University of Mumbai

Bachelor of Engineering

in

- Computer Science and Engineering (Data Science)
- Computer Science and Engineering (Artificial Intelligence and Machine Learning)
- Artificial Intelligence and Data Science
- Artificial Intelligence and Machine Learning
- Data Engineering

Third Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

University of Mumbai

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	~~New~~/ Revised (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year:2022-2023**

Dr. S.K.Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr. Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.

Dr. S.K. Ukarande   Dr Anuradha Muzumdar
Associate Dean   Dean
Faculty of Science and Technology   Faculty of Science and Technology
University of Mumbai   University of Mumbai

Incorporation and Implementation of Online Contents fromNPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S.K.Ukarande   Dr Anuradha Muzumdar
Associate Dean   Dean
Faculty of Science and Technology   Faculty of Science and Technology
University of Mumbai   University of Mumbai

Preface by Board of Studies in Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Third Year Computer Engineering syllabus effective from the Academic Year 2021-22 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting, challenging, fulfill certain needs and expectations.

Computer Engineering is one of the most sought-after courses amongst engineering students. The syllabus needs revision in terms of preparing the student for the professional scenario relevant and suitable to cater the needs of industry in present day context. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquainted with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus is finalized through a brain storming session attended by Heads of Departments or senior faculty from the Department of Computer Engineering of the affiliated Institutes of the Mumbai University. The syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:
1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. The department Optional Courses will provide the relevant specialization within the branch to a student.
3. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
4. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Board of Studies in Computer Engineering

Prof. Sunil Bhirud   : Chairman
Prof. SunitaPatil   : Member
Prof. Leena Ragha   : Member
Prof. Subhash Shinde   : Member
Prof .Meera Narvekar   : Member
Prof. Suprtim Biswas   : Member
Prof. Sudhir Sawarkar   : Member
Prof. Dayanand Ingle   : Member
Prof. Satish Ket   : Member

PROGRAM STRUCTURE FOR THIRD YEAR
UNIVERSITY OF MUMBAI (With Effect from 2022-2023)
Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
CSC501	Computer Network	3	--	3	--	3
CSC502	Web Computing	3	--	3		3
CSC503	Artificial Intelligence	3	--	3	--	3
CSC504	Data Warehousing & Mining	3	--	3	--	3
CSDLO501X	Department Level Optional Course- 1	3	--	3	--	3
CSL501	Web Computing and Network Lab	--	2	--	1	1
CSL502	Artificial Intelligence Lab	--	2	--	1	1
CSL503	Data Warehousing & Mining Lab	--	2	--	1	1
CSL504	Business Communication and Ethics-II	--	2*+2	--	2	2
CSM501	Mini Project: 2 A	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract &oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
CSC501	Computer Network	20	20	20	80	3	-	--	100
CSC502	Web Computing	20	20	20	80	3	--	--	100
CSC503	Artificial Intelligence	20	20	20	80	3	--	--	100
CSC504	Data Warehousing & Mining	20	20	20	80	3	--	--	100
CSDLO501X	Department Level Optional Course- 1	20	20	20	80	3	--	--	100
CSL501	Web Computing and Network Lab	--	--	--	--	--	25	25	50
CSL502	Artificial Intelligence Lab	--	--	--	--	--	25	25	50
CSL503	Data Warehousing & Mining Lab	--	--	--	--	--	25	25	50
CSL504	Business Communication and Ethics-II	--	--	--	--	--	50	--	50
CSM501	Mini Project : 2A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**150**	**100**	**750**

* Theory class to be conducted for full class and $ indicates workload of Learner (Not Faculty), students can formgroups with minimum 2(Two) and not more than 4(Four). Faculty Load: 1hour per week per four groups.

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
CSC601	Data Analytics and Visualization	3	--	3	--	3
CSC602	Cryptography and System Security	3	--	3		3
CSC603	Software Engineering and Project Management	3	--	3	--	3
CSC604	Machine Learning	3	--	3	--	3
CSDLO601X	Department Level Optional Course -2	3	--	3	--	3
CSL601	Data Analytics and Visualization Lab	--	2	--	1	1
CSL602	Cryptography & System Security Lab	--	2	--	1	1
CSL603	Software Engineering and Project Management Lab	--	2	--	1	1
CSL604	Machine Learning Lab	--	2	--	1	1
CSL605	Skill base Lab Course: Cloud Computing	--	4	--	2	2
CSM601	Mini Project Lab: 2B	--	4$	--	2	2
Total		**15**	**16**	**15**	**08**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. &oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC601	Data Analytics and Visualization	20	20	20	80	3	--	--	100
CSC602	Cryptography and System Security	20	20	20	80	3	--	--	100
CSC603	Software Engineering and Project Management	20	20	20	80	3	--	--	100
CSC604	Machine Learning	20	20	20	80	3	--	--	100
CSDLO601X	Department Level Optional Course -2	20	20	20	80	3	--	--	100
CSL601	Data Analytics and Visualization Lab	--	--	--	--	--	25	25	50
CSL602	Cryptography & System Security Lab	--	--	--	--	--	25	--	25
CSL603	Software Engineering and Project Management Lab	--	--	--	--	--	25	-	25
CSL604	Machine Learning Lab						25	25	50
CSL605	Skill base Lab Course: Cloud Computing	--	--	--	--	--	50	25	75
CSM601	Mini Project Lab: 2B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**100**	**775**

PROGRAM STRUCTURE FOR THIRD YEAR

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

DEPARTMENT OPTIONAL COURSES

Department Optional Courses	Semester	Code & Subject
Department Optional Course -1	V	CSDLO5011 : Statistics for Artificial Intelligence & Data Science CSDLO5012: Advanced Algorithms CSDLO5013: Internet of Things
Department Optional Course -2	VI	CSDLO6011 :High Performance Computing CSDLO6012: Distributed Computing CSDLO6013: Image & Video processing

Course Code	Course Name	Credit
CSC501	**Computer Networks**	**03**

Pre-requisite: None

Course Objectives: The course aims:

1	To introduce concepts of computer networks and working of various layers of OSI.
2	To explore the issues and challenges of protocols design while delving into TCP/IP protocol suite.
3	To assess the strengths and weaknesses of various routing algorithms.
4	To understand various transport layer and application layer protocols
5	To design enterprise network for given user requirements in an application.

Course Outcomes:

1	Demonstrate the concepts of data communication at physical layer and compare ISO - OSI model with TCP/IP model.
2	Explore different design issues at data link layer.
3	Design the network using IP addressing and sub netting / supernetting schemes.
4	Analyze transport layer protocols and congestion control algorithms.
5	Explore protocols at application layer
6	Understand the customer requirements and Apply a Methodology to Network Design and software defined networks

Module		Detailed Content	Hours
1		**Introduction to Networking**	
	1.1	Introduction to computer network, Network Devices, Network topology, Switching: Circuit-Switched Networks, Packet Switching, Network Types: LAN, MAN, WAN	6
	1.2	Reference models: Layer details of OSI, TCP/IP models. Difference between OSI and TCP/IP	
2		**Physical and Data Link Layer**	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**	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**	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
		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**	4
		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.	

Textbooks:	
1	A.S. Tanenbaum, Computer Networks,4 th edition Pearson Education
2	B.A. Forouzan, Data Communications and Networking, 5 th 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, Forouzan Mosharrat , Computer Networks A Top down Approach, Mc Graw Hill education
5	Diane Teare , Authorized Self-Study Guide, Designing for Cisco Internetwork Solutions (DESGN), Second Edition, Cisco Press.
6	Paul Göransson, Chuck Black, Software Defined Networks: A Comprehensive Approach, MK Publication
7	Thomas D. Nadeau and Ken Gray, Software Defined Networks,1st Edition,O'Reilly publication

	References:
1	S.Keshav,An Engineering Approach To Computer Networking, Pearson .
2	Natalia Olifer & Victor Olifer,Computer Networks: Principles, Technologies & Protocols for Network Design, Wiley India, 2011
3	Larry L.Peterson, Bruce S.Davie, Computer Networks: A Systems Approach, Second Edition The Morgan Kaufmann Series in Networking
4	Siamak Azodolmolky, Software Defined Networking with Open Flow : PACKT Publishing.
5	Priscilla Oppenheimer, Top-Down Network Design (Networking Technology) 3rd Edition, Cisco Press Book

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed.Duration of each test shall be one hour.

