NEW HORIZON
COLLEGE OF ENGINEERING

Department of Computer Science and Engineering (Data Science)

Academic Year 2025-26

7th and 8th Semester

Scheme and Syllabus

BATCH: 2022-26

CREDITS: 160

NEW HORIZON COLLEGE OF ENGINEERING

VISION

To emerge as an institute of eminence in the fields of engineering, technology and management in serving the industry and the nation by empowering studentswith a high degree of technical, managerial and practical competence.

MISSION

- To strengthen the theoretical, practical and ethical dimensions of the learning process by fostering a culture of research and innovation among faculty members and students.
- To encourage long-term interaction between the academia and industry through their involvement in the design of curriculum and its hands-on implementation.
- To strengthen and mould students in professional, ethical, social and environmental dimensions by encouraging participation in co-curricular and extracurricular activities

QUALITY POLICY

To provide educational services of the highest quality both curricular and co-curricular to enable students integrate skills and serve the industry and society equally well at global level.

VALUES

- Academic Freedom
- Integrity
- Inclusiveness
- Innovation
- Professionalism
- Social Responsibility

DEPARTMENT OF COMPUTER SCIENCE ANDENGINEERING
(DATA SCIENCE)

PROGRAM OUTCOMES (POs)

PO1 Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and computer science and business systems to the solution of complex engineering and societal problems.

PO2 Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering and business problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design / Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO4 Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering and business practices.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in business societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering and business practices.

PO9 Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings..

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend

and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project Management and Finance: Demonstrate knowledge and understanding of the engineering, business and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-Long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	Apply Computer Science and Data Science principles, practices, and mechanisms to produce sustainable products and use knowledge in various domains to identify research gaps and hence provide solution to new ideas and innovations.
PSO2	Collaborate proficiently with experts from diverse fields and actively engage in continuous professional growth in the domain of computing.

NEW HORIZON COLLEGE OF ENGINEERING

B. E. in Computer Science and Engineering (Data Science)

Scheme of Teaching and Examinations for 2022- 2026 BATCH (2022 Scheme)

VII Semester

S. No.	Course and Course Code		Course Title	BoS	Credit Distribution				Overall Credits	Contact Hours	Marks		
					L	T	P	S			CIE	SEE	Total
1	PCC	22CDS71	Full Stack Development	DS	3	0	0	0	3	3	50	50	**100**
2	PCCL	22CDL71	Full Stack Development Lab	DS	0	0	1	0	1	2	50	50	**100**
3	PCC	22CDS72	Statistical Machine Learning for Data Science	DS	3	0	0	0	3	3	50	50	**100**
4	PCCL	22CDL72	Statistical Machine Learning for Data Science Lab	DS	0	0	1	0	1	2	50	50	**100**
5	PCC	22CDS73	Cryptography and Network Security	DS	3	0	0	0	3	3	50	50	**100**
6	PROJ	22CDS74	Project Phase - II	DS	0	0	10	0	10	20	100	100	**200**
7	OEC	23NHOP7XX	Industrial Open Elective Course-II	Offering Dept.	3	0	0	0	3	3	50	50	**100**
								Total	**24**	**36**	**400**	**400**	**800**

PCC: Professional Core Course, **PCCL**: Professional Core Course laboratory, **PEC**: Professional Elective Course, **OEC**: Open Elective Course, **PROJ**: Project work**, L:** Lecture, **T**: Tutorial, **P**: Practical **S: SDA**: Self Study for Skill Development, C**IE**: Continuous Internal Evaluation, **SEE**:Semester End Evaluation.

Industrial Open Elective Courses-II:

Credit for OEC is 03 (L: T: P: S) can be considered as (3: 0: 0 : 0). The teaching and learning of these Courses will be based on hands-on. The Course Assessment will be based on CIE and SEE in practical mode. This Courses will be offered by Centre of Excellence to students of all the branches. Registration to Industrial open electives shall be documented and monitored on college level.

Project Phase-II:

The objective of the Project work is

(i) To encourage independent learning and the innovative attitude of the students.

(ii) To develop interactive attitude, communication skills, organization, time management, and presentation skills.

(iii) To impart flexibility and adaptability.

(iv) To inspire team working.

(v) To expand intellectual capacity, credibility, judgment and intuition.

(vi) To adhere to punctuality, setting and meeting deadlines.

(vii) To install responsibilities to oneself and others.

(viii) To train students to present the topic of project work in a seminar without any fear, face the audience confidently, enhance communication skills, involve in group discussion to present and exchange ideas.

CIE procedure for Project Work:

(1) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work, shall be based on the evaluation of the project work Report, project presentation skill, and question and answer session in the percentage ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(2)Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the percentage ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

SEE procedure for Project Work: SEE for project work will be conducted by the two examiners appointed by the University. The SEE marks awarded for the project work shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the percentage ratio of 50:25:25.

Credit Definition: 1-hour Lecture (L) per week=1Credit 2-hoursTutorial(T) per week=1Credit 2-hours Practical / Drawing (P) per week=1Credit 2-hous Self Study for Skill Development (SDA) per week = 1 Credit	03-Credits courses are to be designed for 40 hours in Teaching-Learning Session 02- Credits courses are to be designed for 25 hours of Teaching-Learning Session 01-Credit courses are to be designed for 15 hours of Teaching-Learning Sessions

NEW HORIZON COLLEGE OF ENGINEERING

B. E. in Computer Science and Engineering (Data Science)

Scheme of Teaching and Examinations for 2022- 2026 BATCH (2022 Scheme)

VIII Semester

S. No.	Course and Course Code		Course Title	BoS	Credit Distribution				Overall Credits	Contact Hours	Marks		
					L	T	P	S			CIE	SEE	Total
1	PEC	22CDS81X	Professional Elective Courses -III	DS	3	0	0	0	3	3	50	50	**100**
2	PEC	22CDS82X	Professional Elective Courses -IV	DS	3	0	0	0	3	3	50	50	**100**
3	INT	22CDS83	Internship	DS	0	0	10	0	10	20	100	100	**200**
Total									**16**	**26**	**200**	**200**	**400**

PEC: Professional Elective Course, **L:** Lecture, **T**: Tutorial, **P**: Practical **S: SDA**: Self Study for Skill Development, **INT**: Industry Internship / Research Internship / Rural Internship, **CIE**: Continuous Internal Evaluation, **SEE**:Semester End Evaluation.

Professional Elective Course-III			
22CDS811	Natural Language Processing	22CDS814	Prompt Engineering
22CDS812	Social Network Analysis	22CDS815	Introduction to Augmented Reality and Virtual Reality
22CDS813	Recommender Systems		

Professional Elective Course-IV			
22CDS821	Green IT and Sustainability	22CDS824	Introduction to Blockchain Technologies
22CDS822	User Interface Design	22CDS825	Deep Learning
22CDS823	High Performance Computing		

Elucidation:

At the beginning of IV years of the program i.e., after VI semester, VII semester classwork and VIII semester Internship shall be permitted to be operated simultaneously by the University so that students have ample opportunity for an internship. In other words, a good percentage of the class shall attend VII semester classwork and a similar percentage of others shall attend to Internship.

Internship: The mandatory Internship is for **14 to 20 weeks**. The internship shall be considered as a head of passing and shall be considered for the award of a degree. Those, who do not take up/complete the internship shall be declared to fail and shall have to complete it during the subsequent SEE examination after satisfying the internship requirements. If the students are opting for the 8th semester, the following internship options are available:

- Industry Internship
- Research Internship
- Skill Enhancement Courses
- Post-Placement Training as Internship
- Online Internship

Industry internship: It is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints. Students undertaking industry internships must ensure the organization is listed on the VTU Internship Portal. If not, request the organization to register on the portal.

Research internship: A research internship is intended to offer the flavor of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research. Research internships must be carried out in recognized research centers. Ensure that these centers are registered on the portal.

Skill Enhancement Courses: Students can take Skill-based courses with credits totalling the same as those of the internship. Students must be taken from registered providers listed on the VTU Internship Portal.

Post-Placement Training as Internship: The post-placement training is also considered an internship. For students placed during their 6th/7th semester and willing to take the training during their final year, colleges must inform the recruiting companies in advance to register on the VTU Internship Portal.

Online Internship: Reputed online internship platforms, including those identified by NSDC, are already listed on the VTU Internship portal. If colleges come across other eligible organizations not yet listed, they are informed to ask the organization to register on the VTU Internship portal.

The faculty coordinator or mentor has to monitor the student's internship progress and interact with them to guide for the successful completion of the internship. The students are permitted to carry out the internship anywhere in India or abroad. University shall not bear any expenses incurred in respect of the internship. With the consent of the internal guide and Principal of the Institution, students shall be allowed to carry out the internship at their hometown (within or outside the state or abroad), provided favorable facilities are available for the internship and the student remains regularly in contact with the internal guide.

Credit Definition:	03-Credits courses are to be designed for 40 hours in Teaching-Learning Session
1-hour Lecture (L) per week=1 Credit	02- Credits courses are to be designed for 25 hours of Teaching-Learning Session
2-hoursTutorial(T) per week=1 Credit	01-Credit courses are to be designed for 15 hours of Teaching-Learning

2-hours Practical / Drawing (P) per week=1 Credit 2-hous Self Study for Skill Development (SDA) per week = 1 Credit	Sessions

VII

Semester

FULL STACK DEVELOPMENT

Course Code	**22CDS71**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS71.1	Understand the basic full stack principles and modern JavaScript and their practical applications
22CDS71.2	Illustrate the architecture of Node.js and Express.js in the context of dynamic web-based applications.
22CDS71.3	Apply the principles of MongoDB to facilitate effective client/server communication.
22CDS71.4	Analyze the concepts of connecting Node.js with MongoDB for efficient client/server communication.
22CDS71.5	Identify the fundamentals of Angular framework for dynamic frontend development
22CDS71.6	Evaluate the role of React in constructing enterprise software solutions.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS71.1	3	2	2	-	-	-	-	-	-	-	-	1	3	3
22CDS71.2	2	-	3	-	2	-	-	-	-	-	-	2	3	3
22CDS71.3	2	-	2	-	3	-	-	-	-	-	-	1	3	3
22CDS71.4	3	-	2	-	3	-	-	-	-	-	-	2	3	3
22CDS71.5	3	-	2	-	-	-	-	-	-	-	-	1	3	3
22CDS71.6	2	-	3	2	2	-	-	-	-	-	-	2	3	3

MODULE-1	**Foundations of Full Stack Development**	**22CDS71.1**	**8 Hours**

Overview of the Full Stack Architecture: User, Browser, Web Browser, Backend Services and APIs, MVC, Overview of popular Tech Stacks, Collaborating with Git, JavaScript Fundamentals and Modern JavaScript: DOM manipulation, Forms, Array methods, Events, Fetch and Callbacks, ES6 features, Introduction to promises and Asynchronous Programming, JSON & Data Handling.

Case Study	1. Analyse how Netflix or LinkedIn uses the MERN Stack 2. Design a JSON-based Data Viewer using fetch() and Promises(without backend)
Text Book	Textbook 1: 1.1,1.2

MODULE-2	**Server-side Development with Node.js and Express.js**	**22CDS71.2**	**8 Hours**

Introduction to Node, Browser Vs Server, V8 Engine, Built-In Modules, Module Exports, Creating a Node Server, JSON response, Postman for API testing, HTTP Routing, Web Framework, Node.js Runtime, npm, Introduction to Express.js, Understanding RESTful APIs, API Vs SSR, JSON Basics, Params, Query String, Middleware, HTTP Methods-GET,POST,PUT,DELETE, Express Router, Session and Cookies, Authentication using JWT, dotenv, CORS.

Case Study	1 1. Analyzing a Real-Time Weather Data API Service 2. Compare apps that uses sessions vs those that uses JWT(modern SPAs)
Text Book	Textbook 1: 2.3,2.4,2.5,2.6,2.7,4.18,4.19

MODULE-3	**NoSQL with MongoDB**	**22CDS71.3, 22CDS71.4**	**8 Hours**

Introduction to NoSQL and MongoDB, MongoDB Basics- Collection, Documents, JSON & BSON, Basic CRUD operations, Querying and Filtering, Connecting MongoDB with Node.js(Mongoose), Aggregation Framework Basics, MongoDB Atlas and Compass.

Applications	1.Online Library Management System using MongoDB 2. Design a schema for an E-Commerce platform
Text Book	Textbook 1: 3.11,3.12,3.13,3.14,3.15,3.16

MODULE-4	Frontend Development with Angular	22CDS71.5	8 Hours
Introduction to Angular and SPAs, Typescript Basics, Components & Data Binding, Directives, Services & Dependency Injection, Routing and Navigation, Forms in Angular: template-driven and reactive forms, HTTP Client and API Integration, Pipes, Component Communication- Event Emitter, Parent-Child Data sharing, Lifecycle Hooks, Observables and RxJS Basics,			
Case Study	1. Learn about Angular Material (for UI component) 2.Student Registration Portal using Angular		
Text Book	Textbook 1: 5.20,5.21,5.22,5.23,5.24,5.25,5.28		
MODULE-5	**Frontend Development with React**	**22CDS71.6**	**8 Hours**
React Vs Angular, JSX and Components, State and Events, Component Communication, Forms in React, useEffect and Lifecycle, React Router, HTTP Requests and API Integration, Conditional and Dynamic Rendering, Introduction to Redux.			
Applications	1. Job Listings Portal using React 3. Create a contact form with validation using React		
Text Book	Textbook 2 : 3.1,4.1,5.1,5.2,8.1		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	10	5	5
L4	Analyze	5	5	5
L5	Evaluate	-	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	15
L4	Analyze	15
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Text Books:

1)Brad Dayley, Brendan Dayley, Caleb Dayley – "Node.js, MongoDB and Angular Web Development", Publisher: Addison-Wesley, ISBN-13: 978-13-465553-6, ISBN-10: 0-13-465553-2

2) Vasan Subramanian, 'Pro MERN Stack, Full Stack Web App Development with Mongo, Express, React, and Node', Second Edition, Apress, 2019.

