Characteristics–Integrated IoT Sensors – Description & Characteristics		
UNIT III	IoT PROTOCOLS AND TECHNOLOGY	15
SCADA and RFID Protocols - BACnet Protocol -Zigbee Architecture - 6LowPAN - CoAP -Wireless Sensor Structure–Energy Storage Module–Power Management Module–RF Module–Sensing Module		
UNIT IV	CLOUD ARCHITECTURE BASICS	15
The Cloud types; IaaS, PaaS, SaaS.- Development environments for service development; Amazon, Azure, Google Appcloud platform in industry		
UNIT V	IOT PROJECTS ON RASPBERRY PI	15
Building IOT with RASPBERRY PI- Creating the sensor project - Preparing Raspberry Pi - Clayster libraries – Hardware Interacting with the hardware - Interfacing the hardware- Internal representation of sensor values - Persisting data - External representation of sensor values - Exporting sensor data		
SUGGESTED ACTIVITIES:		
1.Develop an application for LED Blink and Pattern using Arduino or Raspberry Pi		
2.Develop an application for LED Pattern with Push Button Control using Arduino or Raspberry Pi		
3.Develop an application for LM35 Temperature Sensor to display temperature values using arduino or Raspberry Pi		
4.Develop an application for Forest fire detection end node using Raspberry Pi device and sensor		
5.Develop an application for home intrusion detection web application		
6.Develop an application for Smart parking application using python and Django for web application		
COURSE OUTCOMES:		
CO1: Understand the various concept of the IoT and their technologies		
CO2: Develop the IoT application using different hardware platforms		
CO3: Implement the various IoT Protocols		
CO4: Understand the basic principles of cloud computing		
CO5: Develop and deploy the IoT application into cloud environment		
		TOTAL: 75 PERIODS
REFERENCES:		
1. Arshdeep Bahga, Vijay Madiseti, Internet of Things: A hands-on approach, Universities Press, 2015		
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles (Eds), Architecting the Internet of Things, Springer, 2011		
3.Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015		
4. Ovidiu Vermesan Peter Friess, 'Internet of Things – From Research and Innovation to Market Deployment', River Publishers, 2014		

5.N. Ida, Sensors, Actuators and Their Interfaces: A Multidisciplinary Introduction, 2nd Edition Scitech Publishers, 202014

6. Reese,G.(2009).Cloud Application Architectures:Building Applications and Infrastructure in the Cloud. Sebastopol, CA: O'Reilly Media, Inc. (2009)

CS4202	ADVANCED OPERATING SYSTEM	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To get a comprehensive knowledge of the architecture of distributed systems.
- To understand the deadlock and shared memory issues and their solutions in distributed environments.
- To know the security issues and protection mechanisms for distributed environments.
- To get a knowledge of multiprocessor operating systems and database operating systems.

UNIT I	INTRODUCTION	15
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Architectures of Distributed Systems - System Architecture types - issues in distributed operating systems - communication networks – communication primitives. Theoretical Foundations – inherent limitations of a distributed system – lamport’s logical clocks – vector clocks – causal ordering of messages – global state – cuts of a distributed computation – termination detection. Distributed Mutual Exclusion – introduction – the classification of mutual exclusion and associated algorithms – a comparative performance analysis.

UNIT II	DISTRIBUTED DEADLOCK DETECTION AND RESOURCE MANAGEMENT	15
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Distributed Deadlock Detection -Introduction - deadlock handling strategies in distributed systems – issues in deadlock detection and resolution – control organizations for distributed deadlock detection – centralized and distributed deadlock detection algorithms –hierarchical deadlock detection algorithms. Agreement protocols – introduction-the system model, a classification of agreement problems, solutions to the Byzantine agreement problem, applications of agreement algorithms. Distributed resource management: introduction-architecture – mechanism for building distributed file systems – design issues – log structured file systems.

UNIT III	DISTRIBUTED SHARED MEMORY AND SCHEDULING	15
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Distributed shared memory-Architecture– algorithms for implementing DSM – memory coherence and protocols – design issues. Distributed Scheduling – introduction – issues in load distributing – components of a load distributing algorithm – stability – load distributing algorithms – performance comparison – selecting a suitable load sharing algorithm – requirements for load distributing –task migration and associated issues. Failure Recovery and Fault tolerance: introduction– basic concepts – classification of failures – backward and forward error recovery, backward error recovery- recovery in concurrent systems – consistent set of checkpoints – synchronous and asynchronous check pointing and recovery – check pointing for distributed database systems-recovery in replicated distributed databases.

UNIT IV	DATA SECURITY	15
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Protection and security -preliminaries, the access matrix model and its implementations.-safety in matrix model- advanced models of protection. Data security – cryptography: Model of cryptography, conventional

cryptography- modern cryptography, private key cryptography, data encryption standard- public key cryptography – multiple encryption – authentication in distributed systems.

UNIT-V	MULTIPROCESSOR AND DATABASE OPERATING SYSTEM	15
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Multiprocessor operating systems - basic multiprocessor system architectures – interconnection networks for multiprocessor systems – caching – hypercube architecture. Multiprocessor Operating System - structures of multiprocessor operating system, operating system design issues- threads- process synchronization and scheduling. Database Operating systems :Introduction- requirements of a database operating system Concurrency control : theoretical aspects – introduction, database systems – a concurrency control model of database systems- the problem of concurrency control – serializability theory- distributed database systems, concurrency control algorithms – introduction, basic synchronization primitives, lock based algorithms-timestamp based algorithms, optimistic algorithms – concurrency control algorithms: data replication.

SUGGESTED ACTIVITIES

1. Installation of LINUX using Virtual Machine
2. Basics of UNIX and LINUX commands
3. Write programs using the following system calls of UNIX operating system fork, exec, getpid, exit, wait, close, stat, opendir, readdir
4. Implementation of Deadlock Avoidance Algorithms
5. Implementation of Deadlock Detection Algorithms
6. Implementation of Shared memory and IPC
7. Perform encryption, decryption using the following substitution techniques
(i) Ceaser cipher, (ii) playfair cipher iii) Hill Cipher iv) Vigenere cipher
8. Perform encryption and decryption using following transposition techniques
(i) Rail fence ii) row & Column Transformation

TOTAL: 75 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to

CO1:Understand and explore the working of Theoretical Foundations of OS.

CO2:Analyze the working principles of Distributed Deadlock Detection and resource management

CO3:Understand the concepts of distributed shared memory and scheduling mechanisms

CO4:Understand and analyze the working of Data security

CO5:Apply the learning into multiprocessor system architectures.

REFERENCES:

1. Mukesh Singhal, Niranjan G.Shivaratri, ;Advanced concepts in operating systems: Distributed, Database and multiprocessor operating systems, TMH, 2001
2. Andrew S.Tanenbaum, Modern operating system, PHI, 2003
3. Pradeep K.Sinha, Distributed operating system-Concepts and design, PHI, 2003.
4. Andrew S.Tanenbaum,Distributed operating system, Pearson education, 2003.

CS4203	MACHINE LEARNING	L	T	P	C
		3	0	2	4
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> To understand the concepts and mathematical foundations of machine learning and types of problems tackled by machine learning To explore the different supervised learning techniques including ensemble methods To learn different aspects of unsupervised learning and reinforcement learning To learn the role of probabilistic methods for machine learning To understand the basic concepts of neural networks and deep learning 					
UNIT I	INTRODUCTION AND MATHEMATICAL FOUNDATIONS	15			
What is Machine Learning? Need –History – Definitions – Applications - Advantages, Disadvantages & Challenges -Types of Machine Learning Problems – Mathematical Foundations - Linear Algebra & Analytical Geometry -Probability and Statistics- Bayesian Conditional Probability -Vector Calculus & Optimization - Decision Theory - Information theory					
UNIT II	SUPERVISED LEARNING	15			
Introduction-Discriminative and Generative Models -Linear Regression - Least Squares -Under-fitting / Overfitting -Cross-Validation – Lasso Regression- Classification - Logistic Regression- Gradient Linear Models -Support Vector Machines –Kernel Methods -Instance based Methods - K-Nearest Neighbors - Tree based Methods –Decision Trees –ID3 – CART - Ensemble Methods –Random Forest - Evaluation of Classification Algorithms					
UNIT III	UNSUPERVISED LEARNING AND REINFORCEMENT LEARNING	15			
Introduction - Clustering Algorithms -K – Means – Hierarchical Clustering - Cluster Validity - Dimensionality Reduction –Principal Component Analysis – Recommendation Systems - EM algorithm. Reinforcement Learning – Elements -Model based Learning – Temporal Difference Learning					
UNIT IV	PROBABILISTIC METHODS FOR LEARNING	15			
Introduction -Naïve Bayes Algorithm -Maximum Likelihood -Maximum Apriori -Bayesian Belief Networks -Probabilistic Modelling of Problems -Inference in Bayesian Belief Networks – Probability Density Estimation - Sequence Models – Markov Models – Hidden Markov Models					
UNIT V	NEURAL NETWORKS AND DEEP LEARNING	15			
Neural Networks – Biological Motivation- Perceptron – Multi-layer Perceptron – Feed Forward Network – Back Propagation-Activation and Loss Functions- Limitations of Machine Learning – Deep Learning– Convolution Neural Networks – Recurrent Neural Networks – Use cases					
SUGGESTED ACTIVITIES:					
<ol style="list-style-type: none"> Give an example from our daily life for each type of machine learning problem. Study at least 3 Tools available for Machine Learning and discuss pros & cons of each Take an example of a classification problem. Draw different decision trees for the example and explain the pros and cons of each decision variable at each level of the tree Outline 10 machine learning applications in healthcare Give 5 examples where sequential models are suitable. Give at least 5 recent applications of CNN 					
PRACTICAL EXERCISES					

1. Implement a Linear Regression with a Real Dataset (<https://www.kaggle.com/harrywang/housing>). Experiment with different features in building a model. Tune the model's hyperparameters.
2. Implement a binary classification model. That is, answers a binary question such as "Are houses in this neighborhood above a certain price?"(use data from exercise 1). Modify the classification threshold and determine how that modification influences the model. Experiment with different classification metrics to determine your model's effectiveness.
3. Classification with Nearest Neighbors. In this question, you will use the scikit-learn's KNN classifier to classify real vs. fake news headlines. The aim of this question is for you to read the scikit-learn API and get comfortable with training/validation splits. Use California Housing Dataset
4. In this exercise, you'll experiment with validation sets and test sets using the dataset. Split a training set into a smaller training set and a validation set. Analyze deltas between training set and validation set results. Test the trained model with a test set to determine whether your trained model is overfitting. Detect and fix a common training problem.
5. Implement the k-means algorithm using <https://archive.ics.uci.edu/ml/datasets/Codon+usage> dataset
6. Implement the Naïve Bayes Classifier using <https://archive.ics.uci.edu/ml/datasets/Gait+Classification> dataset

Project - (in Pairs) Your project must implement one or more machine learning algorithms and apply them to some data.

