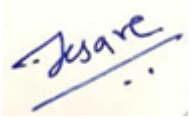
CURRICULUM STRUCTURE

THIRD YEAR UG: B.E.

ARTIFICIAL INTELLIGENCE & DATA SCIENCE

REVISION: FRCRCE-1-24

Effective from Academic Year 2024-25
Board of Studies Approval: 08/03/2024
Academic Council Approval: 16/03/2024



Dr.DEEPAK BHOIR
Dean Academics

Dr.Jagruti Save
HOD(AI&DS)

DR. SURENDRA RATHOD
Principal

Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.

The National Education Policy (NEP), 2020 suggests that students must actively engage with the practical side of their learning as part of a holistic education to further improve their employability. ***Fr. CRCE has taken a strategic decision to implement revised assessment scheme to support more experiential learningand continuous assessment in the form of ISE-1, MSE, ISE-2 and ESE to be taken by the college. The curriculum content and credit structure is maintained same as prescribed by University of Mumbai for third year students of academic year 2024-25.***

Honours and Minor Degree Eligibility Criteria for Students:

i. Following is the eligibility criteria for students opting the Honours/ Minor Degree program:

a. Students with no backlog in semester I, II, and III

b. The CGPI (based on semester I, II, and III) of the students must be 6.75 and above

c. For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above

ii) Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.

iii) However, it is optional for leaners to take Honours/Minor degree program.

iv) The Honours/ Minor degree program can be opted only during regular engineering studies

v) The student have to complete the Honours/ Minor degree program in stipulated four semesters only.

Note:

1. Technical support team for registration of Academic Bank of Credits (ABC), registration of elective/optional courses, registration of online courses, registration for degree options etc. under supervision of Dean Academics.

SEMESTERWISE CURRICULUM STRUCTURE

THIRD YEARArtificial Intelligence & Data Science Program:

SEM-V									
Course Code	Course Name		Contact Hours	Examination Marks					Credits
				ISE1	MSE	ISE2	ESE	Total	Total
CSC 501	Computer Network	TH	3	20	30	20	30	100	3
CSC 502	Web Computing	TH	3	20	30	20	30	100	3
CSC 503	Artificial Intelligence	TH	3	20	30	20	30	100	3
CSC 504	Data Warehousing & Mining	TH	3	20	30	20	30	100	3
CSDLO501X	Department Level Optional Course - 1	TH	3	20	30	20	30	100	3
CSL501	Web Computing and Network Lab	PR	2	20	--	30	--	50	1
CSL502	Artificial Intelligence Lab	PR	2	20	--	30	--	50	1
CSL503	Data Warehousing and Mining Lab	PR	2	20	--	30	--	50	1
CSL504	Business Communication and Ethics-II	PR	4	20	--	30	--	50	2
CSM501	Mini Project: 2A	PR	4	15	--	15	20	50	2
		Total	TH:TU:PR 15:0:14			-	-	750	22

Department Level Optional Courses:

Department LevelOptionalCourse-1(CSDLO501X)
1.Statistics for Artificial Intelligence & Data Science
2.Advanced Algorithms
3.Internet of Things

SEM-VI									
Course Code	Course Name		Contact Hours	Examination Marks					Credits
				ISE1	MSE	ISE2	ESE	Total	Total
CSC 601	Data Analytics and Visualization	TH	3	20	30	20	30	100	3
CSC 602	Cryptography & System Security	TH	3	20	30	20	30	100	3
CSC 603	Software Engineering and Project Management	TH	3	20	30	20	30	100	3
CSC 604	Machine Learning	TH	3	20	30	20	30	100	3
CSDLO601X	Department Level Optional Course -2	TH	3	20	30	20	30	100	3
CSL 601	Data Analytics and Visualization Lab	PR	2	20	--	30	--	50	1
CSL602	Cryptography & System Security Lab	PR	2	10	--	15	--	25	1
CSL603	Software Engineering and Project Management Lab	PR	2	10	--	15	--	25	1
CSL604	Machine Learning Lab	PR	2	20	--	30	--	50	1
CSL605	Skill base Lab Course: Cloud Computing	PR	4	20	--	30	--	75	2
CSM601	Mini Project: 2B	PR	4	15	--	15	20	50	2
		Total	TH:TU:PR 15:0:16			-	-	775	23

Department Level Optional Courses:

Department LevelOptionalCourse -2 (CSDLO601X)
1. High Performance Computing
2.Distributed Computing
3. Image & Video processing

Honors Degree Offered to AI & DS Students from SEM-V to SEM-VIII:

A. Name:**Internet of Things**

1. SEM-V: HIoTC501: IoT Sensor Technologies
2. SEM VI: HIoTC601:IoT System Design
3. SEM VII: HIoTC701:Dynamic Paradigm in IoT
4. SEM VII: HIoTSBL701:Interfacing & Programming with IoTLab (SBL)
5. SEM VIII: HIoTC801: Industrial IoT

B. Name: Blockchain

1. SEM-V: HBCC501: Bit coin and Crypto currency
2. SEM VI: HBCC601: Blockchain Platform
3. SEM VII: HBCC701: Blockchain Development
4. SEM VII: HBCSBL701: Private Blockchain Setup Lab (SBL)
5. SEM VIII: HBCC801: DeFi(Decentralized Finance)

C. Name: Cyber Security

1. SEM-V: HCSC501: Ethical Hacking
2. SEM VI: HCSC601: Digital Forensic
3. SEM VII: HCSC701: Security Information Management
4. SEM VII: HCSSBL601:Vulnerability Assessment Penetration Testing (VAPT) Lab
5. SEM VIII: HCSC801: Application Security

Minors Degree Offered to AI & DS Students from SEM-V to SEM-VIII:

A. Name: **Robotics**

1. SEM-V: HRBC501: Industrial Robotics
2. SEM VI: HRBC601:Mechatronics & IoT
3. SEM VII: HRBC701:Artificial Intelligence & Data Analysis
4. SEM VII: HRBSBL701:Robotics and Automation Lab
5. SEM VIII: HRBC801: Autonomous Vehicle Systems

B. Name:3D Printing

1. SEM-V: H3DPC501: Introduction to CAD
2. SEM VI: H3DPC601:3D Printing: Introduction & Processes
3. SEM VII: H3DPC701:Applications of 3D Printing
4. SEM VIII: H3DPSBL701:Skill Based Lab– Digital Fabrication
5. SEM VIII: HC3DPC801: 3D Printing in Medical Technology

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC501	Computer Networks	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Comprehend the design issues and enumerate the functions of the different layers of network software models
	CO2	Identify the characteristics of network devices and media used to design network
	CO3	Analyze the design issues of DLL,NL and transport layer
	CO4	Design the network using IP addressing and sub netting / supernetting schemes
	CO5	Compare the state-of-the-art network protocols in Data link layer, Network layer and Transport layer
	CO6	Apply a methodology to Network Design and software-defined networks according to customer's requirements

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Networking**	1,2	6
	1.1	Introduction to computer network, Network Devices, Network topology, Switching: Circuit-Switched Networks, Packet Switching, Network Types: LAN, MAN, WAN		
	1.2	Reference models: Layer details of OSI, TCP/IP models. Difference between OSI and TCP/IP		
2		**Physical and Data Link Layer**	1,2	10
	2.1	Physical Layer: Communication mechanisms and Electromagnetic Spectrum, Guided Transmission Media: Twisted pair, Coaxial, Fiber optics		
	2.2	Data Link Layer: DLL Design Issues (Services, Framing, Error Control, Flow Control), Error Detection and Correction (Hamming Code, CRC, Checksum) , Elementary Data Link protocols , Stop and Wait, Sliding Window (Go Back N, Selective Repeat), Medium Access Control sublayer Channel Allocation problem, Multiple access Protocol(ALOHA, Carrier Sense Multiple Access,(CSMA/CD))		
3		**Network Layer**	1,2	7
	3.1	Network Layer: Communication Primitives, IPv4 Addressing (classful and classless), Subnetting, IPv4 Protocol, Network Address Translation (NAT), IPv6 addressing, IPv4 vs IPv6		

		addressing, Routed vs Routing protocols, Classification of Routing algorithms, Shortest Path algorithms (Dijkastra's), Link state routing, Distance Vector Routing		
4		**Transport Layer and Application Layer**	1,2	7
	4.1	Transport Layer: Service primitives, Sockets, Connection management (Handshake), UDP, TCP, TCP state transition, TCP timers, TCP Flow control (sliding Window)		
	4.2	Application Layer: HTTP, SMTP, Telnet, FTP, DHCP, DNS and Types of Name Server		
5		**Enterprise Network Design**	5	5
	5.1	The Cisco Service Oriented Network Architecture, Network Design Methodology, Top-Down vs Bottom up Approach to Network Design, Classic Three-Layer Hierarchical Model: Core, Access and Distribution Layers, Campus Design Considerations, Designing a Campus Network Design Topology		
6		**Software Defined Networks**	6,7	4
	6.1	Introduction to Software Defined Network, Fundamental Characteristics of SDN, SDN Building Blocks, Control and Data planes, SDN Operation, OpenFlow messages – Controller to Switch, Symmetric and Asynchronous messages, SDN OpenFlow Controllers: PoX, NoX Architecture.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Activity: Assignment based on Gate Questions (20 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks(30% weightage) written examination based on entire syllabus

Text Books:

[1] A.S. Tanenbaum, "Computer Networks",4th edition, Pearson Education
[2] B.A. Forouzan, "Data Communications and Networking", 5th edition, TMH
[3] James F. Kurose, Keith W. Ross, "Computer Networking, A Top-Down Approach Featuring the Internet",6th edition, Addison Wesley
[4] Behrouz A. Forouzan, ForouzanMosharrat , "Computer Networks A Top down Approach", McGraw Hill education
[5] Diane Teare ,"Authorized Self-Study Guide, Designing for Cisco Internetwork Solutions (DESIGN)", 2nd Edition, Cisco Press.
[6] Paul Göransson, Chuck Black, "Software Defined Networks: A Comprehensive Approach", 1st edition, MK Publication
[7] Thomas D. Nadeau and Ken Gray, "Software Defined Networks",1st edition,O'Reilly publication.