Reference Books:

1) Chris Northwood, 'The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer', Apress; 1st edition, 2018

2) Kirupa Chinnathambi, 'Learning React: A Hands-On Guide to Building Web Applications Using React and Redux', Addison-Wesley Professional, 2nd edition, 2018.

https://developer.mozilla.org/en-US/docs/Learn_web_development**Web links and Video Lectures (e-Resources):**

- https://www.tutorialspoint.com/the_full_stack_web_development/index.asp
- https://www.udemy.com/course/the-full-stack-web-development
- https://www.coursera.org/specializations/full-stack-react
- https://www.fullstackpathway.com/

- https://www.youtube.com/watch?v=pN6jk0uUrD8&list=PLlasXeu85E9cQ32gLCvAvr9vNaUccPVNP
- https://developer.mozilla.org/en-US/docs/Learn_web_development

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Live demonstration activities like Backend API creation using express.js
- Demonstration of Angular and React Component Lifecycle
- Video demonstration of latest trends in Full Stack Development – Microservices/SPAs/ChatGPT
- Contents related activities (Activity-based discussions)
  - For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - Organizing Group wise discussions
  - Seminars

FULL STACK DEVELOPMENT LAB

Course Code	**22CDL71**	**CIE Marks**	**50**
L:T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs / Week	**2**	**Total Marks**	**100**
Credits	**01**	**Exam Hours**	**03**

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

22CDL71.1	Apply JavaScript and version control effectively in client-side programming.
22CDL71.2	Develop RESTful APIs using Node.js and Express.js with MongoDB integration.
22CDL71.3	Design and integrate frontend components using Angular and React with backend APIs.
22CDL71.4	Build full stack applications integrating frontend and backend technologies.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDL71.1	3	**-**	**2**	**-**	**-**	-	-	-	1	1	-	2	3	3
22CDL71.2	2	**-**	3	**-**	2	-	-	-	1	1	-	2	3	3
22CDL71.3	**2**	**-**	3	**-**	**3**	-	-	-	1	1	-	2	3	3
22CDL71.4	2	**-**	3	**-**	2	-	-	-	1	1	-	2	3	3

Exp. No. / Pgm. No.	**List of Experiments / Programs**	**Hours**	**COs**
	Prerequisite Experiments / Programs / Demo		
	1.Web Design Technologies	2	NA
	PART-A		
1	Create a Student Admission Form using JavaScript DOM manipulation and validation; Initialize Git for version control.	2	22CDL71.1
2	Build a Weather Info Viewer using Fetch API and Promises (OpenWeatherMap API); manage Git commits and pushes.	2	22CDL71.1
3	Develop a portfolio website for yourself by downloading a responsive template which gives details about yourself.	2	22CDL71.1
4	Develop a basic Node.js server using the built-in http module to serve a JSON response. Extend it using Express.js to build a full REST API for product management. Use Postman for testing all endpoints.	2	22CDL71.2
5	Develop a Contact Manager Backend Application using Node.js, Express.js and MongoDB. Use JWT for authentication	2	22CDL71.2
6	Develop a CRUD-based dashboard for project management. Users can Create, Read, Update, and Delete tasks, and update their status (Pending, In Progress, Completed). Use MongoDB to store tasks and Node.js with Express to build the API.	2	22CDL71.2
	PART-B		
7	Design a Student Registration Form in Angular with validation (template-driven and reactive)	2	22CDL71.3
8	Create a Movie Review System using Angular. Users can login to home page and add new movie reviews, rate movies, and view existing reviews. Demonstrate routing, two-way binding, services, form validation, and component communication.	2	22CDL71.3
9	Build a To-do List Application using React with state and props	2	22CDL71.3
10	Create a Login and signup form in React	2	22CDL71.3
11	Build a Task Manager Application using MongoDB, Express.js, Angular, Node.js (MEAN)	2	22CDL71.4
12	Build an online Book Store project using MongoDB, Express.js, React, Node.js(MERN)	2	22CDL71.4

PART-C

Beyond Syllabus Virtual Lab Content

(To be done during Lab but not to be included for CIE or SEE)

1. Create a portfolio gallery using HTML, CSS, JAVASCRIPT
2. Design a chat interface using Angular.
3. Create an admin dashboard using React and Chart.js
4. Build an E-commerce website using MEAN/MERN

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	-	
L3	Apply	10	10
L4	Analyze	5	10
L5	Evaluate	5	10
L6	Create	-	-

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	-
L3	Apply	20
L4	Analyze	20
L5	Evaluate	10
L6	Create	-

Suggested Learning Resources:

Reference Books:

1) **Chris Northwood** – "*The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer*"

2) **Kirupa Chinnathambi –" Learning React: A Hands-On Guide to Building Web Applications Using React and Redux"**

STATISTICAL MACHINE LEARNING FOR DATA SCIENCE

Course Code	**22CDS72**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs. / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS72.1	Understand the key techniques of Exploratory Data Analysis to summarize and visualize data.
22CDS72.2	Examine various Feature engineering techniques used in Machine Learning.
22CDS72.3	Understand fundamental principles of statistical modeling.
22CDS72.4	Analyze regression and Classification models.
22CDS72.5	Evaluate advanced regression strategies like polynomial and spline regression.
22CDS72.6	Interpret unsupervised machine learning techniques like Gaussian Mixture Models.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS72.1	3	-	-	2	-	-	-	-	-	-	-	2	3	3
22CDS72.2	2	-	3	2	-	-	-	-	-	-	-	2	3	3
22CDS72.3	3	3	-	-	-	-	-	-	-	-	-	2	3	3
22CDS72.4	2	3	3	-	-	-	-	-	-	-	-	2	3	3
22CDS72.5	2	2	2	3	-	-	-	-	-	-	-	2	3	3
22CDS72.6	3	3	-	-	-	-	-	-	-	-	-	2	3	3

MODULE-1	**INTRODUCTION**	**22CDS72.1**	**8 Hours**

Exploratory Data Analysis: estimates of locations and variability, exploring data distributions, binary and categorical data, exploring two or more variables. Statistical experiments and significance testing. A/B Testing.

Textbook	Textbook 1: Chapter 1

MODULE-2	**FEATURE ENGINEERING**	**22CDS72.2**	**8 Hours**

Encoding- Categorical data: Label encoding, One-hot encoding, Ordinal encoding, Target encoding. Numerical data: Binning, Box-cox transformation, Normalization: Min-Max and z-score normalization. Interaction features. Information value and Weight of Evidence Encoding (WOE). Feature Selection and Feature importance. Feature importance using Random Forest. Text features: TF-IDF, Bag of Words, Word Embedding. Image features: Histogram of Gradients, Local Binary Pattern, Color histogram.

Textbook	Textbook 2: Chapter 2, 3, 4, 5, 8

MODULE-3	**FOUNDATIONS OF STATISTICAL MODELLING**	**22CDS72.3**	**8 Hours**

Source distribution. Probably approximately correct (PAC) Learning. Generalization. Model capacity, Overfitting and Under fitting. Hyper parameters and validation sets: Cross validation and Model selection. Estimator, Bias and variance. Bias-variance trade off. Maximum likelihood estimator. Bayesian Statistics: Prior, likelihood, and posterior. Maximum a Posteriori estimation (MAP).

Textbook	Textbook 3: Chapter 5

MODULE-4	**REGRESSION AND CLASSIFICATION**	**22CDS72.4 22CDS72.5**	**8 Hours**

Multi-arm bandit algorithm, power and sample size. **Regression**: Polynomial and Spline Regression. Regularized linear regression: LASSO Regression, Ridge Regression. **Classification**: Discriminant analysis: Covariance Matrix, Fisher's Linear Discriminant, Generalized Linear Models, Logistic Regression. Interpreting Coefficients and odds ratios. Strategies for imbalanced data. Support Vector Machine. Kernel Methods.

Textbook	Textbook 1: Chapter 4 & 5

MODULE-5	**UNSUPERVISED LEARNING**	**22CDS72.6**	**8 Hours**

Principal component Analysis (PCA): Interpretation of principal components. Correspondence analysis. Model based clustering. Multi-variable Normal distribution. Gaussian Mixture Model and Expectation Maximization algorithm. Bayesian networks and Bayesian Inference.

Textbook	Chapter 6

CIE Assessment Pattern (50 Marks – Theory) –

RBT Levels		Test (s)	AAT1	AAT2
		25	**15**	**10**
L1	**Remember**	5	**-**	**-**
L2	**Understand**	5	**5**	**5**
L3	**Apply**	5	5	5
L4	**Analyze**	5	5	-
L5	**Evaluate**	5	**-**	-
L6	**Create**	**-**	**-**	**-**

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	10
L2	**Understand**	10
L3	**Apply**	10
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	**--**

Suggested Learning Resources:

Textbooks:

1. Peter Bruce, Andrew Bruce and Peter Gadeck, "Practical Statistics for Data Scientists", 2nd edition, O'Reilly Publications, 2020.
2. Alice Zheng, Amanda Casari, "Feature Engineering for Machine Learning: Principles and Techniques for Data Scientists", 1st edition. O'Reilly Publications, 2018.
3. Ian Good Fellow, Deep Learning.

Reference Books:

1. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006, ISBN-13: 978-0387310732
2. Hastie, Tibshirani, and Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009, ISBN-13: 978-0387848570
3. Larry Wasserman, All of Statistics: A Concise Course in Statistical Inference, Springer, 2004, ISBN-13: 978-0387402727

Web links and Video Lectures (e-Resources):

1. Statistical learning for Reliability Analysis: https://nptel.ac.in/courses/106105239
2. Engineering Statistics: https://nptel.ac.in/courses/127101233

Activity-Based Learning (Suggested Activities in Class)

- Case Studies and discussions
- Experimental learning using various online tools
    - https://scte-iitkgp.vlabs.ac.in/exp/probabilistic-neural-networks/simulation.html

STATISTICAL MACHINE LEARNING FOR DATA SCIENCE LAB

Course Code	**22CDL72**	**CIE Marks**	**50**
L: T:P:S	**0:0:1:0**	**SEE Marks**	**50**
Hrs. / Week	**2**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDL72.1	Analyze datasets using statistical measures and visualizations such as percentiles, IQR, bar plots, and correlation matrices to uncover trends, variability, and outliers.
22CDL72.2	Apply different types of features encoding and feature engineering on real datasets.
22CDL72.3	Interpret regression models - linear, spline, and Poisson regression to analyze relationships and make predictions.
22CDL72.4	Implement classification and dimensionality reduction techniques for imbalanced datasets using logistic regression, Fisher's LDA, and model evaluation metrics.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDL72.1	2	2	-	3	2	-	-	-	-	-	-	2	3	3
22CDL72.2	3	-	2	2	-	-	-	-	-	-	-	2	3	3
22CDL72.3	2	3	-	2	2	-	-	-	-	-	-	2	3	3
22CDL72.4	2	2	2	3	2	-	-	-	-	-	-	2	3	3

Pgm. No.	List of Programs	Hours	Cos
	Prerequisite Programs		
	• Basic Python Programming (Lists, Functions, File Handling, Libraries like NumPy and Pandas). • Fundamentals of Statistics (Mean, Median, Standard Deviation, Percentiles). • Basic Data Visualization using Python (Matplotlib, Seaborn). • CSV File Handling and Data Preprocessing Techniques.	2	**NA**
	PART-A		
1	Consider the monthly electricity bills (in ₹) of 25 households in a residential neighbourhood: Electricity Bills (₹) = [850, 900, 950, 980, 1000, 1020, 1050, 1075, 1100, 1125, 1150, 1175, 1200, 1250, 1300, 1350, 1400, 1450, 1500, 1600, 1700, 1800, 1900, 2100, 2300] **Tasks:** a. Compute the **25th percentile (Q1)** and **75th percentile (Q3)** of the electricity bill data. b. Calculate the **Interquartile Range (IQR)** using the formula: IQR = Q3 - Q1. c. Discuss how the IQR helps in understanding **spending variability** among households and how it can indicate **outliers** such as unusually high consumption.	2	**22CDL72.1**
2	Analyze a dataset containing housing price and attributes like area, number of bedrooms, furnishing status etc. Generate appropriate visualizations to explore the association between various attributes. What can be inferred? Dataset link: https://www.kaggle.com/datasets/yasserh/housing-prices-dataset	2	**22CDL72.1**

