M.E. (Computer Science and Engineering)

2024 Regulations, Curriculum & Syllabi

Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

An Autonomous Institution Affiliated to Anna University - Chennai • Approved by AICTE • Accredited by NAAC with 'A+' Grade

SATHYAMANGALAM - 638401 ERODE DISTRICT TAMILNADU INDIA

Ph: 04295-226000/221289 Fax: 04295-226666 Email: stayahead@bitsathy.ac.in Web: www.bitsathy.ac.in

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CONTENTS

M.E – COMPUTER SCIENCE AND ENGINEERING

Vision of the Department

To excel in the field of Computer Science and Engineering, to meet the emerging needs of the industry, society and beyond.

Mission of the Department

I. To impart need based education to meet the requirements of the industry and society.

II. To equip students for emerging technologies with global standards and ethics that aid in societal sustainability.

III. To build technologically competent individuals for industry and entrepreneurial ventures by providing infrastructure and human resources.

M.E. COMPUTER SCIENCE AND ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. Analyse, design, and develop creative products and solutions for real-world problems.

II. Critically analyse the current literature in a field of study and ethically develop innovative and research-based methodologies to fill the gaps.

III. Participate in lifelong multidisciplinary learning as skilled computer engineers, including working in teams, investigating and implementing research problems, and presenting technical reports.

PROGRAMME OUTCOMES (POs)

The Graduate will be able to

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.

MAPPING OF PEOs WITH POs

POs	1	2	3	4	5	6
PEO I	X	X	X	X		X
PEO II		X	X	X	X	X
PEO III			X	X	X	X

ME COMPUTER SCIENCE AND ENGINEERING-R2024
Minimum Credits to be Earned: 71

I SEMESTER

Course Code	Course Title	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	SEE	Total	
24RM11	Research Methodology and IPR	2	0	0	2	2	40	60	100	ES
24CS12	Engineering Mathematics and Applications	3	0	0	3	3	40	60	100	BS
24CS13	Applications of Data Structures and Algorithms	3	0	0	3	3	40	60	100	PC
24CS14	Database Engineering	3	0	0	3	3	40	60	100	PC
24CS15	Network Technologies	3	0	0	3	3	40	60	100	PC
24CS16	Principles of Programming Languages	3	0	0	3	3	40	60	100	PC
24CS17	Applications of Data Structures Laboratory	0	0	4	2	3	60	40	100	PC
24CS18	Database Engineering Laboratory	0	0	4	2	3	60	40	100	PC
	Audit course I*	2	0	0	-	2	100	0	100	EEC
Total		**19**	**0**	**8**	**21**	**25**	**-**	**-**	**-**	**-**

II SEMESTER

Course Code	Course Title	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	SEE	Total	
24CS21	Internet of Things	3	0	0	3	3	40	60	100	PC
24CS22	Machine Learning	3	0	0	3	3	40	60	100	PC
24CS23	Advanced Software Engineering	3	0	0	3	3	50	50	100	PC
24CS24	Multicore Architecture and Programming	3	0	2	4	5	50	50	100	PC
	Program Elective I	3	0	0	3	3	40	60	100	PE
	Program Elective II	3	0	0	3	3	40	60	100	PE
24CS27	Machine Learning Laboratory	0	0	4	2	4	60	40	100	PC
24CS28	Mini Project	0	0	4	2	4	100	0	100	PC
	Audit course II*	2	0	0	-	2	100	0	100	EEC
Total		**20**	**0**	**10**	**23**	**30**	**-**	**-**	**-**	**-**

III SEMESTER

Course Code	Course Title	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	SEE	Total	
	Program Elective III	3	0	0	3	3	40	60	100	PE
	Program Elective IV	3	0	0	3	3	40	60	100	PE
	Program Elective V	3	0	0	3	3	40	60	100	PE

24CS34	Dissertation Phase I	0	0	12	6	12	60	40	100	EEC
Total		**9**	**0**	**12**	**15**	**21**	**-**	**-**	**-**	**-**

IV SEMESTER

Course Code	Course Title	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	SEE	Total	
24CS41	Dissertation Phase II	0	0	24	12	24	60	40	100	EEC
Total		**0**	**0**	**24**	**12**	**24**	**-**	**-**	**-**	**-**

ELECTIVES

PROFESIONAL ELECTIVES

Course Code	Course Title	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	SEE	Total	
LIST OF PROFESIONAL ELECTIVES										
24CS51	Agent Based Intelligent Systems	3	0	0	3	3	40	60	100	PE
24CS52	Soft Computing	3	0	0	3	3	40	60	100	PE
24CS53	Cloud Computing Technologies	3	0	0	3	3	40	60	100	PE
24CS54	Data Science	3	0	0	3	3	40	60	100	PE
24CS55	Agile Methodologies	3	0	0	3	3	40	60	100	PE
24CS56	Software Quality Assurance	3	0	0	3	3	40	60	100	PE
24CS57	Digital Image Processing	3	0	0	3	3	40	60	100	PE
24CS58	Information Retrieval Techniques	3	0	0	3	3	40	60	100	PE
24CS59	Natural Language Processing	3	0	0	3	3	40	60	100	PE
24CS60	Deep Learning Techniques	3	0	0	3	3	40	60	100	PE
24CS61	Big Data Mining and Analytics	3	0	0	3	3	40	60	100	PE
24CS62	Data Visualization Techniques	3	0	0	3	3	40	60	100	PE
24CS63	Blockchain Technologies	3	0	0	3	3	40	60	100	PE
24CS64	Full Stack Web Application Development	3	0	0	3	3	40	60	100	PE
24CS65	Cyber Physical Systems	3	0	0	3	3	40	60	100	PE
24CS66	Mixed Reality	3	0	0	3	3	40	60	100	PE
24CS67	DevOps and Micro Services	3	0	0	3	3	40	60	100	PE
24CS68	Mobile and Pervasive Computing	3	0	0	3	3	40	60	100	PE
LIST OF AUDIT COURSES I & II										
24XE01	English for Research Paper Writing	2	0	0	-	2	100	0	100	EEC
24XE02	Cost Management of Engineering Projects	2	0	0	-	2	100	0	100	EEC
24XE03	Stress Management	2	0	0	-	2	100	0	100	EEC

24XE04	Disaster Management	2	0	0	-	2	100	0	100	EEC
24XE05	Value Education	2	0	0	-	2	100	0	100	EEC
24XE06	Pedagogy Studies	2	0	0	-	2	100	0	100	EEC
24XE07	Business Analytics	2	0	0	-	2	100	0	100	EEC

SUMMARY OF CREDIT DISTRIBUTION

S.No	CATEGORY	CREDITS PER SEMESTER				TOTAL CREDIT	CREDITS in %	Range of Total Credits	
		I	II	III	IV			Min	Max
1	BS	3	-	-	-	3	4.22	2%	10%
2	ES	2	-	-	-	2	2.81	2%	10%
3	HSS	-	-	-	-	-	-	-	-
4	PC	12	12	-	-	24	33.80	30%	40%
5	PE	-	6	9	-	15	21.12	20%	30%
6	EEC	5	4	6	12	27	38.02	30%	40%
Total		**22**	**22**	**15**	**12**	**71**	**100**	-	-

BS - Basic Sciences
ES - Engineering Sciences
HSS - Humanities and Social Sciences
PC - Professional Core
PE - Professional Elective
EEC - Employability Enhancement Course
CA - Continuous Assessment
ES - End Semester Examination

24CS11	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	2

Pre-requisite	Assessment Pattern	
● Knowledge of research process. ● Research ethics.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- Understand the techniques for research problem formulation, analysis and solution.
- Analyze literature surveys and prepare reports based on research ethics.
- Develop research proposals and apply assessment procedures to review.
- Develop patents using the IPR & PCT guidelines.
- Adapt the licensing process for patents and analyse the developments of IPR.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Formulate the research problems and identify the approaches to solve the problems.
CO2	Analyze literature surveys and prepare reports based on research ethics.
CO3	Develop research proposals and apply assessment procedures to review.
CO4	Develop patents using the IPR & PCT guidelines.
CO5	Adapt the licensing process for patents and analyse the developments of IPR.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	2	2	3	2	3
2	3				1	3
3	3			1	1	2
4	3				1	1
5	3			1	1	1

Unit I	INTRODUCTION TO RESEARCH PROBLEM	6 Hours

Meaning of research problem - Sources of research problem - Criteria characteristics of a good research problem- errors in selecting a research problem-scope and objectives of research problem-Approaches of Investigations of solutions for research problem-Data collection-Analysis-Interpretation-Necessary instrumentations.

Unit II	LITERATURE REVIEW	6 Hours

Effective Literature studies approaches-analysis-Plagiarism-Research ethics- Review of the literature, Searching the existing literature, reviewing the selected literature, developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Unit III	TECHNICAL WRITING/PRESENTATION	6 Hours

Effective technical writing-how to write report-paper-Developing a research proposal-Format of Research proposal-a presentation and assessment by a review committee.

Unit IV	INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS(IPR)	6 Hours

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: Technological research, Innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grant Patents, Patenting under Patent Cooperation Treaty(PCT).

UNIT V	INTELLECTUAL PROPERTY RIGHT(IPR)	6 Hours

Patent Rights: Scope of Patent Rights, Licensing and transfer of Technology, Patent information and databases-Geographical Indications. New Developments in IPR: Administration of Patent system, IPR of Biological systems, Computer Software-Traditional knowledge - Case studies.

	Total	30 Hours

References

1. Wayne Goddard and Stuart Melville, Research methodology-An Introduction, 2nd Edition, Juta and Company Ltd, 2007.
2. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd, 2007
3. Robert P.Merges, Peter S.Menell, Mark.A.Lemley, Intellectual property in new technological age, 2016.

4. T.Ramappa, Intellectual Property Rights under WTO, S.Chand, 2008.
5. Ranjit Kumar, 2nd Edition, Research Methodology: A Step by Step Guide for beginners, 2010.
6. C.R.Kothari, Gaurav Garg, Research Methodology, Methods and Techniques, 4th Edition, New Age International Publishers, 2018.

24CS12	ENGINEERING MATHEMATICS AND APPLICATIONS	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Basic Statistics inference techniques. ● Hypothesis testing and analysis of variance to engineering problems.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To acquire knowledge of vector spaces and its applications in Computer Science and Engineering.
- To understand the basics of random variables, standard distributions, and their applications in the field of computers.
- To apply testing of hypothesis to infer the outcome of experiments and the design of experiments in Computer Science and Engineering.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Demonstrate the properties and applications of vector spaces in computer science and Engineering.
CO2	Understand the concept of decomposition of the matrices into the required form.
CO3	Apply the concepts of probability distributions in an appropriate place of science and engineering.
CO4	Identify the hypothesis to analyze the nature of the data.
CO5	Organize a calculation for identifying the suitability of an experiment.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	3			1
2	3		2	2		3
3			1		3	2
4	2	1	3	2	2	2
5	2	2	1		1	2

Unit I	**VECTOR SPACES**	**9 Hours**

Real vector spaces - Subspaces - Linear dependence - Basis and dimension of a vector space - Rank -Change of basis - Inner product space - Norm - Gram-Schmidt process - Linear transformation.

Unit II	**EIGENVALUES AND EIGENVECTORS**	**9 Hours**

Eigen values and eigenvectors - Diagonalization - Eigenvectors and linear transformations - Complex Eigen values - Discrete dynamical systems - Iterative estimates for Eigen values - Singular value decomposition - QR decomposition.

Unit III	**PROBABILITY THEORY**	**9 Hours**

Axioms of probability - Addition and multiplication theorems on probability - Conditional probability Bayes theorem (problems only) - Random variable: Continuous and discrete random variables Discrete distributions: Binomial and Poisson - Continuous distributions: Normal, Exponential and Weibull – Simple problems and properties.

Unit IV	**TESTING OF HYPOTHESIS**	**9 Hours**

Concepts of sampling - Methods of sampling - Sampling distributions and classifications - Standard Error -Tests of hypothesis: Tests of hypothesis about proportion, mean and their differences - Chi-square distributions: Test of goodness of fit and test of independence of attributes.

UNIT V	**DESIGN OF EXPERIMENTS AND CONTROL CHARTS**	**9 Hours**

One way and two-way classifications - Completely randomized design – Randomized block design - Latin square design - 2X2 factorial design - Control Charts of Variable and Attributes.

Total	**45 Hours**

References

1. D. C. Lay, Linear Algebra and its Applications, Addison Wesley, Massachusetts, Fourth edition, 2012.
2. Johnson R.A., Miller & Freunds: Probability and Statistics for Engineers, Pearson Education, 8th Edition, 2013.
3. Walpole R.E , Myers R.H, Myers R.S.L and Ye K, Probability and Statistics for Engineers and Scientists , Pearsons Education, Delhi , 2002.
4. Lipschutz S and Schiller J, Schaums outline Series: Introduction to Probability and Statistics, McGraw Hill Publications, New Delhi, 1998.
5. Ross. S, A first Course in Probability, 8th Edition, Pearson Education , New Jersey, 2010.

24CS13	**APPLICATIONS OF DATA STRUCTURES AND ALGORITHMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite

- Introduction to Data Structures and Algorithms.
- Problem Solving Skills.
- Basics of Graph Theory.

Assessment Pattern

Mode of Assessment	**Weightage(%)**
Continuous Internal Assessment	40
Semester End Examinations	60

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.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.

PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Design data structures and algorithms to solve computing problems.
CO2	Implement efficient data structures and apply them to solve problems.
CO3	Design algorithms using graph structure and various string-matching algorithms to real-life problems.
CO4	Design one's own algorithm for an unknown problem.
CO5	Apply suitable design strategy for problem solving.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	2	2	3	1	3
2	3	1				3
3	3		1	1		2
4	3	2	1		2	1
5	3	3	1	1		1

Unit I	**ROLE OF ALGORITHMS IN COMPUTING & COMPLEXITY ANALYSIS**	**10 Hours**

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.

Unit II	**HIERARCHICAL DATA STRUCTURES**	**10 Hours**

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- Heap –Heap Implementation.

Unit III	**GRAPHS**	**9 Hours**

Elementary Graph Algorithms: Representations of Graphs – Breadth-First Search – Depth-First Search – Topological Sort – 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; All-Pairs Shortest Paths: The Floyd-Warshall Algorithm.

Unit IV	**ALGORITHM DESIGN TECHNIQUES**	**9 Hours**

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 Hours**
NP-Completeness: Polynomial Time – Polynomial-Time Verification – NP- Completeness and Reducibility – NP-Completeness Proofs – NP-Complete Problems.		
	Total	**45 Hours**
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. Barbara A.Plog, Patricia J.Quinlan, MPH, CIH and Jennifer Villareal Fundamentals of Industrial Hygiene, 6th edition 2012, National Safety Council, 2012.
6. E. Horowitz, S. Sahni and S. Rajasekaran, "Fundamentals of Computer Algorithms", University Press, 2nd Edition, 2008.