	End Semester Theory Examination:
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

	Useful Links
1	https://nptel.ac.in/courses/106105183
2	https://www.coursera.org/specializations/computer-communications
3	https://www.coursera.org/learn/tcpip?action=enroll

Course Code	Course Name	Credit
CSC502	Web Computing	03

Pre-requisite:	
Course Objectives: The course aims:	
1	To orient students to Web Programming fundamental.
2	To expose students to JavaScript to develop interactive web page development
3	To orient students to Basics of REACT along with installation
4	To expose students to node.js applications using express framework
5	To orient students to Fundamentals of node.js
6	To expose students to Advanced concepts in REACT
Course Outcomes:	
1	Select protocols or technologies required for various web applications
2	Apply JavaScript to add functionality to web pages. .
3	Design front end application using basic React. .
4	Construct web based Node.js applications using Express
5	Design front end applications using functional components of React.
6	Design back-end applications using Node.js

Module		Detailed Content	Hours
1		**Web programming fundamentals**	
	1.1	Working of web browser, HTTP protocol, HTTPS, DNS, TLS, XML introduction, Json introduction, DOM, URL, URI, REST API	8
2		**Javascript**	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**	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**	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**		4
	5.1	Introduction, Express router, REST API, Generator, Authentication, sessions, Integrating with React		
6		Advance React		4
	6.1	Functional components- Refs, Use effects, Hooks, Flow architecture, Model-ViewController framework, Flux, Bundling the application. Web pack.		

Textbooks:	
1	Rediscovering JavaScript, Master ES6, ES7, and ES8, By Venkat Subramaniam · 2018
2	Learning React Functional Web Development with React and Redux, Alex Banks and Eve Porcello, O'Reilly
3	Learning Redux, Daniel Bugl, Packt Publication
4	Learning Node.js Development, Andrew Mead, Packt Publishing
5	RESTful Web API Design with Node.js 10, Valentin Bojinov, Packt Publication

References:	
1	"Web Development with Node and Express, Ethan Brown, O'Reilly
2	HTML5 Cookbook, By Christopher Schmitt, Kyle Simpson, O'Reilly Media
3	Core Python Applications Programming by Wesley J Chun Third edition Pearson Publication

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://www.coursera.org/learn/html-css-javascript-for-web-developers?action=enroll
2	ttps://onlinecourses.swayam2.ac.in/ugc19_lb05/preview
3	https://reactjs.org/tutorial/tutorial.html
4	https://react-redux.js.org/introduction/quick-start 4. https://webpack.js.org/

Course Code	Course Name	Credit
CSC503	Artificial Intelligence	03

Pre-requisite: C Programming

Course Objectives: The course aims:

1	To gain perspective of AI and its foundations.
2	To study different agent architectures and properties of the environment
3	To understand the basic principles of AI towards problem solving, inference, perception, knowledge representation, and learning.
4	To investigate probabilistic reasoning under uncertain and incomplete information.
5	To explore the current scope, potential, limitations, and implications of intelligent systems

Course Outcomes:
After successful completion of the course students will be able to:

1	Identify the characteristics of the environment and differentiate between various agent architectures.
2	Apply the most suitable search strategy to design problem solving agents.
3	Represent a natural language description of statements in logic and apply the inference rules to design Knowledge Based agents.
4	Apply a probabilistic model for reasoning under uncertainty.
5	Comprehend various learning techniques.
6	Describe the various building blocks of an expert system for a given real word problem.

Module		Detailed Content	Hours
1		**Introduction to Artificial Intelligence**	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**	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.	
	2.2	Environment Types: Deterministic, Stochastic, Static, Dynamic, Observable, Semi-observable, Single Agent, Multi Agent	
3		**Solving Problems by Searching**	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	
		3.5	Game Playing, Adversarial Search Techniques, Mini-max Search, Alpha-Beta Pruning	
4			**Knowledge and Reasoning**	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**	5
			Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution	
			Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief Networks	
6			**Planning and Learning**	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

Textbooks:	
1	Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach ―Second Edition" Pearson Education.
2	Elaine Rich and Kevin Knight ―Artificial Intelligence‖ Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
3	George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education., Fourth edition.

References:	
1	Ivan Bratko "PROLOG Programming for Artificial Intelligence", Pearson Education, Third Edition.
2	D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall.
3	Saroj Kaushik "Artificial Intelligence", Cengage Learning.
4	Davis E. Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.
5	Patrick Henry Winston, "Artificial Intelligence", Addison-Wesley, Third Edition.
6	N. P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press.

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	[An Introduction to Artificial Intelligence - Course (nptel.ac.in)](#)
2	[NPTEL](#)
3	https://www.classcentral.com/course/independent-elements-of-ai-12469
4	https://tinyurl.com/ai-for-everyone

Course Code	Course Name	Credit
CSC504	**Data Warehousing and Mining**	**03**

Pre-requisite: Database Management concepts

Course Objectives: The course aims:

1	To create awareness of how enterprise can organize and analyze large amounts of data by creating a Data Warehouse
2	To introduce the concept of data Mining as an important tool for enterprise data management and as a cutting edge technology for building competitive advantage.
3	To enable students to effectively identify sources of data and process it for data mining
4	To make students well versed in all data mining algorithms, methods of evaluation
5	To impart knowledge of tools used for data mining,and study web mining

Course Outcomes:

1	Organize strategic data in an enterprise and build a data Warehouse.
2	Analyze data using OLAP operations so as to take strategic decisions and Demonstrate an understanding of the importance of data mining.
3	Organize and Prepare the data needed for data mining using pre preprocessing techniques
4	Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.
5	Define and apply metrics to measure the performance of various data mining algorithms
6	Understand Concepts related to Web mining

Module		Detailed Content	Hours
1		**Data Warehouse and OLAP**	
		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 a cube: Roll-up, Drilldown, Slice, Dice, Pivot ; OLAP Models: MOLAP, ROLAP, HOLAP. Major steps in ETL Process	9
2		**Introduction to Data Mining ,Data Exploration and Data Preprocessing**	8

		Data Mining Task primitives,Architecture,KDD process,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**	6
		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**	4
		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**	8
		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 to Correlation Analysis, lift, ; Introduction to Constraint-Based Association Mining	
6		Web Mining	4
		Introduction to Web content Mining, Crawlers, Personalization, Webstructure mining, Page rank,, Clever, Web Usage Mining	

Textbooks:	
1	Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann 3nd Edition
2	P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", Pearson Education.
3	Paulraj Ponniah, "Data Warehousing: Fundamentals for IT Professionals", 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
References:	
1	Theraja Reema, "Data Warehousing", Oxford University Press, 2009
2	Ralph Kimball, Margy Ross, "The Data Warehouse Toolkit: The Definitive Guide To Dimensional Modeling", 3rd Edition. Wiley India.

3	Michael Berry and Gordon Linoff "Mastering Data Mining- Art & science of CRM", Wiley Student Edition
4	Michael Berry and Gordon Linoff "Data Mining Techniques", 2nd Edition Wiley Publications

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted whenapprox. 40% syllabus is completed and second class test when additional40% syllabus is completed.

Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links

1	https://www.coursera.org/learn/data-warehousing-business-intelligence
2	https://www.coursera.org/specializations/data-mining-foundations-practice
3	https://onlinecourses.nptel.ac.in/noc20_cs12/preview
4	https://nptel.ac.in/courses/106105174

Course Code	Course Name	Credit
CSDLO5011	**Statistics for Artificial IntelligenceData Science**	**03**

Prerequisite: C Programming	
Course Objectives: The course aims:	
1	To Perform exploratory analysis on the datasets
2	To Understand the various distribution and sampling
3	To Perform Hypothesis Testing on datasets
4	To Explore different techniques for Summarizing Data
5	To Perform The Analysis of Variance
6	To Explore Linear Least Squares
Course Outcomes: Learner will be able to	
1	Illustrate Exploratory Data Analysis
2	Describe Data and Sampling Distributions
3	Solve Statistical Experiments and Significance Testing
4	Demonstrate Summarizing Data
5	Interpret the Analysis of Variance
6	Use Linear Least Squares

Prerequisite: Discrete Structures and Graph Theory

Module		Detailed Content	Hours
1		**Exploratory Data Analysis**	5
	1.1	Elements of Structured Data ,Further Reading ,Rectangular Data ,Data Frames and Indexes ,Nonrectangular 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**	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 ,Normal Distribution ,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**	8
	3.1	A/B Testing ,Hypothesis Tests ,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 ,Multiple Testing ,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**	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**	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**	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 $\sigma 2$, 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	

Textbooks:	
1	Bruce, Peter, and Andrew Bruce. Practical statistics for data scientists: 50 essential concepts. Reilly Media, 2017.
2	Mathematical Statistics and Data Analysis John A. Rice University of California, Berkeley,Thomson Higher Education
References:	
1	Dodge, Yadolah, ed. Statistical data analysis and inference. Elsevier, 2014.
2	Ismay, Chester, and Albert Y. Kim. Statistical Inference via Data Science: A Modern Dive into R and the Tidyverse. CRC Press, 2019.
3	Milton. J. S. and Arnold. J.C., "Introduction to Probability and Statistics", Tata McGraw Hill, 4th Edition, 2007.
4	Johnson. R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
5	A. Chandrasekaran, G. Kavitha, "Probability, Statistics, Random Processes and Queuing Theory", Dhanam Publications, 2014.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://www.edx.org/course/introduction-probability-science-mitx-6-041x-2
2	https://www.coursera.org/learn/statistical-inference
3	https://www.datacamp.com/community/open-courses/statistical-inference-and-data-analysis

* Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM501: Mini-Project.

Course Code	Course Name	Credit
CSDL05012	Advanced Algorithms	03

Pre-requisite:

Course Objectives: The course aims:	
1	To provide mathematical approaches for problem solving using advanced concepts of Algorithms
2	To understand and solve problems using various algorithmic approaches like Randomized algorithms, approximation algorithms, Local search and Amortized algorithms.
3	To discuss and apply the Combinatorial Analysis techniques to solve various mathematical and statistical problems

Course Outcomes:	
1	Analyze the classification of problems into various NP classes and their Computational Intractability
2	Describe, apply and analyze the complexity of Approximation Algorithms.
3	Describe, apply and analyze the complexity of Randomized Algorithms.
4	Describe, apply and analyze the complexity of Local Search Algorithms.
5	Design and Apply the concepts of String and Amortized Analysis
6	To Understand Combinatorial Analysis techniques

Module		Detailed Content	Hours
1		**NP and Computational Intractability**	
	1.1	Polynomial-Time Reductions, NP Completeness: Overview, Class P– Class NP – NP Hardness, NP Completeness, Cook Levine Theorem, Characteristics of NP Complete Problems, The Satisfiability Problem, NP-Complete Problems, Sequencing Problems Partitioning Problems, Graph Coloring, Numerical Problems, Co-NP and the Asymmetry of NP, A Partial Taxonomy of Hard Problems. Reduction of standard NP Complete Problems: SAT, 3SAT, Clique, Vertex Cover, Set Cover, Hamiltonian Cycle.	8
2		**Approximation Algorithms**	9

	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**	9
	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: Median-Finding 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**	5
	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**	4
	5.1	String Sort, Tries, Substring Search, Regular Expressions, Data Compression, String Matching Algorithms: Introduction to String matching, The Knuth-Morris-Pratt algorithm, Aho- Korasik algorithm, Z-algorithm, Amortized Analysis: Aggregate analysis, The accounting method, The potential method Dynamic tables.	
6		Combinatorial Analysis	4
	6.1	Introduction, Next subset of n-Set problems, Random Subset of n-Setproblems, Sequencing, Ranking and selection algorithms for general combinatorial families.	

Textbooks:	
1	Jon Kleinberg, Eva Tardos, "Algorithm Design", Cornell University, Pearson Publications
2	Robert Sedgewick, Kevin Wayne, "Algorithms", Princeton, FOURTH EDITION, AddisonWessely.

3	Thomas H. Cormen , Charles E., Ronald l., Clifford Stein, "Introduction to Algorithms",Third Edition, The MIT Press Cambridge.
4	Albert Nijenhuis, Herbert Wilf, "Combinatorial Algorithms for computers and calculators",Second edition, Academic Press
5	George Heineman, Gary Pollice, Stanley Selkow, "Algorithms in a Nutshell", Oreilly Press.

References:	
1	Anany Levitin, Introduction to The design and analysis of algorithms, 3rd Edition, Pearson publication.
2	Peter J. Cameron, "Combinatorics: Topics, Techniques, Algorithms", Cambridge University Press

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://www.binghamton.edu/watson/continuing-education/data-science/advanced-algorithms.html
2	https://nptel.ac.in/courses/106104019
3	https://www.coursera.org/learn/advanced-algorithms-and-complexity
4	https://onlinecourses.swayam2.ac.in/cec20_cs03/preview

*Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM501: Mini-Project.

Course Code	Course Name	Credit
CSDLO5013	**Internet of Things**	03

Course Objectives: To understand Internet of Things (IoT) Characteristics and Conceptual Framework

1. To comprehend Characteristics and Conceptual Framework of IoT
2. To understand levels of the IoT architectures
3. To correlate the connection of smart objects and IoT access technologies
4. To Interpret edge to cloud protocols
5. To explore data analytics and data visualization on IoT Data
6. To explore IoT applications

Course Outcomes: Learner will be able to

1. Describe the Characteristics and Conceptual Framework of IoT
2. Differentiate between the levels of the IoT architectures
3. Analyze the IoT access technologies
4. Illustrate various edge to cloud protocol for IoT
5. Apply IoT analytics and data visualization
6. Analyze and evaluate IoT applications

Prerequisite:

1. Python programming
2. C programing language
3. Computer Networks

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours
1	**Introduction toIoT**	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, Simulators-Circuit.io,Eagle,Tinkercad	4

2	**IoT Architecture**	**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,	7
3	**Principles of Connected Devices and Protocols in IoT**	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 Connectivity-LTE, LTE-A, LoRa and LoRaWAN.	8
4	**Edge to Cloud Protocol**	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.	8
5	**IoT and Data Analytics**	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	7
6	**IoT Application Design**	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 I-IoT, 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 customerservices	5

Text Book

1. Arsheep Bahga (Author), Vijay Madisetti, Internet Of Things: A Hands-On Approach Paperback, Universities Press, Reprint 2020
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, IoT Fundamentals Networking Technologies, Protocols, and Use Cases for the Internet of Things CISCO.
3. Analytics for the Internet of Things (IoT) Intelligent Analytics for Your Intelligent Devices.AndrewMinteer,Packet
4. Giacomo Veneri , Antonio Capasso," Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0", Packt

References:

1. Pethuru Raj, Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases by , CRC press,

2. Raj Kamal, Internet of Things, Architecture and Design Principles, McGraw Hill Education, Reprint 2018.

3. Perry Lea, Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communicationinfrastructure, edge computing, analytics, and security, Packt Publications, Reprint 2018.