Reference Books:

[1] S.Keshav, "An Engineering Approach To Computer Networking", 1st edition, Pearson .
[2] Natalia Olifer& Victor Olifer, "Computer Networks: Principles, Technologies & Protocols for Network Design" , 1st edition, Wiley India,
[3] Larry L.Peterson, Bruce S.Davie, "Computer Networks: A Systems Approach", 2nd edition, The Morgan Kaufmann Series in Networking
[4] SiamakAzodolmolky, "Software Defined Networking with Open Flow", 1st edition, PACKT Publishing.
[5] Priscilla Oppenheimer, "Top-Down Network Design (Networking Technology)", 3rdedition, Cisco Press Book

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC502	Web Computing	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Select protocols or technologies required for various web applications
	CO2	Apply JavaScript to add functionality to web pages.
	CO3	Design front end application using basic React.
	CO4	Construct web based Node.js applications using Express
	CO5	Design front end applications using functional components of React.
	CO6	Design back-end applications using Node.js

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Web programming fundamentals**	1,2	8
	1.1	Working of web browser, HTTP protocol, HTTPS, DNS, TLS, XML introduction, Json introduction, DOM, URL, URI, REST API		
2		**Javascript**	1,2	8
	2.1	Introduction to JavaScript: JavaScript language constructs, Objects in JavaScript- Built in, Browser objects and DOM objects, event handling, form validation and cookies. Introduction to ES5,ES6, Difference between ES5 and ES6. Variables, Condition, Loops, Functions, Events, Arrow functions, Setting CSS Styles using JavaScript, DOM manipulation, Classes and Inheritance. Iterators and Generators, Promise, Client-server communication, Fetch		
3		**React Fundamentals**	2,3	10
	3.1	Installation, Installing libraries, Folder and file structure, Components, Component lifecycle, State and Props, React Router and Single page applications, UI design, Forms, Events, Animations, Best practices.		
4		**Node. js**	4	5
	4.1	Environment setup, First app, Asynchronous programming, Callback concept, Event loops, REPL, Event emitter, Networking module, Buffers, Streams, File system, Web module.		
5		**Express**	5	4
	5.1	Introduction, Express router, REST API, Generator, Authentication, sessions, Integrating with React		

6		**Advance React**	2	4
	6.1	Functional components- Refs, Use effects, Hooks, Flow architecture, Model-ViewController framework, Flux, Bundling the application. Web pack.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Design Game (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE:30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Venkat Subramaniam, "Rediscovering JavaScript, Master ES6, ES7, and ES8",1st edition, O′Reilly
[2] A. Banks, E. Porcello, "Learning React Functional Web Development with React and Redux", 1st edition, O'Reilly
[3] D. Bugl "Learning Redux",1st edition, Packt Publication
[4] A. Mead, "Learning Node.js Development", 1st edition, Packt Publishing
[5] V.Bojinov , "RESTful Web API Design with Node.js 10", 1stedition, Cisco Press.

Reference Books:

[1] Ethan Brown, "Web Development with Node and Express", 1st edition, O'Reilly .
[2] C.Schmitt&K.Simpson, "HTML5 Cookbook" , 1st edition, O'Reilly Media
[3] W.Chun, "Core Python Applications Programming",3rd edition, Pearson Publications

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC503	Artificial Intelligence	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		FEC205
Course Outcomes	CO1	Identify the characteristics of the environment and differentiate between various agent architectures
	CO2	Apply a suitable search strategy to design problem solving agents
	CO3	Design knowledge-based agents using knowledge representation and inference rules
	CO4	Apply a probabilistic model for reasoning under uncertainty
	CO5	Describe various learning techniques

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Artificial Intelligence**	1,2	3
	1.1	Artificial Intelligence (AI), AI Perspectives: Acting and Thinking humanly, Acting and Thinking rationally		
	1.2	History of AI, Applications of AI, The present state of AI, Ethics in AI		
2		**Intelligent Agents**	1	4
	2.1	Introduction of agents, Structure of Intelligent Agent, Characteristics of Intelligent Agents		
	2.2	Types of Agents: Simple Reflex, Model Based, Goal Based, Utility Based Agents.		
	2.3	Environment Types: Deterministic, Stochastic, Static, Dynamic, Observable, Semi-observable, Single Agent, Multi Agent		
3		**Solving Problems by Searching**	1,2	12
	3.1	Definition, State space representation, Problem as a state space search, Problem formulation, Well-defined problems		
	3.2	Solving Problems by Searching, Performance evaluation of search strategies, Time Complexity, Space Complexity, Completeness, Optimality		
	3.3	Uninformed Search: Depth First Search, Breadth First Search, Depth Limited Search, Iterative Deepening Search, Uniform Cost Search, Bidirectional Search		
	3.4	Informed Search: Heuristic Function, Admissible Heuristic, Informed Search Technique, Greedy Best First Search, A* Search, Local Search: Hill Climbing Search, Simulated		

		Annealing Search, Optimization: Genetic Algorithm		
4		**Knowledge and Reasoning**	1,2	10
	4.1	Definition and importance of Knowledge, Issues in Knowledge Representation, Knowledge Representation Systems, Properties of Knowledge Representation Systems		
	4.2	Propositional Logic (PL): Syntax, Semantics, Formal logic-connectives, truth tables, tautology, validity, well-formed-formula, Introduction to logic programming (PROLOG)		
	4.3	Predicate Logic: FOPL, Syntax, Semantics, Quantification, Inference rules in FOPL		
	4.4	Forward Chaining, Backward Chaining and Resolution in FOPL		
5		**Reasoning Under Uncertainty**	1,2	5
	5.1	Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution		
	5.2	Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief Networks		
6		**Planning and Learning**	1,2	5
	6.1	The planning problem, Partial order planning, total order planning.		
	6.2	Learning in AI, Learning Agent, Concepts of Supervised, Unsupervised, Semi -Supervised Learning, Reinforcement Learning, Ensemble Learning.		
	6.3	Expert Systems, Components of Expert System: Knowledge base, Inference engine, user interface, working memory, Development of Expert Systems		
			Total	**39**

Course Assessment:

ISE-1:20 marks
Quiz(10 marks)
Activity: Assignment (10 marks)
ISE-2:20 marks
Quiz (10 marks)
Activity: Case study (10 marks)
MSE:30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach",2nd edition, Pearson Education
[2] Elaine Rich and Kevin Knight, "Artificial Intelligence", 3rd edition, Tata McGraw-Hill Education Pvt. Ltd.
[3] George F Luger, "Artificial Intelligence", 4th edition, Pearson Education.

Reference Books:

[1] Ivan Bratko, "PROLOG Programming for Artificial Intelligence", 3rd edition, Pearson Education
[2] D. W. Patterson, "Artificial Intelligence and Expert Systems", 1st edition, Prentice Hall
[3] Saroj kaushik, "Artificial Intelligence", 1st edition, Cengage Learning
[4] Davis E. Goldberg, "Genetic algorithms: Search, Optimization and Machine Learning", 1st edition, Addison Wesley
[5] Patrick Henry Winston, "Artificial Intelligence", 3rd edition, Addison-Wesley
[6] N. P. Padhy, "Artificial Intelligence and Intelligent Systems", 1st edition, Oxford University Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC504	Data Warehousing and Mining	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		CSC403
Course Outcomes	CO1	Build Data Warehouse to organize strategic data required for data analysis
	CO2	Analyse data using OLAP operations so as to take strategic decisions.
	CO3	Apply data Exploration and Data pre-processing techniques to organize data
	CO4	Apply the appropriate data mining techniques on data sets to extract appropriate knowledge
	CO5	Measure the performance of different data mining techniques
	CO6	Explain different web mining techniques to analyse web data

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Data Warehouse and OLAP**	1,3,4,5	9
	1.1	Data Warehousing, Dimensional Modeling and OLAP The Need for Data Warehousing; Data Warehouse Defined; Benefits of Data Warehousing ; Features of a Data Warehouse; Data Warehouse Architecture; Data Warehouse and Data Marts; Data Warehousing Design Strategies. Dimensional Model Vs ER Model; The Star Schema, The Snowflake Schema; Fact Tables and Dimension Tables; Factless Fact Table; Updates To Dimension Tables, Primary Keys, Surrogate Keys & Foreign Keys; Aggregate Tables; Fact Constellation Schema or Families of Star Need for Online Analytical Processing; OLTP vs OLAP; OLAP Operations in acube: Roll-up, Drilldown, Slice, Dice, Pivot ; OLAP Models: MOLAP, ROLAP, HOLAP. Major steps in ETL Process		
2		**Introduction to Data Mining ,Data Exploration and Data Pre-processing**	1	8
	2.1	Data Mining Task primitives,Architecture,KDDprocess,Issues in data Mining,Types of Attributes; Statistical Description of Data; Data Visualization; Measuring similarity and dissimilarity. Why Preprocessing? Data Cleaning; Data Integration; Data Reduction: Attribute subset selection, Histograms, Clustering and Sampling; Data Transformation & Data		

		Discretization: Normalization, Binning, Histogram Analysis and Concept hierarchy generation.		
3		**Classification**	1	6
	3.1	Basic Concepts; Classification methods: 1. Decision Tree Induction: Attribute Selection Measures, Tree pruning. 2. Bayesian Classification: Naïve Bayes‟ Classifier. Prediction: Structure of regression models; Simple linear regression, Multiple linear regression. Accuracy and Error measures, Precision, Recall		
4		**Clustering**	1	4
	4.1	Cluster Analysis: Basic Concepts; Partitioning Methods: K-Means,KMediods; Hierarchical Methods: Agglomerative, Divisive, BIRCH;Density- Based Methods: DBSCAN What are outliers? Types, Challenges; Outlier Detection Methods: Supervised, Semi Supervised, Unsupervised, Proximity based, Clustering Based		
5		**Frequent Pattern**	1	8
	5.1	Market Basket Analysis, Frequent Itemsets, Closed Itemsets, and Association Rules; Frequent Pattern Mining, Efficient and Scalable Frequent Itemset Mining Methods, The Apriori Algorithm for finding Frequent Itemsets Using Candidate Generation, Generating Association Rules from Frequent Itemsets, Improving the Efficiency of Apriori, A pattern growth approach for mining Frequent Itemsets; Mining Frequent itemsets using vertical data formats; Introduction to Mining Multilevel Association Rules and Multidimensional Association Rules; From Association Mining toCorrelation Analysis, lift, ; Introduction to Constraint-Based Association Mining		
6		**Web Mining**	1,2	4
	6.1	Introduction to Web content Mining, Crawlers, Personalization, Webstructure mining, Page rank, Clever, Web Usage Mining		
			Total	**39**

Course Assessment:

ISE-1: 20 marks

Case study-based data warehouse designing and OLAP Operations (10 Marks)

Activity: Implementation of Data Exploration and Preprocessing for a given database (10 Marks)

ISE-2:20 marks

Research Paper study and implementation based on Data Mining techniques (20 Marks)

MSE: 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] J Han and H. Kamber, "Data Mining: Concepts and Techniques", 3rd edition, Morgan Kaufmann.
[2] P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", 2nd edition, Pearson Education.
[3] Paulraj Ponniah, "Data Warehousing: Fundamentals for IT Professionals", 2nd edition, Wiley India
[4] Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", 3rd edition, McGraw Hill
[5] Elmasri and Navathe, "Fundamentals of Database Systems", 6th Edition, Pearson Education

Reference Books:

[1] Theraja Reema, "Data Warehousing", 1stedition, Oxford University Press
[2] Ralph Kimball, Margy Ross, "The Data Warehouse Toolkit: The Definitive Guide To Dimensional Modeling", 3rdedition, Wiley India
[3] Michael Berry and Gordon Linoff, "Mastering Data Mining- Art & science of CRM", 1st edition, WileyPublications
[4] Michael Berry and Gordon Linoff, "Data Mining Techniques", 2nd edition, Wiley Publications

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO5011	Statistics for Artificial Intelligence & Data Science	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		FEC205
Course Outcomes	CO1	Apply exploratory data analysis techniques to any given structured data base and summarize it
	CO2	Use discrete and continuous probability distribution to solve mathematical problems based on it
	CO3	Apply hypothesis testing techniques to real world scenarios and draw meaningful conclusions.
	CO4	Explain analysis of variance by constructing ANOVA table for one way and two way ANOVA
	CO5	Calculate and Interpret simple and multiple linear regression equation for a set of data

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Exploratory Data Analysis**	1,2	5
	1.1	Elements of Structured Data ,Further Reading ,Rectangular Data , Data Frames and Indexes ,Non rectangular Data Structures , Estimates of Location ,Mean ,Median and Robust Estimates , Estimates of Variability,Standard Deviation and Related Estimates , Estimates Based on Percentiles , Exploring the Data Distribution , Percentiles and Boxplots ,Frequency Tables and Histograms , Density Plots and Estimates		
	1.2	Exploring Binary and Categorical Data , Mode ,Expected Value, Probability ,Correlation ,Scatterplots ,Exploring Two or More Variables ,Hexagonal Binning and Contours (Plotting Numeric Versus Numerical Data) ,Two Categorical Variables ,Categorical and Numeric Data ,Visualizing Multiple Variables		
2		**Data and Sampling Distributions**	1,2	6
	2.1	Random Sampling and Sample Bias ,Bias ,Random Selection ,Size Versus Quality,Sample Mean Versus Population Mean ,Selection Bias ,Regression to the Mean ,Sampling Distribution of a Statistic , Central Limit Theorem ,Standard Error ,The Bootstrap ,Resampling Versus Bootstrapping		

	2.2	Confidence Intervals,NormalDistribution,Standard Normal and QQ-Plots,Long-Tailed Distributions,Student's t-Distribution , Binomial Distribution ,Chi-Square Distribution ,F-Distribution , Poisson and Related Distributions ,Poisson Distributions , Exponential Distribution ,Estimating the Failure Rate ,Weibull Distribution . Self Study : Problems in distributions		
3		**Statistical Experiments and Significance Testing**	1,2	8
	3.1	A/B Testing,HypothesisTests,The Null Hypothesis, Alternative Hypothesis ,One-Way Versus Two-Way Hypothesis Tests , Resampling ,Permutation Test ,Example: Web Stickiness,Exhaustive and Bootstrap Permutation Tests ,Permutation Tests: The Bottom Line for Data Science ,Statistical Significance and p-Values ,p-Value ,Alpha ,Type 1 and Type 2 Errors		
	3.2	Data Science and p-Values, t-Tests,MultipleTesting,Degrees of Freedom,ANOVA,F-Statistic,Two-Way ANOVA, Chi-Square Test,Chi-Square Test: A Resampling Approach,Chi-Square Test: Statistical Theory,Fisher's Exact Test ,Relevance for Data Science, Multi-Arm Bandit Algorithm ,Power and Sample Size ,Sample Size. Self Study : Testing of Hypothesis using any statistical tool		
4		**Summarizing Data**	1,2	6
	4.1	Methods Based on the Cumulative Distribution Function, The Empirical Cumulative Distribution Function,The Survival Function, Quantile-Quantile Plots, Histograms, Density Curves, and Stem-and-Leaf Plots, Measures of Location.		
	4.2	The Arithmetic Mean, The Median, The Trimmed Mean, M Estimates, Comparison of Location Estimates, Estimating Variability of Location Estimates by the Bootstrap, Measures of Dispersion, Boxplots, Exploring Relationships with Scatterplots Self Study: using any statistical tool perform data summarization		
5		**The Analysis of Variance**	1,2	6
	5.1	The One-Way Layout, Normal Theory; the F Test ,The Problem of Multiple Comparisons , A Nonparametric Method—The Kruskal-Wallis Test ,The Two-Way Layout , Additive Parametrization, Normal Theory for the Two-Way Layout , Randomized Block Designs , A Nonparametric Method—Friedman's Test		
6		**Linear Least Squares**	1,2	8
	6.1	Simple Linear Regression, Statistical Properties of the Estimated Slope and Intercept , Assessing the Fit ,		

		Correlation and Regression , The Matrix Approach to Linear Least Squares , Statistical Properties of Least Squares Estimates , Vector-Valued Random Variables , Mean and Covariance of Least Squares Estimates , Estimation of σ2, Residuals and Standardized Residuals , Inference about β , Multiple Linear Regression—An Example , Conditional Inference, Unconditional Inference, and the Bootstrap , Local Linear Smoothing . Self Study :Create a Linear Regression model for a dataset and display the error measures, Chose a dataset with categorical data and apply linear regression model		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE:30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Bruce, Peter, and Andrew Bruce,"Practical statistics for data scientists: 50 essential concepts",1st edition, O'Reilly Media
[2] John A, "Mathematical Statistics and Data Analysis",3rd edition, Thomson Higher Education.

Reference Books:

[1] Dodge, Yadolah, "Statistical data analysis and inference".1st edition, Elsevier
[2] Ismay, Chester, and Albert Y. Kim.,"Statistical Inference via Data Science: A Modern Dive into R and the Tidyverse", 1st edition, CRC Press
[3] Milton. J. S. and Arnold. J.C., "Introduction to Probability and Statistics", 4th Edition ,Tata McGraw Hill
[4] Johnson. R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", 7th Edition, Pearson Education
[5] A. Chandrasekaran, G. Kavitha, "Probability, Statistics, Random Processes and Queuing Theory", 1st edition, Dhanam Publications

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO5012	Advanced Algorithms	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		
Course Outcomes	CO1	Analyze the classification of problems into various NP classes and their Computational Intractability.
	CO2	Describe, apply and analyze the complexity of Approximation Algorithms.
	CO3	Describe, apply and analyze the complexity of Randomized Algorithms.
	CO4	Describe, apply and analyze the complexity of Local Search Algorithms.
	CO5	Design and Apply the concepts of String and Amortized Analysis.
	CO6	To Understand Combinatorial Analysis techniques

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**NP and Computational Intractability**	1,2,3	5
	1.1	Elements of Structured Data ,Further Reading ,Rectangular Data , Data Frames and Indexes ,Non rectangular Data Structures , Estimates of Location ,Mean ,Median and Robust Estimates , Estimates of Variability,Standard Deviation and Related Estimates , Estimates Based on Percentiles , Exploring the Data Distribution , Percentiles and Boxplots ,Frequency Tables and Histograms , Density Plots and Estimates		
2		**Approximation Algorithms**	1,2,3	6
	2.1	Approximation algorithms for known NP hard problems, Inapproximability, Approximation algorithms with small additive error: Edge Coloring, Bin Packing, Randomized rounding and linear programming, Problems having polynomial approximation schemes, Optimization problems with constant factor approximations, Hard-to-approximate problems, Analysis of Approximation Algorithms.		
3		**Randomized Algorithms**	1,2,3	8
	3.1	Introduction to randomized algorithm, Finding the Global Minimum Cut, Random Variables and Their Expectations, A Randomized Approximation Algorithm for MAX 3-SAT, Randomized Divide and Conquer: MedianFinding and Quicksort, Hashing: A Randomized Implementation of Dictionaries, Finding the Closest Pair of Points: A		

		Randomized Approach, Randomized Caching, Chernoff Bounds, Load Balancing, Packet Routing, Las Vegas Algorithm, Monte Carlo Algorithm.		
4		**Local Search**	1,2,3	6
	4.1	The Landscape of an Optimization Problem, The Metropolis Algorithm and Simulated Annealing, An Application of Local Search to Hopfield Neural Networks, Maximum-Cut Approximation via Local Search, Choosing a Neighbour Relation, Classification via Local Search, Best-Response Dynamics and Nash Equilibria.		
5		**String and Amortized Analysis**	1,2,3	6
	5.1	String Sort, Tries, Substring Search, Regular Expressions, Data Compression, String Matching Algorithms: Introduction to String matching, The KnuthMorris-Pratt algorithm, Aho- Korasik algorithm, Z-algorithm, Amortized Analysis: Aggregate analysis, The accounting method, The potential method Dynamic tables.		
6		**Combinatorial Analysis**	1,2,3,4	8
	6.1	Introduction, Next subset of n-Set problems, Random Subset of n- Setproblems, Sequencing, Ranking and selection algorithms for general combinatorial families.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE:30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Jon Kleinberg, Eva Tardos, "Algorithm Design", 1st edition, Pearson Publications
[2] Robert Sedgewick, Kevin Wayne, "Algorithms", 4th edition, Addison Wesley.
[3] Thomas H. Cormen , Charles E., Ronald l., Clifford Stein, "Introduction to Algorithms", 3rd edition, The MIT Press Cambridge
[4] Albert Nijenhuis, Herbert Wilf, "Combinatorial Algorithms for computers and calculators",2ndedition, Academic Press
[5] George Heineman, Gary Pollice, Stanley Selkow, "Algorithms in a Nutshell", 1st edition, Oreilly Press

Reference Books:

[1] Anany Levitin, "Introduction to the design and analysis of algorithms", 3rdEdition, Pearson publication
[2] Peter J. Cameron, "Combinatorics: Topics, Techniques, Algorithms", 1stedition,Cambridge University Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO5013	Internet of Things	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		FEC205, CSL405, CSC501
Course Outcomes	CO1	Describe the Characteristics and Conceptual Framework of IoT
	CO2	Differentiate between the levels of the IoT architectures.
	CO3	Analyze the IoT access technologies.
	CO4	Illustrate various edge to cloud protocol for IoT.
	CO5	Apply IoT analytics and data visualization.
	CO6	Analyze and evaluate IoT applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to IoT**	1,2	4
	1.1	Introduction to IoT- Defining IoT, Characteristics of IoT, Conceptual Framework of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Brief review of applications of IoT. Smart Object – Definition, Characteristics and Trends Self-learning Topics: Hardware and software development tools for - Arduino, NodeMCU, ESP32, Raspberry Pi, for implementing internet of things, SimulatorsCircuit.io,Eagle,Tinkercad		
2		**IoT Architecture**	1,2	7
	2.1	Drivers Behind New Network Architectures : Scale,Security,Constrained Devices and Networks ,Data,Legacy Device Support Architecture : The IoT World Forum (IoTWF) Standardized Architecture :Layer 1-7, IT and OT Responsibilities in the IoT Reference Model,Additional IoT Reference Models A Simplified IoT Architecture The Core IoT Functional Stack ::Layer 1-3 , Analytics Versus Control Applications , Data Versus Network Analytics Data Analytics Versus Business Benefits , Smart Services, IoT Data Management and Compute Stack :Fog Computing , Edge Computing ,The Hierarchy of Edge, Fog, and Cloud Self-learning Topics: Brief review of applications of IoT: Connected Roadways,Connected Factory, Smart Connected Buildings , Smart Creatures etc.		