24CS14	**DATABASE ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Introduction to Databases. ● Basics of Relational Database Management Systems (RDBMS). ● Fundamental Programming Skills.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- Exemplify the data models and to conceptualize a database system using ER diagrams.
- Interpret the concepts of parallel and distributed databases.
- Comprehend the use of object and object relational databases.
- Understand the spatial, multimedia and emerging database technologies.
- Explore about the NoSQL Databases.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Design a Relational Database for an Enterprise
CO2	Analyze the transaction processing, concurrency control in parallel and distributed databases.
CO3	Apply the real time data in object and object relational databases.
CO4	Design and implement real-world applications with the use of Spatial Database and Multimedia Database.
CO5	Implement NoSQL database systems and manipulate the data associated with it.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2	1	3	1	2
2	2	2		2	1	1
3	3	1	2	1		1
4	3	2	2	1	1	1
5	2	3	1	1		1

Unit I	**DATABASE SYSTEM CONCEPTS**	**9 Hours**

Purpose of Database systems - Data Storage and Querying - Database architecture - Data models: Relational model - Entity relationship model: Constraints- Removing redundant attributes in entity sets – Entity relationship diagrams - Reduction to relational schemas - Entity relationship design issue - Extended E-R features - Normalization and database design.

Unit II	**PARALLEL AND DISTRIBUTED DATABASES**	**9 Hours**

Parallel Databases – I/O Parallelism - Inter-Query and Intra-Query Parallelism– Inter-Operation and Intra-operation Parallelism – Performance evaluation for Parallel DB Systems –Distributed Database Architecture – Distributed Data Storage – Distributed Transactions – Distributed Query Processing – Distributed Transaction Management – Load balancing tools for DDB – DDB Security.

Unit III	**OBJECT AND OBJECT RELATIONAL DATABASES**	**9 Hours**

Concepts for Object Databases: Object Identity - Object structure - Type Constructors - Encapsulation of Operations - Methods - Persistence - Type and Class Hierarchies - Inheritance - ODMG Model - ODL - OQL - Object Database Conceptual Design.	
Unit IV	**SPATIAL AND MULTIMEDIA DATABASES** **9 Hours**
Spatial database concepts, Spatial data types, and models, Spatial operators and queries, Indexing in spatial databases, Multimedia database concepts, Automatic Analysis of Images, Object Recognition in Images, Semantic Tagging of Images.	
UNIT V	**NOSQL DATABASES** **9 Hours**
NoSQL – CAP Theorem – Sharding – Document based - MongoDB Operation: Insert, Update, Delete, Query, Indexing, Application, Replication, Sharding, Deployment – Using MongoDB with PHP / JAVA/ Python – Cassandra: Data Model – Key Space – Table Operations – CRUD Operations – CQL Types – HIVE : Data types – Database Operations – Partitioning – HiveQL - OrientDB Graph database - OrientDB Features.	
Total	**45 Hours**

References

1. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, Seventh Edition, Pearson Education, 2016.
2. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, Database System Concepts, Seventh Edition, McGraw Hill Education 2020.
3. Brad Dayley, “Teach Yourself NoSQL with MongoDB in 24 Hours”, Sams Publishing, 2014.
4. Thomas Cannolly and Carolyn Begg, “Database Systems, A Practical Approach to Design, Implementation and Management”, Third Edition, Pearson Education, 2007.
5. V.S.Subramanian, “Principles of Multimedia Database Systems”, Harcourt India Pvt. Ltd.,2001.
6. C.J.Date, A.KannanandS.Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.
7. ShashankTiwari, ”Professional NoSQL”, Wiley, 2011.
8. David Lane, Hugh.E.Williums, Web Database Applications with PHP and MySQL, O’Reilly Media; 2nd edition, 2004.

24CS15	**NETWORKING TECHNOLOGIES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
• Basic Networking concepts. • Networking hardware and software. • Basic Network Configuration.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the basic concepts of networks.
- To explore various technologies in the network domain.
- To understand the paradigm of SDN and NFV.
- To study about 4G and 5G cellular networks.
- To learn about Network Function and Orchestration.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the advanced concepts of networking, routing and switching.
CO2	Analyze the different types of technologies involved in networking.
CO3	Apply the concepts of SDN and NFV architecture to establish a network
CO4	Analyze the importance of 4G and 5G technologies for communication.
CO5	Apply the mechanism of network automation and Orchestration for real world applications.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	3	2		1	
2	1	3	3	3		
3	1	3	3	2	2	2
4	1	2	2	1	2	1
5	1	3	1	1	1	2

Unit I	**NETWORKING, ROUTING AND SWITCHING**	**9 Hours**

Advanced Networking Concepts: Overview of computer networks - Network topologies - Network protocols and communication models - OSI model and TCP/IP stack - Routing and Switching: Basics of routing algorithms - Switching techniques and VLANs - Introduction to routing protocols RIP, OSPF, BGP.

Unit II	**NETWORK TECHNOLOGIES**	**9 Hours**

Introduction: Overview of networking technologies landscape - Historical perspective and evolution of networking - Emerging trends in networking - Internet of Things (IoT) Technologies: IoT architecture and components - Protocols used in IoT - Cloud Computing Technologies: Cloud service & Deployment models (IaaS, PaaS, SaaS) - Virtualization and hypervisor technologies.

Unit III	**SOFTWARE-DEFINED NETWORKING (SDN) & NETWORK FUNCTION VIRTUALIZATION (NFV)**	**9 Hours**

SDN: SDN architecture and components - OpenFlow protocol - SDN use cases and applications, NFV: Introduction to NFV - NFV architecture and components - NFV use cases.		
Unit IV	**4G AND 5G TECHNOLOGIES**	**9 Hours**
Introduction to 4G: Evolution of Mobile Communication - Goals and Objectives of 4G - LTE (Long-Term Evolution) Technology: LTE Architecture and Components - LTE Physical Layer - LTE Radio Access Network (RAN) - 5G: Evolution from 4G to 5G - Key technologies enabling 5G - Applications and use cases of 5G.		
UNIT V	**NETWORK AUTOMATION AND ORCHESTRATION**	**9 Hours**
Introduction to network automation - Configuration management tools - Orchestration and its role in modern networks – Case Studies: Analysis of real-world implementations - Experience with a Globally-Deployed Software Defined WAN.		
	Total	**45 Hours**

References

1. Olivier Bonaventure, "Computer Networking: Principles, Protocols and Practice", 2016.
2. "Routing and Switching Essentials v6 Companion Guide", Cisco Networking Academy, 2017.
3. Jeffrey S. Beasley and Piyasat Nilkaew, "Networking Essentials", 2022.
4. B. S. Soni, "Internet of Things (IoT): Technologies, Applications, Challenges and Solutions", 2020.
5. Ricardo Puttini, Zaigham Mahmood, Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture", 2013.
6. Abhishek Ranjan, "Software-Defined Networking: Anatomy of OpenFlow", 2015.
7. Rajendra Chayapathi, Syed Hassan, Paresh Shah, "Network Function Virtualization (NFV) with a Touch of SDN", 2016.
8. Johan Skold, Erik Dahlman, Stefan Parkvall, "5G NR: The Next Generation Wireless Access Technology", 2018.
9. Jason Edelman, Matt Oswalt, and Scott Lowe, "Network Programmability and Automation", 2018.

24CS16	PRINCIPLES OF PROGRAMMING LANGUAGES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
• Fundamental Programming Skill. • Basic understanding of language design and implementation.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand and describe syntax and semantics of programming languages.
- To understand data, data types, and basic statements.
- To understand call-return architecture and ways of implementing them.
- To understand object-orientation, concurrency, and event handling in programming languages.
- To develop programs in non-procedural programming paradigms.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Describe syntax and semantics of programming languages
CO2	Explain data, data types, and basic statements of programming languages
CO3	Design and implement subprogram constructs
CO4	Apply object-oriented, concurrency, and event handling programming constructs
CO5	Develop programs in Scheme, ML, and Prolog and Understand and adopt new programming language

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1					1
2	1		1		1	2
3	1	1			1	2
4		2	1	1	2	2
5	1	2	1		2	3

Unit I	**SYNTAX AND SEMANTICS**	**9 Hours**

Evolution of programming languages – describing syntax – context – free grammars –attribute grammars – describing semantics – lexical analysis – parsing – recursive-descent – bottom- up parsing.

Unit II	**DATA, DATA TYPES, AND BASIC STATEMENTS**	**9 Hours**

Names – variables – binding – type checking – scope – scope rules – lifetime and garbage collection –primitive data types–strings–array types– associative arrays–record types– union types – pointers and references – Arithmetic expressions – overloaded operators – type conversions – relational and boolean expressions – assignment statements – mixed- mode assignments – control structures – selection – iterations – branching – guarded statements.

Unit III	**SUBPROGRAMS AND IMPLEMENTATIONS**	**9 Hours**

Subprograms – design issues – local referencing – parameter passing – overloaded methods – generic methods – design issues for functions – semantics of call and return – implementing simple subprograms – stack and dynamic local variables – nested subprograms – blocks – dynamic scoping.		
Unit IV	**OBJECT-ORIENTATION, CONCURRENCY, AND EVENT HANDLING**	**9 Hours**
Object-orientation – design issues for OOP languages – implementation of object-oriented constructs – concurrency – semaphores – monitors – message passing – threads – statement level concurrency – exception handling – event handling.		
UNIT V	**FUNCTIONAL AND LOGIC PROGRAMMING LANGUAGES**	**9 Hours**
Introduction to lambda calculus – fundamentals of functional programming languages – Programming with Scheme – Programming with ML – Introduction to logic and logic programming – Programming with Prolog – multi-paradigm languages		
	Total	**45 Hours**

References

1. Robert W. Sebesta, "Concepts of Programming Languages", Eleventh Edition, Addison Wesley,2012.
2. W. F. Clocksin and C. S. Mellish, "Programming in Prolog: Using the ISO Standard", Fifth Edition, Springer, 2003.
3. Michael L.Scott, "Programming Language Pragmatics", Fourth Edition, Morgan Kaufmann,2009.
4. R.KentDybvig,"TheScheme programming language", Fourth Edition, MIT Press, 2009.
5. Richard A. O'Keefe, "The craft of Prolog", MIT Press, 2009
6. W.F.Clocksinand C.S.Mellish, "Programming in Prolog: Using the ISO Standard", Fifth Edition, Springer, 2003.

24CS16	APPLICATIONS OF DATA STRUCTURES AND ALGORITHMS LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite	Assessment Pattern	
● Proficiency in Programming languages. ● Understanding of basic Algorithm design techniques. ● Basic understanding of Lab environment and tools.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	60
	Semester End Examinations	40

Course Objectives

- To develop applications using advanced data structures.
- To enhance the knowledge on algorithmic analysis.
- To implement state-of-the-art algorithm design techniques for solving real world problems.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Design and implement basic and advanced data structures extensively.
CO2	Design algorithms using tree and graph data structures.
CO3	Choose appropriate data structures and algorithms, understand the ADT/libraries, and use t to design algorithms for a specific problem.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1		1	1	
2	1		1	2	2	1
3	1	1	1	1	2	1

Unit I	**Experiment 1**	**6 Hours**

Implement the recurrence relation for the recursive and non-recursive problems.
a) Find the nth term of a given recurrence relation.
b) Write a program that use both recursive and non-recursive functions for implementing the following searching methods:
i) Linear search
ii) Binary search
c) Write a program to find merge sort analysis.

Unit II	**Experiment 2**	**6 Hours**

Implement the following data structures: a) Leftist heaps b) Skew heaps

Unit III	**Experiment 3**	**3 Hours**

Create two binomial queue structures and perform merging of two binomial queues.

Unit IV	**Experiment 4**	**3 Hours**

Write a program to perform the following: a) Create a binary tree of integers b) Traverse the binary tree using pre-order, in-order and post-order traversals		
UNIT V	**Experiment 5**	**6 Hours**
Write a program to perform the insertion and deletion operations in AVL Tree using a) Single Rotation b) Double Rotation.		
UNIT VI	**Experiment 6**	**5 Hours**
a) Implement insertion, deletion and search operations in Red-Black Tree b) Write a program to implement B-Tree operations.		
UNIT VII	**Experiment 7**	**5 Hours**
a) Implement Dijkstra's algorithm and Floyd Warshall's algorithm for solving single source shortest path problems. b) Write a program to detect Hamiltonian cycles in a Hamiltonian graph.		
UNIT VIII	**Experiment 8**	**5 Hours**
a) Write a program to implement graph coloring algorithms. b) Write a program to find chromatic index of cyclic graphs.		
UNIT IX	**Experiment 9**	**5 Hours**
a) Solve rod cutting problem using dynamic programming technique. b) Implement the Huffman coding algorithm to decode the given text.		
UNIT X	**Experiment 10**	**5 Hours**
Simulate Tic-Tac-Toe game using backtracking strategy		
	Total	**60 Hours**

References

1. Anany Levitin, Introduction to the Design and Analysis of Algorithms, Third Edition, Pearson, 2014.
2. Alfred V.Aho, John E.Hopcroft, Jeffrey D. Ullman, Data Structures and Algorithms, Third Edition, Pearson, 2015
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest , Clifford Stein, Introduction to Algorithms, Third Edition, Prentice Hall of India, Reprint 2012.
4. Mark Allen Weiss, Data Structures and Algorithms in C++, Fourth Edition, Pearson, 2014
5. E. Horowitz, S. Sahni and S. Rajasekaran, Computer Algorithms, University Press, 2008.
6. Adam Drozdek, Data Structures and Algorithms in C++, 4th Edition, Cengage Learning, 2013.