4. Amita Kapoor, "Hands on Artificial intelligence for IoT", 1st Edition, Packt Publishing, 2019.

5. Sheng-Lung Peng, Souvik Pal, Lianfen Huang Editors: Principles of Internet of Things (IoT)Ecosystem:Insight Paradigm, Springer

Online References:

1. https://owasp.org/www-project-internet-of-things/
2. NPTEL: Sudip Misra, IIT Khargpur, Introduction to IoT: Part-1, https://nptel.ac.in/courses/106/105/106105166/
3. NPTEL: Prof. Prabhakar, IISc Bangalore, Design for Internet of Things, https://onlinecourses.nptel.ac.in/noc21_ee85/preview
4. Mohd Javaid, Abid Haleem, Ravi Pratap Singh, Shanay Rab, Rajiv Suman,Internet of Behaviors (IoB) and its role in customer services,Sensors International,Volume 2,2021,100122,ISSN 2666-3511,https://doi.org/10.1016/j.sintl.2021.100122

* Suggestion: Laboratory work based on the above syllabus can be incorporated as amini project in CSM501: Mini-Project.

Lab Code	Lab Name	Credit
CSL501	**Web Computing and Network Lab**	**1**

Prerequisite: Operating System, Basics of Java and Python Programming.
Lab Objectives:

1	To orient students to HTML for making webpages
2	To expose students to CSS for formatting web pages
3	To expose students to developing responsive layout
4	To expose students to JavaScript to make web pages interactive
5	To orient students to React for developing front end applications
6	To orient students to Node.js for developing backend applications

Lab Outcomes:

1	Identify and apply the appropriate HTML tags to develop a webpage
2	Identify and apply the appropriate CSS tags to format data on webpage
3	Construct responsive websites using Bootstrap
4	Use JavaScript to develop interactive web pages.
5	Construct front end applications using React and back end using Node.js/express
6	Use simulator for CISco packet tracer/GNS3

Suggested Experiments: Students are required to complete at least 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
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

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

Term Work:	
1	Term work should consist of 10 experiments from above list.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL501and CSC502

Lab Code	Lab Name	Credit
CSL502	**Artificial Intelligence Lab**	**1**

Prerequisite: C Programming Language.	
Lab Objectives:	
1	To design suitable Agent Architecture for a given real world AI problem
2	To implement knowledge representation and reasoning in AI language
3	To design a Problem-Solving Agent
4	To incorporate reasoning under uncertainty for an AI agent
Lab Outcomes: **At the end of the course, students will be able to —-**	
1	Identify suitable Agent Architecture for a given real world AI problem
2	Implement simple programs using Prolog.
3	Implement various search techniques for a Problem-Solving Agent.
4	Represent natural language description as statements in Logic and apply inference rules to it.
5	Construct a Bayesian Belief Network for a given problem and draw probabilistic inferences from it

Suggested Experiments: Students are required to complete at least 10 experiments.	
Sr. No.	**Name of the Experiment**
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

Useful Links:	
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/

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus

Lab Code	Lab Name	Credit
CSL503	**Data warehousingand Mining Lab**	1

Prerequisite: Java and Python Programming.	
Lab Objectives:	
1	To create awareness of how enterprise can organize and analyze large amounts of data by creating a Data Warehouse
2	To introduce the concept of data Mining as an important tool for enterprise data management and as a cutting edge technology for building competitive advantage
3	To enable students to effectively identify sources of data and process it for data mining
4	To make students well versed in all data mining algorithms, methods, and tools..
Lab Outcomes:	
1	Build a data warehouse
2	Analyze data using OLAP operations so as to take strategic decisions.
3	Demonstrate an understanding of the importance of data mining
4	Organize and Prepare the data needed for data mining using pre preprocessing techniques
5	Perform exploratory analysis of the data to be used for mining.
6	Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.

Suggested Experiments: Students are required to complete all experiments from the list given below.	
Sr. No.	**Name of the Experiment**
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.

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

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL301and CSC303

Course Code	Course Name	Credit
CSL504	**Business Communication & Ethics II**	**02**

Course Rationale: This curriculum is designed to build up a professional and ethical approach, effective oral and written communication with enhanced soft skills. Through practical sessions, it augments student's interactive competence and confidence to respond appropriately and creatively tothe implied challenges of the global Industrial and Corporate requirements. It further inculcates the
social responsibility of engineers as technical citizens.

Course Objectives

1	To discern and develop an effective style of writing important technical/business documents.
2	To investigate possible resources and plan a successful job campaign.
3	To understand the dynamics of professional communication in the form of group discussions,meetings, etc. required for career enhancement.
4	To develop creative and impactful presentation skills.
5	To analyze personal traits, interests, values, aptitudes and skills.
6	To understand the importance of integrity and develop a personal code of ethics.

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

1	Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2	Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3	Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4	Deliver persuasive and professional presentations.
5	Develop creative thinking and interpersonal skills required for effective professional communication.
6	Apply codes of ethical conduct, personal integrity and norms of organizational behaviour.

Module	Contents	Hours
1	**ADVANCED TECHNICAL WRITING: PROJECT/PROBLEM BASED LEARNING (PBL)**	06
	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**		**06**
	Cover Letter & Resume: Parts and Content of a Cover Letter, Differencebetween 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**		**02**
	Conducting Business Meetings: Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquette **Documentation:** Notice, Agenda, Minutes		
4	**TECHNICAL/ BUSINESS PRESENTATIONS**		**02**
	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 thecontents and visuals together, Transition Phases		
5	**INTERPERSONAL SKILLS**		**08**
	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**		**02**
	Intellectual Property Rights: Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits, TradeSecrets (Undisclosed Information) **Case Studies:** Cases related to Business/ Corporate Ethics		

List of assignments: (In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)	
Sr. No.	**Title of Experiment**
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.
Assessment:	
Term Work:	
1	Term work shall consist of minimum 8 experiments.
2	The distribution of marks for term work shall be as follows: Assignment : 10 Marks Attendance : 5 Marks Presentation slides : 5 Marks Book Report (hard copy) : 5 Marks
3	The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.
Internal oral: **Oral Examination will be based on a GD & the Project/Book Report presentation.**	
	Group Discussion : 10 marks Project Presentation : 10 Marks Group Dynamics : 5 Marks
Books Recommended: Textbooks and Reference books	
1	Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2	Bovée, C. L., &Thill, J. V. (2021). *Business communication today*. Upper Saddle River, NJ: Pearson.
3	Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
4	Masters, L. A., Wallace, H. R., & Harwood, L. (2011). *Personal development for life and work*. Mason: South-Western Cengage Learning.
5	Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow, England: Pearson.
6	Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7	Archana Ram (2018) Place Mentor, Tests of Aptitude for Placement Readiness. Oxford University Press
8	Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Course Code	Course Name	Credits
CSM501	**Mini Project 2A**	**02**

	Objectives
1	To understand and identify the problem
2	To apply basic engineering fundamentals and attempt to find solutions to the problems.
3	Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
4	To develop communication skills and improve teamwork amongst group members and inculcate the process of self-learning and research.

	Outcome: Learner will be able to…
1	Identify societal/research/innovation/entrepreneurship problems through appropriate literature surveys
2	Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it
3	Validate, Verify the results using test cases/benchmark data/theoretical/ inferences/experiments/simulations
4	Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development
5	Use standard norms of engineering practices and project management principles during project work
6	Communicate through technical report writing and oral presentation. ● The work may result in research/white paper/ article/blog writing and publication ● The work may result in business plan for entrepreneurship product created ● The work may result in patent filing.
7	Gain technical competency towards participation in Competitions, Hackathons, etc.
8	Demonstrate capabilities of self-learning, leading to lifelong learning.
9	Develop interpersonal skills to work as a member of a group or as leader

	Guidelines for Mini Project
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, statistical data 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 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.