3		**Principles of Connected Devices and Protocols in IoT**	1,2	8
	3.1	RFID and NFC (Near-Field Communication), Bluetooth Low Energy (BLE) roles, LiFi , WPAN std : 802.15 standards: Bluetooth, IEEE 802.15.4, Zigbee, Z-wave, Narrow Band IoT, Internet Protocol and Transmission Control Protocol, 6LoWPAN, WLAN and WAN , IEEE 802.11, Long-range Communication Systems and Protocols: Cellular ConnectivityLTE, LTE-A, LoRa and LoRaWAN.		
4		**Edge to Cloud Protocol**	1,2	8
	4.1	HTTP, WebSocket, Platforms. HTTP - MQTT -.Complex Flows: IoT Patterns: Real-time Clients, MQTT, MQTT-SN, Constrained Application Protocol (CoAP), Streaming Text Oriented Message Protocol (STOMP), Advanced Message Queuing Protocol (AMQP), Comparison of Protocols		
5		**IoT and Data Analytics**	1,2	7
	5.1	Defining IoT Analytics, IoT Analytics challenges, IoT analytics for the cloud, Strategies to organize Data for IoT Analytics, Linked Analytics Data Sets, Managing Data lakes, The data retention strategy, visualization and Dashboarding-Designing visual analysis for IoT data, creating a dashboard ,creating and visualizing alerts. Self-learning Topics: AWS and Hadoop Technology		
6		**IoT Application Design**	1,2	5
	6.1	Prototyping for IoT and M2M, Case study related to : Home Automation (Smart lighting, Home intrusion detection), Cities (Smart Parking), Environment (Weather monitoring, weather reporting Bot, Air pollution monitoring, Forest fire detection, Agriculture (Smart irrigation), Smart Library. Introduction to IIoT, Use cases of the I-IoT,IoT and I-IoT – similarities and differences, Introduction to Internet of Behavior (IoB) Self-learning Topics: Internet of Behaviors (IoB) and its role in customer services		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] ArsheepBahga (Author), Vijay Madisetti, Internet Of Things: A Hands-On Approach Paperback, 1st edition, Universities Press
[2] David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals Networking Technologies, Protocols, and Use Cases for the Internet of Things"1st edition, CISCO
[3] AndrewMinteer, "Analytics for the Internet of Things (IoT) Intelligent Analytics for Your Intelligent Device",1st edition, Packt Publication
[4] Giacomo Veneri , Antonio Capasso, "Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0", 1st edition, Packt Publication

Reference Books:

[1] Pethuru Raj, Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases by", 1st edition, CRC press
[2] Raj Kamal, Internet of Things, "Architecture and Design Principles", 1st edition, McGraw Hill Education
[3] Perry Lea, "Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security", 1stedition,Packt Publication
[4] Amita Kapoor, "Hands on Artificial intelligence for IoT", 1st Edition, Packt Publishing
[5] Sheng-Lung Peng, Souvik Pal, Lianfen Huang "Principles of Internet of Things (IoT)Ecosystem:Insight Paradigm", 1st edition, Springer

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL501	Web Computing and Network Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	CSL304, CSC404, CSL405	
Course Outcomes	CO1	Identify and apply the appropriate HTML tags to develop a webpage
	CO2	Identify and apply the appropriate CSS tags to format data on webpage
	CO3	Construct responsive websites using Bootstrap
	CO4	Use JavaScript to develop interactive web pages.
	CO5	Construct front end applications using React and back end using Node.js/express
	CO6	Use simulator for CISco packet tracer/GNS3

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	HTML:Elements, Attributes, Head, Body, Hyperlink, Formatting, Images, Tables, List, Frames, Forms, Multimedia
2	CSS3.Syntax, Inclusion, Color, Background, Fonts, Tables, lists,CSS3 selectors, Pseudo classes, Pseudo elements .
3	Bootstrap:BootstrapGrid system, Forms, Button, Navbar, Breadcrumb, Jumbotron
4	Javascript:Variables, Operators, Conditions, Loops, Functions, Events, Classes and Objects, Error handling, Validations, Arrays, String, Date
5	React:Installation and Configuration. JSX, Components, Props, State, Forms, Events, Routers, Refs, Keys.
6	Node.Js:Installation and Configuration, Callbacks, Event loops, Creating express app
7	To design and simulate the environment for Dynamic routing using Cisco packet tracer/ GNS3
8	To design and Simulate VLANs on the switch/router using Cisco packet tracer/ GNS3
9	To design and Simulate NAT on the router using Cisco packet tracer/ GNS3
10	Simulation of Software Defined Network using Mininet

Course Assessment:

ISE-1: 20 marks
Experiments (1-5): Continuous pre-defined rubrics-based evaluation (10 Marks)
Activity: Design Thinking (10 Marks)
ISE-2:30 marks
Experiments (6-10): Continuous pre-defined rubrics-based evaluation (10 Marks)
Activity:Competition for Mini Project (20 Marks)

References:

1. www.leetcode.com
2. www.hackerrank.com
3. www.cs.usfca.edu/~galles/visualization/Algorithms.html
4. www.codechef.com

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL502	Artificial Intelligence Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	FEC205	
Course Outcomes	CO1	Identify suitable agent architecture for given AI problem.
	CO2	Write programs using Prolog facts and rules.
	CO3	Implement various search techniques for problem solving agent.
	CO4	Design knowledge-based agents using knowledge representation and inference rules.
	CO5	Construct a Bayesian Belief Network for a given problem and draw probabilistic inferences from it.
	CO6	Discuss the components of real-world expert systems.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	Provide the PEAS description and TASK Environment for a given AI problem.
2	Identify suitable Agent Architecture for the problem
3	Write simple programs using PROLOG as an AI programming Language
4	Implement any one of the Uninformed search techniques
5	Implement any one of the Informed search techniques E.g. A-Star algorithm for 8 puzzle problem
6	Implement adversarial search using min-max algorithm.
7	Implement any one of the Local Search techniques. E.g. Hill Climbing, Simulated Annealing, Genetic algorithm
8	Prove the goal sentence from the following set of statements in FOPL by applying forward, backward and resolution inference algorithms.
9	Create a Bayesian Network for the given Problem Statement and draw inferences from it. (You can use any Belief and Decision Networks Tool for modeling Bayesian Networks)
10	Implement a Planning Agent
11	Design a prototype of an expert system
12	Case study of any existing successful AI system

Course Assessment:

ISE-1:20 marks
Experiments (1-5): Continuous pre-defined rubrics-based evaluation (20 Marks)

ISE-2: 30 marks
Experiments (6-10): Continuous pre-defined rubrics-based evaluation (10 Marks)
Critical appreciation of technical paper and presentation- (10 Marks)
Oral- (10 marks)

References:

1. An Introduction to Artificial Intelligence - Course (nptel.ac.in)
2. https://tinyurl.com/ai-for-everyone
3. https://ai.google/education/
4. https://openai.com/research/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL503	Data warehousing and Mining Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	CSL304, CSL405	
Course Outcomes	CO1	Build Data Warehouseschema for real life application
	CO2	Analyse data using OLAP operations so as to take strategic decisions.
	CO3	Apply data Exploration and Data pre-processing techniques to organize data
	CO4	Implement Classification, Clustering and Association Mining techniques to extract knowledge
	CO5	To evaluate performance of data mining techniques applied on large dataset using open-source tool for data mining
	CO6	Implement web mining algorithm for web data

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	Data Warehouse Construction a) Real life Problem to be defined for Warehouse Design b) Construction of star schema and snow flake schema c) ETL Operations.
2	Construction of Cubes , OLAP Operations, OLAP Queries
3	Tutorials a) Solving exercises in Data Exploration b) Solving exercises in Data preprocessing
4	Using open source tools Implement Classifiers
5	Using open source tools Implement Association Mining Algorithms
6	Using open source tools Implement Clustering Algorithms
7	Implementation of any one classifier using languages like JAVA/ python
8	Implementation of any one clustering algorithm using languages like JAVA/ python
9	Implementation of any one association mining algorithm using languages like JAVA/ python
10	Implementation of page rank algorithm.
11	Implementation of HITS algorithm.

Course Assessment:

ISE-1: 20 marks
Experiments (1-5): Continuous pre-defined rubrics-based evaluation (20 Marks)

ISE-2:30 marks
Experiments (6-10): Continuous pre-defined rubrics-based evaluation (20 Marks)
Activity: Practical Exam (10 Marks)

References:

1. www.leetcode.com
2. www.hackerrank.com
3. www.cs.usfca.edu/~galles/visualization/Algorithms.html
4. www.codechef.com

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL504	Business Communication and Ethics-II	L	T	P	L	T	P	Total
		--	--	2*+2	--	--	2	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	--	
Course Outcomes	CO1	Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
	CO2	Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
	CO3	Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
	CO4	Deliver persuasive and professional presentations.
	CO5	Develop creative thinking and interpersonal skills required for effective professional communication.
	CO6	Apply codes of ethical conduct, personal integrity and norms of organizational behaviour

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Advanced technical writing: Project/Problem Based Learning (PBL)**	1,2	6
	1.1	**Purpose and Classification of Reports:** Classification on the basis of: Subject Matter (Technology, Accounting, Finance, Marketing, etc.), Time Interval (Periodic, One-time, Special), Function (Informational, Analytical, etc.), Physical Factors (Memorandum,Letter, Short & Long) **Parts of a Long Formal Report**: Prefatory Parts (Front Matter), ReportProper (Main Body), Appended Parts (Back Matter) **Language and Style of Reports**: Tense, Person & Voice of Reports, Numbering Style of Chapters, Sections, Figures, Tables and Equations, Referencing Styles in APA & MLA Format, Proofreading through Plagiarism Checkers **Definition, Purpose & Types of Proposals**: Solicited (in conformance withRFP) & Unsolicited Proposals, Types (Short and Long proposals) **Parts of a Proposal**: Elements, Scope and Limitations, Conclusion **Technical Paper Writing**: Parts of a Technical Paper (Abstract, Introduction,Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References), Language and Formatting, Referencing in IEEE Format		