<table>
<tr><td>24CS17</td><td colspan="2">DATABASE ENGINEERING LABORATORY</td><td>L
0</td><td>T
0</td><td>P
4</td><td>C
2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="5">Assessment Pattern</td></tr>
<tr><td colspan="2" rowspan="2">● Proficiency in Programming languages.
● Basic Database concepts and data modelling skills.
● Advanced SQL techniques.</td><td>Mode of Assessment</td><td colspan="4">Weightage(%)</td></tr>
<tr><td>Continuous Internal Assessment</td><td colspan="4">60</td></tr>
<tr><td colspan="2"></td><td>Semester End Examinations</td><td colspan="4">40</td></tr>
<tr><td colspan="7">Course Objectives</td></tr>
</table>

- To study and implement the basic SQL commands.
- To implement the database design in an Object oriented database.
- To implement distributed databases and parallel databases.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Execute the basic SQL commands in ORACLE.
CO2	Implement a parallel and distributed database using ORACLE.
CO3	Develop an object oriented database using Case tools.
CO4	Develop a NoSQL Database to maintain data of an enterprise using MongoDB.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2	1	3	1	2
2	2	2		2	1	1
3	3	1	2	1		1
4	3	2	2	1	1	1

Unit I	**Experiment 1**	**12 Hours**
Working basic SQL commands, Single Row and Group functions		
Unit II	**Experiment 2**	**6 Hours**
Implement Parallel Database of University Counselling for Engineering colleges and improve the data access from the databases through parallelization of various operations.		
Unit III	**Experiment 3**	**6 Hours**
Design a Distributed Database to store and retrieve data efficiently.		
Unit IV	**Experiment 4**	**6 Hours**

Create ODL schema to store the data and ODL Queries to access the data from Object Oriented Database.		
UNIT V	**Experiment 5**	**6 Hours**
MySQL Database Creation, Table Creation, Query		
UNIT VI	**Experiment 6**	**6 Hours**
Spatial Database Query Processing using open source DB (MongoDB/MySQL etc)		
UNIT VII	**Experiment 7**	**6 Hours**
MongoDB - CRUD operations and Indexing		
UNIT VIII	**Experiment 8**	**6 Hours**
Cassandra - Table Operations, CQL Types.		
UNIT IX	**Experiment 9**	**6 Hours**
HIVE: Database Operations, Partitioning - HiveQL OrientDB Graph database - OrientDB Features.		
	Total	**60 Hours**

References

1. HIVE: Database Operations, Partitioning - HiveQL OrientDB Graph database - OrientDB Features Education/Addison Wesley, 2016.
2. Henry F. Korth, Abraham Silberschatz, and S. Sudharshan, Database System Concepts New Delhi: McGraw Hill, 2010.
3. Vijay Kumar, Mobile Database Systems Wiley Series on Parallel and Distributed Computing, USA, Wiley-Interscience, 2006.
4. C.J.Date, A.Kannan and S.Swamynathan, An Introduction to Database Systems, Eighth Edition, Pearson Education, 2006.
5. Brad Dayley, Teach Yourself NoSQL with MongoDB in 24 Hours, Sams Publishing, Second Edition, 2015.

24CS21	**INTERNET OF THINGS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Pre-requisite		**Assessment Pattern**			

● Basics of Embedded Systems. ● Networking fundamentals. ● Data Communication and IoT Protocols.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the definition and characteristics of IoT.
- To understand Software Defined Networks (SDN) and Network Function Virtualization (NFV) in the context of IoT.
- To explore various sensors and their applications in IoT.
- To understand the basics of networking, explore a variety of sensors and computing in the context of IoT.
- To apply data analytics tools such as Apache Hadoop, Chef, and Puppet for IoT.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Identify and analyze different communication models and protocols used in IoT.
CO2	Acquire practical skills in IoT system management through various protocols.
CO3	Use Arduino, Raspberry Pi and control different hardware components.
CO4	Apply diverse range of sensors along with a solid grasp of networking and computing principles pertinent to IoT.
CO5	Develop Web Servers and RESTful Web APIs for IoT applications.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1	2	1	1	3
2	3	2	1	2	3	2
3	1	1	2	1	3	3
4	2	3	2	1	2	2
5	1	2	1	2	1	1

Unit I	**INTRODUCTION TO IoT**	**9 Hours**

Definition and Characteristics of IoT, Sensors, Actuators, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs, IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Embedded Systems, IoT Levels and Templates, Domain Specific IoTs – Home, City, Environment, Energy, Agriculture and Industry.		
Unit II	**IoT and M2M**	**9 Hours**
Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCONF, YANG- NETCONF, YANG, SNMP NETOPEER.		
Unit III	**IOT PHYSICAL DEVICES AND HARDWARE**	**9 Hours**
Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C) – Controlling Hardware-Connecting LED, Buzzer, Switching High Power devices with transistors, Controlling AC Power devices with Relays, Controlling servo motor, speed control of DC Motor, unipolar and bipolar Stepper motors.		
Unit IV	**SENSORS, NETWORKING AND COMPUTING**	**9 Hours**
Light sensor, temperature sensor with thermistor, voltage sensor, ADC and DAC, Temperature and Humidity Sensor DHT11, Motion Detection Sensors, Wireless Bluetooth Sensors, Level Sensors, USB Sensors, Embedded Sensors, Distance Measurement with ultrasound sensor- File Handling, Python Packages for IoT, IoT Physical Servers – Cloud Storage Models, Communication APIs.		
UNIT V	**IoT CLOUDS AND DATA ANALYTICS**	**9 Hours**
Introduction to Cloud Storage models and communication- APIs Web Server – Web server for IoT - RESTful Web API, Amazon Web Services for IoT, Apache Hadoop, Batch Data Analysis, Chef, Chef Case Studies, Puppet. Case studies: smart cities, smart home, connected vehicles, Industrial IOT.		
	Total	**45 Hours**
References		

1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547.
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759.
3. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN 7989352133895.
4. Kamal, R.,"Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill,2017.
5. Simone Cirani," Internet of Things- Architectures, Protocols and Standards", WILEY,2018.
6. Alessandro Bassi," Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model", Springer,2013.

24CS22	MACHINE LEARNING	L	T	P	C

		3	0	0	3

Pre-requisite	Assessment Pattern	
● Mathematics for Machine Learning. ● Basics of Machine Learning and Data Science.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- Understand the concepts and mathematical foundations of machine learning and types of problems tackled by machine learning.
- Explore the different supervised learning techniques including ensemble methods.
- Learn different aspects of unsupervised learning and reinforcement learning.
- Learn the role of probabilistic methods for machine learning.
- Analyze the advanced learning methods.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Formulate the necessity of mathematical foundation for machine learning.
CO2	Implement supervised learning algorithms for any real life application.
CO3	Apply clustering algorithms for unlabeled datasets and implement reinforcement learning for suitable problems.
CO4	Design and implement probabilistic graphical models for machine learning.
CO5	Analyze the advanced learning algorithms and identify the suitable applications for solving using these advanced learning techniques.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	3	1	1
2	2	3	1	2	1	2
3	1	1	2	1		2
4	2	2				3
5	3	3	1	1	1	3

Unit I	**INTRODUCTION AND MATHEMATICAL FOUNDATIONS**	**9 Hours**
Machine Learning -Machine Learning Foundations – Design of a Learning system - Types of Machine Learning –Applications - Mathematical Foundations of Machine Learning - Random Variables and Probabilities -Probability Theory – Bayesian Conditional Probability - Decision Theory - Bayes Decision Theory - Information Theory.		
Unit II	**SUPERVISED LEARNING**	**9 Hours**
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 – Bagging and Boosting - Evaluation of Classification Algorithms.		
Unit III	**UNSUPERVISED LEARNING AND REINFORCEMENT LEARNING**	**9 Hours**
Clustering Algorithms – K-Means – Hierarchical Clustering - Cluster Validity - Dimensionality Reduction –Principal Component Analysis – Recommendation Systems- EM Algorithm - Mixtures of Gaussians. Reinforcement Learning – Elements -Model based Learning – Temporal Difference Learning.		
Unit IV	**PROBABILISTIC GRAPHICAL MODELS**	**9 Hours**
Graphical Models -Undirected Graphical Models - Markov Random Fields -Directed Graphical Models – Naïve Bayes Algorithm -Maximum Likelihood -Maximum Apriori -Bayesian Belief Networks -Conditional independence properties - Inference –Learning - Generalization - Hidden Markov Models - Conditional random fields(CRFs).		
UNIT V	**ADVANCED LEARNING**	**9 Hours**
Sampling –Basic sampling methods –Monte Carlo. Exploration Strategies - Deterministic and Non-Deterministic Rewards and Actions Computational Learning Theory -Mistake Bound Analysis, Sample Complexity Analysis, VC Dimension. Occam Learning, Accuracy and Confidence Boosting.		
	Total	**45 Hours**

References

1. Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
3. EthemAlpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.
4. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
5. Jure Leskovec, Anand Rajaraman and Jeffrey D. Ullman,”Mining of Massive Datasets”, Cambridge University Press, Second Edition.
6. Tom Mitchell, "Machine Learning", McGraw-Hill Education, 2013.
7. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer, Second Edition, 2011.
8. Stephen Marsland, “Machine Learning -An Algorithmic Perspective”, Chapman and Hall/CRC Press, Second Edition, 2014.

24CS23	ADVANCED SOFTWARE ENGINEERING	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Basic Software Engineering Concepts. ● Usage of basic Software Development Tools.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- 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 agile software development and devops tools.
- To understand the different stages of testing from testing during development of a software system.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

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	Use the important dimensions of software dependability, namely, availability, reliability, safety, security, and resilience.
CO4	Understand the basic notions of developing a software by using Agile methodology and Devops tools.
CO5	Understand Software testing approaches.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2		1	1	1
2	2	1	1	2	1	2
3	1	1		1		1
4	1		1	1		1
5	1	1			1	

Unit I	**SOFTWARE PROCESS & MODELING**	**9 Hours**
Prescriptive Process Models – Agility and Process – Scrum – XP – Kanban – DevOps – Prototype Construction – Prototype Evaluation – Modelling – Principles –Requirements Engineering – Scenario-based Modelling – Class-based Modelling – Functional Modelling – Behavioural Modelling.		
Unit II	**SOFTWARE DESIGN**	**9 Hours**
Design Concepts – Design Model – Object Oriented Design using the UML Data Flow Diagrams- Software Architecture – Architectural Styles – Architectural Design – Component-Level Design – User Experience Design – Design for Mobility – Refactoring.		
Unit III	**SYSTEM DEPENDABILITY AND SECURITY**	**9 Hours**
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 Cybersecurity – Sociotechnical Resilience.		
Unit IV	**AGILE METHODOLOGIES AND DEVOPS**	**9 Hours**
Understanding Agile Values - The Agile Manifesto, Purpose Behind Each Practice. Individuals and Interactions Over Processes and Tools, Working Software Over Comprehensive Documentation - The 12 Principles of Agile Software - The Rules of Scrum - Daily Scrum, Feedback and the Visibility-Inspection-Adaptation Cycle, The Last Responsible Moment - Understanding DevOps - DevOps Lifecycle - DevOps Tools - Integrating Agile and DevOps - Continuous Integration and Continuous Deployment (CI/CD) - Case Studies.		
UNIT V	**SOFTWARE TESTING AND SOFTWARE CONFIGURATION MANAGEMENT**	**9 Hours**
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.		
	Total	**45 Hours**
References		

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.
6. Andrew Stellman, Jill Alison Hart, Learning Agile, O'Reilly, 2015.

7. Kim, Gene, Jez Humble, Patrick Debois, John Willis, and Nicole Forsgren. The DevOps handbook: How to create world-class agility, reliability, & security in technology organizations. IT Revolution, 2021.

24CS24	MULTICORE ARCHITECTURE AND PROGRAMMING	L	T	P	C
		3	0	2	4

Pre-requisite	Assessment Pattern	
● Basic knowledge on Computer Architecture. ● Parallel Computing Basics.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

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.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will 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 parallel processors.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	3	3	3	3
2	1	1	1	2	1	2
3	2	1			2	2
4	1		2	1	1	2
5	2	1	1	1	2	2

Unit I	**MULTI-CORE PROCESSORS**	**9 Hours**
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	**PARALLEL PROGRAM CHALLENGES**	**9 Hours**
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 pipe		
Unit III	**SHARED MEMORY PROGRAMMING WITH OpenMP**	**9 Hours**
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 Hours**
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 Hours**
Case studies – n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.		
	Total	**45 Hours**
EXPERIMENT 1		**3 Hours**
Write a simple Program to demonstrate an OpenMP Fork-Join Parallelism.		
EXPERIMENT 2		**3 Hours**
Create a program that computes a simple matrix-vector multiplication b=Ax, either in C/C++. Use OpenMP directives to make it run in parallel.		
EXPERIMENT 3		**3 Hours**

Create a program that computes the sum of all the elements in an array A (C/C++) or a program that finds the largest number in an array A. Use OpenMP directives to make it run in parallel.	
EXPERIMENT 4	**3 Hours**
Write a simple Program demonstrating Message-Passing logic using OpenMP.	
EXPERIMENT 5	**3 Hours**
Implement the All-Pairs Shortest-Path Problem (Floyd's Algorithm) Using OpenMP.	
EXPERIMENT 6	**3 Hours**
Implement a program Parallel Random Number Generators using Monte Carlo Methods in OpenMP.	
EXPERIMENT 7	**3 Hours**
Write a Program to demonstrate MPI-broadcast-and-collective-communication in C.	
EXPERIMENT 8	**3 Hours**
Write a Program to demonstrate MPI-scatter-gather-and-all gather in C.	
EXPERIMENT 9	**3 Hours**
Write a Program to demonstrate MPI-send-and-receive in C.	
EXPERIMENT 10	
Write a Program to demonstrate by performing-parallel-rank-with-MPI in C.	**3 Hours**
Total	**30 Hours**
Total	**75 Hours**
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.
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.

24CS26	MACHINE LEARNING LABORATORY	L	T	P	C
		0	0	4	2

Pre-requisite	Assessment Pattern	
● Fundamental Programming Skills. ● Minimal experience with machine learning frameworks.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	60
	Semester End Examinations	40

Course Objectives

- Understand the implementation procedures for the machine learning algorithms.
- Use tools to solve the classification problems using machine learning techniques.
- Implement state-of-the-art algorithm design techniques for real life applications.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Implement the supervised learning algorithms for classification of labeled datasets and compute accuracy of the classifiers.
CO2	Design Bayesian network for classifying the medical data.
CO3	Apply clustering algorithms for classifying the unlabeled datasets.
CO4	Select appropriate algorithms/ techniques to solve computing problems in real-world.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	3	1	1
2	2	3	1	2	1	2
3	1	1	2	1		2
4	2	2				3

Unit I	**Experiment 1**	**3 Hours**

Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.

Unit II	**Experiment 2**	**6 Hours**

For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.

Unit III	**Experiment 3**	**9 Hours**

Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

Unit IV	**Experiment 4**	**3 Hours**

Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.

UNIT V	**Experiment 5**	**6 Hours**

Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.

UNIT VI	**Experiment 6**	**3 Hours**

Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/API.

UNIT VII	**Experiment 7**	**9 Hours**

Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.

UNIT VIII	Experiment 8	6 Hours
Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.		
UNIT IX	**Experiment 9**	**9 Hours**
Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs		
UNIT X	**Experiment 10**	**6 Hours**
Case Study of Disease Prediction on google Colab.		
	Total	**60 Hours**

References

1. Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
3. EthemAlpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.
4. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
5. Jure Leskovec, Anand Rajaraman and Jeffrey D. Ullman,”Mining of Massive Datasets”, Cambridge University Press, Second Edition.
6. Tom Mitchell, "Machine Learning", McGraw-Hill Education, 2013.
7. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer, Second Edition, 2011.
8. Stephen Marsland, “Machine Learning -An Algorithmic Perspective”, Chapman and Hall/CRC Press, Second Edition, 2014.