Term Work	
The review/ progress monitoring committee shall be constituted by the heads of departments of each institute. The progress of the mini project to be evaluated on a continuous basis, based on the SRS document submitted. minimum two reviews in each semester.	
In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.	

Distribution of Term work marks for both semesters shall be as below:	**Marks 25**
1	Marks awarded by guide/supervisor based on logbook	10
2	Marks awarded by review committee	10
3	Quality of Project report	05

Review / progress monitoring committee may consider following points for assessment based on either one year or half year project asmentioned in general guidelines

One-year project:

1	In one-year project (sem V and VI), first semester the entire theoretical solution shall be made ready, including components/system selection and cost analysis. Two reviews will be conducted based on a presentation given by a student group. ☐ First shall be for finalization of problem ☐ Second shall be on finalization of proposed solution of problem.
2	In the second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester. ☐ First review is based on readiness of building working prototype to be conducted. ☐ Second review shall be based on poster presentation cum demonstration of working model in the last month of the said semester.

Half-year project:

1	In this case in one semester students' group shall complete project in all aspects including, ☐ Identification of need/problem ☐ Proposed final solution ☐ Procurement of components/systems ☐ Building prototype and testing
2	Two reviews will be conducted for continuous assessment, ☐ First shall be for finalization of problem and proposed solution ☐ Second shall be for implementation and testing of solution.

Mini Project shall be assessed based on following points
1	Clarity of problem and quality of literature Survey for problem identification

2	Requirement Gathering via SRS/ Feasibility Study
3	Completeness of methodology implemented
4	Design, Analysis and Further Plan
5	Novelty, Originality or Innovativeness of project
6	Societal / Research impact
7	Effective use of skill set : Standard engineering practices and Project management standard
8	Contribution of an individual's as member or leader
9	Clarity in written and oral communication
10	Verification and validation of the solution/ Test Cases
11	Full functioning of working model as per stated requirements
12	Technical writing /competition/hackathon outcome being met

In one year project (sem V and VI), first semester evaluation may be based on first 10 criteria and remaining may be used for second semester evaluation of performance of students in mini projects.
In case of half year projects (completing in V sem) all criteria in generic may be considered for evaluation of performance of students in mini projects.

Guidelines for Assessment of Mini Project Practical/Oral Examination:	
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.

Course Code	Course Name	Credit
CSC601	**Data Analytics and Visualization**	**03**

Prerequisite:Basic statistics and Maths, Python programming

Course Objectives: The course aims:

1	To Introduce the concept of Data Analytics Lifecycle.
2	To Develop Mathematical concepts required for advance regression.
3	To Understand data modeling in time series and its process.
4	To create awareness about Text analytics and its applications.
5	To provide overview of Data analytics and visualization with R.
6	To provide overview of Data analytics and visualization with Python.

Course Outcomes: After successful completion of the course students will be able to:

1	Comprehend basics of data analytics and visualization.
2	Apply various regression models on given data set and perform prediction.
3	Demonstrate advance understanding of Time series concepts and analysis of data using various time series models.
4	Analyze Text data and gain insights.
5	Experiment with different analytics techniques and visualization using R.
6	Experiment with different analytics techniques and visualization using Python.

Modu le		Detailed Content	Hours
1		**Introduction to Data analytics and life cycle**	5
	1.1	Data Analytics Lifecycle overview:Key Roles for a Successful Analytics, Background and Overview of Data Analytics Lifecycle Project **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**	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**	7
		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**	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.	
		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**	6
	5.1	Introduction to R: Data Import and Export, Attribute and Data type, Descriptive statistics. Exploratory Data Analysis: Visualization before analysis, DirtyData, visualizing single variable, examining Multiple variable, Data Exploration versus presentation.	
6		**Data analytics and Visualization with Python**	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, Pie chart, Box Plot, violin plot using Matplotlib.	
	6.2	Introduction to seaborn Library, MultiplePlots, Regressionplot, regplot.	
		Total	39

	Textbooks:
1	Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data,EMC Education services Wiley Publication
2	Data Analytics using Python: Bharati Motwani, Wiley Publications.
3	Practical Statistics for Data Scientists 50+ Essential Concepts Using R and Python, O'Reilly Publications 2nd Edition
4	Practical Text Mining and statistical Analysis for non-structured text data applications,1st edition,Grey Miner,Thomas Hill.

	References:
1	Data Mining, Concepts and Techniques: 3rd edition, Jiawei Han, Micheline Kamber and Jian Pei
2	Data Analytics using R, Bharati Motwani, Wiley Publications
3	Python for Data Analysis: 3rd Edition, Wes McKinney ,Publisher(s): O'Reilly Media, Inc.

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

	Useful Links
1	http://varianceexplained.org/RData/
2	https://www.kaggle.com/code/iamleonie/time-series-interpreting-acf-and-pacf
3	https://www.geeksforgeeks.org/data-visualization-using-matplotlib/

Course Code	Course Name	Credit
CSC602	**Cryptographyand System Security**	**03**

Pre-requisite: Basic concepts of OSI Layer

Course Objectives: The course aims:

1	The concepts of classical encryption techniques and concepts of finite fields and number theory.
2	To explore the working principles and utilities of various cryptographic algorithms including secret key cryptography, hashes and message digests, and public key algorithms
3	To explore the design issues and working principles of various authentication protocols, PKI standards.
4	To explore various secure communication standards including Kerberos, IPsec, and SSL/TLS and email.
5	The ability to use existing cryptographic utilities to build programs for secure communication.
6	The concepts of cryptographic utilities and authentication mechanisms to design secure applications

Course Outcomes:

1	Identify information security goals, classical encryption techniques and acquire fundamental knowledge on the concepts of finite fields and number theory.
2	Understand, compare and apply different encryption and decryption techniques to solve problems related to confidentiality and authentication
3	Apply the knowledge of cryptographic checksums and evaluate the performance of different message digest algorithms for verifying the integrity of varying message sizes
4	Apply different digital signature algorithms to achieve authentication and create secure applications .
5	Apply network security basics, analyze different attacks on networks and evaluate the performance of firewalls and security protocols like SSL, IPSec, and PGP
6	Apply the knowledge of cryptographic utilities and authentication mechanisms to design secure applications

Module		Detailed Content	Hours
1		**Introduction & Number Theory**	
	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).	7
2		**Block Ciphers & Public Key Cryptography**	7
	2.1	Data Encryption Standard-Block cipher principles-block cipher modes of operationAdvanced 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**	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**	6
	4.1	Digital signature and authentication protocols : Needham Schroeder Authentication protocol, Digital Signature Schemes – RSA, EI Gamal and Schnorr, DSS.	
5		**System Security**	6
		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**	**6**
	6.1	Web Security Considerations, User Authentication and Session Management, Cookies, SSL, HTTPS, SSH, Web Browser Attacks, WebBugs, Clickjacking, CrossSite Request Forgery, Session Hijacking and Management, Phishing Technique, DNS Attack, Secure Electronic Transaction, Email Attacks, Firewalls, Penetration Testing	

Textbooks:	
1	Computer Security Principles and Practice, William Stallings, Sixth Edition, Pearson Education
2	Security in Computing, Charles P. Pfleeger, Fifth Edition, Pearson Education
3	Network Security and Cryptography, Bernard Menezes, Cengage Learning
4	Network Security Bible, Eric Cole, Second Edition, Wiley
5	Mark Stamp's Information Security Principles and Practice, Wiley

References:	
1	Web Application Hackers Handbook by Wiley.
2	Computer Security, Dieter Gollman, Third Edition, Wiley
3	CCNA Security Study Guide, Tim Boyle, Wiley
4	Introduction to Computer Security, Matt Bishop, Pearson. 5.
5	Cloud Security and Privacy, Tim Mather, Subra Kumaraswamy, Shahed Latif , O'Riely
6	Cryptography and Network Security, Atul Kahate, Tata Mc Graw Hill

Assessment:
Internal Assessment:

	Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted whenapprox. 40% syllabus is completed and second class test when additional40% syllabus is completed.
	Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://nptel.ac.in/courses/106105031
2	https://onlinecourses.nptel.ac.in/noc22_cs03/preview
3	https://www.coursera.org/learn/basic-cryptography-and-crypto-api

Course Code	Course Name	Credit
CSC603	Software Engineering and Project Management	03

Pre-requisite: None

Course Objectives: The course aims:

1	To provide the knowledge of software engineering discipline.
2	To understand Requirements and analyze it
3	To do planning and apply scheduling
4	To apply analysis, and develop software solutions
5	To demonstrate and evaluate real time projects with respect to software engineering principles and Apply testing and assure quality in software solution.
6	To understand need of project management and project management life cycle.

