



Program Curriculum

for

**B. Tech. –Computer Science & Engineering
[B. Tech. – CSE (2021-2025)]**

B. Tech. - Computer Science & Engineering [CSE]

Sem	Category	Sub-Category	Course Title	Credits	L-D-P
1	Co-Curricular			1	1-0-0
1	Perspective	School	Joy of Engineering – I	3	2-0-2
1	Skill	School	Communication Skills	1	0-0-2
1		School	Engineering Ethics	1	0-1-0
1	Foundation	School	Basic Electrical and Electronics Engineering	3	2-0-2
1		School	Mathematics for Engineers – I	2	2-0-0
		School	Engineering Chemistry	1	1-0-0
		School	Physics for Engineers	2	2-0-0
1		Program Specific	Fundamentals of Data Science	3	2-0-2
1		Program Specific	Object Oriented Programming using C++	4	2-0-4
			Semester Total	21	
Sem	Category	Sub-Category	Course Title	Credits	L-D-P
2	Co-Curricular			1	1-0-0
2	Perspective	School	Joy of Engineering – II	3	1-0-4
2		School	Environmental Studies	2	1-1-0
2	Skill	School	Technical Report Writing	2	1-0-2
2	Foundation	School	Mathematics for Engineers – II	3	2-0-2
2	Foundation	Program Specific	Fundamentals of Digital Logic	3	2-0-2
2		Program Specific	Data Structures and Algorithms	3	2-0-2
	Core	Classroom	Applied Data Science	2	1-0-2
			Semester Total	19	
ST1	Practice School		Practice School –I	Audit	

Sem	Category	Sub-Category	Course Title	Credits	L-D-P
3	Co-Curricular			1	1-0-0
3	Skill	School	Etiquettes and Conversational Skills	2	1-1-0
3	Foundation	Program Specific	Software Engineering	2	1-0-2
3		Program Specific	Design and Analysis of Algorithms	3	2-0-2
3		Program Specific	Database Management System	3	2-0-2
3	Core	Classroom	Web Programming	2	1-0-2
3		Classroom	Java Programing	3	2-0-2
3		Classroom	Operating Systems	3	2-0-2
3	Core		Project-I	1	
			Semester Total	20	
Sem	Category	Sub-Category	Course Title	Credits	L-D-P
4	Co-Curricular			1	1-0-0
4	Perspective	School	Global Energy: Politics, Markets and Policy	1	0-1-0
4		School	Design Thinking	2	0.5-1-1
4	Foundation	Program Specific	Machine Learning	3	2-0-2
4	Core	Classroom	Computer Organization & Architecture	3	2-1-0
4		Classroom	Data Communications & Computer Networks	3	2-0-2
4		Classroom	Mobile Application Development	2	2-0-0
4		Classroom	Human Computer Interaction	2	2-0-0
4	Core		Project-II (MAD/Web Programming/HCI/ML)	3	
			Semester Total	20	
ST2	Practice School		Practice School –II	4	

Sem	Category	Sub-Category	Course Title	Credits	L-D-P
5	Co-Curricular			1	1-0-0
5	Perspective	Student Specific	Innovation and Entrepreneurship	2	0.5-1-1
5	Core	Classroom	Digital Image Processing	4	3-0-2
5		Classroom	Artificial Intelligence	3	2-0-2
5	Foundation	School	Discrete Mathematics	3	2-1-0
5		Classroom	Network Security	3	3-0-0
5		Classroom	IoT Sensors, Peripherals and Processors	2	1-0-2
5	Core Elective	Classroom	Elective-I (Specialization Specific)	3	
5	Skill	School	Seminar / Case Studies	2	
			Semester Total	23	
Sem	Category	Sub-Category	Course Title	Credits	L-D-P
6	Perspective	Student Specific		1	
6	Core	Classroom	Theory of Computation	3	2-1-0
		Classroom	IoT Networks, Architectures and Applications	3	3-0-0
		Classroom	Cryptography	2	2-0-0
6	Core Elective	Classroom	Elective II (Specialization Specific)	3	
6	Core Elective	Project-III	Elective III (Specialization Specific)	3	
6	Open Elective	Classroom / Lab		3	
			Semester Total	18	
Sem	Category	Sub-Category	Course Title	Credits	L-D-P
7	Core Elective	Classroom	Elective IV (Specialization Specific)	3	
7		Classroom	Elective V (Specialization Specific)	3	
7	Core	Project IV		5	
7	Open Elective	Classroom / Lab		3	
7		Classroom / Lab		3	
			Semester Total	17	
Sem	Category	Sub-Category	Course Title	Credits	
8	Practice School		Practice School-III	14	
			Semester Total	14	
			Program Total	156	