24CS27	MINI PROJECT	L	T	P	C
		0	0	4	2

Pre-requisite	Assessment Pattern	
● Develop skills to identify and convert a real-world problem into a technical problem	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- To develop skills to identify and convert a real-world problem into a technical problem.
- To teach use of new tools and techniques required to carry out the project.
- To teach use of new tools and techniques required to carry out the project.
- To make familiar in developing the proof of concept.
- To provide guidelines to prepare standard project report.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Develop the solutions for the real-world problem.
CO2	Identify the suitable strategies and methodologies to carry out the project.
CO3	Use of required new tools and techniques to carry out the project.
CO4	Test and validate the developed proof of concept.
CO5	Prepare a standard project report with demonstration.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	1	1	2
2	2	1		1	1	1
3	1	1		2	2	2
4	2	1		2	1	
5	1	2		1		

Total **40 Hours**

24CS34	DISSERTATION PHASE I	L	T	P	C
		0	0	12	6

Pre-requisite

- Develop skills to identify and convert a real-world problem into a technical problem

Assessment Pattern

Mode of Assessment	Weightage(%)
Continuous Internal Assessment	60
Semester End Examinations	40

Course Objectives

- To develop skills to identify and convert a real world problem into a technical problem.
- To provide knowledge on methodology of carrying out project in phases.
- To teach use of new tools and techniques required to carry out the project.
- To make familiar in developing the proof of concept.
- To provide guidelines to prepare standard project report.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Develop the solutions for the real world problem.
CO2	Identify the suitable strategies and methodologies to carry out the project.
CO3	Use of required new tools and techniques to carry out the project.
CO4	Test and validate the developed proof of concept.
CO5	Prepare a standard project report with demonstration.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	1	1	2
2	2	1		1	1	1
3	1	1		2	2	2
4	2	1		2	1	
5	1	2		1		

Total | **120 Hours**

24CS41	DISSERTATION PHASE II	L	T	P	C
		0	0	24	12

Pre-requisite

- Develop skills to identify and convert a real-world problem into a technical problem

Assessment Pattern

Mode of Assessment	Weightage(%)
Continuous Internal Assessment	60
Semester End Examinations	40

Course Objectives

- To develop skills to identify and convert a real world problem into a technical problem.
- To provide knowledge on methodology of carrying out project in phases.
- To teach use of new tools and techniques required to carry out the project.
- To make familiar in developing the proof of concept.
- To provide guidelines to prepare standard project report.

Programme Outcomes (POs)

PO1	Apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer-based systems of varying complexity.
PO2	Identify, formulate, critically analyse, and solve problems in the field of Computer Science and Engineering, considering recent and future trends.
PO3	Design a system, component, or process to meet desired needs within realistic constraints such as economic, social and ethical in the field of Computer Science and Engineering.
PO4	Use current techniques, skills, and tools necessary for computing practice and demonstrate advanced knowledge of a selected area within the Computer Science and Engineering discipline.
PO5	Demonstrate an ability to engage in lifelong learning for professional development and function effectively on teams to accomplish a common goal.
PO6	Critically analyse existing literature in an area of specialization and develop innovative and research- oriented methodologies to tackle gaps identified.
PSO1	
PSO2	

Course Outcomes (COs)

The students will be able to

CO1	Develop the solutions for the real-world problem.
CO2	Identify the suitable strategies and methodologies to carry out the project.
CO3	Use of required new tools and techniques to carry out the project.
CO4	Test and validate the developed proof of concept.
CO5	Prepare a standard project report with demonstration.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	1	1	2
2	2	1		1	1	1
3	1	1		2	2	2
4	2	1		2	1	
5	1	2		1		

Total | **240 Hours**

24CS51	AGENT BASED INTELLIGENT SYSTEMS	L	T	P	C
		3	0	0	3

Pre-requisite

- Fundamentals of Artificial Intelligence.
- Operating Systems and Networking.
- Introduction to Multi-Agent Systems.

Assessment Pattern

Mode of Assessment	Weightage(%)
Continuous Internal Assessment	40
Semester End Examinations	60

Course Objectives

- To introduce the fundamental concepts of artificial intelligence.
- To explore the different paradigms in knowledge representation and reasoning.
- To solve the problem using artificial intelligence and machine learning algorithms.
- To introduce the notions of AI ethics and Explainable AI.

Programme Outcomes (POs)

PO1	Apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer-based systems of varying complexity.
PO2	Identify, formulate, critically analyse, and solve problems in the field of Computer Science and Engineering, considering recent and future trends.
PO3	Design a system, component, or process to meet desired needs within realistic constraints such as economic, social and ethical in the field of Computer Science and Engineering.
PO4	Use current techniques, skills, and tools necessary for computing practice and demonstrate advanced knowledge of a selected area within the Computer Science and Engineering discipline.
PO5	Demonstrate an ability to engage in lifelong learning for professional development and function effectively on teams to accomplish a common goal.
PO6	Critically analyse existing literature in an area of specialization and develop innovative and research- oriented methodologies to tackle gaps identified.

Course Outcomes (COs)

The students will be able to

CO1	Apply the searching techniques, heuristic algorithms and game playing to solve real time problems.
CO2	Analyze the logical inference in first order logic and the logical language to express knowledge about complex worlds.
CO3	Examine basic ideas of planning types and monitoring for the successful completion of the plan.
CO4	Apply utility theory and probability theory for handling uncertain worlds.
CO5	Examine the ethical considerations of Artificial Intelligence and interpret the concepts of explainable Artificial Intelligence.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	3	1	1
2	2	3	1	2	1	2
3	1	1	2	1		2
4	2	2				3
5	1		2	1		1

Unit I	**INTELLIGENT AGENTS AND SEARCH TECHNIQUES**	**9 Hours**

Definitions - Intelligent agents: Nature of environment-Structure of agents-problem solving- Searching: uninformed search strategies-Searching with partial information -Heuristics: Local search algorithms - Constraint satisfaction problems: Backtracking search - Game playing: Optimal decisions-Alpha, Beta pruning.

Unit II	**KNOWLEDGE REPRESENTATION AND REASONING**	**9 Hours**

Logical Agents: Propositional logic-Reasoning patterns in propositional logic-Agent based propositional logic-First order logic: Syntax and semantics-First order inference: Unification- Chaining- Resolution strategies-Knowledge representation: Objects-Actions-Events- Techniques.

Unit III	**PLANNING AGENTS**	**9 Hours**

Planning problem: STRIPS- State space search-Partial order planning-Graphs-Hierarchical network planning-Nondeterministic domains-Conditional planning-Execution monitoring and replanning- Continuous planning-Multi agent planning.

Unit IV	**AGENTS AND UNCERTAINTY**	**9 Hours**

Acting under uncertainty - Probability notation-Baye's rule and use -Probabilistic reasoning: Bayesian networks-Other approaches-Time and uncertainty: Temporal models-Simple decisions: Utility theory - Decision network - Complex decisions: Value iteration-Policy iteration..

UNIT V	**AI ETHICS AND RESPONSIBLE AI**	**9 Hours**

Ethical considerations in AI development and deployment – Discrimination, bias and fairness- Algorithmic decision making- Interpretable versus explainable models - Newly emerging paradigms - Case studies and discussions on ethical dilemmas in AI.

Total	**45 Hours**

References

1. Stuart Russell and Peter Norvig, Artificial Intelligence - A Modern Approach, Pearson Education Limited, 2016.
2. Elaine Rich, Kevin Knight and Shivashankar B Nair, Artificial Intelligence, Tata McGraw Hill, 2019.
3. M. Tim Jones, Artificial Intelligence: A Systems Approach, Jones and Bartlett Publisher, 2010.
4. Animesh Mukherjee, AI and Ethics AI and Ethics, A computational perspective, IOP Science, 2023.
5. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, Second Edition, 2017.
6. Sohom Ghosh, Dwight Gunning, Natural Language Processing Fundamentals, Packet Publisher, 2019.

24CS52	SOFT COMPUTING	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Fundamentals of Artificial Intelligence. ● basic knowledge of Neural Networks and Fuzzy Logic.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To conceptualize the functioning of the human brain using neural networks.
- To analyze and integrate soft computing and optimization techniques in order to solve problems effectively and efficiently.
- To analyze and integrate soft computing and optimization techniques in order to solve problems effectively and efficiently.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Classify the soft computing techniques and the functionalities of artificial neural networks.
CO2	Compare the supervised and unsupervised learning networks and illustrate the architecture and working principles of neural networks.
CO3	Analyze the concept of fuzzy logic and design an expert system by applying the fuzzy membership function.
CO4	Analyze the features and operators in genetic algorithms and apply the genetic algorithm for real time problems.
CO5	Apply the hybrid soft computing techniques in multi spectral image fusion modeling and optimization of traveling salesman problems.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2	1	3	1	1
2	2	3	1	2	2	2
3	1	2	2	1		2
4	2	1				3
5	2		2	1		3

Unit I	**INTRODUCTION**	**9 Hours**

Introduction to Soft Computing- Difference between soft computing and hard computing - Various types of soft computing techniques - Applications of soft computing - Biological Neuron-Nerve structure and synapse - Artificial Neuron and its model - Activation functions - Neural network architecture - single layer and multilayer feed forward networks – McCullochPitt's neuron model.

Unit II	**NEURAL NETWORKS**	**9 Hours**

Supervised Learning Networks: Perceptron Networks - Adaptive Linear Neuron- Multiple Adaptive Linear Neuron - Back-propagation Network. Unsupervised Learning Networks: Counter propagation network - architecture & functioning – Adaptive Resonance Theory - Architecture & functioning.

Unit III	**FUZZY SYSTEMS**	**9 Hours**

Introduction to Fuzzy logic - Crisp sets - Fuzzy sets - Crisp relations - Fuzzy relations - Fuzzy membership functions - Operations on Fuzzy sets - Fuzzification - Defuzzification techniques -Fuzzy logic controller design - Applications of Fuzzy logic.

Unit IV	**GENETIC ALOGORITHMS**	**9 Hours**

Genetic algorithms: Basic concepts - Encoding, Fitness function, Reproduction- Encoding- Binary, Octal, Hexadecimal, Permutation, Value, Tree Encoding - Selection - Roulette wheel, Boltzmann, Random, Tournament, Rank, and Steady state selections - Crossover - Mutation- Convergence of GA – Applications of GA.

UNIT V	**HYBRID SOFT COMPUTING TECHNIQUES**	**9 Hours**
Neuro-fuzzy hybrid systems - Genetic neuro hybrid systems - Genetic fuzzy hybrid and fuzzy genetic hybrid systems - Applications: A fusion approach of multispectral images with SAR - optimization of traveling salesman problem using genetic algorithm approach.		
	Total	**45 Hours**

References

1. J.S.R. Jang, C.T. Sun and E. Mizutani, Neuro-Fuzzy and Soft Computing, PHI / Pearson Education, 2015.
2. S. Rajasekaran and G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications, Prentice-Hall of India Pvt. Ltd., 2017.
3. David E. Goldberg, Genetic Algorithm in Search Optimization and Machine Learning, Pearson Education India, 2013.
4. S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, 3rd Edition, Wiley Publisher, 2018.
5. Timothy J.Ross, Fuzzy Logic with Engineering Application, McGraw Hill, 2016.

24CS53	**CLOUD COMPUTING TECHNOLOGIES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Understanding of basic networking concepts. ● Basic knowledge of Cloud Computing and Cyber security principles.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To articulate the differences between deployment model and service model of cloud computing.
- To impart virtualization technologies, resource management techniques and scheduling schemes in cloud environments.
- To enhance knowledge on different types of programming models to deploy web applications with security in the cloud.

Programme Outcomes (POs)

PO1	Apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer-based systems of varying complexity.
PO2	Identify, formulate, critically analyse, and solve problems in the field of Computer Science and Engineering, considering recent and future trends.
PO3	Design a system, component, or process to meet desired needs within realistic constraints such as economic, social and ethical in the field of Computer Science and Engineering.
PO4	Use current techniques, skills, and tools necessary for computing practice and demonstrate advanced knowledge of a selected area within the Computer Science and Engineering discipline.
PO5	Demonstrate an ability to engage in lifelong learning for professional development and function effectively on teams to accomplish a common goal.
PO6	Critically analyse existing literature in an area of specialization and develop innovative and research- oriented methodologies to tackle gaps identified.

Course Outcomes (COs)

The students will be able to

CO1	Elaborate the components of cloud computing to understand how business agility in an organization can be created.
CO2	Critique the consistency of virtualization technologies in cloud environments.
CO3	Evaluate the deployment of web services from cloud architecture with scheduling schemes and resource management.
CO4	Analyze cloud programming models to solve issues on cloud.
CO5	Design a secure cloud to deploy an application based on different security concerns.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1				2	2	1
2	2	3	1			1
3	3		3		1	3
4				2		3
5	3	2				

Unit I	**INTRODUCTION - CLOUD INFRASTRUCTURE**	**9 Hours**

Cloud computing - Cloud computing delivery models and services - Ethical issues - Cloud vulnerabilities - Cloud computing at Amazon - Cloud computing the Google perspective - Microsoft Windows Azure and online services - Open-source software platforms for private clouds.

Unit II	**CLOUD VIRTUALIZATION TECHNOLOGIES**	**9 Hours**

Introduction - Virtualization Defined-Virtualization Benefits - Server Virtualization-Virtual Machine - Virtualization technologies-Hardware Virtualization- OS Virtualization Virtualization for x86 Architecture - Paravirtualization - Virtual Infrastructure Requirements - Server Virtualization Sustainability Assessment.