2		**Employment Skills**	1,2	6
	2.1	**Cover Letter & Resume**: Parts and Content of a Cover Letter, Difference between Bio-data, Resume & CV, Essential Parts of a Resume, Types of Resume (Chronological, Functional & Combination) **Statement of Purpose**: Importance of SOP, Tips for Writing an Effective SOP **Verbal Aptitude Test**: Modelled on CAT, GRE, GMAT exams **Group Discussions:** Purpose of a GD, Parameters of Evaluating a GD,Types of GDs (Normal, Case-based & Role Plays), GD Etiquettes **Personal Interviews:** Planning and Preparation, Types of Questions,Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based), Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual		
3		**Business Meetings**	1,2	2
	3.1	**Conducting Business Meetings**: Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquette **Documentation:** Notice, Agenda, Minutes		
4		**Technical/ Business Presentations**	1,2,6	2
	4.1	**Effective Presentation Strategies**: Defining Purpose, Analyzing Audience, Location and Event, Gathering, Selecting & Arranging Material, structuring a Presentation, Making Effective Slides, Types ofPresentations Aids, Closing a Presentation, Platform skills **Group Presentations:** Sharing Responsibility in a Team, Building the contents and visuals together, Transition Phases		
5		**Interpersonal Skills**	1,2	8
	5.1	**Interpersonal Skills:** Emotional Intelligence, Leadership &Motivation,Conflict Management & Negotiation, Time Management, Assertiveness,Decision Making **Start-up Skills:** Financial Literacy, Risk Assessment, Data Analysis(e.g. Consumer Behaviour, Market Trends, etc.)		
6		**Corporate Ethics**	1,2	2
	6.1	**Intellectual Property Rights**: Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits, TradeSecrets (Undisclosed Information) **Case Studies:** Cases related to Business/ Corporate Ethics		
			Total	**26**

List of assignments: (In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)	
Experiment No.	**Title**
1	Cover Letter and Resume
2	Short Proposal
3	Meeting Documentation
4	Writing a Technical Paper/ Analyzing a Published Technical Paper
5	Writing a SOP
6	IPR
7	Interpersonal Skills
Note:	
1	The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2	The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3	There will be an end–semester presentation based on the book report.

Course Assessment:

ISE-1: 20 marks
(1) Report/Proposal Writing (2) Movie Analysis to learn interpersonal skills (3) Reading &
Understanding Statement of Purpose (4) Cover Letter and Resume - Continuous pre-definedrubrics-based evaluation (20 marks)

ISE-2:30 marks
a. 1)Meeting Documentation (Notice, Agenda and Minutes) 2)Role Play/ Case Study Documentation 3) Technical Paper and GD 4) Quiz on IPR
Continuous pre-defined rubrics-based evaluation (10 marks)
b. Report Presentation : (10 Marks)
c. Group Discussion : (10 Marks)

Text Books:

[1] Arms, V. M. "Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication", 2nd edition. Boston, MA: McGraw-Hill
[2] Bovée, C. L., &Thill, J. V., "Business communication today". 1st edition, Upper Saddle River, NJ: Pearson.
[3] Butterfield, J.,"Verbal communication: Soft skills for a digital workplace", 1st edition, Boston, MA: Cengage Learning
[4] Masters, L. A., Wallace, H. R., & Harwood, L.,"Personal development for life and work.", 1st edition, Mason: South-Western Cengage Learning
[5] Robbins, S. P., Judge, T. A., & Campbell, T. T., "Organizational behaviour", 1st edition, Harlow, England: Pearson.

[6] Meenakshi Raman, Sangeeta Sharma, "Technical Communication, Principles and Practice", 1st edition, Oxford University Press
[7] Archana Ram,"Place Mentor, Tests of Aptitude for Placement Readiness", 1st edition, Oxford University Press
[8] Sanjay Kumar &PushpLata,"Communication Skills a workbook", 1st edition, New Delhi: Oxford University Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSM501	Mini Project 2A	L	T	P	L	T	P	Total
		--	--	4	--	--	2	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	15	--	15	20	50	

Pre-requisite Course Codes	--	
Course Outcomes	CO1	Identify societal/research/innovation/entrepreneurship problems through appropriate literature surveys
	CO2	Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it
	CO3	Validate, Verify the results using test cases/benchmark data/theoretical/ inferences/experiments/simulations
	CO4	Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development
	CO5	Use standard norms of engineering practices and project management principles during project work
	CO6	Communicate through technical report writing and oral presentation.
	CO7	Gain technical competency towards participation in Competitions, Hackathons, etc.
	CO8	Demonstrate capabilities of self-learning, leading to lifelong learning.
	CO9	Develop interpersonal skills to work as a member of a group or as leader

Guidelines for Mini Project	
Sr. No.	**Title**
1	Mini project may be carried out in one or more form of following: Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statisticaldata analysis, creating awareness in society/environment etc.
2	Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
3	Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor or head of department/internal committee of faculties.
4	Students shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini projects.
5	A logbook may be prepared by each group, wherein the group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6	Faculty supervisors may give inputs to students during mini project activity;

	however, focus shall be on self-learning.
7	Students under the guidance of faculty supervisor shall convert the best solution into a working model using various components of their domain areas and demonstrate.
8	The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
9	With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality becarried out in two semesters by all the groups of the students. i.e. Mini Project 2 insemesters V and VI.
10	However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed towork on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis

Course Assessment:

ISE-1: 15 marks
Idea Presentation & Review of Literature(15 Marks)
ISE-2:15 marks
Analysis,Design,Proof of Concept(15 Marks)
ESE: Project Exam(20 Marks)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC601	Data Analytics and Visualization	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Comprehend basics of data analytics and visualization.
	CO2	Apply various regression models on given data set and perform prediction.
	CO3	Demonstrate advance understanding of Time series concepts and analysis of data using various time series models.
	CO4	Analyze Text data and gain insights.
	CO5	Experiment with different analytics techniques and visualization using R.
	CO6	Experiment with different analytics techniques and visualization using Python.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Data analytics and life cycle**	1,2	5
	1.1	Data Analytics Lifecycle overview:Key Roles for a Successful Analytics, Background and Overview of Data Analytics LifecycleProject **Phase 1:** Discovery: Learning the Business Domain, Resources Framing the Problem, Identifying Key Stakeholders. Interviewing the Analytics Sponsor, Developing Initial Hypotheses Identifying Potential Data Sources **Phase 2:** Data Preparation: Preparing the Analytic Sandbox, Performing ETLT, Learning About the Data, DataConditioning, Survey and visualize, Common Tools for the Data Preparation Phase **Phase 3:** Model Planning: Data Exploration and Variable Selection, Model Selection ,Common Tools for the Model Planning Phase **Phase 4:** Model Building: Common Tools for the Model Building Phase Phase 5: Communicate Results Phase 6: Operationalize		
2		**Regression Models**	1,2	8
	2.1	Introduction to simple Linear Regression: The Regression Equation, Fittedvalue and Residuals, Least Square		

		Introduction to Multiple Linear Regression: Assessing the Model, Cross-Validation, Model Selection and Stepwise Regression, Prediction Using Regression		
	2.2	Logistic Regression: Logistic Response function and logit, Logistic Regression and GLM, Generalized Linear model, Predicted values from Logistic Regression, Interpreting the coefficients and odds ratios, Linear and Logistic Regression: similarities and Differences, Assessing the models.		
3		**Time Series**	1,2	7
	3.1	Overview of Time Series Analysis Box-Jenkins Methodology, ARIMA Model Autocorrelation Function (ACF) ,Autoregressive Models ,Moving Average Models ,ARMA and ARIMA Models ,Building and Evaluating an ARIMA Model, Reasons to Choose and Cautions		
4		**Text Analytics**	1,4	7
	4.1	History of text mining, Roots of text mining overview of seven practices of text analytic, Application and use cases for Text mining: extracting meaning from unstructured text, Summarizing Text.		
	4.2	Text Analysis Steps, A Text Analysis Example , Collecting Raw Text ,Representing Text ,Term Frequency—Inverse Document Frequency (TFIDF),Categorizing Documents by Topics, Determining Sentiments , Gaining Insights.		
5		**Data analytics and visualization with R**	1,3	6
	5.1	Introduction to R: Data Import and Export, Attribute and Data type, Descriptive statistics. Exploratory Data Analysis: Visualization before analysis, Dirty Data, visualizing single variable, examining Multiple variable, Data Exploration versus presentation.		
6		**Data analytics and Visualization with Python**	1,3	6
	6.1	Essential Data Libraries for data analytics:Pandas, NumPy, SciPy.Plotting and visualization with python: Introduction to Matplotlib,Basic Plotting with Matplotlib, Create Histogram, BarChart, Piechart, Box Plot, violin plot using Matplotlib.		
	6.2	Introduction to seaborn Library, MultiplePlots, Regressionplot, regplot.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Case study presentation (10 Marks)
Activity: Assignment/Quiz (10 Marks)
ISE-2:20 marks

Problem solving (10 Marks)
Activity: Presentation on Python and R libraries (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data",1st edition, Wiley Publication.
[2] Bharati Motwani, "Data Analytics using Python", 1stedition,Wiley Publications.
[3] Peter Bruce and Andrew Bruce, "Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python", 2ndedition, O'Reilly Publications
[4] Grey Miner and Thomas Hill, "Practical Text Mining and Statistical Analysis for Non-Structured Text Data Applications", 1st edition, Academic Press

Reference Books:

[1] Micheline Kamber and Jian Pei, "Data Mining, Concepts and Techniques", 3rdedition, Morgan Kaufmann .
[2] Bharati Motwani, "Data Analytics using R" , 1st edition, Wiley Publication
[3] Wes McKinney, "Python for Data Analysis", 3rd edition, O'Reilly Media

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC602	Cryptography and System Security	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		CSC501
Course Outcomes	CO1	Identify information security goals and apply classical encryption techniques to secure information.
	CO2	Apply different encryption and decryption techniques to solve problems related to confidentiality and authentication.
	CO3	Apply cryptographic checksums and evaluate the performance of different message digest algorithms for verifying the integrity of varying message sizes.
	CO4	Apply different digital signature algorithms to achieve authentication to secure applications.
	CO5	Apply computer security concepts to secure system assets like OS and Databases.
	CO6	Apply the concepts in information security to web applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction & Number Theory**	1	7
	1.1	Services, Mechanisms and attacks-the OSI security architecture-Network security model-Classical Encryption techniques Symmetric cipher model, mono-alphabetic and poly-alphabetic substitution techniques: Vignere cipher, playfair cipher, Hill cipher, transposition techniques: keyed and keyless transposition ciphers, steganography).		
2		**Block Ciphers & Public Key Cryptography**	1	7
	2.1	Data Encryption Standard-Block cipher principles-block cipher modes of operation Advanced Encryption Standard (AES)-Triple DES-Blowfish-RC5 algorithm. Public key cryptography: Principles of public key cryptosystems- The RSA algorithm, The knapsack algorithm, El-Gamal Algorithm. Key management – Diffie Hellman Key exchange		
3		**Cryptographic Hashes, Message Digests and Digital Certificates**	1	7
	3.1	Authentication requirement – Authentication function , Types of Authentication, MAC – Hash function – Security of hash function and MAC –MD5 – SHA – HMAC – CMAC, Digital		

		Certificate: X.509, PKI		
4		**Digital signature schemes and authentication Protocols**	1	6
	4.1	Digital signature and authentication protocols : Needham Schroeder Authentication protocol, Digital Signature Schemes – RSA, EI Gamal and Schnorr, DSS.		
5		**System Security**	2	6
	5.1	Operating System Security: Memory and Address Protection, File Protection Mechanism, User Authentication. Linux and Windows: Vulnerabilities, File System Security Database Security: Database Security Requirements, Reliability and Integrity, Sensitive Data, Inference Attacks, Multilevel Database Security		
6		**Web security**	2	6
	6.1	Web Security Considerations, User Authentication and Session Management, Cookies, SSL, HTTPS, SSH, Web Browser Attacks,Web Bugs, Clickjacking, CrossSite Request Forgery, SessionHijacking and Management, Phishing Technique, DNS Attack,Secure Electronic Transaction, Email Attacks, Firewalls, Penetration Testing		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz(10 Marks)
Activity: Case study (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] William Stallings, "Computer Security Principles and Practice",6th edition, Pearson Education
[2] Charles P. Pfleeger, "Security in Computing", 5thedition, Pearson Education
[3] Bernard Menezes, "Network Security and Cryptography",1st edition, Cengage Learning
[4] Eric Cole, "Network Security Bible", 2nd edition, Wiley.
[5] Mark Stamp, "Information Security Principles and Practice", 1stedition,Wiley.