Course Outcomes:

1	Understand and use basic knowledge in software engineering.
2	Identify requirements, analyze and prepare models.
3	Plan, schedule and track the progress of the projects.
4	Design & develop the software solutions for the growth of society
5	Apply testing and assure quality in software solutions
6	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		Detailed Content	Hours
1		Introduction to Software Engineering	
		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	08
2		Requirements Analysis and Cost Estimation	06
	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	07

	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	05
	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	05
	5.1	Testing: Software Quality, Testing: Strategic Approach, Strategic Issues-Testing: Strategies for Conventional Software, Object oriented software, Web AppsValidating 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	08
	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 chartsWBS, Developing the Project Schedule, Network Diagrams (AON, AOA), CPM and PERT, Gantt Chart , Tracking the Schedule, Earned Value Analysis	

Textbooks:	
1	Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill
2	Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India
3	John M. Nicholas, Project Management for Business and Technology, 3rd edition, Pearson Education.
References:	
1	"Software Engineering : A Precise Approach" Pankaj Jalote , Wiley India
2	Ian Sommerville " Software Engineering" 9th edition Pearson Education SBN-13: 978-0- 13-703515-1, ISBN-10: 0-13-703515-2
3	PankajJalote, An integrated approach to Software Engineering, Springer/Narosa.

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when
approx. 40% syllabus is completed and second class test when additional40% syllabus is completed.Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links
1   https://onlinecourses.swayam2.ac.in/cec21_cs21/preview
2   https://nptel.ac.in/courses/106101061
3   http://www.nptelvideos.com/video.php?id=911&c=9 4

Course Code	Course Name	Credit
CSC604	**Machine Learning**	**03**

Pre-requisite: Data Structures, Basic Probability and Statistics, Algorithms

Course Objectives: The course aims:

1	To introduce Machine learning concepts
2	To develop mathematical concepts required for Machine learning algorithms
3	To understand various Regression techniques
4	To understand Clustering techniques
5	To develop Neural Network based learning models

Course Outcomes:
After successful completion of the course students will be able to:

1	Comprehend basics of Machine Learning
2	Build Mathematical foundation for machine learning
3	Understand various Machine learning models
4	Select suitable Machine learning models for a given problem
5	Build Neural Network based models
6	Apply Dimensionality Reduction techniques

Module		Detailed Content	Hours
1		**Introduction to Machine Learning**	6
	1.1	Introduction to Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps of developing a Machine Learning Application.	
		Supervised and Unsupervised Learning: Concepts of Classification, Clustering and prediction, Training, Testing and validation dataset, cross validation, overfitting and underfitting of model	
		Performance Measures: Measuring Quality of model- Confusion Matrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE	
2		**Mathematical Foundation for ML**	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**	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**	4
	4.1	Hebbian Learning rule	

	4.2	Expectation -Maximization algorithm for clustering	
5		**Classification models**	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 of Perceptron.	
	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**	07
	6.1	Curse of Dimensionality.	
	6.2	Feature Selection and Feature Extraction	
	6.3	Dimensionality Reduction Techniques, Principal Component Analysis.	

Textbooks:	
1	Nathalie Japkowicz & Mohak Shah, "Evaluating Learning Algorithms: A Classification Perspective", Cambridge.
2	Marc Peter Deisenroth, Aldo Faisal, Cheng Soon Ong, "Mathematics for machine learning",
3	Samir Roy and Chakraborty, "Introduction to soft computing", Pearson Edition.
4	Ethem Alpaydın, "Introduction to Machine Learning", MIT Press McGraw-Hill Higher Education
5	Peter Flach, "Machine Learning", Cambridge University Press

References:	
1	Tom M. Mitchell, "Machine Learning", McGraw Hill
2	Kevin P. Murphy, "Machine Learning ― A Probabilistic Perspective", MIT Press
3	Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press
4	Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", Cambridge University Press
5	Peter Harrington, "Machine Learning in Action", DreamTech Press

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful links:

1	NPTEL
2	AI and ML Certification - Enroll in PGP AI ML Courses with Purdue (simplilearn.com)
3	https://www.learndatasci.com/out/coursera-machine-learning/
4	https://www.learndatasci.com/out/google-machine-learning-crash-course/

CourseCode	Course Name	Credit
CSDLO6011	High PerformanceComputing	03

Course Objectives: Students will try to:

1. Learn the concepts of high-performance computing.
2. Gain knowledge of platforms for high performance computing.
3. Design and implement algorithms for parallel programming applications.
4. Analyze the performance metrics of High Performance Computing.
5. Understand the parallel programming paradigm, algorithms and applications.
6. Demonstrate the understanding of different High Performance Computing tools.

Course Outcomes: Students will be able to:

1. Understand the fundamentals of parallel Computing.
2. Describe different parallel processing platforms involved in achieving High PerformanceComputing.
3. Demonstrate the principles of Parallel Algorithms and their execution.
4. Evaluate the performance of HPC systems.
5. Apply HPC programming paradigm to parallel applications
6. Discuss different current HPC Platforms.

Prerequisite: Computer Organization, C Programming, Data structures and Algorithm Analysis.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours
0	Prerequisite	Computer Organization, C Programming, Data structures andAlgorithm Analysis.	**02**
I	Introduction	**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-drivenComputation). **Self-learning Topics:** Parallel Architectures: Interconnectionnetwork, Processor Array, Multiprocessor.	**05**

II	Parallel Programming Platforms	**Parallel Programming Platforms:** Implicit Parallelism:Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs inParallel Machines. **Self-learning Topics:** Trends in Microprocessor & Architectures,Limitations of Memory System Performance.	**04**
III	Parallel Algorithm And Concurrency	**Principles of Parallel Algorithm Design:** Preliminaries,Decomposition Techniques, Characteristics of Tasks andInteractions, Mapping Techniques for Load Balancing, Basic Communication operations: Broadcast and ReductionCommunication types. **Self-learning Topics: Parallel Algorithm Models**	**09**
IV	Performance Measures for HPC	**Performance Measures :** Speedup, execution time, efficiency,cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl's Law, Gustavson's Law. **Self-learning Topics:** Performance Bottlenecks.	**05**
V	Programming Paradigms for HPC	**Programming Using the Message-Passing Paradigm :** Principles of Message Passing Programming, The BuildingBlocks: Send and Receive Operations, MPI: the Message Passing Interface, Topology and Embedding. **Parallel Algorithms and Applications :**	**09**
		One-Dimensional Matrix-Vector Multiplication, Graph Algorithms, Sample Sort, Two-Dimensional MatrixVectorMultiplication. **Self-learning Topics:** Introduction to OpenMP.	
VI	General Purpose Graphics Processing Unit(GPGPU) Architecture and Programming	OpenCL Device Architectures, Introduction to OpenCL Programming. **Self-learning Topics:** Introduction to CUDA architecture, andIntroduction to CUDA Programming.	**05**

Text Books:

1. AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar , "Introduction to Parallel Computing", Pearson Education, Second Edition, 2007.