Unit III	**CLOUD RESOURCE MANAGEMENT AND SCHEDULING**	**9 Hours**

Policies and Mechanisms for Resource Management - Stability of a Two-Level Resource Allocation Architecture - A Utility-Based Model for Cloud-Based Web Services - Resource Bundling: Combinatorial Auctions for Cloud Resources - Scheduling Algorithms for Computing Clouds - Fair Queuing - Start –Time Fair Queuing - Borrowed Virtual Time.		
Unit IV	**CLOUD PROGRAMMING MODEL**	**9 Hours**
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 - Cloud Software Environments -Eucalyptus, Open Nebula, Open Stack, Nimbus.		
UNIT V	**CLOUD SECURITY**	**9 Hours**
Cloud Infrastructure security: network, host and application level-aspects of data security, provider data and its security, Identity and access management architecture, IAM practices in the cloud, SaaS, PaaS, IaaS availability in the cloud - Key privacy issues in the cloud -Cloud Security and Trust Management.		
	Total	**45 Hours**
References		

1. Cloud Computing Theory and Practice, Dan C Marinescu, Elsevier (MK), 2013. David A.Bies, Colin Hansen, Carl Howard, Engineering Noise Control – 2017.
2. Cloud Computing, Dr Kumar Saurabh, 2 Edition, Wiley, 2012.
3. Cloud Computing Strategies, Dimitris N Chorafas, CRC Press, 2010.
4. Cloud Computing: Implementation, Management, and Security, John W. Rittinghouse and James F. Ransome, CRC Press, 2010.
5. Tim Mather, Subra Kumaraswamy, and Shahed Latif, Cloud Security and Privacy, O Reilly Media,Inc., 2009.
6. Tom White, Hadoop: The Definitive Guide, Yahoo Press, 2012.

24CS54	**DATA SCIENCE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Understanding of linear algebra, Calculus, Probability and Statistics. ● Basic knowledge of machine learning concepts, data processing and analysing.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To introduce the fundamental concepts of data science.
- To apply statistical methods to summarize, explore and draw conclusions from data.
- To utilize probability theory to understand data uncertainty and relationships

- To employ basic machine learning algorithms for both supervised and unsupervised learning tasks.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the growing importance of data science in today's world by evaluating its impact on various industries.
CO2	Apply core probability concepts and relevant statistical distributions to analyze and model network mobilization patterns.
CO3	Evaluate the validity of claims and hypotheses using appropriate statistical tests and confidence intervals, considering potential limitations and power of the tests.
CO4	Examine relationships between variables using correlation analysis and linear algebra techniques.
CO5	Create basic machine learning models using supervised and unsupervised learning algorithms to solve real-world data science problems.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	2	3		2	2
2			2	3		
3	1				3	3
4	2	1		3		
5	1		3	3		

Unit I	**INTRODUCTION TO DATA SCIENCE AND STATISTICS**	**9 Hours**

Data Science- Big Data and Data Science – Datafication – Current landscape of perspectives, Matrices – Matrices to represent relations between data, and necessary linear algebraic operations on matrices - Approximately representing matrices by decompositions (SVD and PCA); Statistics: Descriptive Statistics and Data Visualization – Statistical Inference: Populations and samples- Measures of Central Tendency - Measures of Variation-Measures of Shape-Data Visualization.

Unit II	**NETWORK MOBILIZATION AND SAMPLING STATISTICS**	**9 Hours**

Probability Theory - Terminology - Axioms of Probability -Bayes' Theorem-Random Variables - PDF & CDF of Continuous-Random Variable-Binomial Distribution-Poisson Distribution-Geometric Distribution-Uniform Distribution-Exponential Distribution-Normal Distribution-Chi-Square Distribution - Student's t-Distribution - F: Distribution – Population Parameter & Sample Statistic - Probabilistic Sampling - Non-Probability Sampling - Sampling Distribution - Central Limit Theorem - Sample Size Estimation for Mean of the Population - Estimation of Population Parameters - Method of Moments - Estimation of Parameters Using Maximum Likelihood Estimation.

Unit III	**INFERENCE STATISTICS AND ADVANCED ANALYSIS TECHNIQUES**	**9 Hours**

Confidence Intervals (CI) : CI for Population Mean - CI for Population Proportion - CI for Population Mean when Standard Deviation is unknown - CI for Population Variance - Hypothesis Testing : Setting up a Hypothesis Test - One-Tailed and Two-Tailed Test - Type I Error, Type II Error, and Power of the Hypothesis Test - Hypothesis testing for Population Mean with Known Variance: Z-Test - Hypothesis testing for Population Proportion: Z-Test - Hypothesis test for Population Mean under Unknown Population Variance: t-test – Paired Sample t-test - Two-Sample Z and t-test - Two-Sample Z-Test for Proportions - Effect Size: Cohen's D - Hypothesis Test for Equality of Population Variances - Nonparametric Tests: Chi-Square Tests - Analysis of Variance: Multiple t-Tests for Comparing Several Means - One-way ANOVA - Two-way ANOVA.

Unit IV	**CORRELATION ANALYSIS AND APPLIED LINEAR ALGEBRA**	**9 Hours**

Correlation Analysis : Pearson Correlation Coefficient - Spearman Rank Correlation – Point Bi-Serial Correlation - The Phi-Coefficient - Applied Linear Algebra : Why do we need Linear Algebra? - Matrix Algebra and Operations - EigenValues and EigenVectors – Linear Algebra in Dimensionality Reduction - Linear Algebra in Natural Language Processing - Linear Algebra in Machine Learning.

UNIT V	**BASIC MACHINE LEARNING ALGORITHMS**	**9 Hours**

Data Cleaning and handling - Supervised Learning : Linear regression - The bias-variance tradeoff - LASSO, Ridge and Elastic Net - An overview of classification - Decision trees and k-nearest neighbors - Ensemble methods (Bagging, Random Forests and Boosting) - Unsupervised learning : Clustering (k-means, spectral clustering and overview of other methods) - Principal Component Analysis.

Total	**45 Hours**

References

1. Cathy O'Neil and Rachel Schutt, " Doing Data Science, Straight Talk From The Frontline", O'Reilly, 2014.
2. Jiawei Han, Micheline Kamber and Jian Pei, " Data Mining: Concepts and Techniques", Third Edition. ISBN 0123814790, 2011.
3. Mohammed J. Zaki and Wagner Miera Jr, "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2014.
4. Matt Harrison, "Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization , O'Reilly, 2016.
5. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2015.
6. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media, 2012.

24CS55	AGILE METHODOLOGIES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Basic knowledge of software development and agile principles. ● Fundamental concepts of Project Management.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- Understand the software design and a set of software technologies and APIs Impart knowledge on Agile development and testing techniques.
- Acquire knowledge on Agile based software development.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Compare the software project with traditional and agile model based on customer requirements.
CO2	Develop the software product using Agile-based methodology.
CO3	Plan and execute the iterative software development process based on knowledge management.
CO4	Choose the better process between requirement gathering and requirement elicitation techniques.
CO5	Develop techniques and tools for improving team collaboration and software quality.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	3		2	3
2	2		3	3	1	3
3	3				3	3
4	2		1	2	3	3
5	1	3			2	3

Unit I	**AGILE SOFTWARE DEVELOPMENT**	**9 Hours**

Fundamentals of Agile Process Methods, Values of Agile, Principles of Agile, stakeholders, - Agile Software Development -Traditional Model vs. Agile Model - Classification of Agile Methods -Agile Manifesto and Principles -Agile Project Management -Agile Team Interactions -Ethics in Agile Teams -Agility in Design, Testing - Testing plan links between testing, roles and key techniques, principles, understand as

a means of assessing the initial status of a project -Agile Documentations - Agile Drivers, Capabilities and Values.		
Unit II	**AGILE PROCESS**	**9 Hours**
Lean Production -SCRUM, Crystal, Feature Driven Development- Adaptive Software Development - Extreme Programming: Method Overview -Lifecycle -Work Products, Roles and Practices.		
Unit III	**AGILITY AND KNOWLEDGE MANAGEMENT**	**9 Hours**
Agile Information Systems -Agile Decision Making -EarlS Schools of KM -Institutional Knowledge Evolution Cycle -Development, Acquisition, Refinement, Distribution, Deployment, Leveraging -KM in Software Engineering -Managing Software Knowledge -Challenges of Migrating to Agile Methodologies -Agile Knowledge Sharing -Role of Story-Cards -Story-Card Maturity Model (SMM)		
Unit IV	**AGILITY AND REQUIREMENTS ENGINEERING**	**9 Hours**
Impact of Agile Processes in RE-Current Agile Practices -Variance -Overview of RE - Using Agile - Managing - Unstable Requirements -Requirements Elicitation -Agile Requirements Abstraction Model - Requirements Management in Agile Environment, Agile Requirements Prioritization -Agile Requirements Modeling and Generation -Concurrency in Agile Requirements Generation.		
UNIT V	**AGILITY AND QUALITY ASSURANCE**	**9 Hours**
Agile Product Development -Agile Metrics -Feature Driven Development (FDD) -Financial and Production Metrics in FDD -Agile Approach to Quality Assurance -Test Driven Development -Agile Approach in Global Software Development. Agile Risk Management: Agile Tools. Agile Testing Techniques, User Acceptance Test.		
	Total	**45 Hours**
References		

1. Robert C. Martin, Agile Software Development, Principles, Patterns, and Practices Al an Apt Series (2011).
2. Paul VII, Agile: The Complete Overview of Agile Principles and Practices (Agile Product Management), 1st Edition, 2016.
3. Robert Martin, Agile Software Development, Principles, Patterns, and Practices, Pearson New International Edition, 2013.
4. Hazza and Dubinsky, - Agile Software Engineering, Series: Undergraduate Topics in Computer Science, Springer, 2009.
5. David J. Anderson and Eli Schragenheim, - Agile Management for Software Engineering: Applying the Theory of Constraints for Business Results, Prentice Hall, 2009.
6. Craig Larman, Agile and iterative development: A Manager"s Guide, Addison-Wesley, 2004.

24CS56	**SOFTWARE QUALITY ASSURANCE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Understanding of Basic Software Engineering. ● Fundamentals of Software testing.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40

	Semester End Examinations	60

Course Objectives

- To introduce the importance of Quality of Software Products.
- To elicit, analyze, prioritize, and manage both functional and quality requirements.
- To plan for Software quality assurance.
- To learn the concepts of Reliability.
- To understand and apply configuration and quality management techniques in software development processes.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the significance of software quality assurance in software projects.
CO2	Understand and apply software quality assurance metrics in software projects.
CO3	Understand and apply software standardization in software projects.
CO4	Identify contemporary issues in applying software quality and reliability techniques.
CO5	Develop and apply the practice software reliability techniques.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	3	3	3	2	3
2	2	2	2	3	2	3
3	3	1	1	2	1	3
4	2	2	2	3	2	1
5	1	1	1	3	1	2

Unit I	**FUNDAMENTALS OF SOFTWARE QUALITY ASSURANCE**	**9 Hours**

The Role of SQA - Software Quality Assurance Plan - Software Quality Assurance considerations - Need of Software Quality Assurance - SQA People.

Unit II	MANAGING SOFTWARE QUALITY	9 Hours
Quality Management-Software Configuration Management-Managing Software organizations- Managing Software quality –Defect Prevention.		
Unit III	**SQA METRICS**	**9 Hours**
Software Quality-Total Quality Management (TQM)-Quality Metrics-Software Quality metric Analysis.		
Unit IV	**SOFTWARE QUALITY PROGRAM AND SQA STANDARDIZATION**	**9 Hours**
Software quality program Concepts-Establishment of a software quality program-Software Quality Assurance planning-purpose and scope of Software Quality Program- Software standards-ISO 9000 Quality system standards-Capability Maturity model and the Role of SQA in software development maturity- Six Sigma Concepts.		
UNIT V	**RELIABILITY ENGINEERING PROCESS**	**9 Hours**
Reliability Definition-Quality and Reliability-Reliability Functions-Reliability Mathematics - Measures of Reliability - Defining the product-Testing the acquired software-Learning reliability concepts-s/w and h/w reliability.		
	Total	**45 Hours**
References		

1. Mordechai Ben-Menachem / Garry S Marliss, ―Software Quality, Vikas Publishing House, Pvt, Ltd., New Delhi, 2021.
2. Meir Liraz,Quality Assurance: How to set up and manage a Quality Control System,Kindle Edition,2013.
3. SolisTech, Quality Assurance: Software Quality Assurance made easy, KindleEdition, 2016.
4. Watts S Humphrey, ― Managing the Software Process‖, Pearson Education Inc, 2007.
5. John D Musa, ―Software Reliability Engineering, 1998.
6. Gordon G Schulmeyer, ―Handbook of Software Quality Assurance, Third Edition, Artech House Publishers, 2007.
7. Charles E. Ebeling, ―An introduction to Reliability and Maintainability engineering, TMH, 2000.
8. RoyBillington and Ronald N. Allan, ―Reliability Evaluation of Engineering Systems, Springer, 2007

24CS57	DIGITAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3
Pre-requisite		**Assessment Pattern**			

● Basic of Computer Vision, including feature extraction, pattern extraction, pattern recognition. ● Basic knowledge of transforms and compression techniques.	**Mode of Assessment** / **Weightage(%)** Continuous Internal Assessment / 40 Semester End Examinations / 60

Course Objectives

- To impart fundamental steps of digital image processing based on image representations, operations and transform function.
- To inculcate the knowledge about enhancement, restoration, compression by appropriate techniques to obtain the desired image quality.
- To apply the related to image segmentation and recognition techniques to real world problems.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the image types and representations involved in digital image processing system.
CO2	Implement the arithmetic, logical, geometrical operations and transforms techniques to process an image.
CO3	Analyze the techniques suitable for image enhancement and image restoration in spatial and frequency domain.
CO4	Apply image compression and segmentation techniques to perform image processing.
CO5	Apply an image representation and recognition techniques to solve real world problems.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2		3		
2	2		3	3	2	3
3	3	3		2		
4	3			2	3	3
5	2	2	2	2	2	3

Unit I	**Digital Image Fundamentals**	**9 Hours**

Nature of digital image processing - digital image representation - types of images - digital image processing operations - fundamental steps in image processing - image processing applications - digital imaging system - physical aspects of image acquisition - sampling and quantization – relationship between pixels - image storage and file formats.		
Unit II	**Image Processing Operations and Transforms**	**9 Hours**
Arithmetic operations - logical operations - geometrical operations - image interpolation techniques - convolution and correlation operations - data structures and image processing applications development – transforms: need for image transforms - properties of fourier transform - discrete cosine transform - discrete sine transform - walsh transform - hadamard transform - haar transform - slant transform - SVD and KL transforms.		
Unit III	**Image Enhancement and restoration**	**9 Hours**
Need for image enhancement - Point operations - Spatial filtering concepts - Frequency domain filtering - Image restoration model: Categories of image degradations - Image restoration in noise - Image restoration techniques.		
Unit IV	**Image Compression and Segmentation**	**9 Hours**
Compression: Model – Types of redundancy – Lossless compression and lossy compression algorithms - Segmentation: Classification – Detection of Discontinuities – Edge detection - Corner detection – Principles of Thresholding – Region based segmentation – Dynamic segmentation. Morphology-Dilation, Erosion, Opening and Closing. Hit and Miss Algorithms Feature Analysis.		
UNIT V	**Image Representation and Recognition**	**9 Hours**
Boundary representation – Boundary Descriptions – Regional Descriptors – Feature Selection Techniques – Recognition: Pattern and Pattern classes – Template matching – classifier algorithms – Evaluation of classifier algorithms – Case study: Biometrics- clustering techniques and its evaluation.		
	Total	**45 Hours**
References		

1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. 4ed, PHI/Pearson Education, 2018.
2. S. Jayaraman, S. Esakkirajan, T. Veerakumar, Digital Image Procesing, McGraw Hill Education, 2nd edition, 2020.
3. S. Sridhar, Digital Image Processing , Oxford University Press; Second edition, 2016.

