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

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I.	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.
II.	Analyze and adapt quickly to new environments and technologies, gather new information, and work on emerging technologies to solve multidisciplinary engineering problems.
III.	Possess the ability to think analytically and logically to understand technical problems with computational systems for a lifelong learning which leads to pursuing research.
IV.	Adopt ethical practices to collaborate with team members and team leaders to build technology with cutting-edge technical solutions for computing systems
V.	Strongly focus on design thinking and critical analysis to create innovative products and become entrepreneurs.

2. 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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M.E COMPUTER SCIENCE AND ENGINEERING
REGULATION-2023A
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA AND SYLLABI
SEMESTER – I

S.NO	SUBJECT CODE	COURSE TITLE	CATEGORY	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	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	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CS4201	Internet of Things	PCC	5	3	0	2	4
2.	CS4202	Advanced Operating Systems	PCC	3	3	0	0	3
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
PRACTICALS								
7.	CS4205	Term Paper Writing and Seminar	EEC	2	0	0	2	1
8.	CS4206	Software Engineering Laboratory	PCC	2	0	0	2	1
TOTAL				26	18	0	8	22

SEMESTER-III

S.NO	SUBJECT CODE	COURSE TITLE	CATE GORY	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
6.		Internship						
TOTAL				26	12	0	14	19

SEMESTER-IV

S.NO	SUBJECT CODE	COURSE TITLE	CATEGO RY	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	CATEG ORY	CONTACT PERIODS	L	T	P	C
1.	CS4207	Human Computer Interaction	PEC	3	3	0	0	3
2.	CS4208	Cloud Computing Technologies	PEC	3	3	0	0	3
3.	CS4209	Foundations of Data Science	PEC	3	3	0	0	3
4.	CS4210	Wireless Communications	PEC	3	3	0	0	3
5.	CS4211	Agile Methodologies	PEC	3	3	0	0	3
6.	CS4212	Performance Analysis of Computer Systems	PEC	3	3	0	0	3
7.	CS4213	Advanced Operating System	PEC	3	3	0	0	3
8.	CS4214	Digital Image Processing	PEC	3	3	0	0	3

SEMESTER-II, ELECTIVE-II

S.NO	SUBJECT CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CS4215	High Performance Computing for Big Data	PEC	3	0	0	3	3
2.	CS4216	Information Retrieval Techniques	PEC	3	0	0	3	3
3.	CS4217	Software Quality Assurance	PEC	3	0	0	3	3
4.	CS4218	Autonomous Systems	PEC	3	0	0	3	3
5.	CS4219	Web Analytics	PEC	3	0	0	3	3
6.	CS4220	Cognitive Computing	PEC	3	0	0	3	3
7.	CS4221	Quantum Computing	PEC	3	0	0	3	3
8.	CS4222	Big Data Mining and Analytics	PEC	3	0	0	3	3

SEMESTER-III, ELECTIVE-III

S.NO	SUBJECT CODE	COURSE TITLE	CATEGORY	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	CATEGORY	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.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ்இலக்கியம்	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	22	22	19	12	75

MA4101 MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- 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

- 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:

1. Bronson, R.,"Matrix Operation" Schaum's outline series, Tata McGraw Hill, New York, 2011.
2. Oliver C. Ibe, "Fundamentals of Applied probability and Random Processes", Academic Press, Boston, 2014.
3. 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.
4. NarsinghDeo, "Graph Theory: With Application to Engineering and Computer Science", Prentice Hall of India, 2003.
5. Hopcroft and Ullman, "Introduction to Automata Theory, Languages and Computation", Narosa Publishing House, Delhi, 2002.

RM4101 RESEARCH METHODOLOGIES AND IPR

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- 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

COURCE 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**

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**

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**

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**

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**

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

- Create, Alter and Drop
- Enforce Primary Key, Foreign Key, Check, Unique and Not Null Constraints
- Creating Views

Data Manipulation Language

- 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:

- 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:

- 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:

- 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

- 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:

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:

- 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/ax/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:

- 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

- 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

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COURSE OBJECTIVES:

- 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

1. Implementation of recursive function for tree traversal and Fibonacci
2. Implementation of iteration function for tree traversal and Fibonacci
3. Implementation of Merge Sort and Quick Sort
4. Implementation of a Binary Search Tree
5. Red-Black Tree Implementation
6. Heap Implementation
7. Fibonacci Heap Implementation
8. Graph Traversals
9. Spanning Tree Implementation
10. Shortest Path Algorithms(Dijkstra's algorithm, Bellman Ford Algorithm)
11. Implementation of Matrix Chain Multiplication
12. 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

COURSE OUTCOMES:

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

- Design and implement basic and advanced data structures extensively
- Design algorithms using graph structures
- Design and develop efficient algorithms with minimum complexity using design techniques
- Develop programs using various algorithms.
- Choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem.

REFERENCES:

1. Lipschutz Seymour, “Data Structures Schaum's Outlines Series”, Tata McGraw Hill, 3rd
2. Edition, 2014.
3. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, “Data Structures and Algorithms”,
4. Pearson Education, Reprint 2006
5. http://www.coursera.org/specializations/data-structures-algorithms
6. http://www.tutorialspoint.com/data_structures_algorithms
7. http://www.geeksforgeeks.org/data-structures/