Course Baskets

[1]. Foundation Courses

School Courses

Basic Electrical and Electronics Engineering
Mathematics for Engineers – I
Discrete Mathematics
Mathematics for Engineers - II

Credits

3
2
3
3

Program Specific Courses

Fundamentals of Data Science
Object Oriented Programming using C++
Fundamentals of Digital Logic
Data Structures and Algorithms
Database Management Systems
Software Engineering
Design and Analysis of Algorithms
Machine Learning

[2]. Skill Courses

School Courses	Credits	Student Specific Courses
Communication Skills	1	Business Correspondence and Report Writing
Technical Report Writing	2	Problem Solving and Consulting Skills
Engineering Ethics	2	Quantitative and Analytical Skills
Etiquettes and conversational skills	2	Writing Skills
		Resume Writing and Career Skills
		Selling, Negotiating and Persuading Skills
		Technical Communication
		Theatre Studies

[3]. Perspective Courses

School Courses	Credits	Student Specific Courses
Joy of Engineering- I	3	Geo-politics and Geo-economics
Joy of Engineering – II	3	Good Citizenry
Environmental Studies	2	Human Geography
Global Energy: Politics, Markets and Policy	1	Indian Political System
Innovation and Entrepreneurship	1	Intellectual Property Laws
		International Human Rights
		Living Arts and Literature
		Public Administration
		Right to Information
		Science, Technology and Public Policy
		Systems Approach
		World Civilizations
		Philosophy and Logic
		Principles of Management
		Understanding Business

[4]. [Basic] Core Electives Courses

- 1 Research Methodology
- 2 Paper Writing and Story Telling
- 3 Paper Reading and Concluding, Referencing, Latex introduction, Mendeley
- 4 Microprocessor Based System Design
- 5 Computer Graphics
- 6 Graph Theory
- 7 Compiler Design
- 8 Theory of Computation
- 9 Cloud Computing
- 10 Fog Computing
- 11 Advanced Database Management Systems
- 12 Any other course on recent development

[5]. Specialization Courses [Elective]

Specialization: Data Science and Artificial Intelligence

- 1 Natural Language Processing and Text Analytics
- 2 Semantic Web and Knowledge Graphs
- 3 Audio and Speech Processing
- 4 Information Retrieval System
- 5 Computer Vision
- 6 Reinforcement Learning
- 7 Multi-agent Systems
- 8 Deep Learning
- 9 Soft Computing
- 10 Biomedical Data Analysis
- 11 Data Science and Complex System
- 12 Cloud Computing
- 13 Data Science in Financial Markets
- 14 Advanced Data Science
- 15 Interaction Design
- 16 Social Network Analysis
- 17 Big Data Analytics
- 18 Data Visualization with R
- 19 Any other course on recent development

Specialization: Cyber Security

- 1 Cloud Computing
- 2 Cyber Forensics
- 3 Cloud Security
- 4 Mobile Security
- 5 IoT Security
- 6 Information Security
- 7 Vulnerability Assessment and Penetration Testing
- 8 Malware Analysis
- 9 Cyberspace Operations and Design
- 10 Security Attack and Defense
- 11 Online Social network and Security
- 12 Security Audit
- 13 Cyber Threat Intelligence
- 14 Security Risk Analysis
- 15 Information Retrieval
- 16 Blockchain
- 17 Applied Cryptography
- 18 Cyber security tools and cyber-attacks
- 19 Any other course on recent development