24CS58	INFORMATION RETRIEVAL TECHNIQUES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Understanding of database concepts and retrieval techniques. ● Basic knowledge of information theory concepts.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To gain the knowledge in information retrieval with relevance to modelling, query operations, indexing and web searching.
- To learn the retrieval modelling and retrieval evaluation and understand the various applications of IR.
- To familiarize with the concepts of web search, digital libraries and recommender systems functions.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Classify the information retrieval system and web search.
CO2	Outline the classic information retrieval models and evaluate the performance of an information retrieval system.
CO3	Implement the concepts of index construction and compression for information retrieval and query processing in information retrieval.
CO4	Design an efficient search engine and analyse the web content structure in web crawler.
CO5	Understand the fundamental concepts of Information Retrieval (IR) models and their applications in various linguistic contexts.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2	1	3	3	2
2	1	1	1	3	2	1
3	2	1	2	3	3	3
4	1	2	2	1	2	3
5	2	2	3	3	1	3

Unit I	INTRODUCTION	9 Hours
Motivation-Information versus Data Retrieval-Basic Concepts -Past, Present, Future-Retrieval Process Information Retrieval Systems-Architecture-Characterization of IR Model -Documents and Update-Performance Evaluation-Indexing-Web Searching-IR Versus Web Search-Components of a Search Engine.		
Unit II	**RETRIEVAL MODELING AND RETRIEVAL EVALUATION**	**9 Hours**
Taxonomy and Characterization of IR Models-Classic Information Retrieval Model- Alternative Set Theoretic, Algebraic, Probabilistic Model-Structured Text Retrieval Model-Models for Browsing-Retrieval Evaluation-Retrieval Metrics-Retrieval Performance Evaluation-Reference Collection.		
Unit III	**SQA INDEXING AND QUERY PROCESSING**	**9 Hours**
Static and Dynamic Inverted Indices-Index Construction and Index Compression. Searching- Sequential Searching and Pattern Matching. Query Operations-Query Languages-Structural Query- Query Protocols-Query Processing-Automatic Local and Global Analysis.		
Unit IV	**WEB RETRIEVAL AND WEB CRAWLING**	**9 Hours**
The Web-Search Engine Architectures-Crawling the web-Crawling Documents and Email-Document Parsing-Link Analysis -Ranking-Simple Ranking Functions-Learning to Rank-Browsing - Applications of a Web Crawler-Evaluating Search Engines-Social Search.		
UNIT V	**CROSS LINGUAL AND MULTIMEDIA INFORMATION RETRIEVAL**	**9 Hours**
Cross Lingual Information Retrieval: IR models – Language Problems in IR - Problems of CLIR - Approaches to Translation in CLIR - Using manually constructed Translation systems and resources for CLIR – Other methods to improve CLIR - Multimedia Information retrieval (MIR): Introduction - data modelling - Query languages - Spatial access methods - A general multimedia indexing approach - One-dimensional time series - Two-dimensional colour images - Automatic picture extraction.		
	Total	**45 Hours**
References		

1. Ricardo Baeza Yates, Berthier Ribeiro Neto, Modern Information Retrieval: The Concepts and Technology behind Search, (ACM Press Books), Second Edition, Reprint 2016.
2. Chrstopher D. Manning, Prabhakar Raghavan, Hinrich Schutze, Introduction to Information Retrieval Cambridge University Press, First South Asian Edition, 2011.
3. Stefan Buttcher, Charles L. A. Clarke, Gordon V. Cormack, Information Retrieval Implementing and Evaluating Search Engines, The MIT Press, Cambridge, Massachusetts London, England, 2016.
4. Bruce Croft, Donald Metzler, Trevor Strohman, Search Engines: Information Retrieval in Practice, Pearson Education, 2015.
5. Jian-Yun Nie, Cross-Language Information Retrieval by Morgan & Claypool Publisher series, 2010.

24CS59	NATURAL LANGUAGE PORCESSING	L	T	P	C

		3	0	0	3

Pre-requisite	Assessment Pattern	
● Understanding of basic linguistic concepts, language models and grammars. ● Basic experience with text processing techniques.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the basics of linguistics, probability and statistics.
- To understand statistical approaches to NLP and sequence labeling.
- To outline different parsing techniques associated with NLP.
- To explore the semantics of words and semantic role labeling of sentences.
- To apply the methods for discourse analysis, question answering, and chatbots.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the basics of linguistics, probability, and statistics associated with NLP.
CO2	Understand various techniques in NLP, including n-grams, language models, named entity tagging, and evaluating vector models for language tasks.
CO3	Understand and apply techniques for analyzing and representing the structure of natural language sentences.
CO4	Identify and analyze different word senses, semantic roles, and relationships between words and concepts.
CO5	Develop a simple chatbot using dialogue system concepts.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1		2	3	1	1	
2	2	2	2	3		3
3	3		3	3		3
4	1		2	3		3
5	1		2	3		3

Unit I	INTRODUCTION TO NLP	9 Hours
Natural Language Processing – Components - Basics of Linguistics, Probability and Statistics – Words-Tokenization-Morphology-Finite State Automata- Finite State Automata for more Grammatical Categories.		
Unit II	**STATISTICAL NLP AND SEQUENCE LABELING**	**9 Hours**
N-grams and Language models –Smoothing -Text classification- Naïve Bayes classifier – Evaluation - Vector Semantics – TF-IDF - Word2Vec- Evaluating Vector Models –Sequence Labeling – Part of Speech – Part of Speech Tagging -Named Entities –Named Entity Tagging.		
Unit III	**CONTEXTUAL EMBEDDING**	**9 Hours**
Constituency –Context Free Grammar –Lexicalized Grammars- CKY Parsing – Earley's algorithm - Evaluating Parsers -Partial Parsing – Dependency Relations- Dependency Parsing Transition Based - Graph-Based.		
Unit IV	**COMPUTATIONAL SEMANTICS**	**9 Hours**
Word Senses and WordNet – Word Sense Disambiguation - types of word sense disambiguation – Semantic Role Labeling – Proposition Bank- FrameNet- Selectional Restrictions - Information Extraction - Template Filling.		
UNIT V	**DISCOURSE ANALYSIS AND SPEECH PROCESSING**	**9 Hours**
Discourse Coherence – Discourse Structure Parsing – Centering and Entity Based Coherence – Question Answering –Factoid Question Answering – Classical QA Models – Chatbots and Dialogue systems – Frame-based Dialogue Systems – Dialogue–State Architecture.		
	Total	**45 Hours**
References		

1. Daniel Jurafsky and James H.Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition" (Prentice Hall Series in Artificial Intelligence), 2020.
2. Jacob Eisenstein. "Natural Language Processing ", MIT Press, 2019 Samuel Burns "Natural Language Processing: A Quick Introduction to NLP with Python and NLTK, 2019.
3. Christopher Manning, "Foundations of Statistical Natural Language Processing", MIT Press, 2009.
4. Nitin Indurkhya,Fred J. Damerau, "Handbook of Natural Language Processing", Second edition, Chapman & Hall/CRC: Machine Learning & Pattern Recognition, Hardcover, 2010.
5. Deepti Chopra, Nisheeth Joshi, "Mastering Natural Language Processing with Python", Packt Publishing Limited, 2016.
6. Mohamed Zakaria Kurdi "Natural Language Processing and Computational Linguistics: Speech, Morphology and Syntax (Cognitive Science)", ISTE Ltd., 2016.
7. Atefeh Farzindar,Diana Inkpen, "Natural Language Processing for Social Media (Synthesis Lectures on Human Language Technologies)", Morgan and Claypool Life Sciences, 2015.

24CS60	DEEP LEARNING TECHNIQUES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Understanding of linear algebra, Calculus, Probability and Statistics. ● Basic knowledge of machine learning concepts and Optimization techniques.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To introduce the fundamental concepts of deep learning.
- To explore the different types of neural networks.
- To gain proficiency in implementing and training reinforcement learning algorithms.
- To learn techniques for interpreting and improving model performance.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Apply the deep learning techniques to train neural networks effectively.
CO2	Analyze the performance of different neural network architectures suitable for different application scenarios.
CO3	Implement reinforcement learning algorithms to train deep reinforcement learning agents for various environments.
CO4	Analyze case studies and real-world applications of model interpretability and explain ability techniques.
CO5	Deploy, scale, and maintain deep learning models effectively in real-world production environment.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	2		3	3	3
2	2	2	2	3	3	2
3	2	2	2	3	2	3
4	2	2	1	3	3	3
5	2	2		3	2	2

Unit I	**INTRODUCTION TO DEEP LEARNING**	**9 Hours**

Overview of Deep Learning: Definition and brief history - Key concepts: neurons, layers, activation functions-Neural Networks Fundamentals: Perceptron's and the basics of artificial neural networks-Forward and backward propagation-Gradient descent and optimization algorithms-Deep Learning Frameworks: Introduction to popular frameworks: TensorFlow, PyTorch, Keras.

Unit II	**NEURAL NETWORKS**	**9 Hours**

Convolutional Neural Networks (CNNs): Structure and working principle of CNNs- Applications in image recognition and computer vision- Implementation and training of CNNs- Recurrent Neural Networks (RNNs): Understanding sequential data processing-Structure and functioning of RNNs- Generative Adversarial Networks (GANs): Introduction to GAN architecture-Training GANs-Graph Neural Networks: Basics of graph representation learning.

Unit III	**DEEP REINFORCEMENT LEARNING**	**9 Hours**

Introduction to Reinforcement Learning (RL): Basics of reinforcement learning: agents, environments, rewards-Markov decision processes (MDPs)-Q-Learning and Deep Q-Networks (DQNs): Understanding Q-learning algorithm-Introduction to Deep Q-Networks (DQNs) and experience replay-Policy Gradient Methods: Policy gradients and REINFORCE algorithm.

Unit IV	**MODEL INTERPRETABILITY AND EXPLAINABILITY**	**9 Hours**

Importance of Model Interpretability: Motivation for model interpretability and explainability-Ethical considerations in AI-Interpretability Techniques: Feature importance methods-Local and global explanation methods-Interpretable Models: Decision trees and rule-based models-Linear models and logistic regression-Case Studies and Applications.

UNIT V	**DEPLOYMENT AND SCALABILITY**	**9 Hours**

Model Deployment Strategies: Introduction to model deployment-Considerations for deploying deep learning models-Scalability and Performance Optimization: Techniques for improving model performance-Distributed training and model parallelism.

Total	**45 Hours**

References

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.
2. Charu C. Aggarwal, Neural Networks and Deep Learning: A Textbook, Springer International Publishing AG, 2018.
3. Rajalingappaa Shanmugamani, Deep Learning for Computer Vision, Packt Publishing, 2018.
4. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press, 2018.
5. Christoph Molnar, Interpretable Machine Learning, Lulu.com, 2020.
6. Emmanuel Ameisen, Building Machine Learning Powered Applications: Going from Idea to Product, O'Reilly Media, Inc., 2020.

24CS61	BIG DATA MINING AND ANALYTICS	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Basic understanding of Data Mining techniques. ● Familiarity with big data storage and processing technologies.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the concepts and challenges of big data mining and analytics.
- To explore different data mining algorithms and their applications.
- To understand the various search algorithms applicable to Big Data.
- To apply data visualization techniques to communicate insights effectively.
- To analyse real-world case studies and practical applications of big data analytics.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Apply the computational approaches to modelling, analyse and interpret the data.
CO2	Apply the search techniques for efficient retrieval of similar data from large database.
CO3	Design a model to extract valuable insights from continuous data streams efficiently.
CO4	Analyze and optimize web link structures, detect link spam, and extract frequent item sets.
CO5	Analyze streaming data and parallelize clustering algorithms, culminating in the practical application of clustering methods to solve real-world problems.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	3	1	1
2	2	3		2	1	2
3	1	1	2	1		2
4	2					3
5	1		2	1		1

Unit I	**DATA MINING AND LARGE SCALE FILES**	**9 Hours**

Modelling – Summarization – Feature Extraction – Statistical Limits on Data Mining - Distributed File Systems – Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques.

Unit II	**SIMILARITY DETECTION**	**9 Hours**

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 Hours**

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 Hours**

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 Hours**

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.

	Total	**45 Hours**

References

1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, MichelineKamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
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.
5. Saumyadipta Pyne, B.L.S. Prakasa Rao, S.B. Rao, “Big Data Analytics: Methods and Applications”, Springer, 2018.

24CS62	DATA VISUALIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Understanding of various types of data visualizations. ● Familiarity with principles of good data visualization.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the concepts and challenges of big data mining and analytics.
- To explore different data mining algorithms and their applications.
- To understand the various search algorithms applicable to Big Data.
- To apply data visualization techniques to communicate insights effectively.
- To analyse real-world case studies and practical applications of big data analytics.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the key techniques and theory behind data visualization.
CO2	Analyze and use effectively the various visualization structures (like tables, spatial data, tree and network etc.).
CO3	Evaluate information visualization systems and other forms of visual presentation for their effectiveness.

CO4	Design and build data visualization systems.
CO5	Analyse streaming data and parallelize clustering algorithms, culminating in the practical application of clustering methods to solve real-world problems.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	2	2	1	2
2	2	1	2	3	2	2
3	1		2	2	1	1
4	3	1	3	3	2	2
5	2	1	3	2	1	1

Unit I	**FUNDAMENTALS OF VISUALIZATION**	**9 Hours**

Introduction to Visualization: Purpose of Visualization, External Representation and Significance, Validation Challenges. Data Abstraction in Visualization: Datasets Types & Characteristics, Attribute Types and Semantic Representations.

Unit II	**PRINCIPLES OF REPRESENTATION**	**9 Hours**

Marks and Channels: Exploring Different Marks and Uses, Understanding Channels in Data Visualization, Table and Spatial Data Organization: Rules for Arranging Tables, Spatial Data Representation: Geometry, Scalar Fields, Vector Fields, Tensor Fields.

Unit III	**ADVANCED DATA VISUALIZATION TECHNIQUES**	**9 Hours**

Networks and Trees Visualization: Strategies for Arranging Networks and Trees, Matrix Views for Representing Connections. Mapping Color in Visualization: Color Theory and Its Application, Effective Use of Color Maps and Other Channels.