3	A dataset contains information about **smartphones**, including their **battery capacity (mAh)**, **screen size (inches)**, and **price (in ₹)**. Use a **pair plot** or **correlation matrix** to explore the relationships between these variables. • Which variables show the strongest correlations? • What practical insights can you draw from these relationships about smartphone features and pricing? Dataset Link: https://www.kaggle.com/datasets/nishantdeswal1810/smartphones	2	**22CDL72.1**
4	Estimate the average **daily step count** of users of a fitness tracking app. The underlying daily step count data is known to be **right-skewed** (i.e., most users have moderate activity, but a few have very high step counts). Consider 10 different random samples, each consisting of 50 users, and calculate the sample mean step count for each sample. • Plot the distribution of these sample mean	2	**22CDL72.1**
5	Perform Weight of Evidence (WOE) encoding on various features of titanic dataset. https://www.kaggle.com/c/titanic	2	**22CDL72.2**
6	Take 2 documents each from sports and politics category and perform TF-IDF and Bag of Words encoding.	2	**22CDL72.2**
	PART-B		
7	Fit a polynomial of degree 1, 2, 3,4 and 5 for synthetically generated data of 2nd degree polynomial. Illustrate model capacity, overfitting, and underfitting using the results. Identify the model without overfitting or underfitting.	2	**22CDL72.2**
8	Use SVM classifier with linear and RBF kernel for binary classification using titanic dataset. Compare the results.	2	**22CDL72.3**
9	Perform regression experiments on housing price dataset. Notice that the relationship between square footage and price is nonlinear. Fit a spline regression model to allow the relationship between square footage and price to change at 2,000 square feet. Explain how spline regression can capture different behaviours of the relationship before and after 2,000 square feet	2	**22CDL72.3**
10	Perform LASSO and Ridge regression on diabetes dataset, which is built-in in scikit-learn, to illustrate the effect of regularization.	2	**22CDL72.3**
11	Generate 2-dimensional synthetic data samples (use make_blob function in sklearn.datasets) for a Gaussian Mixture Model with 3 clusters. Run EM algorithm on the dataset to estimate the parameters of Gaussian. Compare the results with actual parameters used to generate the data.	2	**22CDL72.4**
12	A dataset contains two numerical features and a binary target variable with imbalanced classes (e.g., 90% of Class 0 and 10% of Class 1). a. Compute the **covariance matrix** of the input features to understand their linear relationship. b. Apply **Fisher's Linear Discriminant Analysis** to reduce the dimensionality of the data and observe how well the classes are separated in the projected space. c. Fit a **logistic regression model** (a Generalized Linear Model) to classify the target variable using the input features, incorporating a strategy to handle class imbalance. d. Interpret the **model coefficients** and compute the corresponding **odds ratios** for each feature. e. Evaluate the model using appropriate metrics (precision, recall, F1-score) and	2	**22CDL72.4**

	discuss its performance on the minority class.		

PART-C

Beyond Syllabus Virtual Lab Content

(To be done during Lab but not to be included for CIE or SEE)

1. https://www.calculatorsoup.com/calculators/statistics/quartile-calculator.php
2. https://onlinestatbook.com/rvls.html
3. https://statpages.info/

CIE Assessment Pattern (50 Marks – Lab)

RBT Levels		Test (s)	Weekly Assessment
		20	30
L1	Remember	-	-
L2	Understand	-	5
L3	Apply	5	10
L4	Analyze	10	10
L5	Evaluate	5	5
L6	Create		

SEE Assessment Pattern (50 Marks – Lab)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	

*** SEE EXAM:** Students will be assigned one program from Part A and one program from Part B**.**

Suggested Learning Resources:

Text Books:

4. Peter Bruce, Andrew Bruce and Peter Gadeck, "Practical Statistics for Data Scientists", 2nd edition, O'Reilly Publications, 2020Debasis Samanta: Classic Data Structures,2nd Edition, PHI, 2009, ISBN-13: 978-8120337312.
5. Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, An Introduction to Statistical Learning: with Applications in R, 2nd Edition, Springer, 2021, ISBN-13: 978-1071614174.
6. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012, ISBN-13: 978-0262018029

Reference Books:

4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006, ISBN-13: 978-0387310732
5. Hastie, Tibshirani, and Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009, ISBN-13: 978-0387848570.
6. Larry Wasserman, All of Statistics: A Concise Course in Statistical Inference, Springer, 2004, ISBN-13: 978-0387402727

Web links and Video Lectures (e-Resources):

1. Statistical learning for Reliability Analysis: https://nptel.ac.in/courses/106105239
2. Engineering Statistics: https://nptel.ac.in/courses/127101233

CRYPTOGRAPHY & NETWORK SECURITY			
Course Code	**22CDS73**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS73.1	Apply the fundamental concepts of security services, classical cryptography techniques, and symmetric key encryption algorithms.
22CDS73.2	Illustrate modern symmetric and asymmetric encryption algorithms such as AES, RSA, and ECC in real-world scenarios for secure data communication.
22CDS73.3	Analyze cryptographic hash functions, message authentication codes, and digital signature schemes to ensure data integrity and authenticity.
22CDS73.4	Demonstrate the working of authentication protocols such as Kerberos, X.509, and secure key distribution
22CDS73.5	Examine the effectiveness of Internet security protocols including TLS/SSL, IPSec, HTTPS, SSH, and VPN in securing network communications.
22CDS73.6	Investigate system-level security mechanisms, intrusion detection, firewall configurations, and explore emerging trends like Zero Trust and AI in cybersecurity.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS73.1	3	3	-	-	-	-	-	-	-	-	-	2	3	3
22CDS73.2	3	2	-	-	-	-	-	-	-	-	-	2	3	3
22CDS73.3	3	3	-	-	-	-	-	-	-	-	-	2	3	3
22CDS73.4	2	3	-	-	2	-	-	-	-	-	-	2	3	3
22CDS73.5	3	3	-	-	2	-	-	-	-	-	-	2	3	3
22CDS73.6	3	2	2	-	2	-	-	-	-	-	-	2	3	3

MODULE 1	**FUNDAMENTALS OF CRYPTOGRAPHY & SYMMETRIC ENCRYPTION**	**22CDS73.1 22CDS73.2**	**8 HOURS**

Introduction to Security – Goals, Services, Attacks, non-repudiation, CVE, SSO, Rainbow table & salting, Modular arithmetic, Prime theory, Euler's theorem, Totients, GCD & Extended Euclidean Algorithm, Chinese Remainder Theorem, Types of cryptography, classical cryptography, Elliptic Curve Cryptography (ECC), Modern symmetric Cipher; DES, AES, block vs stream modes (ECB, CBC, CFB, OFB).

Applications	Steganography & Digital Puzzles • Hidden messages in digital art and websites often use classical ciphers (e.g., Caesar, Vigenère).
Textbook	Chapter 1.1, 1.4, 1.7, Chapter 3.2, 3.3, Chapter 4.1, 4.2,6.1

MODULE 2	**PUBLIC-KEY CRYPTOGRAPHY & KEY MANAGEMENT**	**22CDS73.2 22CDS73.3**	**8 HOURS**

Asymmetric vs Symmetric, Real world use cases, RSA Algorithm, EIGamal, DSA– Diffie-Hellman key –exchange, Encryption, Decryption, Attacks on RSA, OAuth 2.0, MFA, biometrics, Message Authentication, AAA, Zero-knowledge proofs, HMAC construction, MAC algorithms, Needham-Schroeder, Kerberos, Digital Signature & Digital Certificate, king's, and Newcastle signature module, MD5, SHA 1-2-3, Collision resistance.

Case Study	• An e-voting system is implemented for a university election. Votes must be encrypted and anonymous.
Text Book	Chapter 6.2, 6.3, 6.4, 6.5, Chapter 7.1, 7.2, 7.3, Chapter 9.1, 9.2, Chapter 10.1, 10.2, 10.4

MODULE 3	CRYPTOGRAPHIC HASH FUNCTIONS & AUTHENTICATION	22CDS73.4	8 HOURS
Hash Function, HMAC with SHA-256/512, PKI fundamentals– Role of Certificate Authority (CA) and Registration Authority (RA), Digital certificates (X.509 format), Key Distribution and Key Management: Random Number Generators (RNGs), Cryptographically Secure RNGs (CSPRNGs), Session key vs Master key, Kerberos Authentication Protocol, Needham–Schroeder Symmetric Protocol, RSA-based Key Transport, Key Distribution Challenges.			
Case Study	• A smart home system connects multiple IoT devices like smart bulbs, thermostats, and locks.		
Text Book	Chapter 11.4, 11.5, 11.6, Chapter 12.1, 12.5, 12.7		
MODULE 4	**NETWORK SECURITY PROTOCOLS**	**22CDS73.5**	**8 HOURS**
Overview of Internet Security: Network Threats and Attacks- Secure Network Design Principles, Access Control Models, Network Security Tools, Secure Protocol Practices: Email Security Protocols (PGP, S/MIME), IP Security (IPSec) – Architecture, Modes, AH, ESP, Transport Layer Security (TLS) / SSL, HTTPS – Secure Web Access, SSH – Secure Shell Protocol, Wireless Security (WPA, WPA2), Introduction to VPN, Introduction to OSI Model and Mapping with Network Security Protocols.			
Applications	• To secure data communication over the internet, protecting against eavesdropping, tampering, and impersonation.		
Text Book	Chapter 16.1, Chapter 18.1,18.2, Chapter 19.1,19.2, 19.3		
MODULE-5	**SYSTEM SECURITY & EMERGING TRENDS**	**22CDS73.6**	**8 HOURS**
Intrusion Detection Systems (IDS), Firewalls – Types, Architecture, Filtering Techniques, Security Hardening Techniques: Patch management, disabling unused services, Security policies and system configuration., Cloud Security, Secure API's, IAM In cloud, Zero Trust Architecture, AI and Machine Learning in Security, DevSecOps security, Security Compliance and Governance.			
Case Study	• Examples of system attacks (e.g., ransomware, privilege escalation)		
Text Book	Chapter 22.2, Chapter 23.1, 23.2, Chapter 24.1, 24.2, 24.3.		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	10	7.5	5
L4	Analyze	5	7.5	5
L5	Evaluate	-	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	15
L4	Analyze	15
L5	Evaluate	-
L6	Create	-

Suggested Learning Resources:

Text Books:

1. Stallings, William. Cryptography and Network Security: Principles and Practice. United Kingdom, Pearson Education, 2016.

Reference Books:

1. Behrouz A. Ferouzan, "Cryptography & Network Security", Tata Mc Graw Hill, 2007, Reprint 2015.
2. William Stallings, "Network Security Essentials Applications and Standards", Third Edition, Pearson Education, 2008.
3. Man Young Rhee, "Internet Security: Cryptographic Principles", "Algorithms And Protocols", Wiley Publications, 2003.
4. Ulysess Black, "Internet Security Protocols", Pearson Education Asia, 2000.
5. Charles Pfleeger, "Security In Computing", 4th Edition, Prentice Hall Of India, 2006.

Web links and Video Lectures (e-Resources):

- **https://archive.nptel.ac.in/courses/106/105/106105162/**
- **https://www.coursera.org/learn/packt-fundamentals-of-network-security-and-cryptography-oa77b**
- **https://thectoclub.com/tools/best-cybersecurity-software/**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Worksheet activity
- Quiz and Assignments
- Simulation based Learning
- Prototyping

PROJECT WORK

Course Code	**22CDS74**	**CIE Marks**	**100**
L:T:P:S	**0:0:10:0**	**SEE Marks**	**100**
Hrs. / Week	**-**	**Total Marks**	**200**
Credits	**10**	**Exam Hours**	**03**

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

22CDS74.1	Recall societal problems under sustainable development goals and classify them under different domains of computer science and engineering with interdisciplinary perspective.
22CDS74.2	Demonstrate the ability to conduct comprehensive literature reviews using appropriate research databases, search strategies, and citation management tools to identify relevant sources of information.
22CDS74.3	Apply knowledge of relevant programming languages, software and hardware development methodologies, tools, and technologies to address project requirements effectively.
22CDS74.4	Experiment with the models for the proposed system.
22CDS74.5	Interpret their communication skills effectively with the technical presentation
22CDS74.6	Create the article logically, following a structured format with well-defined sections such as Introduction, background, methodology, results, discussion, and conclusion.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS74.1	3	2	1	-	-	3	2	-	3	2	2	2	-	2
22CDS74.2	3	3	2	-	-	2	2	3	3	1	-	2	-	2
22CDS74.3	3	3	3	3	3	2	1	2	3	3	2	3	2	2
22CDS74.4	3	3	3	2	2	-	-	-	3	3	-	2	2	2
22CDS74.5	3	3	3	2	2	-	-	-	3	3	2	2	2	2
22CDS74.6	3	3	2	-	-	2	-	3	3	1	2	2	-	2

Project Work: Roadmap, activities, and deliverables

Goal Selection and Project Planning:

- Identification of suitable topic based on Sustainable Development Goals.
- Forming project teams based on common interests and skill sets.
- Teams' involvement in developing project proposals outlining objectives, strategies, and expected outcomes.

Research and Needs Assessment:

Survey conduction by thorough research on the chosen SDGs, including global and local context, challenges, and opportunities.