Reference Books:

[1] DafyddStutard, "Web Application Hackers Handbook", 2nd edition, Wiley.
[2] Dieter Gollman, "Computer Security" , 3rd edition, Wiley Publication
[3] Tim Boyle, "CCNA Security Study Guide", 1st edition, Wiley
[4] Matt Bishop, "Introduction to Computer Security", 1st edition, Pearson Education

[5] Tim Mather, Subra Kumaraswamy, Shahed Latif, "Cloud Security and Privacy", 1st edition, O'Riely
[6] Atul Kahate, " Cryptography and Network Security", 3rd edition, Tata Mc Graw Hill

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC603	Software Engineering and Project Management	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		--
Course Outcomes	CO1	Relate to basic concepts in software engineering
	CO2	Identify requirements, analyze and prepare models.
	CO3	Plan, schedule and track the progress of the projects.
	CO4	Design & develop the software solutions for the growth of society
	CO5	Apply testing and assure quality in software solutions
	CO6	Generate project schedule and can construct, design and develop network diagram for different type of Projects. They can also organize different activities of project.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Software Engineering**	1	8
	1.1	Nature of Software, Software Engineering, Software Process, Capability Maturity Model (CMM) Generic Process Model, Prescriptive Process Models: The Waterfall Model, V-model, Incremental Process Models, Evolutionary Process Models, Concurrent Models, Agile process, Agility, Principles, Extreme Programming (XP), Scrum, Kanban model		
2		**Requirements Analysis and Cost Estimation**	1	6
	2.1	Software Requirements: Functional & non-functional – user-system requirement engineering process – feasibility studies – elicitation – validation & management – software prototyping – S/W documentation – Analysis and modelling Requirement Elicitation, Software requirement specification (SRS) 3Ps (people, product and process) Process and Project metrics Software Project Estimation: LOC, FP, Empirical Estimation Models - COCOMO II Model		
3		**Design Engineering**	1	7
	3.1	Design Process & quality, Design Concepts, The design Model, Pattern-based Software Design. 4.2 Architectural Design :Design Decisions, Views, Patterns, Application Architectures, Modeling Component level Design: component, Designing class based components, conducting component-level design, User Interface Design: The golden		

		rules, Interface Design steps & Analysis, Design Evaluation		
4		**Software Risk, Configuration Management**	1	5
	4.1	Risk Identification, Risk Assessment, Risk Projection, RMMM Software Configuration management, SCM repositories, SCM process Software Quality Assurance Task and Plan, Metrics, Software Reliability, Formal Technical Review (FTR), Walkthrough.		
5		**Software Testing and Maintenance**	1	5
	5.1	Testing: Software Quality, Testing: Strategic Approach, Strategic Issues- Testing: Strategies for Conventional Software, Object oriented software, Web Apps, Validating Testing- System Testing- Art of Debugging. Maintenance : Software Maintenance-Software Supportability- Reengineering- Business Process Reengineering- Software Reengineering- Reverse Engineering- Restructuring- Forward Engineering.		
6		**IT Project Management and Project Scheduling**	3	8
	6.1	Introduction, 4 P's, W5HH Principle, Need for Project management, Project Life cycle and ITPM, Project Feasibility, RFP, PMBOK Knowledge areas, Business Case, Project Planning, Project Charter and Project Scope.		
	6.2	Project Scheduling:Defining a Task Set for the Software Project, Timeline charts, WBS, Developing the Project Schedule, Network Diagrams (AON,AOA), CPM and PERT, Gantt Chart , Tracking the Schedule, Earned Value Analysis		
			Total	**39**

Course Assessment:

ISE-1: 20 marks

Case study based SRS document preparation and presentation (10 Marks)

Activity: Case study based project estimation and Design document Presentation (10 Marks)

ISE-2:20 marks

Implementation of different testing techniques(10 Marks)

Activity: Case study based project management task presentation (10 Marks)

MSE: 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Roger S. Pressman, "Software Engineering: A Practitioner's Approach,", 7th edition, McGraw Hill.
[2] Rajib Mall, "Fundamentals of Software Engineering", 5th edition, Prentice Hall India.
[3] John M. Nicholas, "Project Management for Business and Technology", 3rd edition, Pearson Education

Reference Books:

[1] Pankaj Jalote, "Software Engineering : A Precise Approach", 1st edition, Wiley.

[2] Ian Sommerville, "Software Engineering" , 9th edition, Pearson Education
[3] Pankaj Jalote, "An integrated approach to Software Engineering,", 3rd edition, Wiley

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSC604	Machine Learning	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		CSC301, CSC303,CSC402
Course Outcomes	CO1	Comprehend basics of Machine Learning
	CO2	Build Mathematical foundation for machine learning
	CO3	Select and apply suitable Machine learning models for a given problem
	CO4	Build Neural Network based models
	CO5	Apply Dimensionality Reduction techniques

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Machine Learning**	1	6
	1.1	Introduction to Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps of developing a MachineLearning Application.		
	1.2	Supervised and Unsupervised Learning: Concepts of Classification, Clustering and prediction, Training, Testing and validation dataset, cross validation, overfitting and underfitting of model		
	1.3	Performance Measures: Measuring Quality of model- Confusion Matrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE		
2		**Mathematical Foundation for ML**	1,2	5
	2.1	System of Linear equations, Norms, Inner products, Length of Vector, Distance between vectors, Orthogonal vectors		
	2.2	Symmetric Positive Definite Matrices, Determinant, Trace, Eigenvalues and vectors, Orthogonal Projections, Diagonalization, SVD and its applications		
3		**Linear Models**	1,2	7
	3.1	The least-squares method, Multivariate Linear Regression, Regularized Regression, Using Least-Squares Regression for classification		
	3.2	Support Vector Machines		
4		**Clustering**	1	4
	4.1	Hebbian Learning rule		
	4.2	Expectation -Maximization algorithm for clustering		
5		**Classification models**	1	10

	5.1	Introduction, Fundamental concept, Evolution of Neural Networks, Biological Neuron, Artificial Neural Networks, NN architecture, McCulloch-Pitts Model. Designing a simple network, Non-separable patterns, Perceptron model with Bias. Activation functions, Binary, Bipolar, continuous, Ramp. Limitations ofPerceptron.		
	5.2	Perceptron Learning Rule. Delta Learning Rule (LMS-Widrow Hoff), Multi-layer perceptron network. Adjusting weights of hidden layers. Error back propagation algorithm.		
	5.3	Logistic regression		
6		**Dimensionality Reduction**	1,2	7
	6.1	Curse of Dimensionality.		
	6.2	Feature Selection and Feature Extraction		
	6.3	Dimensionality Reduction Techniques, Principal Component Analysis.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Presentation (10 Marks)
Activity: Assignment (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Nathalie Japkowicz and Mohak Shah, "Evaluating Learning Algorithms: A Classification Perspective", 1st edition, Cambridge
[2] Marc Peter Deisenroth, Aldo Faisal, and Cheng Soon Ong, "Mathematics for Machine Learning.",1st edition, Cambridge University Press
[3] Samir Roy and Chakraborty, "Introduction to Soft Computing", 1st edition, Pearson Education
[4] EthemAlpaydın, "Introduction to Machine Learning",1st edition, MIT Press
[5] Peter Flach, "Machine Learning,"1st edition, Cambridge University Press.

Reference Books:

[1] Tom M. Mitchell, "Machine Learning", 1st edition, McGraw Hill.
[2] Kevin P. Murphy, "Machine Learning — A Probabilistic Perspective" , 1stedition, MIT Press
[3] Stephen Marsland, "Machine Learning an Algorithmic Perspective,", 2ndedition, CRC Press
[4] Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", 1st edition, CambridgeUniversity Press
[5] Peter Harrington, "Machine Learning in Action", 1st edition, DreamTech Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO6011	High Performance Computing	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		FEC205, CSC303, CSC402
Course Outcomes	CO1	Understand the fundamentals of parallel Computing.
	CO2	Describe different parallel processing platforms involved in achieving High Performance Computing.
	CO3	Demonstrate the principles of Parallel Algorithms and their execution.
	CO4	Evaluate the performance of HPC systems.
	CO5	Apply HPC programming paradigm to parallel applications
	CO6	Discuss different current HPC Platforms.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Parallel Computing**	1	5
	1.1	**Introduction to Parallel Computing:** Motivating Parallelism, Scope of Parallel Computing, Levels of parallelism (instruction, transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand- driven Computation). **Self-learning Topics:** Parallel Architectures: Interconnection network, Processor Array, Multiprocessor.		
2		**Parallel Programming Platforms**	1,2	6
	2.1	**Parallel Programming Platforms:** Implicit Parallelism: Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines. **Self-learning Topics:** Trends in Microprocessor & Architectures, Limitations of Memory System Performance.		
3		**Parallel Algorithms and Concurrency**	1,2	9
	3.1	**Principles of Parallel Algorithm Design:** Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Basic Communication operations: Broadcast and Reduction Communication types. **Self-learning Topics: Parallel Algorithm Models**		
4		**Performance Measures for HPC**	1,4	5
	4.1	**Performance Measures :**Speedup, execution time,		

		efficiency, cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl's Law, Gustavson'sLaw. **Self-learning Topics:** Performance Bottlenecks.		
5		**Programming Paradigms for HPC**	1,4	9
	5.1	**Programming Using the Message-Passing Paradigm :**Principles of Message Passing Programming, The Building Blocks: Send and Receive Operations, MPI: the Message Passing Interface, Topology and Embedding.		
	5.2	**Parallel Algorithms and Applications:** One-Dimensional Matrix-Vector Multiplication, Graph Algorithms, Sample Sort, Two-Dimensional Matrix Vector Multiplication. **Self-learning Topics:** Introduction to OpenMP.		
6		**General Purpose GraphicsProcessingUnit(GPGPU)Architecture and Programming**	1,3	5
	6.1	OpenCL Device Architectures, Introduction to OpenCL Programming. architecture, and Introduction to CUDA Programming.		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks) Activity: Assignment (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction to Parallel Computing", 2nd edition, Pearson Education
[2] Kai Hwang and Naresh Jotwani, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", 2nd edition, McGraw Hill
[3] Edward Kandrot and Jason Sanders, "CUDA by Example – An Introduction to General Purpose GPU Programming", 1st edition, Addison-Wesley Professional
[4] Georg Hager and Gerhard Wellein, "Introduction to High Performance Computing for Scientists and Engineers", 1st edition, Chapman & Hall/CRC Computational Science series
[5] Benedict Gaster, Lee Howes, David Kaeli, Perhaad Mistry, and Dana Schaa, "Heterogeneous Computing with OpenCL" 2nd Edition, Elsevier