- a. Your project may be a comparison of several existing algorithms, or it may propose a new algorithm in which case you still must compare it to at least one other approach.
- b. You can either pick a project of your own design, or you can choose from the set of pre-defined projects.
- c. You are free to use any third-party ideas or code that you wish as long as it is publicly available.
- d. You must properly provide references to any work that is not your own in the write-up.
- e. Project proposal You must turn in a brief project proposal. Your project proposal should describe the idea behind your project. You should also briefly describe software you will need to write, and papers (2-3) you plan to read.

List of Projects (datasets available)

1. Sentiment Analysis of Product Reviews
2. Stock Prediction
3. Sales Forecasting
4. Music Recommendation
5. Handwriting Digit Classification
6. Fake News Detection
7. Sports Prediction
8. Object Detection
9. Disease Prediction

COURSE OUTCOMES:

Upon the completion of course, students will be able to

CO1: Understand and outline problems for each type of machine learning

CO2: Design a Decision tree and Random forest for an application

CO3: Implement Probabilistic Discriminative and Generative algorithms for an application and analyze the results.

CO4: Use a tool to implement typical Clustering algorithms for different types of applications.

CO5: Design and implement an HMM for a Sequence Model type of application and identify applications suitable for different types of Machine Learning with suitable justification.

TOTAL:75 PERIODS

REFERENCES

1. Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012
3. Ethem Alpaydin, “Introduction to Machine Learning”, Third Edition, Adaptive Computation and Machine Learning Series, MIT Press, 2014
4. Tom M Mitchell, “Machine Learning”, McGraw Hill Education, 2013.
5. Peter Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, First Edition, Cambridge University Press, 2012.
6. Shai Shalev-Shwartz and Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2015
7. Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.
8. Hal Daumé III, “A Course in Machine Learning”, 2017 (freely available online)
9. Trevor Hastie, Robert Tibshirani, Jerome Friedman, “The Elements of Statistical Learning”, Springer, 2009 (freely available online)
10. Aurélien Géron , Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition, o'reilly, (2017)

CS4204	ADVANCED SOFTWARE ENGINEERING	L	T	P	C
		3	0	2	4
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • To understand the rationale for software development process models. • To understand why the architectural design of software is important. • To understand the five important dimensions of dependability, namely, availability, reliability, safety, security, and resilience. • To understand the basic notions of a web service, web service standards, and service-oriented architecture. • To understand the different stages of testing from testing during development of a software system. 					
UNIT I	SOFTWARE PROCESS & MODELING	9			
Prescriptive Process Models – Agility and Process – Scrum – XP – Kanban – DevOps – Prototype Construction – Prototype Evaluation – Prototype Evolution – Modelling – Principles – Requirements Engineering – Scenario-based Modelling – Class-based Modelling – Functional Modelling – Behavioural Modelling.					
UNIT II	SOFTWARE DESIGN	9			
Design Concepts – Design Model – Software Architecture – Architectural Styles – Architectural Design – Component-Level Design – User Experience Design – Design for Mobility – Pattern- Based Design.					
UNIT III	SYSTEM DEPENDABILITY AND SECURITY	9			

Dependable Systems – Dependability Properties – Sociotechnical Systems – Redundancy and Diversity – Dependable Processes – Formal Methods and Dependability – Reliability Engineering – Availability and Reliability – Reliability Requirements – Fault-tolerant Architectures – Programming for Reliability – Reliability Measurement – Safety Engineering – Safety-critical Systems – Safety Requirements – Safety Engineering Processes – Safety Cases – Security Engineering – Security and Dependability – Safety and Organizations – Security Requirements – Secure System Design – Security Testing and Assurance – Resilience Engineering – Cybersecurity – Sociotechnical Resilience – Resilient Systems Design.		
UNIT IV	SERVICE-ORIENTED SOFTWARE ENGINEERING, SYSTEMS ENGINEERING AND REAL-TIME SOFTWARE ENGINEERING	9
Service-oriented Architecture – RESTful Services – Service Engineering – Service Composition – Systems Engineering – Sociotechnical Systems – Conceptual Design – System Procurement – System Development – System Operation and Evolution – Real-time Software Engineering – Embedded System Design – Architectural Patterns for Real-time Software – Timing Analysis – Real-time Operating Systems.		
UNIT V	SOFTWARE TESTING AND SOFTWARE CONFIGURATION MANAGEMENT	9
Software Testing Strategy – Unit Testing – Integration Testing – Validation Testing – System Testing – Debugging – White-Box Testing – Basis Path Testing – Control Structure Testing – Black-Box Testing – Software Configuration Management (SCM) – SCM Repository – SCM Process – Configuration Management for Web and Mobile Apps		
45 PERIODS		
SUGGESTED ACTIVITIES:		
<ol style="list-style-type: none"> 1. Comparatively analysing different Agile methodologies. 2. Describing the scenarios where ‘Scrum’ and ‘Kanban’ are used. 3. Mapping the data flow into suitable software architecture. 4. Developing behavioural representations for a class or component. 5. Implementing simple applications as RESTful service. 		
COURSE OUTCOMES:		
The Students will be able to		
CO1: Identify appropriate process models based on the Project requirements		
CO2: Understand the importance of having a good Software Architecture		
CO3: Understand the five important dimensions of dependability, namely, availability, reliability, safety, security, and resilience.		
CO4: Understand the basic notions of a web service, web service standards, and service-oriented architecture;		
CO5: Be familiar with various levels of Software testing		
REFERENCES		
<ol style="list-style-type: none"> 1. Software Engineering: A Practitioner's Approach, 9th Edition. Roger Pressman and Bruce Maxim, McGraw-Hill 2019. 2. Software Engineering, 10th Edition, Ian Somerville, Pearson Education Asia 2016. 3. Software Architecture In Practice, 3rd Edition, Len Bass, Paul Clements and Rick Kazman, Pearson India 2018 4. An integrated approach to Software Engineering, 3rd Edition, Pankaj Jalote, Narosa Publishing House, 2018 		

5. Fundamentals of Software Engineering, 5th Edition, Rajib Mall, PHI Learning Private Ltd, 2018

CS4205	TERM PAPER WRITING AND SEMINAR	L T P C 0 0 2 1	
<p>In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas. The work involves the following steps:</p>			
Activity	Instructions	Submission week	Evaluation
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2 nd week	3 % Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	<ol style="list-style-type: none"> 1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites) 6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) 8. from your area. 	3 rd week	3% (the selected information must be area specific and of international and national standard)
Collection of Journal papers in the topic in the context of the objective – collect 20 & then filter	<ul style="list-style-type: none"> ● You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar ● When picking papers to read - try to: ● Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them, Favour papers from well-known journals and conferences, 	4 th week	6% (the list of standard papers and reason for selection)

	<ul style="list-style-type: none"> ● Favour “first” or “foundational” papers in the field (as indicated in other people’s survey paper), ● Favour “first” or “foundational” papers in the field (as indicated in other people’s survey paper), ● Favour more recent papers, ● Pick a recent survey of the field so you can quickly gain an overview, ● Find relationships with respect to each other and to your topic area (classification scheme/categorization) ● Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered 		
Reading and notes for first 5 papers	<p>Reading Paper Process</p> <ul style="list-style-type: none"> ● For each paper form a Table answering the following questions: <ul style="list-style-type: none"> ● What is the main topic of the article? ● What was/were the main issue(s) the author said they want to discuss? ● Why did the author claim it was important? ● How does the work build on other’s work, in the author’s opinion? ● What simplifying assumptions does the author claim to be making? ● What did the author do? ● How did the author claim they were going to evaluate their work and compare it to others? ● What did the author say were the limitations of their research? 	5 th week	8% (the table given should indicate your understanding of the
	<ul style="list-style-type: none"> ● What did the author say were the important directions for future research? Conclude with limitations/issues not addressed by the paper (from the perspective of your survey) 		paper and the evaluation is based on your conclusions about each paper)

Reading and notes for next 5 papers	Repeat Reading Paper Process	6 th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Reading and notes for final 5 papers	Repeat Reading Paper Process	7 th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8 th week	8% (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9 th week	6% (Clarity, purpose and conclusion) 6% Presentation & Viva Voce
Introduction Background	Write an introduction and background sections	10 th week	5% (clarity)

Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11 th week	10% (this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12 th week	5% (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of your paper	13 th week	10% (formatting , English, Clarity and linking) 4% Plagiarism Check Report
Seminar	A brief 15 slides on your paper	14 th & 15 th week	10% (based on presentation and Viva-voce)

CS4206	HUMAN COMPUTER INTERACTION	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> To learn the foundations of Human Computer Interaction Understanding Interaction Styles and to become familiar with the design technologies for individuals and persons with disabilities. To understand the process of Evaluation of Interaction Design. To clarify the significance of task analysis for ubiquitous computing To get insight on web and mobile interaction. 					
UNIT I	FOUNDATIONS OF HCI	9			
Context of Interaction –Ergonomics - Designing Interactive systems – Understanding Users- cognition and cognitive frameworks, User Centred approaches Usability, Universal Usability, Understanding and conceptualizing interaction, Guidelines, Principles and Theories. Importance of User Interface: Definition-Importance of good design-Benefits of good design-Human-centered development and Evaluation-Human Performance models-A Brief history of screen design.					
UNIT II	INTERACTION STYLES	9			
GUI: Popularity of graphics - The concept of direct manipulation - Graphical system -Characteristics - Web user - Interface Popularity - Characteristics and Principles of User Interface. Understanding interaction styles, Direct Navigation and Immersive environments, Fluid navigation,Expressive Human and Command Languages, Communication and Collaboration Advancing the user experience, Timely user Experience, Information search, Data Visualization Design process:Human Interaction with computers - Importance of Human Characteristics - Human Consideration -Human Interaction Speeds and Understanding Business Junctions.					
UNIT III	EVALUATION OF INTERACTION	9			
Evaluation Techniques- assessing user experience- usability testing – Heuristic evaluation and walkthroughs, analytics predictive models. Cognitive models, Socio-organizational issues and stakeholder requirements, Communication and collaboration models					
UNIT IV	MODELS AND THEORIES	9			
Task analysis, dialog notations and design, Models of the system, Modeling rich interaction,Ubiquitous computing					
UNIT V	WEB AND MOBILE INTERACTION	9			
Hypertext, Multimedia and WWW, Designing for the web Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow. Use Transitions-Lookup patterns-Feedback patterns Mobile apps, Mobile navigation, content and control idioms, Multi-touch gestures, Inter- app integration, Mobile web					
TOTAL : 45 PERIODS					
COURSE OUTCOMES:					
<p>CO1: Understand the basics of human computer interactions via usability engineering and cognitive modeling.</p> <p>CO2: Understand the basic design paradigms, complex interaction styles.</p> <p>CO3: Understand the models and theories for user interaction</p> <p>CO4: Examine the evaluation of interaction designs and implementations.</p> <p>CO5: Elaborate the above issues for web and mobile applications.</p>					

REFERENCES

1. Ben Shneiderman, Catherine Plaisant, Maxine Cohen, Steven Jacobs, Niklas Elmqvist, “Designing the User Interface: Strategies for Effective Human-Computer Interaction”, Sixth Edition, Pearson Education, 2016.
2. Alan Dix, Janet Finlay, G D Abowd and Russel Beale, "Human Computer Interaction", Pearson Education, Third Edition, 2004.
3. Helen Sharp Jennifer Preece Yvonne Rogers, “Interaction Design: Beyond Human- Computer Interaction”, Wiley, 5th Edition, 2019.
4. Alan Cooper, Robert Reimann, David Cronin, Christopher Noessel, “About Face: The Essentials of Interaction Design”, 4th Edition, Wiley, 2014.
5. Donald A. Norman, “Design of Everyday Things”, MIT Press, 2013.
6. Wilbert O Galitz, "The Essential Guide to User Interface Design", Third Edition, Wiley India Pvt., Ltd., 2007.

CS4207	CLOUD COMPUTING TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution
- To understand the architecture, infrastructure and delivery models of cloud computing.
- To explore the roster of AWS services and illustrate the way to make applications in AWS
- To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure
- To develop the cloud application using various programming model of Hadoop and Aneka

UNIT I	VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE	6
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Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization-Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation

UNIT II	CLOUD PLATFORM ARCHITECTURE	12
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Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Architectural Design Challenges

UNIT III	AWS CLOUD PLATFORM – IAAS	6
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Amazon Web Services: AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manager

UNIT IV	PAAS CLOUD PLATFORM	9
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Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service runtime API- Windows

Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blops

UNIT V	PROGRAMMING MODEL	9
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Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming in Aneka

COURSE OUTCOMES:

- CO1:** Employ the concepts of virtualization in the cloud computing
- CO2:** Identify the architecture, infrastructure and delivery models of cloud computing
- CO3:** Develop the Cloud Application in AWS platform
- CO4:** Apply the concepts of Windows Azure to design Cloud Application
- CO5:** Develop services using various Cloud computing programming models.

TOTAL : 45 PERIODS

REFERENCES

1. Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.
2. Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
3. Sriram Krishnan, Programming: Windows Azure, O’Reilly,2010.
4. Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , McGraw Hill Education (India) Pvt. Ltd., 2013.
5. Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner’s Guidel, McGraw-Hill Osborne Media, 2009.
6. Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
7. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010
8. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
9. McGraw-Hill Osborne Media, 2009.
10. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012

CS4208	FOUNDATIONS OF DATA SCIENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To apply fundamental algorithms to process data.
- Learn to apply hypotheses and data into actionable predictions.
- Document and transfer the results and effectively communicate the findings using visualization techniques.
- To learn statistical methods and machine learning algorithms required for Data Science.
- To develop the fundamental knowledge and understand concepts to become a datascience professional.

UNIT I	INTRODUCTION TO DATA SCIENCE	9
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Data science process – roles, stages in data science project – working with data from files – working with relational databases – exploring data – managing data – cleaning and sampling for modeling and validation – introduction to NoSQL.		
UNIT II	MODELING METHODS	9
Choosing and evaluating models – mapping problems to machine learning, evaluating clustering models, validating models – cluster analysis – K-means algorithm, Naïve Bayes – Memorization Methods – Linear and logistic regression – unsupervised methods.		
UNIT III	INTRODUCTION TO R	9
Reading and getting data into R – ordered and unordered factors – arrays and matrices – lists and data frames – reading data from files – probability distributions – statistical models in R - manipulating objects – data distribution.		
UNIT IV	MAP REDUCE	9
Introduction – distributed file system – algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce – Hadoop - Understanding the Map Reduce architecture - Writing Hadoop MapReduce Programs - Loading data into HDFS - Executing the Map phase - Shuffling and sorting - Reducing phase execution.		
UNIT V	DATA VISUALIZATION	9
Documentation and deployment – producing effective presentations – Introduction to graphical analysis – plot() function – displaying multivariate data – matrix plots – multiple plots in one window - exporting graph using graphics parameters - Case studies.		
TOTAL : 45 PERIODS		
COURSE OUTCOMES:		
<p>CO1: Obtain, clean/process and transform data.</p> <p>CO2: Analyze and interpret data using an ethically responsible approach.</p> <p>CO3: Use appropriate models of analysis, assess the quality of input, derive insight from results, and investigate potential issues.</p> <p>CO4: Apply computing theory, languages and algorithms, as well as mathematical and statistical models, and the principles of optimization to appropriately formulate and use data analyses.</p> <p>CO5: Formulate and use appropriate models of data analysis to solve business-related challenges.</p>		
REFERENCES:		
<ol style="list-style-type: none"> 1. Nina Zumel, John Mount, “Practical Data Science with R”, Manning Publications, 2014. 2. Mark Gardener, “Beginning R - The Statistical Programming Language”, John Wiley & Sons, Inc., 2012. 3. W. N. Venables, D. M. Smith and the R Core Team, “An Introduction to R”, 2013. 4. Tony Ojeda, Sean Patrick Murphy, Benjamin Bengfort, Abhijit Dasgupta, “Practical Data Science Cookbook”, Packt Publishing Ltd., 2014. 5. Nathan Yau, “Visualize This: The Flowing Data Guide to Design, Visualization, and Statistics”, Wiley, 2011. 		

CS4209	WIRELESS COMMUNICATIONS	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> To understand the basic concepts in cellular communication. To learn the characteristics of wireless channels. To understand the impact of digital modulation techniques in fading. To get exposed to diversity techniques in wireless communication. To acquire knowledge in multicarrier systems. 					
UNIT I	CELLULAR CONCEPTS	9			
Frequency Reuse – Channel Assignment Strategies – Handoff Strategies – Interference and system capacity- Co-Channel Interference- Adjacent Channel Interference – Trunking and Grade of service – Improving coverage & capacity in cellular systems-Cell Splitting- Sectoring- Repeaters for Range Extension-Microcell Zone Concept					
UNIT II	THE WIRELESS CHANNEL	9			
Overview of wireless systems – Physical modeling for wireless channels – Time and Frequency coherence – Statistical channel models – Capacity of wireless Channel- Capacity of Flat Fading Channel – Channel Side Information at Receiver – Channel Side Information at Transmitter and Receiver –Capacity comparisons – Capacity of Frequency Selective Fading channels.					
UNIT III	PERFORMANCE OF DIGITAL MODULATION OVER WIRELESS CHANNELS	9			
Performance of flat fading and frequency selective fading – Impact on digital modulation techniques – Outage Probability– Average Probability of Error — Combined Outage and Average Error Probability – Doppler Spread – Inter symbol Interference.					
UNIT IV	DIVERSITY TECHNIQUES	9			
Realization of Independent Fading Paths – Receiver Diversity – Selection Combining – Threshold Combining – Maximal-Ratio Combining – Equal - Gain Combining – Capacity with Receiver diversity – Transmitter Diversity – Channel known at Transmitter – Channel unknownat Transmitter – The Alamouti Scheme– Transmit & Receive Diversity-MIMO Systems.					
UNIT V	MULTICARRIER MODULATION	9			
Data Transmission using Multiple Carriers – Multicarrier Modulation with Overlapping Subchannels – Mitigation of Subcarrier Fading – Discrete Implementation of Multicarrier Modulation					
TOTAL : 45 PERIODS					
COURSE OUTCOMES:					
<p>CO1: Design solutions for cellular communication</p> <p>CO2: Determine the capacity of wireless channels</p> <p>CO3: Analyze the performance of the digital modulation techniques in fading channels</p> <p>CO4: Apply various diversity techniques in wireless communication</p> <p>CO5: Design multicarrier systems in wireless communication</p>					
REFERENCES:					
<ol style="list-style-type: none"> Theodore.S. Rappaport, “Wireless Communications: Principles and Practice”, 2nd Edition, Pearson Education, India, 2010. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005. David T and Pramod Viswanath, “Fundamentals of Wireless Communication”, WileySeries in Telecommunications, Cambridge University Press, 2005. 					

4. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies" CRC press –2019.
5. Keith Q. T. Zhang, "Wireless Communications: Principles, Theory and Methodology" 1st edition, John Wiley & Sons, 2016.
6. Ramjee Prasad, "OFDM for Wireless Communication Systems", Artech House, 2004.
7. Boris Lublinsky, Kevin T. Smith, Alexey Yakubovich, "Professional Hadoop Solutions", John Wiley & Sons Inc., 2013.

CS4210	AGILE METHODOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • To learn the fundamental principles and practices associated with each of the agile development methods. • To apply the principles and practices of agile software development on a project of Interest and relevance to the student. • To provide a good understanding of software design and a set of software technologies And APIs. • To do a detailed examination and demonstration of Agile development And testing techniques. • To understand Agile development and testing. 					

UNIT I	AGILE SOFTWARE DEVELOPMENT	9
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Basics and Fundamentals of Agile Process Methods, Values of Agile, Principles of Agile, stakeholders, Challenges. Lean Approach: Waste Management, Kaizen and Kanban, add process and products add value. Roles related to the lifecycle, differences between Agile and traditional plans, differences between Agile plans at different lifecycle phases. Testing plan links between testing, roles and key techniques, principles, understand as a means of assessing the initial status of a project/ How Agile helps to build quality

UNIT II	AGILE AND SCRUM PRINCIPLES	9
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Agile Manifesto, Twelve Practices of XP, Scrum Practices, Applying Scrum. Need of scrum, working of scrum, advanced Scrum Applications, Scrum and the Organization, scrum values

UNIT III	AGILE PRODUCT MANAGEMENT	9
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Communication, Planning, Estimation Managing the Agile approach Monitoring progress, Targeting and motivating the team, Managing business involvement, Escalating issue. Quality, Risk, Metrics and Measurements, Managing the Agile approach Monitoring progress, Targeting and motivating the team, managing business involvement and Escalating issue

UNIT IV	AGILE REQUIREMENTS AND AGILE TESTING	9
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User Stories, Backlog Management. Agile Architecture: Feature Driven Development. Agile Risk Management: Risk and Quality Assurance, Agile Tools. Agile Testing Techniques, Test-Driven Development, User Acceptance Test

UNIT V	AGILE REVIEW AND SCALING AGILE FOR LARGE PROJECTS	9
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Agile Metrics and Measurements, The Agile approach to estimating and project variables, Agile Measurement, Agile Control: the 7 control parameters. Agile approach to Risk, The Agile approach to Configuration Management, The Atern Principles, Atern Philosophy, the rationale for using Atern, Refactoring, Continuous

integration, Automated Build Tools. Scrum of Scrums, Team collaborations, Scrum, estimate a Scrum Project, Track Scrum Projects, Communication in Scrum Projects, Best Practices to Manage Scrum.

COURSE OUTCOMES:

- CO1:** Analyze existing problems with the team, development process and wider organization.
- CO2:** Apply a thorough understanding of Agile principles and specific practices.
- CO3:** Select the most appropriate way to improve results for a specific circumstance or need.
- CO4:** Judge and craft appropriate adaptations to existing practices or processes depending upon analysis of typical problems.
- CO5:** Evaluate successes and formulate plans to manage risks or problems.

TOTAL: 45 PERIODS

REFERENCES

1. Robert C. Martin ,Agile Software Development, Principles, Patterns, and Practices Alan AptSeries (2011)
2. Succeeding with Agile : Software Development Using Scrum, Pearson (2010)
3. David J. Anderson and Eli Schragenheim, “Agile Management for Software Engineering:Applying the Theory of Constraints for Business Results, Prentice Hall, 2003.
4. Hazza and Dubinsky, “Agile Software Engineering, Series: Undergraduate Topics inComputer Science, Springer, 2009.
5. Craig Larman, “Agile and Iterative Development: A Managers Guide, Addison-Wesley,2004.
6. Kevin C. Desouza, “Agile Information Systems: Conceptualization, Construction, and Management, Butterworth-Heinemann, 2007.

CS4211	PERFORMANCE ANALYSIS OF COMPUTER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the mathematical foundations needed for performance evaluation of computer systems.
- To understand the metrics used for performance evaluation.
- To understand the analytical modeling of computer systems.
- To enable the students to develop new queuing analysis for both simple and complex systems
- To appreciate the use of smart scheduling and introduce the students to analytical techniques for evaluating scheduling policies.

UNIT I	OVERVIEW OF PERFORMANCE EVALUATION	9
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Need for Performance Evaluation in Computer Systems – Overview of Performance Evaluation Methods – Introduction to Queuing – Probability Review – Generating Random Variables for Simulation – Sample Paths, Convergence and Averages – Little’s Law and other Operational Laws- Modification for Closed Systems.

UNIT II	MARKOV CHAINS AND SIMPLE QUEUES	9
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Discrete-Time Markov Chains – Ergodicity Theory – Real World Examples – Google, Aloha – Transition to Continuous-Time Markov Chain – M/M/1.

UNIT III	MULTI-SERVER AND MULTI-QUEUE SYSTEMS	9
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Server Farms: M/M/k and M/M/k/k – Capacity Provisioning for Server Farms – Time Reversibility and Burke’s Theorem – Networks of Queues and Jackson Product Form – Classed and Closed Networks of Queues.

UNIT IV	REAL-WORLD WORKLOADS	9
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Case Study of Real-world Workloads – Phase-Type Distributions and Matrix-Analytic Methods – Networks with Time-Sharing Servers – M/G/1 Queue and the Inspection Paradox – Task Assignment Policies for Server Farms.

UNIT V	SMART SCHEDULING IN THE M/G/1					9			
Performance Metrics – Scheduling Non-Preemptive and Preemptive Non-Size-Based Policies Scheduling Non-Preemptive and Preemptive Size-Based Policies – Scheduling - SRPT and Fairness									
COURSE OUTCOMES:									
Upon completion of this course, the students should be able to									
CO1: Identify the need for performance evaluation and the metrics used for it.									
CO2: Distinguish between open and closed queuing networks.									
CO3: Apply Little’s law and other operational laws to open and closed systems									
CO4: Use discrete-time and continuous-time Markov chains to model real world systems.									
CO5: Develop analytical techniques for evaluating scheduling policies.									
						TOTAL: 45 PERIODS			
REFERENCES									
1. K. S. Trivedi, “Probability and Statistics with Reliability, Queueing and Computer Science Applications”, John Wiley and Sons, 2001.									
2. Krishna Kant, “Introduction to Computer System Performance Evaluation”, McGraw-Hill, 1992.									
3. Lieven Eeckhout, “Computer Architecture Performance Evaluation Methods”, Morgan and Claypool Publishers, 2010.									
4. Mor Harchol - Balter, “Performance Modeling and Design of Computer Systems –Queueing Theory in Action”, Cambridge University Press, 2013.									
5. Paul J. Fortier and Howard E. Michel, “Computer Systems Performance Evaluation and Prediction”, Elsevier, 2003.									
6. Raj Jain, “The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation and Modeling”, Wiley-Interscience, 1991.									
CS4212	MULTICORE ARCHITECTURE AND PROGRAMMING				L	T	P	C	
					3	0	0	3	
COURSE OBJECTIVES:									
<ul style="list-style-type: none"> To understand the need for multi-core processors, and their architecture. To understand the challenges in parallel and multithreaded programming. To learn about the various parallel programming paradigms, To develop multicore programs and design parallel solutions 									
UNIT I	MULTI-CORE PROCESSORS								9
Single core to Multi-core architectures – SIMD and MIMD systems – Interconnection networks – Symmetric and Distributed Shared Memory Architectures – Cache coherence – Performance Issues – Parallel program design.									
UNIT II	SMART SCHEDULING IN THE M/G/1								9
Performance – Scalability – Synchronization and data sharing – Data races – Synchronization primitives (mutexes, locks, semaphores, barriers) – deadlocks and livelocks – communication between threads (condition variables, signals, message queues and pipes).									
UNIT III	SHARED MEMORY PROGRAMMING WITH OpenMP								9

OpenMP Execution Model – Memory Model – OpenMP Directives – Work-sharing Constructs – Library functions – Handling Data and Functional Parallelism – Handling Loops – Performance .Considerations.

UNIT IV	DISTRIBUTED MEMORY PROGRAMMING WITH MPI	9
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MPI program execution – MPI constructs – libraries – MPI send and receive – Point-to-point and Collective communication – MPI derived datatypes – Performance evaluation.

UNIT V	PARALLEL PROGRAM DEVELOPMENT	9
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Case studies – n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.