- Conduct needs assessments to identify specific issues or gaps that student projects can address

Interdisciplinary approaches:

- Applying interdisciplinary approaches and innovative solutions to tackle sustainability challenges.

Deployment:

- Deploy the project on appropriate hardware and software environments, considering scalability, security, and performance requirements.
- Configure servers, databases, and other infrastructure components to support the application's operation.
- Conduct deployment testing to ensure a smooth transition from development to production.

Knowledge Sharing and Communication:

- students to share their project experiences and insights through presentations, reports, and social media.
- Foster peer-to-peer learning and collaboration by creating platforms for knowledge

CIE Assessment Pattern (100 Marks)

RBT Levels		**Periodical Reviews & Evaluation**
		100
L1	**Remember**	**10**
L2	**Understand**	**10**
L3	**Apply**	**20**
L4	**Analyze**	**20**
L5	**Evaluate**	**20**
L6	**Create**	**20**

SEE Assessment Pattern (100 Marks – Demo with viva)

RBT Levels		**Exam Marks Distribution (100)**
L1	**Remember**	**10**
L2	**Understand**	**10**
L3	**Apply**	**20**
L4	**Analyze**	**20**
L5	**Evaluate**	**20**
L6	**Create**	**20**

Suggested Learning Resources: Text Books:

1. Smith, J. A., & Johnson, P. R. (2020), Software Project Management: A Comprehensive Guide (3rd ed.). Acme Publishing. ISBN: 123-456-7890.
2. Johnson, L. M., & Brown, A. S. (2021), Modern Software Project Management: Strategies and Best Practices. Tech Knowledge Publishers.
3. Sustainable Development Goals: An Indian Perspective (Sustainable Development Goals Series) 1st ed. 2020 Edition, Somnath Hazra, Springer

Web links and Video Lectures (e-Resources):

- **https://www.project-everyone.org/**
- **https://www.instructables.com/Engineering-1/**
- **https://www.hackster.io/**
- **https://owl.purdue.edu/** **(For writing effective articles)**
- https://github.com/

VIII

Semester

NATURAL LANGUAGE PROCESSING

Course Code	**22CDS811**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS811.1	Understand the fundamentals and modelling techniques of natural language processing.
22CDS811.2	Apply text preprocessing, regular expressions, and word-level analysis techniques using morphological parsing.
22CDS811.3	Implement syntactic analysis using context-free grammar and various parsing techniques.
22CDS811.4	Analyze semantic aspects of text using meaning representation, lexical semantics and ambiguity resolution techniques
22CDS811.5	Apply NLP techniques for relation extraction, semantic role labelling and Natural language-based web search applications
22CDS811.6	Use modern tools for real-world NLP applications.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS811.1	3	2	-	2	-	-	-	-	-	-	-	2	2	-
22CDS811.2	3	3	2	2	-	-	-	-	-	-	-	2	3	2
22CDS811.3	2	2	3	3	-	-	-	-	-	-	-	2	3	3
22CDS811.4	2	-	3	3	-	-	-	-	-	-	-	2	3	3
22CDS811.5	2	-	3	3	2	-	-	-	-	-	-	2	3	3
22CDS811.6	2	2	3	3	3	-	-	-	-	-	-	2	3	3

MODULE-1	**INTRODUCTION TO NLP**	**22CDS811.1**	**8 Hours**

Natural Language Processing (NLP)- Introduction, origins of NLP, challenges and applications of NLP, language and grammar-based modelling, information retrieval and NLP's role in search.

Language modelling: Introduction, Grammer-based language models, statistical language model. N gram model (unigram, bigram, trigram), smoothing techniques (Laplace, ADD-k, Good Turing).

Case Study	Investigate grammar processing for Indian languages and some successful early NLP systems (e.g. ELIXA, SHRDLU).
Text Book	Text Book 1: 1.1 to 1.9, Text Book 2: chapter 3

MODULE-2	**WORD LEVEL ANALYSIS**	**22CDS811.2**	**8 Hours**

Word Level Analysis- Introduction, Text preprocessing (Tokenization, normalization, stemming, lemmatization). Regular Expression and pattern matching, Finite automata, morphological parsing, spelling error detection and correction, word classes, part-of-speech tagging (rule based and statistical approaches).

Case Study/ applications	Word-level Parsing with Indian Language. Hindi and Tamil POS tagging using open tools
Text Book	Text Book 1: 2.2, 2.3, 2.4 to 2.15. Textbook 2: chapter 4 & 5

MODULE-3	**SYNTAX ANALYSIS**	**22CDS811.3**	**8 Hours**

Syntactic Analysis: Introduction, context-free grammar (Parse trees, derivations, syntactic ambiguity), **constituency Parsing** - probabilistic parsing, top down and bottom-up parsers, CYK parsing, dependency parsing.

Applications	Syntactic parsing using Indian language corpora Use of spaCy or Stanford parser for syntactic structure extraction.
Text Book	Text Book 2: 3.1, 3.3, 3.5, 3.7, 3.10

MODULE-4	**SEMANTIC ANALYSIS**	**22CDS811.4**	**8 Hours**

Sematic Analysis- Introduction, meaning representation, lexical semantics (WordNet, Thesaurus), types of ambiguity: lexical, structural. word sense Disambiguation: Lesk algorithm, supervised and knowledge WSD.

Case Study	Use case: ambiguity in question answering.
Text Book	Text Book 1: chapter 5 Text Book 2: chapter 10

MODULE-5	NLP APPLICATIONS	22CDS811.5, 22CDS811.6	8 Hours

Relation extraction from text: Subsequence and dependency path kernels, experimental methods for relation extraction. Semantic Role labelling (SRL): frame semantics, knowledge role annotation, information extraction from diagnostic reports (annotating knowledge roles). Natural Language Based web search: InFact Systems overview, Case study: GlobalSecurity.org. Overview of current tools: chatbots, summarizers, QA systems.

Applications	Build a simple QA systems using knowledge graphs Annotate sentences with role using a small annotated corpus
Text Book	Text Book 1: chapter 9

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	5	5
L4	Analyze	10	5	5
L5	Evaluate		5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	15
L4	Analyze	15
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Text Books:

1) Tanveer Siddiqui and U.S. Tiwary, *Natural Language Processing and Information Retrieval*, @2018, ISBN: 9780195692327, 0195692322

2) Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Daniel Jurafsky and James H Martin, Prentice Hall, 2008 3rd Edition

Reference Books:

1) Natural Language Processing and Text Mining, Anne Kao and Stephen R. Potee, Springer- Verlag London Limited,2007

2) Natural Language Understanding, D James Allen, Benjamin/Cummings publishing company, 2nd edition, 1995.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/specializations/natural-language-processing
- http://web.stanford.edu/class/cs224n/
- https://web.stanford.edu/~jurafsky/slp3/
- https://nptel.ac.in/courses/106/101/106101007/
- https://www.geeksforgeeks.org/nlp-natural-language-processing/

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Tool-Based NLP Exercises**:
   Students will explore libraries such as NLTK and spaCy to implement tokenization, POS tagging, and parsing for both English and Indian language texts, reinforcing theoretical concepts through practical coding tasks.
2. **Case Study & Flowchart Creation**:
   Analyze systems like ELIZA or Google Translate; create flowcharts showing their NLP pipeline including language modeling and parsing steps.

Social Network Analysis

Course Code	**22CDS812**	**CIE Marks**	**50**
L: T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**3**

Course outcomes:

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

22CDS812.1	Apply the Semantic Web and Electronic sources for social network analysis.
22CDS812.2	Illustrate the Aggregation, Modelling and Representation of social network data.
22CDS812.3	Analyse the human behaviour in social network.
22CDS812.4	Use techniques for detection and decentralization of social network.
22CDS812.5	Examine the visual representation of social network data.
22CDS812.6	Apply ethical, privacy, and security principles in analyzing social network data, ensuring compliance with relevant standards.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS812.1	3	-	2	-	-	-	-	-	-	-	-	2	2	2
22CDS812.2	2	2	2	3	-	-	-	-	-	-	-	2	3	3
22CDS812.3	3	2	2	-	-	-	-	8	-	-	-	2	3	3
22CDS812.4	2	-	3	-	-	-	-	-	-	-	-	2	3	2
22CDS812.5	3	2	2	-	-	-	-	-	-	-	-	2	3	2
22CDS812.6	2	-	-	2	-	-	-	3	-	-	-	2	3	3

MODULE-1	**INTRODUCTION TO SOCIAL NETWORK ANALYSIS**	**22CDS812.1**	**8 HOURS**

Introduction to the Semantic Web: Limitations of the current web and the evolution toward the Semantic Web; the role of the Semantic Web in Social Network Analysis (SNA); emergence of the Social Web. Definition and core characteristics of social networks, types of social networks, overview of network analysis and methodologies.

Self-study / Case Study / Applications	Explore the evolution of the Semantic Web and its role in analyzing online social platforms; investigate real-world applications of social network data collection using web scraping techniques and structured data formats (XML, JSON).
Text Book	Text Book 1: 1.5, 1.15, 1.161.9, 2.3,

MODULE-2	**NETWORK MODELLING, REPRESENTATION, AND AGGREGATION**	**22CDS812.2**	**8 HOURS**

Graph theory basics and techniques for representing and visualizing social networks. Semantic Web concepts: Ontologies, RDF, RDFS, OWL, and their role in modelling social data. Methods for aggregating social network data from multiple sources and handling structural and semantic heterogeneity.

Self-study / Case Study / Applications	Investigate graph theory and network modeling using ontologies in the Semantic Web. Explore network aggregation techniques and handling data heterogeneity in social networks.
Text Book	Text Book 1: 2.2, 2.6, 2.6 to 2.25

MODULE-3	**CENTRALITY AND COMMUNITY DETECTION**	**22CDS812.3, 22CDS812.4**	**8 HOURS**

Centrality and ranking in social networks – Degree, Closeness, Betweenness, and Eigenvector centrality; PageRank algorithm and its application in ranking nodes; Similarity and structural equivalence in networks; Concepts of homophily, influence, and social contagion; Link prediction techniques and social recommendation systems; Community detection algorithms – Girvan-Newman, modularity-based methods, and label propagation.

Self-study / Case Study / Applications	Explore centrality measures and node ranking techniques in social networks.
Text Book	Text Book 2: 3.1, 3.3, 3.5, 3.7, 3.10

MODULE-4	**COMMUNITY DETECTION AND DECENTRALIZED SOCIAL NETWORKS**	**22CDS812.5**	**8 HOURS**

Community detection in social networks – evaluation metrics and methods like modularity, clustering, and label propagation; Tools for detecting communities. Introduction to Decentralized Online Social Networks (DOSNs) –architecture, challenges,

application-specific models, and delay-tolerant networks. Overview of social distributed systems.			
Self-study / Case Study / Applications	Explore tools and algorithms for community detection and investigate real-world decentralized social platforms.		
Text Book	Text Book 1: 6.1, 6.3, 6.5, 6.7, Text Book 2: 10.1, 10.3, 10.5, 10.7		
MODULE-5	**VISUALIZATION OF SOCIAL NETWORKS**	**22CDS812.6**	**8 HOURS**
Visualization of social networks – principles and tools (Gephi, NetworkX, Pajek); Challenges in large-scale network analysis; Introduction to decentralized and distributed social networks; Ethical, privacy, and security issues in social network analysis; Legal frameworks – GDPR, IT Act, and responsible data practices.			
Self-study / Case Study / Applications	Explore network visualization using tools like Gephi or NetworkX. Analyze privacy and ethical concerns through real-world case studies. Study the implications of legal frameworks like GDPR and the IT Act in social data handling.		
Text Book	Text Book 2: 12.1 to 12.10		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	7.5	5	5
L4	Analyze	7.5	5	5
L5	Evaluate	-	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Bo Text Books

1. Peter Mika, "Social Networks and the Semantic Web", First Edition, Springer 2007.
2. Borko Furht, "Handbook of Social Network Technologies and Applications", 1st Edition, Springer,2010.