Unit IV	**INTERACTIVE VISUALIZATION AND MANIPULATION**	**9 Hours**

Manipulating Views: Dynamic View Changes over Time, Selective Element Display & Interaction, Changing Viewpoints & Reducing Attributes. Faceting & Focus/Context: Juxtaposing & Coordinating Multiple Views, Static & Dynamic Layers in Visualization, Filtering and Aggregation.

UNIT V	**VALIDATION AND CASE STUDIES**	**9 Hours**

Validation in Visualization: Levels of Validation, Validation Approaches. Focus & context: Elide – Superimpose – Distort – Case studies: Real World Applications.

Total	**45 Hours**

References

1. Tamara Munzner, Visualization Analysis and Design, A K Peters Visualization Series, CRC Press, 2014.
2. Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.

3. Alberto Cairo, The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, 2012.
4. Nathan Yau, Visualize This: The Flowing Data Guide to Design, Visualization and Statistics, John Wiley & Sons, 2011.

24CS63	BLOCKCHAIN TECHNOLOGIES	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Basic understanding of cryptographic principles. ● Fundamentals of networking concepts and security.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the fundamentals of Blockchain technology.
- To study the architecture of Blockchain and bitcoins.
- To understand and develop an Ethereum ecosystem.
- To understand the hyperledger fabric technology.
- To design different Blockchain based applications.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the cryptographic basics of block chain technology.
CO2	Understand basics of architectural design of block chain and bitcoins trading.
CO3	Develop private block chain environment and develop a smart contract on Ethereum.
CO4	Design the hyperledger architecture and the consensus mechanism applied on it.
CO5	Design of different block chain based applications for increased security.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1	3	2	2	3
2	2	1	2	3	2	2
3	2	1	3	1	2	1
4	2	1	2	3	2	2
5				1	1	1

Unit I	**HISTORY OF BLOCK CHAIN**	**9 Hours**

Digital Money to Distributed Ledgers, Block chain Basics, Growth of block chain technology, Distributed systems, History of block chain and Bitcoin, Types of block chain, Methods of decentralization, Routes of decentralization, Block chain and full ecosystem decentralization, Smart contracts, Decentralized organizations, Platforms for decentralization.

Unit II	**BLOCK CHAIN AND BITCOINS**	**9 Hours**

Block chain Architecture, Versions, Variants, Use cases of block chain, Block chain vs shared Database, Introduction to cryptocurrencies, Types, Applications. Bitcoins: Introduction, Bitcoin digital keys and addresses, Transactions, Block chain mining, Alternative Coins, Limitations of Bitcoin, Applications of Bitcoin Scripts, Bitcoin Blocks.

Unit III	**ETHEREUM**	**9 Hours**

Introduction: Ethereum, The Ethereum ecosystem, IOTA, EOS, Multichain, Bigchain, Advantages and Disadvantages, Ethereum vs Bitcoin, Design of new blockchain, Potential for disruption, Design of distributed application, Viewing Information about blocks in Blockchain, Blockchain applications, Developing smart contract on private Block chain.

Unit IV	**HYPERLEDGER**	**9 Hours**

Introduction to Hyper ledger fabric, components of Hyper Ledger Fabric Technology, Develop Hyper Ledger Block Chain Applications using Composer Framework, Model the Block Chain Applications using Composer modelling language, Alternative Decentralized Solutions, Hyper ledger Fabric II: Beyond Chain code, fabric SDK and Front End-Hyper ledger composer tool.

UNIT V	**APPLICATIONS**	**9 Hours**

Block chain in Financial Software and Systems (FSS): Settlements, KYC, Capital markets-Insurance Block chain in trade/supply chain, Block chain for Government: Digital identity, land records and other kinds of record keeping between government entities, public distribution system / social welfare system.
Total **45 Hours**
References
1. Mastering Bitcoin: Unlocking Digital Cryptocurrencies, by Andreas M Antonopoulos 2018. 2. Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations-2016. 3. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016. 4. Bahga, Vijay Madisetti, “Block chain Applications: A Hands-On Approach”, Arshdeep Bahga, Vijay Madisetti publishers 2016.

24CS64	**FULL STACK WEB APPLICATION DEVELOPMENT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Understanding of web protocols and web standards. ● Basics of Database connectivity..	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To understand the basics and components of frontend web development.
- To understand back end web development basics and tools.
- To understand the PHP components and framework for web development.
- To explore the features of SQL and MySQL for databases.
- To explore integration of PHP and advanced web development features.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the basics of JavaScript, CSS and other web development features.
CO2	Understand various back end web development tools and frameworks.
CO3	Understand and apply techniques for analyzing and representing the structure of natural language sentences.
CO4	Explore the necessity of SQL and MySQL features for databases.
CO5	To develop a simple Web Application by integrating simple and advanced web development features.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1			2	3	3	3
2			2	3	3	3
3	2		1		3	3
4	2		2		3	3
5	3	3			3	3

Unit I	**INTRODUCTION TO WEB DEVELOPMENT**	**9 Hours**

Introducing Flexbox– JavaScript for Front-end- Syntax & Creating Concepts with JavaScriptDesign Patterns & Object Modelling- HTTP Requests & Routes- Introducing CSS- CSS Grid & Creating Responsive Layouts– jQuery & jQuery-mobile- Bootstrap & Angular JS-Node & Express Backend integration- Basics of Web pack & Sass and Web pack.

Unit II	**BACK END WEB DEVELOPMENT**	**9 Hours**

OOPS-JSON-AJAX- Node.js-Development Environment & Tools- Express Framework, Building scalable web applications, Design Patterns & Object Modelling– Database & MongoDB- HTTP & Web sockets for Node.js

Unit III	**HYPERTEXT PREPROCESSOR**	**9 Hours**

Introduction, PHP Document, Language Fundamentals, Decision Making Statement, Loops, Statements, Operators, PHP functions, Arrays & Functions, String Functions, Server-Side Processing, Processing Forms via GET/POST, State and Persistence, Web Application Development, Introduction to PHP Frameworks & Basic OOP

Unit IV	**NO SQL**	**9 Hours**

ntroduction to NoSQL, History of NoSQL Exploring NoSQL, Interfacing and Interacting with NoSQL, NoSQL Storage Architecture, , Querying, Modifying and Managing. Data Storage in NoSQL, Working with NoSQL, Surveying Database Internals, Migrating from RDBMS to NoSQL, Web Frameworks and NoSQL, using MySQL as a NoSQL, case study: implement Advanced columnar data model functions for the real time applications.

UNIT V	DATABASE FOR THE MODERN WEB	9 Hours
Introduction to Node.js- Installing Node.js - Using Events, Listeners, Timers, and Callbacks in Node.js – Introduction to MongoDB- Accessing MongoDB from Node.js. Core Server tools, MongoDB through the JavaScript's Shell, Creating and Querying through Indexes, Document- Oriented, principles of schema design, Constructing queries on Databases, collections and Documents, MongoDB Query Language. Developing Web Application with NOSQL and NOSQL Administration Php and MongoDB, Python and MongoDB, Creating Blog Application with PHP.		
	Total	**45 Hours**

References

1. Chris Northwood, "The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer", First Edition 2018.
2. Frank Zammetti, Modern Full-Stack Development: Using TypeScript, React, Node.js, Webpack, and Docker, Second Edition 2022.
3. Riyaz Ahmed, "Full Stack Web Development For Beginners: Learn Ecommerce Web Development Using HTML5", CSS3, Bootstrap, JavaScript, MySQL, and PHP", Amazon Digital Services LLC - Kdp, 16 Apr 2021.
4. Jack Chan, Ray Chung, Jack Huang, "Python API Development Fundamentals: Develop a full-stack web application with Python and Flask", 2019.
5. Edwin Ross, "Torres Full Stack Web Development: Round One – Begin!" 2021. 6. Brad Dayley, Brendan Dayley, and Caleb Dayley , Node.js, MongoDB and Angular Web Development: The definitive guide to using the MEAN stack to build web applications, 2nd Edition, Pearson Education, 2021.

24CS65	CYBER PHYSICAL SYSTEMS	L	T	P	C
		3	0	0	3

Pre-requisite	Assessment Pattern	
● Understanding basics of physical systems and networking concepts. ● Familiarity with sensor technologies.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To learn about the principles of cyber-physical systems, basic requirements of CPS.
- To know about CPS models, CPS foundations.
- To make the students explore the applications and platforms.
- To provide introduction to practical aspects of cyber physical systems.
- To equip students with essential tools to implement CPS.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.

PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Explain the core principles behind CPS
CO2	Discuss the requirements of CPS
CO3	Explain the various models of CPS
CO4	Describe the foundations of CPS.
CO5	Use the various platforms to implement the CPS

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	3	3		1	
2	2	2	2		1	
3			3	1		1
4			3	1		1
5	2		2	3	3	3

Unit I	**INTRODUCTION TO CYBER-PHYSICAL SYSTEMS**	**9 Hours**

Cyber-Physical Systems (CPS)-Emergence of CPS, Key Features of Cyber-Physical Systems, CPS Drivers-Synchronous Model: Reactive Components, Properties of Components, Composing Components, Designs- Asynchronous Model of CPS: Processes, Design Primitives, Coordination Protocols.

Unit II	**CPS - REQUIREMENTS**	**9 Hours**

Safety Specifications: Specifications, Verifying Invariants, Enumerative Search, Symbolic Search Liveness Requirements: Temporal Logic, Model Checking, Proving Liveness

Unit III	**CPS MODELS**	**9 Hours**

Dynamical Systems: Continuous, Linear Systems-Time Models, Linear Systems, Designing Controllers, Analysis Techniques- Timed Model: Processes, Protocols, Automata- Hybrid Dynamical Models.

Unit IV	**CPS FOUNDATIONS**	**9 Hours**

Symbolic Synthesis for CPS- Security in CPS-Synchronization of CPS-Real-Time Scheduling for CPS

UNIT V	**APPLICATIONS AND PLATFORMS**	**9 Hours**

Medical CPS- CPS Built on Wireless Sensor Networks- CyberSim User Interface- iClebo Kobuki - iRobot Create- myRIO- Cybersim- Matlab toolboxes - Simulink.

Total	**45 Hours**

References

1. Raj Rajkumar, Dionisio De Niz , and Mark Klein, Cyber-Physical Systems, Addison-Wesley Professional, 2016
2. Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.
3. Lee, Edward Ashford, and Sanjit Arunkumar Seshia. Introduction to embedded systems: A cyber physical systems approach. 2nd Edition, 2017.
4. André Platzer, Logical Analysis of Hybrid Systems: Proving Theorems for Complex Dynamics, Springer, 2010. ISBN 978-3-642-14508-7.
5. Jean J. Labrosse, Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C, The publisher, Paul Temme, 2011.
6. Jensen, Jeff, Lee, Edward, A Seshia, Sanjit, An Introductory Lab in Embedded and Cyber Physical Systems, http://leeseshia.org/lab, 2014.

24CS66	**MIXED REALITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Familiarity with computer graphics fundamentals. ● Understanding of 3D modelling and rendering techniques.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To study about Fundamental Concept and Components of Virtual Reality.
- To study about Interactive Techniques in Virtual Reality.
- To study about Visual Computation in Virtual Reality.
- To study about Augmented and Mixed Reality and Its Applications.
- To know about I/O Interfaces and its functions.

Programme Outcomes (POs)

PO1	Apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer-based systems of varying complexity.
PO2	Identify, formulate, critically analyse, and solve problems in the field of Computer Science and Engineering, considering recent and future trends.
PO3	Design a system, component, or process to meet desired needs within realistic constraints such as economic, social and ethical in the field of Computer Science and Engineering.
PO4	Use current techniques, skills, and tools necessary for computing practice and demonstrate advanced knowledge of a selected area within the Computer Science and Engineering discipline.
PO5	Demonstrate an ability to engage in lifelong learning for professional development and function effectively on teams to accomplish a common goal.
PO6	Critically analyse existing literature in an area of specialization and develop innovative and research- oriented methodologies to tackle gaps identified.

Course Outcomes (COs)

The students will be able to

CO1	Apply principles of interaction design to create intuitive and immersive user interactions within mixed reality applications.
CO2	Analyze real-world scenarios and identify suitable applications for mixed reality technology across various domains, including gaming, education, healthcare, manufacturing, and entertainment.
CO3	Develop proficiency in designing user interfaces and experiences tailored for mixed reality environments
CO4	Acquire skills in 3D modeling, animation, and asset creation for mixed reality content
CO5	Demonstrate an understanding of the fundamental concepts and principles of mixed reality technology, including virtual reality (VR), augmented reality (AR), and their integration.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	3	1		
2	3		3		1	
3	3	1			1	
4					1	
5		1	3			2

Unit I	**INTRODUCTION TO VIRTUAL REALITY**	**9 Hours**

Introduction, Fundamental Concept and Components of Virtual Reality. Primary Features and Present Development on Virtual Reality. Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism Stereographic image.

Unit II	**INTERACTIVE TECHNIQUES IN VIRTUAL REALITY**	**9 Hours**

Safety Specifications: Specifications, Verifying Invariants, Enumerative Search, Symbolic Search Liveness Requirements: Temporal Logic, Model Checking, Proving Liveness .

Unit III	**VISUAL COMPUTATION IN VIRTUAL REALITY**	**9 Hours**

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

Unit IV	**AUGMENTED AND MIXED REALITY**	**9 Hours**

Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection interfaces, marker-less tracking for augmented reality, enhancing interactivity in AR environments, evaluating AR systems

UNIT V	**I/O INTERFACE IN VR & APPLICATION OF VR**	**9 Hours**

Human factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modeling virtual world, Physical simulation, VR toolkits, Introduction to VRML, Input -- Tracker, Sensor, Digital globe, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual /Auditory / Haptic Devices. VR Technology in Film & TV Production. VR Technology in Physical Exercises and Games. Demonstration of Digital Entertainment by VR.

Total	**45 Hours**

References

1. Burden, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006.
2. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, First Edition 2013.
3. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.
4. John Vince, “Virtual Reality Systems “, Pearson Education Asia, 2007.
5. Adams, “Visualizations of Virtual Reality”, Tata McGraw Hill, 2000.
6. Grigore C. Burdea, Philippe Coiffet , “Virtual Reality Technology”, Wiley Inter Science, 2nd Edition, 2006.
7. William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann, 2008.

24CS67	**DEVOPS AND MICROSERVICES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Familiarity with cloud platforms and understanding of cloud services. ● Basic understanding of cloud deployment.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To learn the basic concepts and terminology of DevOps.
- To gain knowledge on Devops platform
- To understand building and deployment of code.
- To be familiar with DevOps automation tools.
- To learn basics of MLOps.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the concept of modern software Engineering process
CO2	Analyze the DevOps services and work platform under virtualization
CO3	Build, test and deploy code on micro-services architecture
CO4	Explore DevOps automation tools for infrastructure management
CO5	Correlate MLOps concepts with real time examples

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	2	1	2	3	
2	3	2			3	
3	3	2	2	3	2	3
4	3	2	1	2	3	
5	3	2	2	1	2	3

Unit I	**INTRODUCTION**	**9 Hours**

Software Engineering - traditional and Agile process models - DevOps -Definition - Practices - DevOps life cycle process - need for DevOps –Barriers.