COURSE OUTCOMES:

At the end of the course, the students should be able to:

CO1: Describe multicore architectures and identify their characteristics and challenges.

CO2: Identify the issues in programming Parallel Processors.

CO3: Write programs using OpenMP and MPI.

CO4: Design parallel programming solutions to common problems.

CO5: Compare and contrast programming for serial processors and programming for parallelprocessors.

TOTAL : 45 PERIODS

REFERENCES

1. Peter S. Pacheco, “An Introduction to Parallel Programming, Morgan-Kauffman/Elsevier,2021.
2. Darryl Gove, “Multicore Application Programming for Windows, Linux, and Oracle Solaris, Pearson, 2011 (unit 2)
3. Michael J Quinn, “Parallel programming in C with MPI and OpenMP, Tata McGrawHill,2003.
4. Victor Alessandrini, Shared Memory Application Programming, 1st Edition, Concepts and Strategies in Multicore Application Programming, Morgan Kaufmann, 2015.
5. Yan Solihin, Fundamentals of Parallel Multicore Architecture, CRC Press, 2015

CS4213	DIGITAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study fundamental concepts of digital image processing.
- To understand and learn image processing operations and restoration.
- To use the concepts of Feature Extraction
- To study the concepts of Image Compression.
- To expose students to current trends in the field of image segmentation

UNIT I	INTRODUCTION	9
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Examples of fields that use digital image processing, fundamental steps in digital image processing, components of image processing system. Digital Image Fundamentals: A simpleimage formation model, image sampling and quantization, basic relationships between pixels.

Image enhancement in the spatial domain: Basic gray-level transformation, histogram processing, enhancement using arithmetic and logic operators, basic spatial filtering, smoothing, and sharpening spatial filters, combining the spatial enhancement methods.

Suggested Activities:

- Discussion of Mathematical Transforms.
- Numerical problem solving using Fourier Transform.
- Numerical problem solving in Image Enhancement.
- External learning – Image Noise and its types.

Suggested Evaluation Methods:

- Tutorial – Image transforms.
- Assignments on histogram specification, histogram equalization and spatial filters.
- Quizzes on noise modeling.

UNIT II	IMAGE RESTORATION	9
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Performance – Scalability – Synchronization and data sharing – Data races – Synchronization primitives (mutexes, locks, semaphores, barriers) – deadlocks and livelocks – communication between threads (condition variables, signals, message queues and pipes).

A model of the image degradation/restoration process, noise models, restoration in the presence of noise—only spatial filtering, Weiner filtering, constrained least squares filtering, geometric transforms; Introduction to the Fourier transform and the frequency domain, estimating the degradation function. Color Image Processing: Color fundamentals, color models, pseudo color image processing, basics of full–color image processing, color transforms, smoothing and sharpening, color segmentation

Suggested Activities:

- Discussion on Image Artifacts and Blur.
- Discussion of Role of Wavelet Transforms in Filter and Analysis.
- Numerical problem solving in Wavelet Transforms.
- External learning – Image restoration algorithms.

Suggested Evaluation Methods:

- Tutorial – Wavelet transforms.
 - Assignment problems on order statistics and multi-resolution expansions.
- Quizzes on wavelet transforms.

UNIT III	FEATURE EXTRACTION	9
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Detection of discontinuities – Edge linking and Boundary detection- Thresholding- -Edge based segmentation- Region based Segmentation- matching-Advanced optimal border and surface detection- Use of motion in segmentation. Image Morphology – Boundary descriptors- Regional descriptors.

Suggested Activities:

- External learning – Feature selection and reduction.
- External learning – Image salient features.
- Assignment on numerical problems in texture computation.

Suggested Evaluation Methods:

- Assignment problems on feature extraction and reduction.
- Quizzes on feature selection and extraction.

UNIT IV	IMAGE COMPRESSION	9
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Fundamentals, image compression models, error-free compression, lossy predictive coding, imagecompression standards Morphological Image Processing: Preliminaries, dilation, erosion, open andclosing, hit or miss transformation, basic morphological algorithms

Suggested Activities:

- Flipped classroom on different image coding techniques.
- Practical – Demonstration of EXIF format for given camera.

- Practical – Implementing effects quantization, color change.
- Case study of Google’s WebP image format.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.

Assignment on image file formats

UNIT V	IMAGE SEGMENTATION	9
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Detection of discontinuous, edge linking and boundary detection, thresholding, region–based segmentation. Object Recognition: Patterns and patterns classes, recognition based on decision– theoretic methods, matching, optimum statistical classifiers, neural networks, structural methods – matching shape numbers, string matching.

Suggested Activities:

- Flipped classroom on importance of segmentation.

Suggested Evaluation Methods:

Tutorial – Image segmentation and edge detection.

COURSE OUTCOMES:

CO1: Apply knowledge of Mathematics for image processing operations

CO2: Apply techniques for image restoration.

CO3: Identify and extract salient features of images.

CO4: Apply the appropriate tools (Contemporary) for image compression and analysis.

CO5: Apply segmentation techniques and do object recognition.

TOTAL : 45 PERIODS

REFERENCES

1. Digital Image Processing, Rafeal C.Gonzalez, Richard E.Woods, Second Edition, Pearson Education/PHI., 2002
2. Digital Image Processing, Sridhar S, Second Edition, Oxford University Press, 2016
3. Introduction to Digital Image Processing with Matlab, Alasdair McAndrew, Thomson Course Technology, .Brooks/Cole 2004
4. Milan Sonka, Vaclav Hlavac, Roger Boyle, “Image Processing, Analysis and Machine Vision”, Second Edition, Thompson Learning, 2007.
5. Digital Image Processing using Matlab, Rafeal C.Gonzalez, Richard E.Woods, Steven L. Eddins, Pearson Education.Second Edition, 2017

CS4214	HIGH PERFORMANCE COMPUTING FOR BIG DATA	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamental concepts of High-Performance Computing.
- To learn the network & software infrastructure for high performance computing.
- To understand real time analytics using high performance computing.
- To learn the different ways of security perspectives and technologies used in HPC.
- To understand the emerging big data applications.

UNIT I	INTRODUCTION	9
The Emerging IT Trends- IOT/IOE-Apache Hadoop for big data analytics-Big data into big insights and actions – Emergence of BDA discipline – strategic implications of big data – BDA Challenges –HPC paradigms – Cluster computing – Grid Computing – Cloud computing – Heterogeneous computing – Mainframes for HPC - Supercomputing for BDA – Appliances for BDA.		
UNIT II	NETWORK & SOFTWARE INFRASTRUCTURE FOR HIGH PERFORMANCE BDA	9
Design of Network Infrastructure for high performance BDA – Network Virtualization – Software Defined Networking – Network Functions Virtualization – WAN optimization for transfer of big data-started with SANs-storage infrastructure requirements for storing big data – FC SAN – IP SAN – NAS – GFS – Panasas – Luster file system – Introduction to cloud storage.		
UNIT III	REAL TIME ANALYTICS USING HIGH PERFORMANCE COMPUTING	9
Technologies that support Real time analytics – MOA: Massive online analysis – GPFS: General parallel file system – Client case studies – Key distinctions – Machine data analytics – operational analytics – HPC Architecture models – In Database analytics – In memory analytics		
UNIT IV	SECURITY AND TECHNOLOGIES	9
Security, Privacy and Trust for user – generated content: The challenges and solutions – Role of real time big data processing in the IoT – End to End Security Framework for big sensing data streams – Clustering in big data.		
UNIT V	EMERGING BIG DATA APPLICATIONS	9
Deep learning Accelerators – Accelerators for clustering applications in machine learning - Accelerators for classification algorithms in machine learning – Accelerators for Big data Genome Sequencing.		
COURSE OUTCOMES:		
<p>Upon completion of the course, the student should be able to:</p> <p>CO1: Understand the basics concepts of High Performance computing systems.</p> <p>CO2: Apply the concepts of network and software infrastructure for high performance computing</p> <p>CO3: Use real time analytics using high performance computing.</p> <p>CO4: Apply the security models and big data applications in high performance computing</p> <p>CO5: Understand the emerging big data applications.</p> <p style="text-align: right;">TOTAL : 45 PERIODS</p>		
REFERENCES		
<ol style="list-style-type: none"> 1. Pethuru Raj, Anupama Raman, Dhivya Nagaraj and Siddhartha Duggirala, "High- Performance Big-Data Analytics: Computing Systems and Approaches", Springer, 1st Edition, 2015. 2. "Big Data Management and Processing", Kuan-Ching Li , Hai Jiang, Albert Y. Zomaya, CRC Press,1st Edition,2017. 3. "High Performance Computing for Big Data: Methodologies and Applications", Chao wang ,CRC Press,1st Edition,2018 		

4. "High-Performance Data Mining And Big Data Analytics" , Khosrow Hassibi, Create Space Independent Publishing Platform, 1st Edition, 2014
5. "High performance computing: Modern systems and practices", Thomas Sterling, Matthew Anderson, Morgan Kaufmann publishers, 1st Edition, 2017

WEB REFERENCES:

1. <https://www.hpcwire.com/>

ONLINE RESOURCES:

1. http://hpc.fs.uni-lj.si/sites/default/files/HPC_for_dummies.pdf
2. <https://www.nics.tennessee.edu/computing-resources/what-is-hpc>

CS4215	INFORMATION RETRIEVAL TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of information retrieval with pertinence to modeling, query operations and indexing
- To get an understanding of machine learning techniques for text classification and clustering.
- To understand the various applications of information retrieval giving emphasis to multimedia IR, web search
- To get an understanding of machine learning techniques for text classification and clustering.
- To understand the concepts of digital libraries