Reference Books:

1. Guandong Xu, Yanchun Zhang and Lin Li, "Web Mining and Social Networking – Techniques and applications", First Edition Springer, 2011.
2. Dion Goh and Schubert Foo, "Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively", IGI Global Snippet, 2008.
3. Max Chevalier, Christine Julien and Chantal Soulé-Dupuy, "Collaborative and Social Information oks:

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc22_cs117/preview?utm_source
- https://www.classcentral.com/course/youtube-sna-chapter-1-lecture-1-330222?utm_source
- https://www.youtube.com/watch?v=lnLW6ITFY3M&ab_channel=TheHistoricalNetworkResearchCommunity
- https://www.youtube.com/watch?v=chm200NFOs8&list=PLv4HhF8dU0AH_zXmaoQ3AbHkKcA1wlfyB&ab_channel=RabeehAbbasi
- https://www.youtube.com/watch?v=UxsACr2d-iA&ab_channel=ManeeshAgrawala

Activity-Based Learning (Suggested Activities in Class) / Practical-Based Learning Quizzes & Assignments based on real-world social graphs

- Hands-on lab using NetworkX, Gephi, and NodeXL for network construction and visualization
- Case study analysis of platforms like Facebook, Twitter, LinkedIn using public datasets
- Demonstration of centrality measures, community detection, and information diffusion
- Visualization of social data from XML/JSON using Python libraries
- Web scraping activity using tools like BeautifulSoup or Tweepy
- Video demonstrations on viral marketing, influence spread, and social bots

RECOMMENDER SYSTEMS

Course Code	**22CDS813**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS813.1	Understand the foundations of recommender systems and their types.
22CDS813.2	Designing and implementing filtering-based systems with real-world data.
22CDS813.3	Apply similarity measures and content-based filtering techniques to recommend items using item/user features and profiles.
22CDS813.4	Evaluate recommender systems using precision, recall, NDCG, and other metrics.
22CDS813.5	Explore real-world applications, challenges, and ethical aspects of recommender systems.
22CDS813.6	Design and develop hybrid or advanced recommender systems integrating collaborative, content-based, and contextual information to solve real-world problems

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS813.1	3	2	-	-	-	-	-	-	1	1	-	2	3	3
22CDS813.2	3	2	3	2	2	-	-	-	1	1	-	2	3	3
22CDS813.3	3	-	2	-	2	-	-	-	1	1	-	2	3	3
22CDS813.4	2	3	-	-	-	-	-	-	1	1	-	2	3	3
22CDS813.5	3	-	3	-	-	-	-	2	1	1	-	2	3	3
22CDS816.6	3	3	3	-	2	-	-	-	1	1	-	2	3	3

MODULE-1	**INTRODUCTION TO RECOMMENDER SYSTEMS**	**22CDS813.1**	**8 HOURS**

Introduction and taxonomy of recommender systems, Traditional & non-personalized recommender, Data mining approaches: similarity measures, dimensionality reduction, Singular Value Decomposition (SVD) and applications, implementing similarity measures and applying SVD.

Text Book	Ch 1 (p.1–49) Part I & II (throughout)

MODULE-2	**COLLABORATIVE FILTERING- FINDING SIMILAR USERS AND ITEMS**	**22CDS813.2**	**8 HOURS**

Nearest-Neighbor Collaborative, User-based vs Item-based filtering, How CF Works, Components of Neighborhood-Based Method a. Rating Normalization b. Similarity Weight Computation, Neighborhood Selection, Prediction Formulas

Text Book	

MODULE-3	**CONTENT-BASED RECOMMENDATIONS**	**22CDS813.3**	**8 HOURS**

Basic Components of Content-Based Systems - Preprocessing and Feature Extraction - Learning User Profiles and Filtering - Content-Based Versus Collaborative Recommendations - Using Content-Based Models for Collaborative Filtering

Text Book	Ch 9 (p.211+)

MODULE-4	**EVALUATING RECOMMENDER SYSTEMS**	**22CDS813.4**	**8 HOURS**

Evaluation Paradigms, Goals of Evaluation, Design Issues in Evaluation-(rain-test splitting strategies, e.g., k-fold, leave-one-out, Cold-start vs. warm-start testing, Bias introduced by feedback loops), Metrics for ranking vs. rating predictions, Accuracy Metrics((MAE), (RMSE)), Ranking & Relevance, Limitations of Evaluation Measures

Text Book	Ch 3 (p.51–79)		
MODULE-5	**ATTACK-RESISTANT RECOMMENDER SYSTEMS**	**22CDS813.5 22CDS813.6**	**8 HOURS**

Introduction to vulnerabilities in RS, Types of attacks: Individual, Group, Targeted, Attack detection methods: Behavioural & ML-based, Robust recommender design strategies, Robust CF and Matrix Factorization models.

Text Book	Ch 7 (p.166–187)

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	4	-	-
L2	Understand	4	-	-
L3	Apply	6	3	5
L4	Analyze	8	7	5
L5	Evaluate	3	5	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1)Recommender Systems: An Introduction-**Authors**: Dietmar Jannach, Markus Zanker, Alexander Felfernig, Gerhard Friedrich https://assets.cambridge.org/97805214/93369/toc/9780521493369_toc.pdf

2)Manju Khari, Dr. Sudeep Tanwar, Prof. Satya Prakash, Publisher: BPB Publications

3)"Recommender System Techniques" ,Authors: Dr. S. Sumathi, Dr. M. Krishnamoorthy ,**Publisher**: Charulatha Publications

Reference Books:

1) "Machine Learning and Data Mining with Recommender Systems , **Author**: Prof. P. Radha Krishna, IIIT Hyderabad (editor), **Publisher**: Springer India (in collaboration with academia)

2) "Mining of Massive Datasets" By Jure Leskovec, Anand Rajaraman, Jeff Ullman https://www.youtube.com/playlist?list=PLB2BE3D6CA77BB8F7

3) **NPTEL – Recommender Systems** by Prof. M.P.J. Jenamani (IIT Kharagpur)

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/specializations/recommender-systems
- https://nptel.ac.in/courses/110105145
- http://www.mmds.org/
- https://www.youtube.com/playlist?list=PLyqSpQzTE6M9gCgajvQbc68Hk_JKGBAYT
- https://www.youtube.com/playlist?list=PLDdcY4olLQk3W9l0zXf_zMLtOo4f3ePUe
- https://www.youtube.com/playlist?list=PLB2BE3D6CA77BB8F7

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes & Assignments on concepts like types of RS, similarity measures, SVD, and evaluation metrics.
- **Mini-Seminars**: Each student/group can present:

A case study (e.g., "How Amazon recommends products").

A recent research paper (simplified overview).

- **Industry Visit / Guest Lecture** (Software/Product Companies): Visit or webinar with a data scientist from an e-commerce or OTT company (e.g., Flipkart, Amazon, Netflix) explaining how recommendations are built.

PROMPT ENGINEERING

Course Code	**22CDS814**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS814.1	Understand the importance and benefits of prompt engineering
22CDS814.2	Apply the techniques involved and monitor the prompt for Generative AI
22CDS814.3	Compute the functions and feedback for ChatGPT prompt
22CDS814.4	Identify the framework to find out the Quality prompt
22CDS814.5	Analyze advanced frameworks like LangChain and RAG.
22CDS814.6	Evaluate the various advanced prompt engineering techniques

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS814.1	3	2	-	-	-	-	-	-	-	-	-	2	-	-
22CDS814.2	3	2	-	-	-	-	-	-	-	-	-	2	2	-
22CDS814.3	2	2	-	-	3	-	-	-	-	-	-	2	2	-
22CDS814.4	3	3	3	3	-	-	-	-	-	-	-	2	2	-
22CDS814.5	2	2	2	2	3	-	-	-	-	-	-	2	2	-
22CDS814.6	3	2	2	-	3	-	-	-	-	-	-	2	-	2

MODULE-1	**INTRODUCTION TO LLM AND PROMPT ENGINEERING**	**22CDS814.1**	**8 HOURS**

History and evolution of LLM's: Common NLP Tasks. Generative Models. Transformer, BERT and GPT. Tokenization and embedding. Fine tuning vs prompting. Role of temperature parameter: top-k and top-p prompting. Popular LLM's and conversational models: GPT, Gemini, Llama, Mistral, Claude. Prompt Engineering- Role of prompts in AI model. Importance of effective prompts. Ethical considerations in prompt engineering.

Textbook	Textbook 1: Chapter 1, 2

MODULE-2	**PROMPT ENGINEERING: PRINCIPLES AND TECHNIQUES**	**22CDS814.2**	**8 HOURS**

Designing effective prompts: Five principles of prompt engineering: Give direction, Provide Examples, Specify Format, Evaluate Quality, Divide Labour. Techniques and types of prompts: List generation, Chunking, Summarization. Generator Json and YAML. Text style unbounding. Explain it like I am five. Role prompting. GPT Prompting tactics: Avoiding hallucination by reference, Thinking time, Inner Monologue, Self-eval LLM Responses. Evaluating and validation prompts. Classification with LLMs. Meta prompting. Zero-shot and Few-shot prompting.

Textbook	Textbook 1: Chapter 3

MODULE-3	**PROMPT EVALUATION AND FINE TUNING**	**22CDS814.3**	**8 HOURS**

The CLEAR Framework- Concise and Logical Prompt Crafting. Explicit Prompt Crafting. Adaptive Prompt Crafting. Reflective prompt Crafting. The relationship between prompts and outputs. Prompt tuning and adapter. Prompt templates. Code generation. Evaluating and validation of prompts- Metrics: accuracy, relevance and coherence. Prompt evaluation frameworks.

Iterative prompt refinement.

Textbook	Textbook 1: Chapter 4		
MODULE-4	**ADVANCED TEXT GENRATION WITH LANGCHAIN**	**22CDS814.4, 22CDS814.5**	**8 HOURS**

Introduction to LangChain. LangChain Architecture: Chain, Agents, Tools and Memory. LangChain Expression Language (LCEL). Langchain Evals. OpenAI function calling. Prompt Chaining. Vector Data base: Embeddings. Vector Search. Retrieval Augmented Generation (RAG): Retriever and Generator, chunking strategies, Indexing and Retrieval, Integrating RAG with LangChain.

Textbook	Textbook 1: Chapter 4, 5		
MODULE-5	**ADVANCED PROMPT ENGINEERING**	**22CDS814.6**	**8 HOURS**

Chain-of-Thought (CoT) Prompting, Tree-of-Thoughts (ToT) Prompting, Active prompting, Reason and Act (ReAct), Expert Prompting, Automatic Prompt Engineering (APE). Diffusion models for Image Generation: DALL-E, Mid Journey. Prompts for image generation. text-to-image, text-to-video, image-to-video and video-to-video.

Textbook	Textbook 1: Chapter 7, 8

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		**Marks Distribution**		
		Test (s)	**AAT1**	**AAT2**
		25	15	10
L1	**Remember**	5	-	5
L2	**Understand**	5	-	5
L3	**Apply**	5	7.5	-
L4	**Analyze**	5	7.5	-
L5	**Evaluate**	5	-	-
L6	**Create**	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	**Remember**	10
L2	**Understand**	10
L3	**Apply**	10
L4	**Analyze**	10
L5	**Evaluate**	10
L6	**Create**	--

Suggested Learning Resources:

Text Books:

1. Prompt Engineering for Generative AI, by James Phoenix, Mike Taylor, Published by O'Reilly Media, Inc. in 2024, ISBN: 9781098153434

Reference Books:

1. The Art of Prompt Engineering with ChatGPT: A Hands-On Guide: 3 (Learn AI Tools the Fun Way!) by Nathan Hunter published in 2023.
2. What Is ChatGPT Doing ... and Why Does It Work? Paperback by Stephen Wolfram in 2023.
3. Prompt Engineering: The Art of Asking Hardcover by Yaswanth Sai Palaghat in 2023.

Web links and Video Lectures (e-Resources):

- https://youtu.be/_ZvnD73m40o
- https://youtu.be/jC4v5AS4RIM
- https://www.youtube.com/watch?v=QZosTTcg7F8&pp=ygUZcHJvbXB0IGVuZ2luZWVyaW5nI GNvdXJzZQ%3D%3D
    - https://www.youtube.com/watch?v=6eul1pfGKwk&pp=ygUZcHJvbXB0IGVuZ2luZWVyaW5nI GNvdXJzZQ%3D%3D

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Video demonstration of latest trends in Generative AI.
- Demonstration of sample projects done using ChatGPT
- Contents related activities (Activity-based discussions)

For active participation of students, instruct the students to prepare quality prompts and Handouts.

AUGMENTED REALITY & VIRTUAL REALITY

Course Code	**22CDS815**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs. / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS815.1	Verify the biomimetics principles in relation to the needs at that moment.
22CDS815.2	Evaluate the Bio-material properties for health care applications.
22CDS815.3	Investigate novel bioengineering initiatives by evaluating design and development principles.
22CDS815.4	Investigate creative biobased solutions for socially vital issues with critical thought.
22CDS815.5	Understand the bio computing optimization through research and experiential learning.
22CDS815.6	Explain the fundamental biological ideas through pertinent industrial applications and case studies.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
22CDS815.1	2	-	-	-	-	-	-	-	-	-	-	2	3	3
22CDS815.2	3	-	-	-	-	-	-	-	-	-	-	2	3	3
22CDS815.3	-	3	-	-	-	-	-	-	-	-	-	2	3	3
22CDS815.4	-	-	3	-	3	-	-	-	-	-	-	2	3	2
22CDS815.5	-	-	3	-	3	-	-	-	-	-	-	2	3	3
22CDS815.6	-	-	3	-	3	-	-	-	2	-	-	2	3	3

MODULE-1	**INTRODUCTION TO AUGMENTED REALITY**	**22CDS815.1 22CDS815.2**	**8 Hours**

What Is Augmented Reality - Defining augmented reality, history of augmented reality, Examples, Displays-Multimodal Displays, Visual Perception, Requirements and Characteristics, Spatial Display Model.