Unit II	**DEVOPS PLATFORM AND SERVICES**	**9 Hours**

Cloud as a platform - IaaS, PaaS, SaaS - Virtualization - Containers –Supporting Multiple Data Centers - Operation Services - Hardware provisioning- software Provisioning - IT services - SLA - capacity planning - security - Service Transition - Service Operation Concepts.

Unit III	**BUILDING, TESTING AND DEPLOYMENT**	**9 Hours**

Microservices architecture - coordination model - building and testing - Deployment pipeline - Development and Pre-commit Testing -Build and Integration Testing - continuous integration - monitoring - security - Resources to Be Protected - Identity Management.		
Unit IV	**DEVOPS AUTOMATION TOOLS**	**9 Hours**
Infrastructure Automation- Configuration Management - Deployment Automation - Performance Management - Log Management -Monitoring.		
UNIT V	**MLOPS**	**9 Hours**
MLOps - Definition - Challenges -Developing Models - Deploying to production - Model Governance - Real world examples.		
	Total	**45 Hours**
References		

1. Len Bass, Ingo Weber and Liming Zhu, —"DevOps: A Software Architect's Perspective", Pearson Education, 2016.
2. Joakim Verona - "Practical DevOps" - Packet Publishing , 2016.
3. Viktor Farcic -"The DevOps 2.1 Toolkit: Docker Swarm" - Packet Publishing, 2017.
4. Mark Treveil, and the Dataiku Team-"Introducing MLOps" - O'Reilly Media- 2020.

24CS68	**MOBILE AND PERVASIVE COMPUTING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite	**Assessment Pattern**	
● Basic knowledge of mobile database systems and data synchronization techniques. ● Understanding of mobile OS internals and capabilities.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	40
	Semester End Examinations	60

Course Objectives

- To introduce the concepts of mobile communication system and pervasive computing.
- To understand the concepts of emerging mobile technology.
- To understand wireless networks.
- To be aware of pervasive computing practices.
- To learn concepts of pervasive computing and protocols.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Understand the basics of mobile communication system and pervasive computing.
CO2	Understand the concepts of emerging mobile technology.
CO3	Apply various mobile computing ideas and best practices to solve practical problems.
CO4	Identify the pervasive computing practices and protocols.
CO5	Apply pervasive computing techniques in various domains of importance.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	3	3	1	3	1	3
2	2	2	2	2	2	2
3	1	3	1	1	2	2
4	1	2	2	2	1	1
5	2		2	1	2	2

Unit I	**INTRODUCTION**	**9 Hours**

Mobile Computing – Networks – Middleware and Gateways – Developing Mobile Computing Applications – Mobile Computing Architecture: Architecture for Mobile Computing – Three-Tier Architecture – Design Considerations for Mobile Computing.

Unit II	**TELECOMMUNICATION SYSTEMS**	**9 Hours**

Global System for Mobile Communications – GSM Architecture – GSM Entities - Call Routing in GSM – GSM Addresses and Identifiers – Network Aspects in GSM – GSM Frequency Allocation – Authentication and Security -Mobile Computing through Internet –Mobile Computing through Telephone – Emerging Technologies: - Bluetooth – RFID -Wireless Broadband (WiMax) - Mobile IP.		
Unit III	**WIRELESS NETWORKS**	**9 Hours**
Wireless Standards Wireless LAN – IEEE 802.11 – Infrared vs Radio Transmission, Infrastructure Networks, Ad-hoc Networks, HIPERLAN, Wi-Fi, Emerging Technologies: - Bluetooth – RFID - Wireless Broadband (WiMax) - Mobile IP.		
Unit IV	**MOBILE DATA TECHNOLOGIES**	**9 Hours**
Short Message Service (SMS)- Value Added Services through SMS – GPRS- GPRS and Packet Data Network – GPRS Network Architecture – GPRS Network Operations –Data Services in GPRS- Applications for GPRS – Limitations of GPRS – CDMA and 3G- Spread Spectrum Technology- CDMA Versus GSM – Wireless Data – Third Generation Networks – Applications on 3G.		
UNIT V	**PERVASIVE COMPUTING**	**9 Hours**
Pervasive Computing: Past, Present and Future Pervasive Computing - Pervasive Computing Market – m-Business – Application Examples: Retail, Airline check-in and booking – Sales force automation – Health care – Tracking – Car information system – E-mail access via WAP – Device Technology: Hardware – Human Machine Interfaces – Biometrics – Mobile OS – Programming for Pervasive devices		
	Total	**45 Hours**
References		

1. Ashok K.Talukder and Roopa R.Yuvagal, “Mobile Computing”, 2nd Edition, Tata McGraw Hill, 2010.
2. Jochen Burkhardt, Horst Henn, Stefan Heper, Klaus Rindtorff and Thomas Schack, “Pervasive Computing Technology and Architecture of Mobile Internet Applications” Addison Wesley, 2002.
3. Uwe Hansmann, L. Merk, M. Nicllous, T. Stober and U.Hansmann, “Pervasive Computing”, Springer Verlag, 2003.
4. Johcehn H.Schiller, “Mobile Communications”, Addison-Wesley, 2003.
5. Stojmenovic and Cacute, “Handbook of Wireless Networks and Mobile Computing”, Wiley, 2002.

24XE01	**ENGLISH FOR RESEARCH PAPER WRITING**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Pre-requisite	**Assessment Pattern**	
● Basics English comprehension.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- Illustrate that how to improve your writing skills and level of readability.
- Learn about what to write in each section.
- Recognize the skills needed when writing a Title.
- Ensure the good quality of paper at very first-time submission.

Programme Outcomes (POs)

PO2	An ability to write and present a substantial technical report/document.

Course Outcomes (COs)

The students will be able to

CO1	Illustrate the research ideas and writing journal papers.
CO2	Creating research paper writing.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1		2				
2		3				

Unit I		**6 Hours**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

Unit II		**6 Hours**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

Unit III		**6 Hours**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit IV		**9 Hours**

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.

UNIT V		**6 Hours**

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.

Total	**30 Hours**

References	

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

24XE02	COST MANAGEMENT OF ENGINEERING PROJECTS	L	T	P	C
		2	0	0	0

Pre-requisite	Assessment Pattern	
● Basics of cost aspects and stages of project execution.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- To understand the cost concepts and different stages of project execution and its activities.
- To understand cost behaviour, management and its quantitative techniques.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO3	Students should be able to demonstrate a degree of mastery over the area of Computer Science and Engineering.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.

Course Outcomes (COs)

The students will be able to

CO1	Apply the cost concepts in decision making.
CO2	Analyze the various stages of project execution and its activities.
CO3	Analyze the cost behaviour and various types of costing.
CO4	Analyze the cost management and budget related decisions.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1	1	
2	1		1		1	
3					1	
4					1	

Unit I	**Cost Concepts in Decision-Making**	**6 Hours**

Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control;
Provision of data for Decision-Making.

Unit II	**Project**	**9 Hours**

Meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and
documents Project team: Role of each member. Importance Project site: Data required with significance.

Unit III	**Cost Behaviour and Profit Planning Marginal Costing**	**9 Hours**

Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning.

Unit IV	Total Quality Management and Theory of Constraints	9 Hours
Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.		
UNIT V	**Quantitative Techniques for Cost Management**	**9 Hours**
Relevant provision of factories Act and rules and other statues applicable to textile industry effluent treatment and waste disposal in textile industry		
	Total	**30 Hours**
References		
1. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd. 2. Charles T. Horngren and George Foster, Advanced Management Accounting 3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting 4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher		

24XE03	STRESS MANAGEMENT	L	T	P	C
		2	0	0	0

Pre-requisite	Assessment Pattern	
● Basics of yoga.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- To achieve overall health of body and mind.
- To overcome stress by practicing yoga.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.

Course Outcomes (COs)

The students will be able to

CO1	Develop healthy mind in a healthy body thus improving social health also.
CO2	Improve Efficiency of the body by practicing breathing exercises and yoga.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1				
2		1				

Unit I		**10 Hours**

Definitions of Eight parts of yoga. (Ashtanga)

Unit II		**10 Hours**

Yam and Niyam. Dos and Donts in life.i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan.

Unit III		**10 Hours**

Asan and Pranayam, i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam.

	Total	**30 Hours**

References

1. Yogic Asanas for Group Training-Part-I Janardan Swami Yogabhyasi Mandal, Nagpur. Model Curriculum of Engineering & Technology PG Courses [Volume-I][47].
2. Rajayoga or conquering the Internal Nature by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata.

24XE04	**DISASTER MANAGEMENT**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Pre-requisite	**Assessment Pattern**	
● Disaster risk reduction. ● The strengths and weaknesses of disaster management approaches.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.

Course Outcomes (COs)

The students will be able to

CO1	Illustrate the key concepts in disaster risk reduction and humanitarian response.
CO2	Interpret the strengths and weaknesses of disaster management approaches, planning and programming.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1				
2	2					

Unit I	**Introduction**	**5 Hours**

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**	**5Hours**

Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms and Cyclones, Tsunamis and Floods, Droughts and Famines, Landslides and Avalanches Man-made disaster Nuclear Reactor Meltdown, Industrial Accidents and Oil Slicks and Spills Outbreaks of Disease and Epidemics War and Conflicts.

Unit III	**Disaster Prone Areas in India**	**5 Hours**

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**	**5 Hours**

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	**Disaster Mitigation**	**9 Hours**
Disaster mitigation meaning, concept and strategies of disaster mitigation, emerging trends in mitigation. Structural mitigation and non-structural mitigation, programs of disaster mitigation in India.		
	Total	**30 Hours**
References		
1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies " , New Royal book Company. 2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi 3. Goel S. L. "Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.		

24XE05	**VALUE EDUCATION**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Pre-requisite	**Assessment Pattern**	
● Awareness about ethics and human value	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- Interpret value of education and self- development.
- Imbibe good values in students.
- Let the should know about the importance of character.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.

Course Outcomes (COs)

The students will be able to

CO1	Knowledge of self-development.
CO2	Learn the importance of Human values.
CO3	Developing the overall personality.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1					
2	1					
3		1				

Unit I		**8 Hours**

Values and self-development- Social values and individual attitudes-Work ethics- Indian vision of humanism-Moral and non- moral valuation-Standards and principles-Value judgements.

Unit II		**7 Hours**

Importance of cultivation of values- Sense of duty Devotion- Self-reliance- Confidence-Concentration-Truthfulness- Cleanliness-Honesty- Humanity- Power of faith- National Unity- Patriotism- Love for nature-Discipline.

Unit III		**8 Hours**

Personality and Behavior Development - Soul and Scientific attitude- Positive Thinking- Integrity and discipline-Punctuality- Love and Kindness- Avoid fault Thinking- Free from anger- Dignity of labour-Universal brotherhood and religious tolerance-True friendship-Happiness Vs suffering- love for truth-Aware of self-destructive habits-Association and Cooperation-Doing best for saving nature.

Unit IV		**7 Hours**

Character and Competence -Holy books vs Blind faith, Self-management and Good health. Science of reincarnation, Equality, Nonviolence ,Humility, Role of Women. All religions and same message, Mind your Mind, Self-control. Honesty, Studying effectively.

Total	**30 Hours**
References	
1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi.	

24XE06	**PEDAGOGY STUDIES**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Pre-requisite	**Assessment Pattern**	
● Awareness about basic teaching techniques	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- Review existing evidence on the review topic to inform programmer design and policy making undertaken by the DfID, other agencies and researchers
- Identify critical evidence gaps to guide the development.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.

Course Outcomes (COs)

The students will be able to

CO1	What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
CO2	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
CO3	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? overall personality

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	1					
2	1					
3	1					

Unit I	**Introduction and Methodology**	**8 Hours**

Aims and rationale- Policy background- Conceptual framework and terminology-Theories of learning-Curriculum- Teacher education-Conceptual framework- Research questions-Overview of methodology and Searching.

Unit II	**Thematic Overview**	**7 Hours**

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.

Unit III	**Evidence on the Effectiveness of Pedagogical Practices**	**8 Hours**

Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school, curriculum and guidance materials best support effective pedagogy. Theory of change, Strength and nature of the body of evidence for effective pedagogical, practices, Pedagogic theory and pedagogical approaches, Teachers" attitudes and beliefs and Pedagogic strategies.

Unit IV	**Professional Development**	**7 Hours**

Alignment with classroom practices and follow up, Support Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Total	**30 Hours**

References	

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379
3. Akyeampong K (2003) Teacher training in Ghana - does it count. Multi-site teacher education research project (MUSTER) country report 1. London: DFID
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272-282
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, "learning to read" campaign.

24XE07	BUSINESS ANALYTICS	L	T	P	C
		2	0	0	0

Pre-requisite	Assessment Pattern	
● Business analytics within an organization.	**Mode of Assessment**	**Weightage(%)**
	Continuous Internal Assessment	100
	Semester End Examinations	

Course Objectives

- Illustrate the role of business analytics within an organization.
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and Analyze business data.
- Use decision-making tools/Operations research techniques and Manage business process using analytical and management tools.

Programme Outcomes (POs)

PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO4	Efficiently design, build and develop system application software for distributed and centralized computing environments in varying domains and platforms.
PO5	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.
PO6	Model a computer based automation system and design algorithms that explore the understanding of the tradeoffs involved in digital transformation.

Course Outcomes (COs)

The students will be able to

CO1	Implement the knowledge of data analytics.
CO2	Apply the ability of think critically in making decisions based on data and deep analytics.
CO3	Analyze the ability to use technical skills in predicative and prescriptive modelling to support business decision-making.
CO4	Determine the ability to translate data into clear, actionable insights.
CO5	Analyze the decision problems in business analytics.

Articulation Matrix

CO. No.	PO1	PO2	PO3	PO4	PO5	PO6
1	2			2	1	1
2	2			2	2	1
3	1			1		
4	1					
5	2			1		

Unit I	**Business Analytics and Statistical Tools**	**6 Hours**

Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics-Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit II	**Trendiness and Regression Analysis**	**6 Hours**
Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.		
Unit III	**Organization Structures of Business Analytics**	**6 Hours**
Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.		
Unit IV	**Forecasting Techniques**	**6 Hours**
Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.		
Unit V	**Decision Analysis**	**6 Hours**
Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.		
	Total	**30 Hours**
References		
1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press 2. Business Analytics by James Evans, persons Education.		