UNIT I	INTRODUCTION: MOTIVATION	9
Basic Concepts – Practical Issues - Retrieval Process – Architecture - Boolean Retrieval – Retrieval Evaluation – Open-Source IR Systems–History of Web Search – Web Characteristics–The impact of the web on IR —IR Versus Web Search–Components of a Search engine.		
UNIT II	MODELING	9
Taxonomy and Characterization of IR Models – Boolean Model – Vector Model - Term Weighting – Scoring and Ranking –Language Models – Set Theoretic Models - Probabilistic Models – Algebraic Models – Structured Text Retrieval Models – Models for Browsing		
UNIT III	INDEXING	9
Static and Dynamic Inverted Indices – Index Construction and Index Compression. Searching Sequential Searching and Pattern Matching. Query Operations -Query Languages – Query Processing Relevance Feedback and Query Expansion - Automatic Local and Global Analysis – Measuring Effectiveness and Efficiency		
UNIT IV	EVALUATION AND PARALLEL INFORMATION RETRIEVAL	9
Traditional Effectiveness Measures – Statistics in Evaluation – Minimizing Adjudication Effect – Nontraditional Effectiveness Measures – Measuring Efficiency – Efficiency Criteria–Queueing Theory – Query Scheduling – Parallel Information Retrieval – Parallel Query Processing – MapReduce		
UNIT V	SEARCHING THE WEB	9

Searching the Web –Structure of the Web –IR and web search – Static and Dynamic Ranking – Web Crawling and Indexing – Link Analysis - XML Retrieval Multimedia IR: Models and Languages – Indexing and Searching Parallel and Distributed IR – Digital Libraries

COURSE OUTCOMES:

Upon completion of the course, the student should be able to:

CO1: Build an Information Retrieval system using the available tools.

CO2: Identify and design the various components of an Information Retrieval system.

CO3: Categorize the different types of IR Models.

CO4: Apply machine learning techniques to text classification and clustering which is used for efficient Information Retrieval.

CO5: Design an efficient search engine and analyze the Web content structure

TOTAL: 45 PERIODS

REFERENCES

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schutze, “Introduction to Information Retrieval, Cambridge University Press, First South Asian Edition.
2. Stefan Buttcher, Implementing and Evaluating Search Engines, The MIT Press, Cambridge, Massachusetts London, England, 2016
3. Ricardo Baeza – Yates, Berthier Ribeiro – Neto, “Modern Information Retrieval: The concepts and Technology behind Search (ACM Press Books), Second Edition, 2011.
4. Stefan Buttcher, Charles L. A. Clarke, Gordon V. Cormack, “Information Retrieval”

CS4216	SOFTWARE QUALITY ASSURANCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Be exposed to the software quality factors, Quality Assurance (SQA) architecture and SQA components.
- Understand the integration of SQA components into the project life cycle.
- Be familiar with the software quality infrastructure.
- Be exposed to the management components of software quality.
- Be familiar with the Quality standards, certifications and assessments

UNIT I	INTRODUCTION TO SOFTWARE QUALITY & ARCHITECTURE	9
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Need for Software quality – Software quality assurance (SQA) – Software quality factors- McCall’s quality model – SQA system components – Pre project quality components – Development and quality plans

UNIT II	SQA COMPONENTS AND PROJECT LIFE CYCLE	9
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Integrating quality activities in the project life cycle – Reviews – Software Testing – Quality of software maintenance components – Quality assurance for external participants contribution – CASE tools for software quality Management.

UNIT III	SOFTWARE QUALITY INFRASTRUCTURE	9
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Procedures and work instructions – Supporting quality devices - Staff training and certification - Corrective and preventive actions – Configuration management – Software change control – Configuration management audit - Documentation control.

UNIT IV	SOFTWARE QUALITY MANAGEMENT & METRICS	9
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Project process control – Software quality metrics – Cost of software quality – Classical quality costmodel – Extended model – Application and Problems in application of Cost model.

UNIT V	STANDARDS, CERTIFICATIONS & ASSESSMENTS	9
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Quality management standards – ISO 9001 and ISO 9000-3 –Capability Maturity Models – CMM and CMMI assessment methodologies - Bootstrap methodology – SPICE Project – SQA project process standards – Organization of Quality Assurance – Role of management in SQA – SQA units and other actors in SQA systems

COURSE OUTCOMES

Upon completion of the course, the student should be able to:

- CO1:** Utilize the concepts of SQA in software development life cycle
- CO2:** Demonstrate their capability to adopt quality standards.
- CO3:** Assess the quality of software products.
- CO4:** Apply the concepts in preparing the quality plan & documents.
- CO5:** Ensure whether the product meets company's quality standards and client's expectations and demands

TOTAL : 45 PERIODS

REFERENCES

1. Daniel Galin, “Software Quality Assurance”, Pearson Publication, 2009.
2. Alan C. Gillies, “Software Quality: Theory and Management”, International Thomson Computer Press 2011.
3. Kshirasagar Naim and Priyadarshi Tripathy,” Software Testing and Quality Assurance Theory and Practice”, John Wiley & Sons Inc., 2008.
4. Mordechai Ben-Menachem “Software Quality: Producing Practical Consistent Software”, International Thompson Computer Press, 2014

CS4217	AUTONOMOUS SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on the functional architecture of autonomous vehicles
- To impart knowledge on Localization and mapping fundamentals
- To impart knowledge on process end effectors and robotic controls
- To learn Robot cell design, Robot Transformation and Sensors
- To learn Micro/Nano Robotic Systems

UNIT I	INTRODUCTION AND FUNCTIONAL ARCHITECTURE	9
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Functional architecture - Major functions in an autonomous vehicle system, Motion Modeling - Coordinate frames and transforms, point mass model, Vehicle modeling (kinematic and dynamic bicycle model - two-track models), Sensor Modeling - encoders, inertial sensors, GPS

UNIT II	PERCEPTION FOR AUTONOMOUS SYSTEMS	9
SLAM - Localization and mapping fundamentals, LIDAR and visual SLAM, Navigation – Global path planning, Local path planning, Vehicle control - Control structures, PID control, Linear quadratic regulator, Sample controllers		
UNIT III	ROBOTICS INTRODUCTION, END EFFECTORS AND CONTROL	9
Robot anatomy-Definition, law of robotics, Simple problems Specifications of Robot-Speed of Robot-Robot joints and links-Robot classifications-Architecture of robotic systems, Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers- Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems- Robot controls-Point to point control, Continuous path control, Intelligent robotControl system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT Motion Interpolations- Adaptive control.		
UNIT IV	ROBOT TRANSFORMATIONS, SENSORS AND ROBOT CELLDESIGN	9
Robot kinematics-Types- 2D, 3D Transformation-Scaling, Rotation, Translation- Homogeneous coordinates, multiple transformation-Simple problems. Sensors in robot – Touch sensors-Tactile, Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot-Mobile robot working principle, actuation using MATLAB, NXT Software.		
UNIT V	MICRO/NANO ROBOTICS SYSTEM	9
Micro/Nano robotics system overview-Scaling effect-Top down and bottom up approach Actuators of Micro/Nano robotics system-Nano robot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot-Swarm robot-Nano robot in targeted drug delivery system.		
COURSE OUTCOMES		
Upon completion of the course, the student should be able to:		
CO1: Understand architecture and modeling of autonomous systems.		
CO2: Employ localization mapping techniques for autonomous systems		
CO3: Design solutions for autonomous systems control.		
CO4: Analyze Robot Transformations, Sensors and Cell Design		
CO5: Explain the working principles of Micro/Nano Robotic system		
		TOTAL : 45 PERIODS
REFERENCES		
<ol style="list-style-type: none"> 1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-HillEducation.,2009 2. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, McGraw Hill, 2012. 3. Karsten Berns, Ewald Puttkamer, Springer, Autonomous Land Vehicles: Steps towards Service Robots, 2009 4. Sebastian Thrun, Wolfram Burgard, Dieter Fox., Probabilistic robotics. MIT Press, 2005 5. Steven M. LaValle., Planning algorithms, Cambridge University Press, 2006 		

6. Daniel Watzenig and Martin Horn (Eds.), Automated Driving: Safer and More Efficient Future Driving, Springer, 2017
7. Markus Maurer, Autonomous driving: technical, legal and social aspects. Springer, 2016
8. Jha, Theory, Design and Applications of Unmanned Aerial Vehicles, CRC Press, 2016

CS4218	WEB ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the Web analytics platform, and their evolution.
- To learn about the various Data Streams Data.
- To learn about the benefits of surveys and capturing of data
- To understand Common metrics of web as well as KPI related concepts.
- To learn about the various Web analytics versions.

UNIT I	INTRODUCTION	9
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Definition, Process, Key terms: Site references, Keywords and Key phrases; building block terms: Visit characterization terms, Content characterization terms, Conversion metrics; Categories: Offsite web, on site web; Web analytics platform, Web analytics evolution, Need for web analytics, Advantages, Limitations

UNIT II	DATA COLLECTION	9
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Click stream Data: Web logs, Web Beacons, JavaScript tags, Packet Sniffing; Outcomes Data: E- commerce, Lead generation, Brand/Advocacy and Support; Research data: Mindset, Organizational structure, Timing; Competitive Data: Panel-Based measurement, ISP-based measurement, Search Engine data

UNIT III	QUALITATIVE ANALYSIS	9
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Heuristic evaluations: Conducting a heuristic evaluation, Benefits of heuristic evaluations; Site Visits: Conducting a site visit, Benefits of site visits; Surveys: Website surveys, Post-visit surveys, creating and running a survey, Benefits of surveys. Capturing data: Web logs or JavaScript's tags, Separate data serving and data capture, Type and size of data, Innovation, Integration, Selecting optimal web analytic tool, Understanding click stream data quality, Identifying unique page definition, Using cookies, Link coding issues.