Case Study	Understanding AR Fundamentals and investigate visual perception and spatial display model.
Text Book	Text Book 1: 1-28,33-78

MODULE-2	**TRACKING**	**22CDS815.2 22CDS815.3**	**8 Hours**

Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion

Case Study	Explore tracking method along with advantages and limitations, and the choice of tracking technology depends on factors such as the type of AR/VR application, device capabilities, user experience requirements, and environmental conditions.
Text Book	Text Book 1: 85-120

MODULE-3	**COMPUTER VISION FOR AUGMENTED REALITY**	**22CDS815.2, 22CDS815.3**	**8 Hours**

Marker Tracking, Multiple- Camera Infrared Tracking, Natural Feature Tracking by Detection, Incremental Tracking, Simultaneous Localization and Mapping, Outdoor Tracking Calibration and Registration-Camera Calibration, Display Calibration, Registration

Case Study	Explore the learning Image Processing and Analysis.
Text Book	Text Book 1:121,122,123-190

MODULE-4	**INTRODUCTION TO VIRTUAL REALITY**	**22CDS815.4 22CDS815.5**	**8 Hours**

Fundamental Concept and Components of Virtual Reality. Primary Features and Present Development on Virtual Reality. Multiple Models of Input and Output Interface in Virtual Reality: Input - Tracker, Sensor, Digital Glove, Movement Capture, Video-based Inpu

Case Study	Investigate and explore Mastering VR Development Skills, Understanding Virtual Reality Fundamentals.
Text Book	Text Book 2:1-46

MODULE-5	**VISUAL COMPUTATION IN VIRTUAL REALITY**	**22CDS815.5**	**8 Hours**

		22CDS815.6	

Fundamentals of Computer Graphics. Software and Hardware Technology on Stereoscopic Display. Advanced Techniques in CG: Management of Large-Scale Environments & Real Time Rendering. Interactive Techniques in Virtual Reality: Body Track, Hand Gesture, 3D Manus, Object Grasp Development Tools.

Case Study	Survey on Visual Computation and understanding object grasp development tools..
Text Book	Text Book 2:123-195

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	-	-	-
L2	Understand	5	5	-
L3	Apply	10	10	5
L4	Analyze	10	10	5
L5	Evaluate	-	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	20
L4	Analyze	10
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Text Books:

1. Augmented Reality: Principles and Practice by Dieter Schmalstieg, Tobias Hollerer,2016. ISBN: 9780133153200, 0133153207
2. Virtual Reality Technology Burdea, G. C. P. Coffet Wiley-IEEE Press 2nd Edition 2003/2006. ISBN: 9780471360896, 0471360899

Reference Books:

1. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016), ISBN-10: 9332578494
2. 2. Developing Virtual Reality Applications, Foundations of Effective Design, Alan Craig William Sherman Jeffrey Will Morgan Kaufmann, 2009. ISBN: 9780080959085.

Web links and Video Lectures (e-Resources):

- https://elearn.nptel.ac.in/shop/iit-workshops/completed/foundation-course-onvirtual-reality-and-augmented-reality/?v=c86ee0d9d7ed
- https://www.youtube.com/watch?v=04AMaTsXFJU
- https://www.youtube.com/watch?v=UgE6eG95ddw
- https://www.youtube.com/watch?v=UQpTJ_OTZe4

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Contents related activities (Activity-based discussions)
- **AR Scavenger Hunts:** Create scavenger hunts where students use AR-enabled devices to find and interact with virtual objects or landmarks overlaid onto the real-world environment.
- **Simulated Experiments:** Enable students to conduct science experiments or simulations in VR environments where they can manipulate variables, observe outcomes, and learn through hands-on exploration.
- **Collaborative Problem-Solving:** Facilitate collaborative problem-solving activities in VR environments where students work together to solve puzzles, overcome challenges, or complete tasks that require teamwork and communication.

GREEN IT AND SUSTAINABILITY

Course Code	**22CDS821**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

Course outcomes:

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

22CDS821.1	Understand the Green IT and environmental impact of traditional IT practices.
22CDS821.2	Apply the concepts of green hardware and software methodologies.
22CDS821.3	Illustrate the dimensions of sustainability development
22CDS821.4	Analyze the strategies for implementing Green IT and sustainability initiatives
22CDS821.5	Identify sustainable computing technologies and practices.
22CDS821.6	Examine the keys to sustainability and green IT trends through case studies

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS821.1	3	-	2	2	2	2	3	-	-	-	-	2	2	2
22CDS821.2	3	2	2	-	-	-	3	-	-	-	-	2	2	2
22CDS821.3	3	-	-	-	-	-	3	-	-	-	-	2	2	2
22CDS821.4	3	2	3	-	2	-	3	-	-	-	-	2	2	2
22CDS821.5	3	-	3	2	3	-	3	-	-	-	-	2	2	2
22CDS821.6	3	2	3	2	2	2	3	-	-	-	-	2	2	2

MODULE-1	**INTRODUCTION TO GREEN IT**	**22CDS821.1**	**8 HOURS**

GREEN IT : An Overview : Introduction, Environmental Concerns and Sustainable Development, Introduction, Environmental Concerns and Sustainable Development, Environmental Impacts of IT, Green IT, Holistic Approach to Greening IT, Greening IT, Applying IT for enhancing Environmental sustainability, Green IT

Standards and Eco-Labelling of IT, Enterprise Green IT strategy, Green IT: Burden or Opportunity

Self-study / Case Study / Applications	Investigate the Challenges of Green IT, Compare with traditional areas of science and engineering.
Textbook	Text Book 1 : 1.2, 1.3, 1.4, 1.13, 1.15, 1.16 ; Text Book 2 : 1.1 to 1.5

MODULE-2	**GREEN HARDWARE AND SOFTWARE DEVELOPMENT**	**22CDS821.2**	**8 HOURS**

Green Devices and Hardware with Green Software : Green Devices and Hardware: Introduction, Life Cycle of a device or hardware, Reuse, Recycle and Dispose. Green Software: Introduction, Energy-saving software techniques, Evaluating and Measuring software Impact to platform power.

Self-study	Investigate and explore concepts of green software applications.
Textbook	Textbook 1: 2.2, 2.3, 2.4 to 2.15

MODULE-3	**INTRODUCTION TO SUSTAINABLE DEVELOPMENT**	**22CDS821.3, 22CDS821.4**	**8 HOURS**

Understand the Sustainable Development, three principal dimensions: the ecological, the economic and the social dimension, including intergenerational justice; use a systems perspective, to describe sustainability challenges and possibilities for major technical systems and for their transformation to meet sustainability requirements

Case Study	Explore the sustainable development.
Text Book	Text Book 1: 3.1, 3.3, 3.5, 3.7 to 3.10

MODULE 4	**SUSTAINABLE SOFTWARE DEVELOPMENT PRACTICES**	**22CDS821.5**	**8 HOURS**

Promote the adoption of sustainable software development practices, such as modular design, energy- efficient algorithms, and minimal resource usage, to reduce the environmental impact of software systems throughout their lifecycle

Applications	Scrutinize the sustainable development practices
Text Book	Text Book 1: 6.1, 6.3, 6.5, 6.7, Text Book 2: 10.1, 10.3, 10.5, 10.7

MODULE-5	Green Data Center and Sustainable Development	22CDS821.6	8 Hours

Green Data Centers – Develop strategies and technologies for improving the energy efficiency of data centers and Precision Agriculture: Implement Green computing using the concept of computer vision and IoT
Internet of Things) devices to monitor soil conditions enabling farmers to optimize resource allocation and minimize environmental impact.

Self-study	Survey on green and sustainable development and case studies of the same.
Text Book	Text Book 1 : 12.1 to 12.10

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	Assignment	MCQ's
		25	15	10
L1	Remember	5	-	-
L2	Understand	5	-	-
L3	Apply	5	7.5	5
L4	Analyze	5	7.5	5
L5	Evaluate	5		-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	10
L2	Understand	10
L3	Apply	10
L4	Analyze	10
L5	Evaluate	10
L6	Create	

Suggested Learning Resources:

Text Books:

1) Greening through IT: Information Technology for Environmental Sustainability" by Bill Tomlinson 2019, ISBN-10 : 366257683X, ISBN-13 : 978-3662576830
2) San Murugesan, G.R. Gangadharan, "Harnessing Green IT Principles and Practices", Wiley Publication, 2012. ISBN:9788126539680

Reference Books:

1) John Lamb, "The Greening of IT", Pearson Education, 2009, ISBN 10: 0137150830
2) Jason Harris, "Green Computing and Green IT- Best Practices on regulations & industry",Lulu.com, 2008, ISBN: 1558604898.
3) Bud E. Smith, "Green Computing Tools and Techniques for Saving Energy, Money and Resources", CRC Press, 2014, 978146650340
4) Woody Leonhard, Katherrine Murray, "Green Home computing for dummies", August2009, ISBN: 978-0-470- 46745-9 3.
5) Alvin Galea, Michael Schaefer, Mike Ebbers, "Green Data Center: steps for the Journey", Shoff/IBM rebook, 2011. ISBN: 10: 1-933742-05-4; 13: 978-1-933742-05-2

web links and Video Lectures (e-Resources):

https://sustainablecomputing.umich.edu/it-professionals/

1. https://www.ibm.com/resources/guides/business-operations/embrace-green-it
2. https://virtuslab.com/blog/business-insights/what-is-green-it/
3. https://atrust.com/resources/green-it/greening-your-it-infrastructure

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Sustainable IT Policy Development:
- Green IT Awareness Campaign:
- Virtual Labs and Simulations:

USER INTERFACE DESIGN

Course Code	**22CDS822**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs. / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS822.1	Identify the basic user interface engineering definitions, concepts, principles and theories
22CDS822.2	Recognize the importance of user interactions/interfaces, legal, ethical, and social issues.
22CDS822.3	Apply design principles, guidelines and heuristics to create a user-interaction strategy that solves a real-world problem.
22CDS822.4	Study the characteristics and components of windows
22CDS822.5	Design a usable and compelling user-interface given a set of requirements and available technologies.
22CDS822.6	Perform various testing methods on UI

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO 1	PSO 2
22CDS822.1	3	2	-	-	-	-	-	-	-	-	-	2	3	2
22CDS822.2	3	-	2	-	-	-	-	2	-	-	-	2	3	3
22CDS822.3	3	2	3	-	2	-	-	-	-	-	-	2	3	3
22CDS822.4	3	2	2	-	-	-	-	-	-	-	-	2	3	3
22CDS822.5	2	-	3	-	-	-	-	-	-	-	-	2	3	3
22CDS822.6	3	2	1	-	-	-	-	-	-	-	-	2	3	3

MODULE-1	**THE USER INTERFACE-INTRODUCTION**	**22CDS822.1, 22CDS822.1**	**8 HOURS**

Overview, the importance of user interface, Defining the user interface, The importance of good design, The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics,
Web user – Interface popularity, characteristics, Principles of user interface design.

Case-study	the concept of "direct manipulation" in the context of GUIs. Provide three distinct examples of direct manipulation you encounter in everyday software.
Text Book	Text Book 1: 1.1,1.2, 1.3, 1.5,1.6,1.11

MODULE-2	**THE USER INTERFACE DESIGN PROCESS:**	**22CDS822.2, 22CDS822.3**	**8 HOURS**

Obstacles, Usability, Human characteristics in Design, Human Interaction speeds, Design rules, maximum usability, Principles, Standards and guidelines, Design patterns, Programming Tools, Windowing systems, Interaction tool kit. Evaluating Interface Designs: Expert Reviews, Usability Testing and Labs, Acceptance Tests, Evaluation During Active Use.

Case Study	The Evolution of Google Maps: From a basic map to a complex navigation, discovery, and local business		
Text Book	Text Book 1: 1.1,1.2, 1.3,1.4,1.6,1.10		
MODULE-3	**WINDOWS**	**22CDS822.4**	**8 Hours**
Characteristics, Components of window, Window presentation styles, Types of window, Window management, Organizing window functions, Window operations, Web systems, Screen-Based Controls: Operable control, Text control, Selection control, Custom control, Presentation control, Device Based Controls.			
Case Study	Use pertained models for VGGNet, YOLO and FCNN for image classification, object detection and segmentation.		
Text Book	Text Book 2:2.2,2.5,2.6,2.7,2.13		
MODULE-4	**MENU SELECTION, FORM FILLING, AND DIALOG BOXES:**	**22CDS822.5**	**8 HOURS**
Introduction, Task-Related Menu Organization, Single Menus, Combinations of Multiple Menus, Content Organization, Fast Movement Through Menus, Data Entry with Menus: Form Filling, Dialog Boxes, and Alternatives, Audio Menus and Menus for small Displays.			
Case Study	Would a single menu suffice, or would you need a combination of menus? Justify your choice		
Text Book	Text Book 2: 2.2,2.5,2.7,2.8		
MODULE-5	**INFORMATION SEARCH AND VISUALIZATION**	**22CDS822.5, 22CDS822.6,**	**8 HOURS**
Introduction, Search in Textual Documents and Database Querying, Multimedia Document Searches, Information Visualization. Screen based controls: Operable control, Text control, Selection control, Custom control, Presentation control, Usability, Windows Tests- prototypes, kinds of tests.			
Case study	Developing a Smart Home Energy Management System		
Text Book	Text Book 3: 3.1,3.2,3.3,3.5,3.8,3.9, ,3.20,3.21,3.21.3		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	10	5	-
L3	Apply	5	10	5
L4	Analyze	5	10	5
L5	Evaluate	-	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	5
L2	Understand	15
L3	Apply	15
L4	Analyze	15
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Textbooks:

1. Ben Shneiderman, "Designing the User Interface: Strategies for Effective Human- Computer Interaction", Pearson Education, 5th Edition 2017
2. Wilbent. O. Galitz "The Essential Guide to User Interface Design", Wiley& Sons, Third Edition 2007. .