Reference Books:

[1] Michael J. Quinn, "Parallel Programming in C with MPI and OpenMP", 1st edition, McGraw-Hill International Editions, Computer Science Series
[2] Kai Hwang, Zhiwei Xu, "Scalable Parallel Computing: Technology, Architecture, Programming" , 1st edition, McGraw Hill

[3] Laurence T. Yang, MinyiGuo, "High- Performance Computing: Paradigm and Infrastructure", 1st edition, Wiley
[4] Fayez Gebali, "Algorithms and Parallel Computing", 1st edition, John Wiley & Sons

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO6012	Distributed Computing	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		FEC205
Course Outcomes	CO1	Demonstrate knowledge of the basic elements and concepts related to distributed system technologies.
	CO2	Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object based middleware.
	CO3	Analyze the various techniques used for clock synchronization and mutual exclusion
	CO4	Demonstrate the concepts of Resource and Process management and synchronization algorithms
	CO5	Demonstrate the concepts of Consistency and Replication Management
	CO6	Apply the knowledge of Distributed File System to analyze various file systems like NFS, AFS and the experience in building large-scale distributed applications

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Distributed Systems**	1,2	6
	1.1	Characterization of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models, Hardware concepts, Software Concepts.		
	1.2	Middleware: Models of Middleware, Services offered by middleware, Client Server model.		
2		**Communication**	1,2	6
	2.1	Layered Protocols, Interprocess communication (IPC): MPI, Remote Procedure Call (RPC), Remote Object Invocation, Remote Method Invocation (RMI)		
	2.2	Message Oriented Communication, Stream Oriented Communication, Group Communication		
3		**Synchronization**	1,2	9
	3.1	Clock Synchronization, Physical Clock, Logical Clocks, Election Algorithms, Mutual Exclusion, Distributed Mutual Exclusion-Classification of Mutual Exclusion Algorithm, Requirements of Mutual Exclusion Algorithms, Performance measure.		
	3.2	Non Token based Algorithms: Lamport Algorithm, Ricart–		

		Agrawala's Algorithm, Maekawa's Algorithm		
	3.3	Token Based Algorithms: Suzuki-Kasami's Broadcast Algorithms, Singhal's Heuristic Algorithm, Raymond's Tree.based Algorithm, Comparative Performance Analysis.		
4		**Resource and Process Management**	1,2	6
	4.1	Desirable Features of global Scheduling algorithm, Task assignment approach, Load balancing approach, load sharing approach		
	4.2	Introduction to process management, process migration, Threads,Virtualization, Clients, Servers, Code Migration		
5		**Consistency, Replication and Fault Tolerance**	1,2	6
	5.1	Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management		
	5.2	Fault Tolerance: Introduction, Process resilience, Reliable client-server and group communication, Recovery		
6		**Distributed File Systems and Name Services**	1,2	6
	6.1	Introduction and features of DFS, File models, File Accessing models, File-Caching Schemes, File Replication, Case Study: Distributed File Systems (DSF), Network File System (NFS), Andrew File System (AFS), HDFS		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Andrew S. Tanenbaum and Maarten Van Steen, "Distributed Systems: Principles and Paradigms" 2nd edition, Pearson Education.
[2] George Coulouris, Jean Dollimore, and Tim Kindberg, "Distributed Systems: Concepts and Design," 4th edition, Pearson Education.

Reference Books:

[1] M. L. Liu, "Distributed Computing Principles and Applications", 1st edition, Pearson education
[2] Scrip Demics, "Learn to Master Distributed Computing by ScriptDemics" , 1st edition, StarEdu Solutions

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSDLO6013	Image and Video Processing	L	T	P	L	T	P	Total
		3	--	--	3	--	--	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100(30% weightage)	100	
		Lab	--	--	--	--	--	

Pre-requisite Course Codes		CSC301, CSC402
Course Outcomes	CO1	Explain fundaments of Image processing.
	CO2	Apply image enhancement techniques.
	CO3	Apply image segmentation and compression techniques.
	CO4	Perform transform based analysis of images using different image transforms.
	CO5	Perform basic video processing techniques.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Digital Image Fundamentals**	1,2	6
	1.1	Introduction to Digital Image, Digital Image Processing System, Sampling and Quantization		
	1.2	Representation of Digital Image, Connectivity, Image File Formats : BMP, TIFF and JPEG.		
2		**Image Enhancement in Spatial domain**	1,2	6
	2.1	Introduction to Image Enhancement :Gray Level Transformations, Zero Memory Point Operations		
	2.2	Histogram Processing		
	2.3	Neighbourhood Processing, Spatial Filtering, Smoothing and Sharpening Filters		
3		**Image Segmentation**	1,2	9
	3.1	Segmentation based on Discontinuities (point, Line, Edge)		
	3.2	Image Edge detection using Robert, Sobel, Previtt masks, Image Edge detection using Laplacian Mask.		
	3.3	Region-Oriented Segmentation: Region growing by pixel Aggregation, Split and Merge		
4		**Image Transforms**	1,2	6
	4.1	Introduction to Unitary Transforms		
	4.2	Discrete Fourier Transform(DFT), Inverse DFT, Properties of DFT, Fast Fourier Transform(FFT)		
	4.3	Discrete Hadamard Transform(DHT), Inverse DHT, Fast Hadamard Transform(FHT), Discrete Cosine transform(DCT), Inverse DCT		
5		**Image Compression**	1,2	6
	5.1	Introduction, Redundancy, Fidelity Criteria		

	5.2	Lossless Compression Techniques : Run length Coding, Arithmetic Coding, Huffman Coding		
	5.3	Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization		
6		**Digital Video Processing**	5,6	4
	6.1	Introduction to Digital Video Processing, Sampled Video		
	6.2	Composite and Component Video, Digital video formats and applications		
			Total	**39**

Course Assessment:

ISE-1: 20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
ISE-2:20 marks
Quiz (10 Marks)
Activity: Assignment (10 Marks)
MSE: 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 marks (30% weightage) written examination based on entire syllabus

Text Books:

[1] Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing",3rd edition, Pearson Education Asia
[2] S. Jayaraman, E. Esakkirajan, and T. Veerakumar, "Digital Image Processing", 2nd edition, Tata McGraw Hill Education Private Ltd
[3] Anil K. Jain, "Fundamentals and Digital Image Processing", 3rdedition, Prentice Hall of India Private Ltd
[4] S. Sridhar, "Digital Image Processing", 2nd edition, Oxford University Press
[5] Alan C. Bovik, "The Essential Guide To Video Processing", 2nd edition, Academic Press
[6] Yao Wang, Jorn Ostermann, and Ya-Qin Zang, "Video Processing and Communications", 1st edition, Prentice Hall, Signal Processing series.

Reference Books:

[1] David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", 2nd edition, Pearson Education
[2] Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", 3rd edition, Prentice Hall of India Private Ltd
[3] B. Chandra and D. Dutta Majumder, "Digital Image Processing and Analysis", 2nd edition, Prentice Hall of India Private Ltd
[4] Khalid Sayood, "Introduction to Data Compression", 3rdedition , Morgan Kaufman MK Publication

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL601	Data Analytics and Visualization Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	CSL405	
Course Outcomes	CO1	Explore various data analytics Libraries in R and Python.
	CO2	Implement various Regression techniques for prediction.
	CO3	Build various time series models on a given data set.
	CO4	Design Text Analytics Application on a given data set.
	CO5	Implement visualization techniques to given data sets using R .
	CO6	Implement visualization techniques to given data sets using Python.

Suggested Experiments: Students are required to complete at least 8 experiments.	
Experiment No.	**Title**
1	Getting introduced to data analytics libraries in Python and R.
2	Simple Linear Regression in Python/R.
3	Multiple Linear Regression in Python/R.
4	Time Series Analysis in Python/R.
5	Implementation of ARIMA model in python / R.
6	Text analytics: Implementation of Spam filter/Sentiment analysis in python/R.
7,8	Two visualization experiments in R using different Libraries.
9,10	Two visualization experiments in python using different Libraries.

Course Assessment:

1.ISE-1: 20 marks
Experiments (1-4): Continuous pre-defined rubrics-based evaluation (20 Marks)
2. ISE-2: 30 marks
Experiments (5-8): Continuous pre-defined rubrics-based evaluation(20 Marks)
Activity:- Real world application development (10 marks)

References:

1. https://www.geeksforgeeks.org/data-visualization-with-python
2. https://www.coursera.org/specializations/data-science-python
3. https://www.geeksforgeeks.org/data-visualization-in-r/
4. https://towardsdatascience.com/introduction-to-arima-for-time-series-forecasting-

Text Books:

[1] Bharati Motwani, "Data Analytics using R", 1st edition, Wiley Publications
[2] Wes McKinney, "Python for Data Analysis", 3rdedition," O'Reilly Media, Inc.
[3] Jonathan Schwabish, "Better Data Visualizations: A Guide for Scholars, Researchers, and Wonks", 1st edition, Columbia University Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL602	Cryptographic and system security Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	10	--	15	--	25	

Pre-requisite Course Codes	CSL304,CSL405,CSC404	
Course Outcomes	CO1	Apply cipher techniques to solve symmetric cryptography problems.
	CO2	Apply the concepts of cryptography to implement block ciphers.
	CO3	Analyze and evaluate performance of hashing algorithms.
	CO4	Explore the different network reconnaissance tools to gather information about networks.
	CO5	Use tools like sniffers and port scanners and other related tools for analysing packets in a network.
	CO6	Apply different application security principles and practices.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	Design and Implementation of a product cipher using Substitution and Transposition ciphers.
2	Implementation and analysis of RSA cryptosystem and Digital signature scheme sing RSA/El Gamal.
3	Implementation of Diffie Hellman Key exchange algorithm.
4	For varying message sizes, test integrity of message using MD-5, SHA-1, and analyse the performance of the two protocols. Use crypt APIs.
5	Exploring wireless security tools like Kismet, NetStumbler etc.
6	Study the use of network reconnaissance tools like WHOIS, dig,traceroute, lookup to gather information about networks and domain registrars
7	Study of packet sniffer tools wireshark, :- 1. Observer performance in promiscuous as well as non-promiscuous mode. 2. Show the packets can be traced based on different filters.
8	Download and install nmap. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, etc.
9	Detect ARP spoofing using nmap and/or open source tool ARPWATCH and wireshark
10	Use the NESSUS/ISO Kaali Linux tool to scan the network for vulnerabilities11 Set up IPSEC under LINUX. b) Set up Snort and study the logs. c) Explore the GPG tool of linux to implement email security
11	Set up IPSEC under LINUX. b) Set up Snort and study the logs. c) Explore the GPG tool of linux to implement email security.