UNIT IV	WEB METRICS	9
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Common metrics: Hits, Page views, Visits, Unique visitors, Unique page views, Bounce, Bounce rate, Page/visit, Average time on site, New visits; Optimization (e-commerce, non e-commerce sites): Improving bounce rates, Optimizing adwords campaigns; Real time report, Audience report, Traffic source report, Custom campaigns, Content report, Google analytics, Introduction to KPI, characteristics, Need for KPI, Perspective of KPI, Uses of KPI. Relevant Technologies: Internet & TCP/IP, Client / Server Computing, HTTP (Hypertext Transfer Protocol), Server Log Files & Cookies, Web Bugs.

UNIT V	WEB ANALYTICS 2.0	9
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Web analytics 1.0, Limitations of web analytics 1.0, Introduction to analytic 2.0, Competitive intelligence analysis : CI data sources, Toolbar data, Panel data ,ISP data, Search engine data, Hybrid data, Website traffic analysis: Comparing long term traffic trends, Analyzing competitive site overlap and opportunities. Google Analytics: Brief introduction and working, Adwords, Benchmarking, Categories of traffic: Organic traffic, Paid traffic; Google website optimizer, Implementation technology, Limitations, Performance concerns, Privacy issues.

COURSE OUTCOMES

Upon completion of this course, the students should be able to:

CO1: Understand the Web analytics platform, and their evolution.

CO2: Use the various Data Streams Data.

CO3: Know how the survey of capturing of data will benefit.

CO4: Understand Common metrics of web as well as KPI related concepts.

CO5: Apply various Web analytics versions in existence.

TOTAL : 45 PERIODS

REFERENCES

1. Clifton B., Advanced Web Metrics with Google Analytics, Wiley Publishing, Inc. 2nd ed, 2012.
2. Kaushik A., Web Analytics 2.0, The Art of Online Accountability and Science of Customer Centricity, Wiley Publishing, Inc. 1st ed, 2010.
3. Sterne J., Web Metrics: Proven methods for measuring web site success, John Wiley and Sons, 2002

CS4219	COGNITIVE COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To familiarize Use the Innovation Canvas to justify potentially successful products.
- To learn various ways in which to develop a product idea.
- To understand about how Big Data can play vital role in Cognitive Computing
- To know about the business applications of Cognitive Computing
- To get into all applications of Cognitive Computing

UNIT I	FOUNDATION OF COGNITIVE COMPUTING	9
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Foundation of Cognitive Computing: cognitive computing as a new generation, the uses of cognitive systems, system cognitive, gaining insights from data, Artificial Intelligence as the foundation of cognitive computing, understanding cognition Design Principles for Cognitive Systems: Components of a cognitive system, building the corpus, bringing data into cognitive system, machine learning, hypotheses generation and scoring, presentation, and visualization services

UNIT II	NATURAL LANGUAGE PROCESSING IN COGNITIVE SYSTEMS	9
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Natural Language Processing in support of a Cognitive System: Role of NLP in a cognitive system, semantic web, Applying Natural language technologies to Business problems Representing knowledge in Taxonomies and Ontologies: Representing knowledge, Defining Taxonomies and Ontologies, knowledge representation, models for knowledge representation, implementation considerations

UNIT III	BIG DATA AND COGNITIVE COMPUTING	9
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Relationship between Big Data and Cognitive Computing: Dealing with human-generated data, defining big data, architectural foundation, analytical data warehouses, Hadoop, data in motion and streaming data, integration of big data with traditional data Applying Advanced Analytics to cognitive computing: Advanced analytics is on a path to cognitive computing, Key capabilities in advanced analytics, using advanced analytics to create value, Impact of open source tools on advanced analytics

UNIT IV	BUSINESS IMPLICATIONS OF COGNITIVE COMPUTING	9
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Preparing for change ,advantages of new disruptive models , knowledge meaning to business, difference with a cognitive systems approach , meshing data together differently, using business knowledge to plan for the future , answering business questions in new ways , building business specific solutions , making cognitive computing a reality , cognitive application changing the market
The process of building a cognitive application: Emerging cognitive platform, defining the objective,defining the domain, understanding the intended users and their attributes, questions and exploring insights, training and testing

UNIT V	APPLICATION OF COGNITIVE COMPUTING	9
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Building a cognitive health care application: Foundations of cognitive computing for healthcare, constituents in healthcare ecosystem, learning from patterns in healthcare Data, Building on a foundation of big data analytics, cognitive applications across the health care eco system, starting with a cognitive application for healthcare, using cognitive applications to improve health and wellness, using a cognitive application to enhance the electronic medical record Using cognitive application to improve clinical teaching

COURSE OUTCOMES

Upon completion of this course, the students should be able to:

CO1: Explain applications in Cognitive Computing.
CO2: Describe Natural language processor role in Cognitive computing.
CO3: Explain future directions of Cognitive Computing
CO4: Evaluate the process of taking a product to market
CO5: Comprehend the applications involved in this domain.

TOTAL : 45 PERIODS

REFERENCES

- Judith H Hurwitz, Marcia Kaufman, Adrian Bowles, “Cognitive computing and Big DataAnalytics”, Wiley, 2015
- Robert A. Wilson, Frank C. Keil, “The MIT Encyclopedia of the Cognitive Sciences”, The MIT Press, 1999.
- Noah D. Goodman, Joshua B. Tenenbaum, The ProbMods Contributors,“Probabilistic Models of Cognition”, Second Edition, 2016, <https://probmods.org/>.

CS4220	QUANTUM COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To familiarize Use the Innovation Canvas to justify potentially successful products.
- To learn various ways in which to develop a product idea.
- To understand about how Big Data can play vital role in Cognitive Computing
- To know about the business applications of Cognitive Computing
- To get into all applications of Cognitive Computing

UNIT I	QUANTUM BUILDING BLOCKS	9
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The Quantum Mechanics of Photon Polarization, Single-Qubit Quantum Systems, Quantum State Spaces, Entangled States, Multiple-Qubit Systems, Measurement of Multiple-Qubit States, EPR Paradox and Bell’s Theorem, Bloch sphere.

UNIT II	QUANTUM STATE TRANSFORMATIONS	9
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Unitary Transformations, Quantum Gates, Unitary Transformations as Quantum Circuits, Reversible Classical Computations to Quantum Computations, Language for Quantum Implementations.

UNIT III	QUANTUM ALGORITHMS	9
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Computing with Superpositions, Quantum Subroutines, Quantum Fourier Transformations, Shor's Algorithm and Generalizations, Grover's Algorithm and Generalizations.

UNIT IV	ENTANGLED SUBSYSTEMS AND ROBUST QUANTUM COMPUTATION	9
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Quantum Subsystems, Properties of Entangled States, Quantum Error Correction, Graph states and codes, CSS Codes, Stabilizer Codes, Fault Tolerance and Robust Quantum Computing.

UNIT V	QUANTUM INFORMATION PROCESSING	9
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Limitations of Quantum Computing, Alternatives to the Circuit Model of Quantum Computation, Quantum Protocols, Building Quantum, Computers, Simulating Quantum Systems, Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem

COURSE OUTCOMES

Upon completion of this course, the students should be able to:

At the end of the course, the student will be able to

CO1: Understand the basic principles of quantum computing.

CO2: Gain knowledge of the fundamental differences between conventional computing and quantum computing.

CO3: Understand several basic quantum computing algorithms.

CO4: Understand the classes of problems that can be expected to be solved well by quantum computers.

CO5: Simulate and analyze the characteristics of Quantum Computing Systems.

TOTAL : 45 PERIODS

REFERENCES:

1. John Gribbin, Computing with Quantum Cats: From Colossus to Qubits, 2021
2. William (Chuck) Easttom, Quantum Computing Fundamentals, 2021
3. Parag Lala, Quantum Computing, 2019
4. Eleanor Rieffel and Wolfgang Polak, QUANTUM COMPUTING A Gentle Introduction, 2011
5. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press. 2002
6. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific. 2004
7. Pittenger A. O., An Introduction to Quantum Computing Algorithms 2000.