Reference Books:

1. Alan Cooper, "The Essential Of User Interface Design", Wiley – Dream Tech Ltd., 2012.
2. Jonathan Lazar Jinjuan Heidi Feng, Harry Hochheiser, "Research Methods in Human Computer Interaction", Wiley, 2010.
3. Ben Shneiderman, "Design the User Interface", Pearson Education, 5th Edition

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/professional-certificates/google-ux-design
- https://www.coursera.org/professional-certificates/meta-front-end-developer
- https://www.coursera.org/specializations/ui-ux-design
- https://nptel.ac.in/courses/124107008
- https://www.nngroup.com/

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes and Assignments
- Case Studies

HIGH PERFORMANCE COMPUTING

Course code	**22CDS823**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS823.1	Understand the trends in parallel computing.
22CDS823.2	Apply the concepts of performance measure and hardware technologies
22CDS823.3	Use the basic ideas of multiprocessing and parallel operations with case studies.
22CDS823.4	Analyse the different parallel architectures
22CDS823.5	Identify the key factors affecting performance of the parallel applications.
22CDS823.6	Evaluate the mapping of applications to high-performance computing systems.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS823.1	3	-	-	-	-	-	-	-	-	-	-	2	2	2
22CDS823.2	2	3	-	-	-	-	-	-	-	-	-	2	2	2
22CDS823.3	2	3	2	3	3	-	-	-	-	-	-	2	2	2
22CDS823.4	2	3	3	3	3	-	-	-	-	-	-	2	2	2
22CDS823.5	3	2	-	3	-	-	-	-	-	-	-	2	2	2
22CDS823.6	2	-	2	3	-	-	-	-	-	-	-	2	2	2

MODULE-1	**THEORY OF PARALLELISM**	**22CDS823.1**	**8 HOURS**

Theory of Parallelism: Parallel Computer Models, The State of Computing, Multiprocessors and Multicomputer ,Multi vector and SIMD Computers ,PRAM and VLSI Models, Program and Network Properties ,Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architectures.

Self-study /	Parallel computing on Google's Infrastructure.

Case S t u d y / Applications	.		
Textbook	Text Book1: 1.1,1.3,1.5,1.9,1.10		
MODULE-2	**PERFORMANCE MEASURE AND HARDWARE TECHNOLOGIES**	**22CDS823.2**	**8 HOURS**
Principles of Scalable Performance, Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches Hardware Technologies: Processors and Memory Hierarchy, Advanced Processor Technology, Superscalar and Vector Processors, Memory Hierarchy Technology, Virtual Memory Technology.			
Self-study / Case Study / Applications	Parallel computing on Telephone		
Text Book	Text Book 1 : 2.1, 2.3, 2.4,2.5,2.6,2.7		
MODULE-3	**INSTRUCTION-LEVEL PARALLELISM AND ITS EXPLOITATION**	**22CDS823.3, 22CDS823.4**	**8 HOURS**
Concepts and Challenges – Basic Compiler Techniques for Exposing ILP – Reducing Branch Costs with Prediction – Overcoming Data Hazards with Dynamic Scheduling – Dynamic Scheduling: Algorithm and Examples – Hardware- Based Speculation – Exploiting ILP Using Multiple Issue and Static Scheduling – Exploiting ILP Using Dynamic Scheduling, Limitations on ILP for Realizable Processors –Using ILP Support to Exploit Thread-Level Parallelism.			
Self-study / Case Study / Applications	Applications : ILP-Software Carry Save.		
Text Book	Text Book 1 : 3.1,3.2,3.3,3.4,3.5		
MODULE-4	**PARALLEL ARCHITECTURES**	**22CDS823.5**	**8 HOURS**
Parallel Architectures: Multiprocessors and Multicomputers, Multiprocessor System Interconnects, Cache Coherence and Synchronization Mechanisms, Three Generations of Multicomputers, Message-Passing Mechanisms, Multivector and SIMD Computers, Vector Processing Principles, Multivector Multiprocessors, Compound Vector Processing , SIMD Computer Organizations			
Self-study / Case Study / Applications	Case study : On different Parallel Architecture		
Textbook	Text Book 1 : 4 1.1,4.2,4.3,4.4,4.5		
MODULE-5	**PARALLEL ALGORITHM DESIGN**	**22CDS823.6**	**8 HOURS**
Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models. Basic Communication Operations: One-to-All Broadcast and All-to-One Reduction, All to-All Broadcast and Reduction, All-Reduce and Prefix- Sum Operations, All-to-All Personalized Communication.			
Self-study / Case Study / Applications	Case study : Parallel computing on cellular networks.		
Text Book	Text Book1 : 5.1,5.2,5.3,5.4,5.5		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	MCQ's
		25	15	10
L1	Remember	-	-	-
L2	Understand	5	-	-
L3	Apply	10	7.5	5
L4	Analyze	5	7.5	5
L5	Evaluate	5	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	--
L2	Understand	10
L3	Apply	10
L4	Analyze	20
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources:

Text Books:

1. David.A.Patterson, John L.Hennessy, "Computer Architecture: A Quantitative approach", Elsevier, 6th Edition 2019.

Reference Books:

1. Parallel Programming with Open ACC, Rob Farber, 1st Edition, 2016, Morgan Kaufmann (MK) Publication, ISBN :9780124103979.
2. Grama, A. G Introduction to Parallel Computing, Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, 2nd Edition, 2013, Pearson Education, ISBN 13: 9788131708071.
3. CUDA Programming: A Developers Guide to Parallel Computing with GPUs, Shane Cook, 1 st Edition, 2013, Morgan Kaufmann, ISBN:9780124159334
4. Introduction to Parallel Computing, Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, 2nd edition, Addison-Welsey, 2003

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=WKw_e8j3Bu8
- https://www.youtube.com/watch?v=ZGUP5nUdIyc
- https://www.youtube.com/watch?v=q7sgzDH1cR8
- https://www.youtube.com/watch?v=-nSO3yuM6ss&list=PLiKFau7eKJlqoHxgx_hjLN-xFup7a13Va
- https://www.youtube.com/watch?v=vNzz2tV13Y4

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Contents related activities (Activity-based discussions)
  - ➢ For active participation of students, instruct the students to prepare Flowcharts and Handouts
  - ➢ Organizing Group wise discussions on issues

➢ Seminars

BLOCKCHAIN TECHNOLOGIES

Course Code	**22CDS824**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs / Week	**03**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS824.1	Understand the fundamentals of Blockchain Technology in different domains
22CDS824.2	Apply the cryptographic mechanisms and network protocols used in Blockchain
22CDS824.3	Illustrate smart contracts using solidity
22CDS824.4	Analyzing Decentralized applications using Blockchain
22CDS824.5	Identify the Industry Applications using Regulatory Considerations
22CDS824.6	Examine the projects which are Ethical and contain Social Implications

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS824.1	3	-	-	-	2	-	-	-	-	-	-	2	-	-
22CDS824.2	2	3	-	-	-	-	-	-	-	-	-	2	2	-
22CDS824.3	2	3	3	-	-	-	-	-	-	-	-	-	2	-
22CDS824.4	3	2	3	-	3	-	-	-	-	-	-	-	2	-
22CDS824.5	3	-	3	-	3	-	-	-	-	-	-	-	2	-
22CDS824.6	2	-	2	-	-	-	-	3	-	-	-	-	2	-

MODULE-1	**BLOCKCHAIN FUNDAMENTALS**	**22CDS824.1**	**8 HOURS**

Overview of Blockchain Technology: Pros and Cons of Blockchain, Historical development and background, Key components and participants in a blockchain network, Distributed Ledger Technology, Consensus mechanisms, mining.
Types of Blockchain: Public, private, and consortium blockchains, Permissioned and permissionless blockchain, Use cases for different types of blockchains, Blockchain wallets.

Case Study:
1. Demonstration of a simple blockchain network using a blockchain simulator or tool
2. Implementing a basic Proof of Work (PoW) consensus algorithm and understanding its working principles
3. Setting up a private blockchain network using Hyperledger Fabric or Ethereum

Text Book	Text Book 1: Chapter 1,2,3

MODULE-2	**BLOCKCHAIN SECURITY PROTOCOLS**	**22CDS824.2**	**8 HOURS**

Cryptography and Security: Cryptographic principles in blockchain, Public and private key cryptography, Security challenges and solutions, Understanding digital signatures, Merkle Trees.
Blockchain Networks and Protocols: Bitcoin and Ethereum as case studies, Other prominent blockchain platforms (e.g., Hyperledger, Corda), Interoperability and cross-chain communication.

Case Study: 1. Encryption and Decryption using SHA 256/MD5
2. Generating cryptographic key pairs, signing and verifying transactions using cryptographic algorithms
3. Deploying a smart contract on the Ethereum or Biance Smart Chain network

Text Book	Text Book 1 : Chapter 4,5

MODULE-3	SMART CONTRACT APPLICATION DEVELOPMENT	22CDS824.3, 22CDS824.4	8 HOURS
Solidity: Introduction, Need and features, Types, Structures, Control Flow and Smartcontract structure. Decentralized Applications: Introduction to DApps and their characteristics, Building DApps using blockchain platforms, Usability and scalability challenges of DApps.			
Case Study: 1. Writing smart contract programs using Solidity 2. Developing a decentralized application using Truffle (Ethereum) or Substrate (Polkadot) 3. Debugging and testing blockchain applications			
Text Book	Text Book 1 : Chapter 10		
MODULE-4	**INDUSTRY USE CASES AND LEGAL CONSIDERATIONS**	**22CDS824.5**	**8 HOURS**
Use Cases and Industry Applications : Finance and cryptocurrencies, Supply chain management and traceability, Healthcare and identity management, Voting and governance systems Legal and Regulatory Considerations : Blockchain and data privacy, Intellectual property issues in blockchain applications, Regulatory challenges and compliance			
Case Study 1. Exploring real-world blockchain use cases using Corda or Hyperledger Fabric			
Text Book	Text Book 1 : Chapter 8,9		
MODULE-5	**ETHICAL CONSIDERATIONS AND FUTURE TRENDS**	**22CDS824.6**	**8 HOURS**
Ethical and Social Implications : Addressing trust and transparency, Potential societal impacts of blockchain adoption, Responsible blockchain development and usage Future Trends and Challenges : Emerging technologies in blockchain (e.g., sharding, sidechains), Environmental impact and sustainability, Scalability and performance improvements			
Case Study: 1. Decentralized Voting System – case study 2. Charity and Donations Tracking – case study 3. Supply Chain Traceability – case study			
Text Book	Text Book1: Chapter 6,7		

CIE Assessment Pattern (50 Marks – Theory and Lab)

RBT Levels		Marks Distribution		
		Test (s)	**AAT1**	**AAT2**
		25	15	10
L1	Remember	-	-	-
L2	Understand	5	-	-
L3	Apply	10	7.5	5
L4	Analyze	5	7.5	5
L5	Evaluate	5	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	-
L2	Understand	10
L3	Apply	20
L4	Analyze	10
L5	Evaluate	10
L6	Create	--

Suggested Learning Resources: Text Books:

1) Mark Gates, Blockchain : ultimate guide to understanding Blockchain, Bitcoin, cryptocurrencies, smart contracts and the future of money, Wise Fox publishing, 2017.

Reference Books:

1) Daniel Drescher, Blockchain Basics, A press, 2017.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=SSo_EIwHSd4
- https://www.youtube.com/watch?v=_J6G5nKg0&pp=ygUjYmxvY2tjaGFpbiBzb2xpZGl0eSBzbWFydCBjb250cmFjdHM%3D
- https://www.youtube.com/watch?v=yubzJw0uiE4
- https://www.youtube.com/watch?v=ZE2HxTmxfrI

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Visit to any IT company which uses Blockchain Technology
- Demonstration of sample projects done using Blockchain
- Video demonstration of latest trends in Blockchain Technology ● Contents related activities (Activity-based discussions)
  - ➢ For active participation of students, instruct the students to prepare Flowcharts and algorithms
  - ➢ Organizing Group wise discussions

DEEP LEARNING

Course Code	**22CDS825**	**CIE Marks**	**50**
L:T:P:S	**3:0:0:0**	**SEE Marks**	**50**
Hrs. / Week	**3**	**Total Marks**	**100**
Credits	**03**	**Exam Hours**	**03**

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

22CDS825.1	Understand the concept of linear models for classification, neural networks and deep neural networks.
22CDS825.2	Apply multi-layer perceptions for solving tasks. Regularization and Optimization.
22CDS825.3	Design CNN architectures for Image classification
22CDS825.4	Understand and Explain Representation learning with some popular approaches like GAN, VAE, RBM.
22CDS825.5	Design sequence models for classification, forecasting and sequence to sequence translation using LSTM
22CDS825.6	Understand applications of deep learning: Computer vision and Natural Language Processing.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
22CDS825.1	3	3	-	-	-	-	-	-	-	-	-	2	3	2
22CDS825.2	2	2	-	3	-	-	-	-	-	-	-	2	3	3
22CDS825.3	2	2	3	2	-	-	-	-	-	-	-	2	3	3
22CDS825.4	3	2	-	-	-	-	-	-	-	-	-	2	3	3
22CDS825.5	3	2	3	-	2	-	-	-	-	-	-	2	3	3
22CDS825.6	3	-	2	-	2	-	-	-	-	-	-	2	3	3

MODULE-1	**FUNDAMENTALS OF DEEP LEARNING**	**22CDS825.1**	**8 HOURS**

Introduction to Deep Learning, Applications of Deep Learning. Optimization in high dimensions. Linear Models: Principal component Analysis, Fisher Discriminant Analysis, Support Vector Machine. Kernel function: RBF kernel. Neural Networks. Biological Neural Network and Artificial Neural Network. Perceptron algorithm. Backpropagation algorithm.