2. Kai Hwang, Naresh Jotwani, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", McGraw Hill, Second Edition, 2010.

3. Edward Kandrot and Jason Sanders, "CUDA by Example – An Introduction to General Purpose GPU Programming", Addison-Wesley Professional ©, 2010.

4. Georg Hager, Gerhard Wellein, "Introduction to High Performance Computing for Scientists and Engineers", Chapman & Hall / CRC Computational Science series, 2011.

5. Benedict Gaster, Lee Howes, David Kaeli, Perhaad Mistry, Dana Schaa , "Heterogeneous Computing with OpenCL" , 2nd Edition, Elsevier, 2012.

Reference Books:

1. Michael J. Quinn, "Parallel Programming in C with MPI and OpenMP", McGraw-Hill International Editions, Computer Science Series, 2008.

2. Kai Hwang, Zhiwei Xu, "Scalable Parallel Computing: Technology, Architecture, Programming", McGraw Hill, 1998.

3. Laurence T. Yang, MinyiGuo, "High- Performance Computing: Paradigm and Infrastructure" Wiley, 2006.

4. Fayez Gebali, "Algorithms and Parallel Computing", John Wiley & Sons, Inc., 2011.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc21_cs46/preview
2.	https://onlinecourses.nptel.ac.in/noc22_cs21/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

End Semester Examination: Some guidelines for setting the question papers are as:

- Weightage of each module in end semester examination is expected to be/will be proportional to number of respective lecture hours mentioned in the syllabus.
- **Question paper format**
- Question Paper will comprise of a total of **six questions each carrying 20 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

- **Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM601: Mini-Project.**

Course Code	Course Name	Credit
CSDLO6012	**Distributed Computing**	**03**

Pre-requisite: C Programming	

Course Objectives: The course aims:

1	To provide students with contemporary knowledge in distributed systems
2	To equip students with skills to analyze and design distributed applications.
3	To provide master skills to measure the performance of distributed synchronization algorithms
4	To equip students with skills to availability of resources
5	To provide master skills to distributed file system

Course Outcomes:

1	Demonstrate knowledge of the basic elements and concepts related to distributed system technologies.
2	Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object based middleware.
3	Analyze the various techniques used for clock synchronization and mutual exclusion
4	Demonstrate the concepts of Resource and Process management and synchronization algorithms
5	Demonstrate the concepts of Consistency and Replication Management
6	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		Detailed Content	Hours
1		**Introduction to Distributed Systems**	
	1.1	Characterization of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models, Hardware concepts, Software Concept.	06
	1.2	Middleware: Models of Middleware, Services offered by middleware, Client Server model.	
2		**Communication**	06
	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**	09
	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**	06
	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**	06
	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**	06
	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	

Textbooks:	
1	Andrew S. Tanenbaum and Maarten Van Steen, "Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education.
2	George Coulouris, Jean Dollimore, Tim Kindberg, , "Distributed Systems: Concepts and Design", 4th Edition, Pearson Education, 2005.
References:	
1	A. S. Tanenbaum and M. V. Steen, "Distributed Systems: Principles and Paradigms", Second Edition, Prentice Hall, 2006.
2	M. L. Liu, "Distributed Computing Principles and Applications", Pearson Addison Wesley, 2004.
3	Learn to Master Distributed Computing by ScriptDemics, StarEdu Solutions

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_cs87/
2	https://nptel.ac.in/courses/106106168

* Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM601: Mini-Project.

Course Code:	Course Title	Credit
CSDLO6013	**Image and Video Processing**	**3**

Prerequisite: Engineering Mathematics, Algorithms	
Course Objectives:	
1	To introduce students to the basic concepts of image processing, file formats.
2	To acquire an in-depth understanding of image enhancement technqiues.
3	To gain knowledge of image segmentation and compression techniques.
4	To acquire fundamentals of image transform techniques.
Course Outcomes	
1	To gain fundamental knowledge of Image processing.
2	To apply image enhancement techniques.
3	To apply image segmentation and compression techniques.
4	To gain an in-depth understanding of image transforms.
5	To gain fundamental understanding of video processing.

Module		Content	Hrs
1		**Digital Image Fundamentals**	**04**
	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**	**08**
	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**	**06**
	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**	**09**
	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**	**08**
	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**	**04**
	6.1	Introduction to Digital Video Processing, Sampled Video	
	6.2	Composite and Component Video, Digital video formats and applications	
		Total	**39**

Textbooks:	
1	Rafael C. Gonzalez and Richard E. Woods, 'Digital Image Processing', Pearson Education Asia, Third Edition, 2009
2	S. Jayaraman, E. Esakkirajan and T. Veerkumar, "Digital Image Processing" TataMcGraw Hill Education Private Ltd, 2009
3	Anil K. Jain, "Fundamentals and Digital Image Processing", Prentice Hall of India Private Ltd, Third Edition
4	S. Sridhar, "Digital Image Processing", Oxford University Press, Second Edition, 2012.
5.	Alan C. Bovik, "The Essential Guide To Video Processing" Academic Press,
6	Yao Wang, Jorn Ostermann, Ya-Qin Zang, "Video Processing and Communications", Prentice Hall, Signal Processing series.

References Books	
1.	David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", Pearson Education, Limited, 2011
2.	Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", Prentice Hall of India Private Ltd, Third Edition
3	B. Chandra and D. Dutta Majumder, "Digital Image Processing and Analysis", Prentice Hall of India Private Ltd, 2011
4	Khalid Sayood, "Introduction to Data Compression", Third Edition , Morgan Kaufman MK Publication

Assessment:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and the second class test when an additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks.
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4	Only Four questions need to be solved.
5	In question, paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Useful Links	
1	https://swayam.gov.in
2	https://nptel.ac.in/courses
3	https://www.coursera.org

* Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM601: Mini-Project.

Lab Code	Lab Name	Credit
CSL601	**Data Analytics and Visualization Lab**	**1**

Prerequisite: Basic Python
Lab Objectives:

1	To effectively use libraries for data analytics.
2	To understand the use of regression Techniques in data analytics applications.
3	To use time series models for prediction.
4	To introduce the concept of text analytics and its applications.
5	To apply suitable visualization techniques using R and Python.

Lab Outcomes:
At the end of the course, students will be able to —-

1	Explore various data analytics Libraries in R and Python.
2	Implement various Regression techniques for prediction.
3	Build various time series models on a given data set.
4	Design Text Analytics Application on a given data set.
5	Implement visualization techniques to given data sets using R .
6	Implement visualization techniques to given data sets using Python.

Suggested Experiments: Students are required to complete at least 08 experiments
Preferably using **R Programming Language/Python**

Sr. No.	Name of the Experiment
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.

Useful Links:

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/
5	https://towardsdatascience.com/introduction-to-arima-for-time-series-forecasting-

References:

1	Data Analytics using R, Bharati Motwani, Wiley Publications
2	Python for Data Analysis: 3rd Edition, WesMcKinney, Publisher(s): O'Reilly Media, Inc.

3	Better Data Visualizations A Guide for Scholars, Researchers, and Wonks, Jonathan Schwabish, Columbia University Press

Term Work:	
1	Term work should consist of 08 experiments.
2	Journal must include at least 2 assignments based on Theory and Practicals
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus

Lab Code	Lab Name	Credit
CSL602	**Cryptographic and system security Lab**	1

Prerequisite: Operating System, Basics of Java and Python Programming.
Lab Objectives:

1	To be able to apply the knowledge of symmetric cryptography to implement simple ciphers
2	To be able to analyze and implement public key algorithms like RSA and El Gamal
3	To analyze and evaluate performance of hashing algorithms
4	To explore the different network reconnaissance tools to gather information about networks .