CS4221	BIG DATA MINING AND ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the computational approaches to Modeling, Feature Extraction
- To understand the need and application of Map Reduce
- To understand the various search algorithms applicable to Big Data
- To analyze and interpret streaming data

□ To learn how to handle large data sets in main memory and learn the various clustering techniques applicable to Big Data.		
UNIT I	DATA MINING AND LARGE SCALE FILES	9
Introduction to Statistical modeling – Machine Learning – Computational approaches to modeling – Summarization – Feature Extraction – Statistical Limits on Data Mining - Distributed File Systems –Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques.		
UNIT II	SIMILAR ITEMS	9
Nearest Neighbor Search – Shingling of Documents – Similarity preserving summaries – Locality sensitive hashing for documents – Distance Measures – Theory of Locality Sensitive Functions – LSH Families – Methods for High Degree of Similarities.		
UNIT III	MINING DATA STREAMS	9
Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows		
UNIT IV	LINK ANALYSIS AND FREQUENT ITEMSETS	9
Page Rank –Efficient Computation - Topic Sensitive Page Rank – Link Spam – Market Basket Model – A-priori algorithm – Handling Larger Datasets in Main Memory – Limited Pass Algorithm – Counting Frequent Item sets.		
UNIT V	CLUSTERING	9
Introduction to Clustering Techniques – Hierarchical Clustering –Algorithms – K-Means – CURE – Clustering in Non – Euclidean Spaces – Streams and Parallelism – Case Study: Advertising on the Web – Recommendation Systems.		
COURSE OUTCOMES		
Upon completion of this course, the students will be able to		
CO1: Design algorithms by employing Map Reduce technique for solving Big Data problems.		
CO2: Design algorithms for Big Data by deciding on the apt Features set .		
CO3: Design algorithms for handling petabytes of datasets		
CO4: Design algorithms and propose solutions for Big Data by optimizing main memoryconsumption		
CO5: Design solutions for problems in Big Data by suggesting appropriate clustering techniques		
TOTAL: 45 PERIODS		
REFERENCES:		
1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 3rd Edition, 2020.		
2. Jiawei Han, MichelineKamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufman Publications, Third Edition, 2012.		
3. Ian H.Witten, Eibe Frank “Data Mining – Practical Machine Learning Tools and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.		
4. David Hand, HeikkiMannila and Padhraic Smyth, “Principles of Data Mining”, MIT PRESS,2001		
WEB REFERENCES:		
1. https://swayam.gov.in/nd2_arp19_ap60/preview		
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106104189/lec1.pdf		

ONLINE RESOURCES:

1. <https://examupdates.in/big-data-analytics/>
2. https://www.tutorialspoint.com/big_data_analytics/index.htm
3. https://www.tutorialspoint.com/data_mining/index.htm

CS4301	SECURITY PRACTICES	L	T	P	C
		3	0	0	3
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • To learn the core fundamentals of system and web security concepts • To have through understanding in the security concepts related to networks • To deploy the security essentials in IT Sector • To be exposed to the concepts of Cyber Security and cloud security • To perform a detailed study of Privacy and Storage security and related Issues 					
UNIT I	SYSTEM SECURITY	9			
Model of network security – Security attacks, services and mechanisms – OSI security architecture - A Cryptography primer- Intrusion detection system- Intrusion Prevention system - Security web applications- Case study: OWASP - Top 10 Web Application Security Risks.					
UNIT II	NETWORK SECURITY	9			
Internet Security - Intranet security- Local Area Network Security - Wireless Network Security - Wireless Sensor Network Security- Cellular Network Security - Mobile security - IOT security - Case Study - Kali Linux.					
UNIT III	SECURITY MANAGEMENT	9			
Information security essentials for IT Managers- Security Management System - Policy Driven System Management- IT Security - Online Identity and User Management System. Case study: Metasploit					
UNIT IV	CYBER SECURITY AND CLOUD SECURITY	9			
Cyber Forensics- Disk Forensics – Network Forensics – Wireless Forensics – Database Forensics – Malware Forensics – Mobile Forensics – Email Forensics- Best security practices for automate- Cloud infrastructure management – Establishing trust in IaaS, PaaS, and SaaS Cloud types. Case study: DVWA					
UNIT V	PRIVACY AND STORAGE SECURITY	9			
Privacy on the Internet - Privacy Enhancing Technologies - Personal privacy Policies - Detection of Conflicts in security policies- privacy and security in environment monitoring systems. Storage Area Network Security - Storage Area Network Security Devices - Risk management - Physical Security Essentials.					
					45 PERIODS
COURSE OUTCOMES:					
CO1: Understand the core fundamentals of system security					
CO2: Apply the security concepts to wired and wireless networks					
CO3: Implement and Manage the security essentials in IT Sector					
CO4: Explain the concepts of Cyber Security and Cyber forensics					
CO5: Be aware of Privacy and Storage security Issues.					
REFERENCES					
1. John R. Vacca, Computer and Information Security Handbook, Third Edition, Elsevier 2017					
2. Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, Seventh Edition, Cengage Learning, 2022					

3. Richard E. Smith, Elementary Information Security, Third Edition, Jones and Bartlett Learning, 2019
4. Mayor, K.K.Mookhey, Jacopo Cervini, Fairuzan Roslan, Kevin Beaver, Metasploit Toolkit for Penetration Testing, Exploit Development and Vulnerability Research, Syngress publications, Elsevier, 2007. ISBN : 978-1-59749-074-0
5. John Sammons, "The Basics of Digital Forensics- The Primer for Getting Started in Digital Forensics", Syngress, 2012
6. Cory Altheide and Harlan Carvey, "Digital Forensics with Open Source Tools",2011 Syngress, ISBN: 9781597495875.
7. Siani Pearson, George Yee "Privacy and Security for Cloud Computing" Computer Communications and Networks, Springer, 2013.

AC4001	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> • Teach how to improve writing skills and level of readability • Tell about what to write in each section • Summarize the skills needed when writing a Title • Infer the skills needed when writing the Conclusion • Ensure the quality of paper at very first-time submission 					
UNIT I	INTRODUCTION TO RESEARCH PAPER WRITING	6			
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness					
UNIT II	PRESENTATION SKILLS	6			
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction					
UNIT III	TITLE WRITING SKILLS	6			
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check					
UNIT IV	RESULT WRITING SKILLS	6			
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions					
UNIT V	VERIFICATION SKILLS	6			
Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission					
					45 PERIODS
COURSE OUTCOMES:					
CO1 - Understand that how to improve your writing skills and level of readability CO2 – Learn about what to write in each section CO3 – Understand the skills needed when writing a Title CO4 – Understand the skills needed when writing the Conclusion CO5 – Ensure the good quality of paper at very first-time submission					
REFERENCES					
1.Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011 2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006 3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006 4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman’s 5. book 1998					

AC4002	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> Summarize basics of disaster Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response. Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. Develop the strengths and weaknesses of disaster management approaches 					
UNIT I	INTRODUCTION	6			
Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.					
UNIT II	REPERCUSSIONS OF DISASTERS AND HAZARDS	6			
Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.					
UNIT III	DISASTER PRONE AREAS IN INDIA	6			
Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics					
UNIT IV	DISASTER PREPAREDNESS AND MANAGEMENT	6			
Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.					
UNIT V	RISK ASSESSMENT	6			
Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival					
					45 PERIODS
COURSE OUTCOMES:					
<p>CO1 - Ability to summarize basics of disaster</p> <p>CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.</p> <p>CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.</p> <p>CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.</p> <p>CO5: Ability to develop the strengths and weaknesses of disaster management approaches</p>					

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies”, Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “New book Company,2007.
3. Sahni, Pradeep Et.Al. ,” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, Delhi,2001

AC4003	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0
COURSE OBJECTIVES:					
<ul style="list-style-type: none"> Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the commencement of the Bolshevik Revolution 1917 And its impact on the initial drafting of the Indian Constitution. 					
UNIT I	HISTORY OF MAKING OF THE INDIAN CONSTITUTION	6			
History, Drafting Committee, (Composition & Working)					
UNIT II	PHILOSOPHY OF THE INDIAN CONSTITUTION	6			
Preamble, Salient Features					
UNIT III	CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES	6			
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties					
UNIT IV	ORGANS OF GOVERNANCE	6			
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.					
UNIT V	LOCAL ADMINISTRATION	6			
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Panchayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.					
UNIT VI	ELECTION COMMISSION	6			
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.					
					30 PERIODS
COURSE OUTCOMES:					
<ul style="list-style-type: none"> Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. Discuss the passage of the Hindu Code Bill of 1956 					

SUGGESTED READING

1. The Constitution of India,1950(Bare Act), Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., LexisNexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, LexisNexis, 2015.

AC4004	நற்றமிழ் இலக்கியம்	L	T	P	C
		2	0	0	0
UNIT I	சங்க இலக்கியம் 1. தமிழின் துவக்க நூல் தொல்காப்பியம் எழுத்து, சொல், பொருள் 2. அகநானூறு (82) இயற்கை இன்னிசை அரங்கம் 3. குறிஞ்சிப் பாட்டின் மலர்க் காட்சி 4. புறநானூறு (95,195) – போரை நிறுத்திய ஔவையார்				6
UNIT II	அறநெறித்தமிழ் 1. அறநெறி வகுத்த திருவள்ளுவர் - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புறவு அறிதல், ஈகை, புகழ் 2. பிற அறநூல்கள் - இலக்கிய மருந்து - ஏலாதி, சிறுபஞ்ச மூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)				6
UNIT III	இரட்டைக்காப்பியங்கள் 1. கண்ணகியின் புரட்சி - சிலப்பதி கார வழக்குரை காதை 2. சமூக சேவை இலக்கியம் மணிமேகலை - சிரைகோட்டம் அறக்கோட்டமாகிய காதை				6
UNIT IV	அருள்நெறித்தமிழ் 1. சிறுபாணாற்றுப்படை – பாரி முல்லைக்குத் தேர்கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள் 2. நற்றிணை - அன்னைக்குரிய புன்னை சிறப்பு 3. திருமந்திரம் (617, 618) - இயமம் நியமம் விதிகள் 4. தர்மசாலையை நிறுவிய வள்ளலார் 5. புறநானூறு - சிறுவனே வள்ளலானான் 6. அகநானூறு (4) - வண்டு நற்றிணை (11) - நண்டு கலித்தொகை (11) – யானை, புறா ஐந்திணை 50 (27) - மான் ஆகியவை பற்றி செய்திகள்				6
UNIT V	நவீன தமிழ் இலக்கியம் 1. உரை நடைத்தமிழ். தமிழின் முதல் புதினம், தமிழின் முதல் சிறுகதை				6

	<p>கட்டுரை இலக்கியம், பயண இலக்கியம் நாடகம், 2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும், 3. சமதாய விடுதலையும் தமிழ் இலக்கியமும், 4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பட்டில் தமிழ் இலக்கியமும், 5. அறிவியல் தமிழ், 6. இணையத்தில் தமிழ் 7. சுற்று சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்</p>	
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30 PERIODS

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