Self-study / Case Study / Applications	Latent semantic analysis using SVD
Text Book	Textbook 1: 4.3, 5.7.2, 6.5, Textbook 2: 4.1.1, 4.1.7, 7.1, 5.1, 5.2

MODULE-2	**MULTI-LAYER PERCEPTRON**	**22CDS825.2**	**8 HOURS**

Multi-layer Perceptron (MLP): XOR problem, Back propagation: Vanishing and Exploding Gradient, Activation functions and loss functions for various tasks. Optimization Techniques: Stochastic Gradient Descent and its variants. Batch Normalization.

Self-study	Comparative study between deep and wide networks. Increasing number of units in a layer vs increasing number of layers.
Text Book	Textbook 1: 6.1-6.3, 6.5, 8.1, 8.3, 8.5, Textbook 2: 5.1

MODULE-3	SUPERVISED DEEP LEARNING ARCHITECTURES	22CDS825.3	8 Hours
Regularization: Parameter norm penalties: L1 and L2. Dropout and other regularization in Deep Neural Networks. Convolutional Neural Networks: Convolution. Max Pooling. CNN Architectures: AlexNet, VGGNet, ResNet. Transfer Learning. Image Classification and Object detection using CNN.			
Applications	Use pertained models for VGGNet, YOLO and FCNN for image classification, object detection and segmentation.		
Text Book	Textbook 1: 7.1, 7.4, 7.5, 7.7, 7.8, 7.9, 7.10, 7.12, Chapter 9		
MODULE-4	**UNSUPERVISED DEEP LEARNING ARCHITECTURES**	**22CDS825.4**	**8 Hours**
Representation Learning. Restricted Boltzmann Machine (RBM). Auto-encoder. Generative Adversarial Networks (GAN): Generator and Discriminator. Variational Auto-encoder (VAE): KL Divergence and Reconstruction loss. alpha-VAE.			
Case Study	Train a VAE and GAN for Generating handwritten digits		
Text Book	Textbook 1: 16.7, 14.1, 14.2,14.3 20.10.3 20.10.4		
MODULE-5	**SEQUENCE MODELLING AND DEEP LEARNING APPLICATION**	**22CDS825.5, 22CDS825.6**	**8 Hours**
Sequence Modelling: Recurrent Neural Network: Unfolding RNN. Sequence classification, Sequence to Sequence modelling, Forecasting. Long Term dependencies: Vanishing and Exploding Gradient in RNN. Gated Recurrent Unit (GRU). Long Short-Term Memory (LSTM). Attention in LSTM. Training with Graphical Processing Unit (GPU). Distributed GPU Training: Data parallel and Model parallel approaches. Applications of Deep Learning: Computer Vision, Natural Language Programming.			
Case Study	Language Translator using LSTM		
Text Book	Textbook 1: Chapter 10		

CIE Assessment Pattern (50 Marks – Theory)

RBT Levels		Marks Distribution		
		Test (s)	AAT1	AAT2
		25	15	10
L1	Remember	5	-	-
L2	Understand	10	5	-
L3	Apply	5	10	5
L4	Analyze	5	10	5
L5	Evaluate	-	-	-
L6	Create	-	-	-

SEE Assessment Pattern (50 Marks – Theory)

RBT Levels		Exam Marks Distribution (50)
L1	Remember	5
L2	Understand	15
L3	Apply	15
L4	Analyze	15
L5	Evaluate	--
L6	Create	--

Suggested Learning Resources:

Textbooks:

1) Deep Learning. Ian Good Fellow, Yoshua Bengio, Aaron Courville. www.deeplearningbook.org . Publisher: MIT Press. 2016.

ISBN: ISBN:9780262337373, 0262337371
2) Pattern Recognition and Machine Learning. Christopher M Bishop. Publisher: Springer. 2009 ISBN-10: 0-387-31073-8, ISBN-13: 978-0387-31073-2

Reference Books:

1) Deep Learning an MIT Press book: https://www.deeplearningbook.org/

Web links and Video Lectures (e-Resources):

- **https://www.deeplearningbook.org/**
- **https://www.coursera.org/learn/neural-networks-deep-learning**
- **https://www.youtube.com/watch?v=7sB052Pz0sQ**
- **https://www.youtube.com/watch?v=Mubj_fqiAv8**
- **https://onlinecourses.nptel.ac.in/noc20_cs62/preview**

Activity-Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes and Assignments
- Case Studies
- Open Book Test

INTERNSHIP

Course Code	**22CDS83**	**CIE Marks**	**100**
L:T:P:S	**0:0:10:0**	**SEE Marks**	**100**
Hrs. / Week	**-**	**Total Marks**	**200**
Credits	**10**	**Exam Hours**	**03**

Course outcomes:

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

22CDS83.1	Classify appropriate workplace behaviors in a professional setting.
22CDS83.2	Demonstrate content knowledge appropriate to job assignment.
22CDS83.3	Interpret evidence of increased content knowledge gained through practical experience.
22CDS83.4	Analyze the nature and function of the organization in which the internship experience takes place.
22CDS83.5	Evaluate how the internship placement site fits into their broader career field.
22CDS83.6	Compile the internship experience in terms of their personal, educational and career needs.

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
22CDS83.1	3	3	3	3	3	-	-	-	3	-	-	3	3	3
22CDS83.2	3	3	3	3	3	-	-	-	3	-	-	3	3	3
22CDS83.3	3	3	3	3	3	-	-	-	3	-	-	3	3	3
22CDS83.4	3	3	3	3	3	-	-	-	3	-	-	3	3	3
22CDS83.5	3	3	3	3	3	-	-	-	3	-	-	3	3	3
22CDS83.6	3	3	3	3	3	-	-	-	3	-	-	3	3	3

Project Work: Roadmap, activities, and deliverables

- Industrial Internships Outcomes
  - To bridge a gap between the theoretical knowledge obtained in the classrooms and the practical skills required in the actual workplace.
  - Understanding of the analytical concepts and tools, hone their skills in the real-life situations and build confidence in applying the skills learned.
  - Have ample opportunities to attend seminars, symposiums, workshops, etc. This in turn provides an opportunity to establish rapports with professionals and pioneers in their respective fields for further growth.
  - Have wide scope to publish paper/s in journals and also helps to acquire team spirit, motivated acts, techniques to resolve conflicts, develop a lot of leadership skills etc.
  - Increases the prospect of placement in the same concern, provided the intern has exhibited a clear understanding of basics and successfully completed the internship.
  - Fosters to substantiate the issues with facts and figures.

Elucidation:

At the beginning of IV years of the program i.e., after VI semester, VII semester classwork and VIII semester Internship shall be permitted to be operated simultaneously by the University so that students have ample opportunity for an internship. In other words, a good percentage of the class shall attend VII semester classwork and a similar percentage of others shall attend to Internship.

Internship: The mandatory Internship is for **14 to 20 weeks**. The internship shall be considered as a head of passing and shall be considered for the award of a degree. Those, who do not take up/complete the internship shall be declared to fail and shall have to complete it during the subsequent SEE examination after satisfying the internship requirements. If the students are opting for the 8th semester, the following internship options are available:

- Industry Internship
- Research Internship
- Skill Enhancement Courses
- Post-Placement Training as Internship
- Online Internship

Industry internship: It is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints. Students undertaking industry internships must ensure the organization is listed on the VTU Internship Portal. If not, request the organization to register on the portal.

Research internship: A research internship is intended to offer the flavor of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research. Research internships must be carried out in recognized research centers. Ensure that these centers are registered on the portal.

Skill Enhancement Courses: Students can take Skill-based courses with credits totalling the same as those of the internship. Students must be taken from registered providers listed on the VTU Internship Portal.

Post-Placement Training as Internship: The post-placement training is also considered an internship. For students placed during their 6th/7th semester and willing to take the training during their final year, colleges must inform the recruiting companies in advance to register on the VTU Internship Portal.

Online Internship: Reputed online internship platforms, including those identified by NSDC, are already listed on the VTU Internship portal. If colleges come across other eligible organizations not yet listed, they are informed to ask the organization to register on the VTU Internship portal.

The faculty coordinator or mentor has to monitor the student's internship progress and interact with them to guide for the successful completion of the internship. The students are permitted to carry out the internship anywhere in India or abroad. University shall not bear any expenses incurred in respect of the internship. With the consent of the internal guide and Principal of the Institution, students shall be allowed to carry out the internship at their hometown (within or outside the state or abroad), provided favorable facilities are available for the internship and the student remains regularly in contact with the internal guide.

Evaluation Procedure:

Assessment of CIE marks

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the internship, shall be based on the evaluation of the diary, report, presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the internship report shall be the same for all the batch mates.

(ii) Interdisciplinary: The CIE marks awarded for the internship, shall be group- wise size at the institution level with the participation of all guides of the internship. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the internship, shall be based on the evaluation of the diary, report, presentation skill and question and answer session in the ratio 50:25:25.

Assessment of SEE marks

(i) Single discipline: Contribution to the internship and the performance of each group member shall be assessed individually in semester-end examination (SEE) conducted at the department. Marks shall be awarded based on the evaluation of the diary, report, presentation skill and question and answer session in the ratio 50:25:25.

(ii) Interdisciplinary: Contribution to the internship and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong to. Marks shall be

awarded based on the evaluation of the diary, report, presentation skill and question and answer session in the ratio 50:25:25.

CIE Assessment Pattern (100 Marks)

RBT Levels		Periodical Reviews & Evaluation
		100
L1	**Remember**	**-**
L2	**Understand**	**20**
L3	**Apply**	**20**
L4	**Analyze**	**20**
L5	**Evaluate**	**20**
L6	**Create**	**20**

SEE Assessment Pattern (100 Marks)

RBT Levels		**Exam Marks Distribution (100)**
L1	**Remember**	**-**
L2	**Understand**	**20**
L3	**Apply**	**20**
L4	**Analyze**	**20**
L5	**Evaluate**	**20**
L6	**Create**	**20**

APPENDIX A

List of Assessment Patterns

SLNO	Assessments
1	Continuous Internal Evaluation
2	Assignments
3	Online/Offline Quizzes
4	Mini Projects/ Projects
5	Group Discussions
6	Case studies
7	Practical Activities/Problem Solving Exercises
8	Practical Orientation on design thinking, Creative & Innovation
9	Participatory & Industry-Integrated Activities
10	Class Presentations

APPENDIX B

Outcome Based Education

Outcome-based education (OBE) is an educational theory that bases each part of an educational system around goals (outcomes). By the end of the educational experience each student should have achieved the goal. There is no specified style of teaching or assessment in OBE; instead classes, opportunities, and assessments should all help students achieve the specified outcomes.

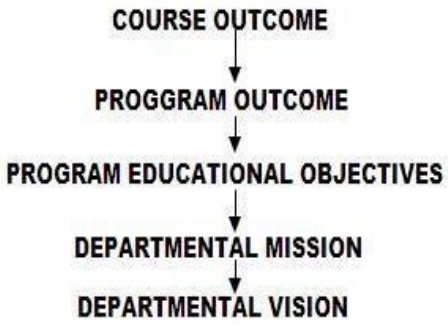
There are three educational Outcomes as defined by the National Board of Accreditation:

Program Educational Objectives: The Educational objectives of an engineering degree program are the statements that describe the expected achievements of graduate in their career and also in particular what the graduates are expected to perform and achieve during the first few years after graduation. [nbaindia.org]

Program Outcomes: What the student would demonstrate upon graduation. Graduate attributes are separately listed in Appendix C

Course Outcome: The specific outcome/s of each course/subject that is a part of the program curriculum. Each subject/course is expected to have a set of Course Outcomes

Mapping of Outcomes



APPENDIX C

The Graduate Attributes of NBA

Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
Problem analysis	Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, andthe cultural, societal, and environmental considerations.
Conduct investigations of complex problems	The problems that cannot be solved by straight forward application of knowledge, theories and techniques applicable to the engineering discipline that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions that require consideration of appropriate constraints/requirements not explicitly given in the problem statement (like: cost, power requirement, durability, product life, etc.) which need to be defined (modeled) within appropriate mathematical framework that often require use of modern computational concepts and tools.
Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

APPENDIX D

BLOOM'S TAXONOMY

Bloom's taxonomy is a classification system used to define and distinguish different levels of human cognition—i.e., thinking, learning, and understanding. Educators have typically used Bloom's taxonomy to inform or guide the development of assessments (tests and other evaluations of student learning), curriculum (units, lessons, projects, and other learning activities), and instructional methods such as questioning strategies.