Lab Outcomes:	
1	Apply the knowledge of symmetric cryptography to implement simple ciphers
2	Analyze and implement public key algorithms like RSA and El Gamal
3	Analyze and evaluate performance of hashing algorithms
4	Explore the different network reconnaissance tools to gather information about networks
5	Use tools like sniffers, port scanners and other related tools for analyzing packets in a network.
6	Apply and set up firewalls and intrusion detection systems using open source technologies and to explore email security.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	Design and Implementation of a product cipher using Substitution and Transposition ciphers.
2*	Implementation and analysis of RSA cryptosystem and Digital signature scheme using 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, nslookup 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 vulnerabilities

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.

Useful Links:

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

Term Work:

1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral & Practical exam

	Based on the entire syllabus of CSL602and CSC602

Lab Code	Lab Name	Credit
CSL603	**Software Engineering andProject Management Lab**	1

Prerequisite: Knowledge of Linux Operating system, installation and configuration of services and command line basics, Basics of Computer Networks and Software Development Life cycle.
Lab Objectives:

1	To understand DevOps practices which aims to simplify Software Development Life Cycle.
2	To be aware of different Version Control tools like GIT, CVS or Mercurial
3	To Integrate and deploy tools like Jenkins and Maven, which is used to build, test and deploy applications in DevOps environment
4	To understand the importance of Jenkins to Build and deploy Software Applications on server environment
5	To use Docker to Build, ship and manage applications using containerization
6	To understand the concept of Infrastructure as a code and install and configure Ansible tool

Lab Outcomes:

1	To understand the fundamentals of DevOps engineering and be fully proficient with DevOps terminologies, concepts, benefits, and deployment options to meet your business requirements
2	To obtain complete knowledge of the "version control system" to effectively track changes augmented with Git and GitHub
3	Understand the importance of Selenium and Jenkins to test Software Applications
4	To understand the importance of Jenkins to Build and deploy Software Applications on server environment
5	To understand concept of containerization and Analyze the Containerization of OS images and deployment of applications over Dockerk.
6	To Synthesize software configuration and provisioning using Ansible.

Suggested Experiments: Students are required to complete at least 10 experiments from the list given below.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
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.

Useful Links:	
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

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL603 and CSC603

Lab Code	Lab Name	Credit
CSL604	**Machine LearningLab**	1

Prerequisite: C Programming Language.
Lab Objectives:
1	To introduce platforms such as Anaconda, COLAB suitable to Machine learning
2	To implement various Regression techniques
3	To develop Neural Network based learning models
4	To implement Clustering techniques
Lab Outcomes:
After successful completion of the course students will be able to:
1	Implement various Machine learning models
2	Apply suitable Machine learning models for a given problem
3	Implement Neural Network based models
4	Apply Dimensionality Reduction techniques

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

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

4	https://www.learndatasci.com/out/edx-columbia-machine-learning/

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL604and CSC604

Lab Code	Lab Name	Credit
CSL605	**Skill Based Lab course : Cloud Computing**	**2**

Prerequisite: Computer Networks	
Lab Objectives:	
1	To make students familiar with key concepts of virtualization.
2	To make students familiar with various deployment models of cloud such as private, public, hybrid and community so that they start using and adopting appropriate types of cloud for their application.
3	To make students familiar with various service models such as IaaS, SaaS, PaaS, Security as a Service (SECaaS) and Database as a Service.
4	To make students familiar with security and privacy issues in cloud computing and how to address them.
Lab Outcomes:	
1	Implement different types of virtualization techniques.
2	Analyze various cloud computing service models and implement them to solve the given problems.
3	Design and develop real world web applications and deploy them on commercial cloud(s).
4	Explain major security issues in the cloud and mechanisms to address them.
5	Explore various commercially available cloud services and recommend the appropriate one for the given application.
6	Implement the concept of containerization

Theory :

Module	Detailed Contents	Hours
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

Lab: (Teachers are requested to complete above theory before staring lab work)

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.	4
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.	4
3	To study and Implement Storage as a Service using Own Cloud/ AWS S3, Glaciers/ Azure Storage.	2
4	To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase.	2
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.	3

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.	2
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.	4
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,	2
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.]	4

Suggested Experiments: Students are required to complete the above experiments.	
Sr. No.	**Assignment**
1	Assignment based on selection of suitable cloud platform solution based on requirement analysis considering given problem statement
2	Assignment on recent trends in cloud computing and related technologies
3	Assignment on comparative study of different computing technologies [Parallel, Distributed, Cluster, Grid, Quantum)
4	Comparative study of different hosted and bare metal Hypervisors with suitable parameters along with their use in public/private cloud platform
5	Assignment on explore and compare the similar type of services provided by AWS and Azure [Any ten services]

Useful Links:	
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/

Term Work:	
1	Term work should consist of 10 experiments and mini project.
2	Journal must include at least 3 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
	Oral examination will be based on Laboratory work, mini project and above syllabus

Course code	Course Name	Credits
CSM601	**Mini Project 2B**	**02**

	Objectives
1	To understand and identify the problem
2	To apply basic engineering fundamentals and attempt to find solutions to the problems.
3	Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
4	To develop communication skills and improve teamwork amongst group members and inculcate the process of self-learning and research.

	Outcome: Learner will be able to…
1	Identify societal/research/innovation/entrepreneurship problems through appropriate literature surveys
2	Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it
3	Validate, Verify the results using test cases/benchmark data/theoretical/ inferences/experiments/simulations
4	Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development
5	Use standard norms of engineering practices and project management principles during project work
6	Communicate through technical report writing and oral presentation. ● The work may result in research/white paper/ article/blog writing and publication ● The work may result in business plan for entrepreneurship product created ● The work may result in patent filing.
7	Gain technical competency towards participation in Competitions, Hackathons, etc.
8	Demonstrate capabilities of self-learning, leading to lifelong learning.
9	Develop interpersonal skills to work as a member of a group or as leader

	Guidelines for Mini Project
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, statistical data 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/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 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.

Term Work

The review/ progress monitoring committee shall be constituted by the heads of departments of each institute. The progress of the mini project to be evaluated on a continuous basis, based on the SRS document submitted. minimum two reviews in each semester.

In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Distribution of Term work marks for both semesters shall be as below:	Marks 25
1	Marks awarded by guide/supervisor based on logbook	10
2	Marks awarded by review committee	10
3	Quality of Project report	05

Review / progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines

One-year project:

1	In the first semester the entire theoretical solution shall be made ready, including components/system selection and cost analysis. Two reviews will be conducted based on a presentation given by a student group. ☐ First shall be for finalization of problem ☐ Second shall be on finalization of proposed solution of problem.
2	In the second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester. ☐ First review is based on readiness of building working prototype to be conducted. ☐ Second review shall be based on poster presentation cum demonstration of working model in the last month of the said semester.

Half-year project:

1	In this case in one semester students' group shall complete project in all aspects including, ☐ Identification of need/problem ☐ Proposed final solution ☐ Procurement of components/systems ☐ Building prototype and testing
2	Two reviews will be conducted for continuous assessment, ☐ First shall be for finalization of problem and proposed solution ☐ Second shall be for implementation and testing of solution.

Mini Project shall be assessed based on following points

1	Clarity of problem and quality of literature Survey for problem identification
2	Requirement gathering via SRS/ Feasibility Study
3	Completeness of methodology implemented

4	Design, Analysis and Further Plan
5	Novelty, Originality or Innovativeness of project
6	Societal / Research impact
7	Effective use of skill set : Standard engineering practices and Project management standard
8	Contribution of an individual's as member or leader
9	Clarity in written and oral communication
10	**Verification and validation of the solution/ Test Cases**
11	**Full functioning of working model as per stated requirements**
12	**Technical writing /competition/hackathon outcome being met**

In one year project (sem V and VI), first semester evaluation may be based on first 10 criteria and remaining may be used for second semester evaluation of performance of students in mini projects.

In case of half year projects (completing in VI sem) all criteria's in generic may be considered for evaluation of performance of students in mini projects.

Guidelines for Assessment of Mini Project Practical/Oral Examination:	
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.