Course Assessment:

1.ISE-1: 10 marks
Experiments (1-5) Continuous pre-defined rubrics-based evaluation (10 Marks)
2. ISE-2: 15 marks
Experiments (6-10)Continuous pre-defined rubrics-based evaluation (10 Marks)
Activity: Hacking competition/challenge on try hack me or similar sites- (5 Marks)

References:

1. www.leetcode.com
2. www.hackerrank.com
3. www.cs.usfca.edu/
4. www.codechef.com

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL603	Software Engineering and Project Management Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	10	--	15	--	25	

Pre-requisite Course Codes	CSC404, CSL403, CSC501	
Course Outcomes	CO1	Understand the fundamentals of DevOps engineering and be fully proficient with DevOps terminologies, concepts, benefits, and deployment options to meet your business requirements
	CO2	Acquire complete knowledge of the - version control system to effectively track changes augmented with Git and GitHub
	CO3	Understand the importance of Selenium and Jenkins to test Software Applications
	CO4	Understand the importance of Jenkins to Build and deploy Software Applications on server environment
	CO5	Understand concept of containerization and Analyze the Containerization of OS images and deployment of applications over Docker.
	CO6	Synthesize software configuration and provisioning using Ansible.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	To understand DevOps: Principles, Practices, and DevOps Engineer Role and Responsibilities
2	To understand Version Control System / Source Code Management, install git and create a GitHub account
3	To Perform various GIT operations on local and Remote repositories using GIT Cheat-Sheet
4	To understand Continuous Integration, install and configure Jenkins with Maven/Ant/Gradle to setup a build Job
5	To Build the pipeline of jobs using Maven / Gradle / Ant in Jenkins, create a pipeline script to Test and deploy an application over the tomcat server.
6	To understand Jenkins Master-Slave Architecture and scale your Jenkins standalone implementation by implementing slave nodes.
7	To Setup and Run Selenium Tests in Jenkins Using Maven.
8	To understand Docker Architecture and Container Life Cycle, install Docker and execute docker commands to manage images and interact with containers
9	To learn Dockerfile instructions, build an image for a sample web application using Dockerfile.

10	To install and Configure Pull based Software Configuration Management and provisioning tools using Puppet
11	To learn Software Configuration Management and provisioning using Puppet Blocks(Manifest, Modules, Classes, Function)
12	To provision a LAMP/MEAN Stack using Puppet Manifest.

Course Assessment:

1.ISE-1: 10 marks
Practical exam based on first 5 experiments(10 Marks)
2. ISE-2: 15 marks
Practical exam based on 6-10 experiments(15 Marks)

References:

1. https://nptel.ac.in/courses/128106012
2. https://www.edureka.co/devops-certification-training
3. https://www.coursera.org/professional-certificates/devops-and-software-engineering

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL604	Machine Learning Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	FEC205	
Course Outcomes	CO1	Comprehend basics of machine learning.
	CO2	Apply suitable machine learning models for a given problem
	CO3	Implement neural network-based models
	CO4	Apply dimensionality reduction technique

Suggested Experiments: Students are required to complete at least 10 experiments.	
Experiment No.	**Title**
1	Introduction to platforms such as Anaconda, COLAB
2	Study of Machine Learning Libraries and tools (Python library, tensorflow, keras,...)
3	Implementation of following algorithms for a given example data set
4	Linear Regression.
5	Logistic Regression.
6	Support Vector Machines
7	Hebbian Learning
8	Expectation -Maximization algorithm
9	McCulloch Pitts Model.
10	Single Layer Perceptron Learning algorithm
11	Error Backpropagation Perceptron Training Algorithm
12	Principal Component Analysis

Course Assessment:

ISE-1: 20 marks
Experiments (1-4): Continuous pre-defined rubrics-based evaluation (10 Marks)
Activity: Article Discussion (10 marks)
ISE-2: 30 marks
Experiments (5-8): Continuous pre-defined rubrics-based evaluation(10 Marks)
Activity: Research Paper Implementation (20 marks)

References:

1. https://www.learndatasci.com/out/edx-columbia-machine-learning/
2. https://www.learndatasci.com/out/oreilly-hands-machine-learning-scikit-learn-keras-and-ten sorflow-2nd-edition/
3. https://www.learndatasci.com/out/google-machine-learning-crash-course/
4. https://www.learndatasci.com/out/edx-columbia-machine-learning/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSL605	Skill Based Lab course : Cloud Computing	L	T	P	L	T	P	Total
		--	--	4	--	--	2	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	25	--	50	--	75	

Pre-requisite Course Codes	CSC501	
Course Outcomes	CO1	Implement different types of virtualization techniques.
	CO2	Analyze various cloud computing service models and implement them to solve the given problems.
	CO3	Design and develop real world web applications and deploy them on commercial cloud(s).
	CO4	Explain major security issues in the cloud and mechanisms to address them.
	CO5	Explore various commercially available cloud services and recommend the appropriate one for the given application.
	CO6	Implement the concept of containerization

Module No.	Topics	Hrs
1	Introduction and overview of cloud computing. To understand the origin of cloud computing, cloud cube model, NIST model, characteristics of cloud, different deployment models service models, advantages and disadvantages.	4
2	Concept of Virtualization along with their types, structures and mechanisms. Demonstration of creating and running Virtual machines inside hosted hypervisors like Virtual Box and KVM with their comparison based on various virtualization parameters.	4
3	Functionality of Bare-metal hypervisors and their relevance in cloud computing platforms. Installation, configure and manage Bare Metal hypervisor along with instructions to create and run virtual machines inside it. It should also emphasize on accessing VMs in different environments along with additional services provided by them like Load balancing, Auto-Scaling, Security etc	4

Teachers are requested to complete above theory before staring lab work	
Experiment No.	**Title**
1	**Title:** To study and Implement Infrastructure as a Service using AWS/Microsoft Azure. **Objective:** To demonstrate the steps to create and run virtual machines inside a Public cloud platform. This experiment should emphasize on creating and running Linux/Windows Virtual machines inside Amazon EC2 or Microsoft Azure Compute and accessing them using RDP or VNC tools.

2	**Title:** To study and Implement Platform as a Service using AWS Elastic Beanstalk/ Microsoft Azure App Service. **Objective:** To demonstrate the steps to deploy Web applications or Web services written in different languages on AWS Elastic Beanstalk/ Microsoft Azure App Service.
3	To study and Implement Storage as a Service using Own Cloud/ AWS S3, Glaciers/ Azure Storage.
4	To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase.
5	**Title:** To study and Implement Security as a Service on AWS/Azure **Objective:** To understand the Security practices available in public cloud platforms and to demonstrate various Threat detection, Data protection and Infrastructure protection services in AWS and Azure.
6	**Title:** To study and implement Identity and Access Management (IAM) practices on AWS/Azure cloud. **Objective:** To understand the working of Identity and Access Management IAM in cloud computing and to demonstrate the case study based on Identity and Access Management (IAM) on AWS/Azure cloud platform.
7	**Title:** To study and Implement Containerization using Docker **Objective:** To know the basic differences between Virtual machine and Container. It involves demonstration of creating, finding, building, installing, and running Linux/Windows application containers inside a local machine or cloud platform.
8	**Title:** To study and implement container orchestration using Kubernetes **Objective:** To understand the steps to deploy Kubernetes Cluster on local systems, deploy applications on Kubernetes, creating a Service in Kubernetes, develop Kubernetes configuration files in YAML and creating a deployment in Kubernetes using YAML,
9	**Mini-project:** Design a Web Application hosted on a public cloud platform [It should cover the concept of IaaS, PaaS, DBaaS, Storage as a Service, Security as a Service etc.]

Course Assessment:

ISE-1: 25 marks
Experiments 1 to 4 Continuous pre-defined rubrics-based evaluation (15 marks)
Activity: Assignment based on Courses provided by awsacademy.com/ (10 Marks)
ISE-2: 50 marks
Experiments 5 to 8 and Mini Project (15 Marks)
Activity: Assignment based on Courses provided by awsacademy.com/ (10 Marks)
Activity: Oral examination based on Laboratory Work and Mini Project (25 Marks)

References:

1. https://docs.aws.amazon.com/
2. https://docs.microsoft.com/en-us/azure
3. https://kubernetes.io/docs/home/
4. https://docs.docker.com/get-started/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
CSM601	Mini Project 2B	L	T	P	L	T	P	Total
		--	--	4	--	--	2	2
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	15	--	15	20	50	

Pre-requisite Course Codes	--	
Course Outcomes	CO1	Identify societal/research/innovation/entrepreneurship problems through appropriate literature surveys
	CO2	Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it
	CO3	Validate, Verify the results using test cases/benchmark data/theoretical/ inferences/experiments/simulations
	CO4	Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development
	CO5	Use standard norms of engineering practices and project management principles during project work
	CO6	Communicate through technical report writing and oral presentation.
	CO7	Gain technical competency towards participation in Competitions, Hackathons, etc.
	CO8	Demonstrate capabilities of self-learning, leading to lifelong learning.
	CO9	Develop interpersonal skills to work as a member of a group or as leader

Guidelines for Mini Project	
Sr. No.	**Title**
1	Report should be prepared as per the guidelines issued by the University of Mumbai.
2	Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by the head of Institution.
3	Students shall be motivated to publish a paper/participate in competition based on the work in Conferences/students competitions
4	Students shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini projects.
5	A logbook may be prepared by each group, wherein the group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6	Faculty supervisors may give inputs to students during mini project activity; however, focus shall be on self-learning.
7	Students under the guidance of faculty supervisor shall convert the best solution into a working model using various components of their domain areas and

	demonstrate.
8	The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of annexure to the report.
9	With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. Mini Project 2 in semesters V and VI.
10	However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis

Course Assessment:

ISE-1: 15 marks
Implementation & Presentation(15 Marks)
ISE-2:15 marks
Report Writing & Poster Presentation (15 Marks)
ESE: Project Exam (20 Marks)