Specialization: Internet of Things

- 1 Sensor, Actuators and Programming in IoT
- 2 Wearable and Body Area Network
- 3 Embedded System
- 4 Control Systems
- 5 IoT Using RFID and microcontroller
- 6 Applications of IoT in Robotics
- 7 Communications and Networking Technologies for IoT
- 8 IoT in Big Data
- 9 Industrial and Medical IoT
- 10 5G and IoT
- 11 IoT in healthcare
- 12 IoT architecture and technologies
- 13 IoT interface design and protocols Architecting smart IoT devices
- 14 Security in IoT
- 15 IoT Testbed
- 16 Google Cloud IoT platform
- 17 IoT automation
- 18 Processors and Peripherals
- 19 IoT Architecture and Protocols
- 20 Mobile Application Development for IoT
- 21 Data Management in IoT
- 22 Cloud Computing
- 23 Any other course on recent development

Specialization: Robotics & Automation

- 1 Drives and Control Systems
- 2 Human Machine Interface
- 3 Hydraulic and Pneumatic Systems
- 4 Industrial Automation
- 5 Kinematics and Dynamics of Robots
- 6 Mechatronic Systems Design
- 7 Advanced Robotics
- 8 Automation and Robotics
- 9 Electromechanical System Design
- 11 Sensors Network
- 12 Control Theory

Specialization: Automobile Engineering

- 1 Automotive Chassis and Suspension
- 2 Automotive Components and Assembly Drawing
- 3 Automotive Control Engineering
- 4 Automotive Electrical and Electronics System
- 5 Automotive Pollution Control and Alternative Fuels
- 6 Automotive Structures and Design
- 7 Automotive Transmission Systems
- 8 Battery Engineering
- 9 Vehicle Body Engineering and Aerodynamics
- 10 Vehicle Dynamics
- 11 Automotive Materials and Processes
- 12 Fuel Cells and Energy Storage

[6]. Minor Program Courses [Elective]

Minor Program: Computational Linguistics

- 1 Formal languages and automata theory
- 2 Grammar and Parsing
- 3 Text processing
- 4 Speech and Audio Processing
- 5 Lexical Semantics and Computational Discourse

Minor Program: Cyber Physical Systems

- 1 IT fundamentals of Cyber Physical Systems
- 2 Cyber Physical Systems: Modelling and Simulation
- 2 Embedded Hardware and Operating System
- 3 Web Connectivity and Security in Embedded System
- 4 Design and Analyze Secure Networked System
- 5 Real Time Cyber Threat Detection and Mitigation

Minor Program: Computational Mathematics

- 1 Advanced Numerical methods/ Numerical Linear Algebra
- 2 Computational Geometry
- 3 Design and Analysis of Experiments
- 4 Industrial Statistics
- 5 Mathematical Finance
- 6 Mathematical Modelling in Industry
- 7 Number Theory and Cryptography
- 8 Numerical solution of PDE's
- 9 Probability theory and Monte Carlo simulation
- 10 Time Series Analysis and Dynamical Modelling

Minor Program: Energy Harvesting and Storage

- 1 Biofuels
- 2 Characterization Techniques for Energy Materials and Devices
- 3 Fuel Cell, Li- ion Battery and Supercapacitors
- 4 Hydrogen Energy
- 5 Renewable and Non-renewable Energy Resources
- 6 Solar Energy

Minor Program: Functional English

- 1 Critical Reasoning, Writing and Presentation
- 2 Culture and Civilization
- 3 Introduction to Theatre Studies
- 4 Landmarks in English Literature
- 5 Media Studies
- 6 Methodology Functional Language

Minor Program: Liberal Arts

- 1 Cultures of Computing
- 2 Geo-politics and Geo-economics
- 3 Indian Political System
- 4 Living Arts and Literature
- 5 Public Administration
- 6 Science, Technology and Public Policy

Minor Program: Material Science

- 1 Computational Materials Science
- 2 Energy Materials
- 3 Engineering Materials
- 4 Materials Characterization
- 5 Science and Engineering of Composite Materials
- 6 Science and Engineering of Light Weight materials for Transportation applications
- 7 Surface Engineering

Minor Program: Nanotechnology

- 1 Applications of Nanotechnology
- 2 Bio Nanomaterials
- 3 Computational Materials Science
- 4 Micro and Nano systems
- 5 Nano Metrology
- 6 Synthesis and Fabrication of Nano Materials

Minor Program: VLSI Design

- 1 Advanced VLSI Design
- 2 Analog CMOS Design
- 3 Design for Testability
- 4 Hardware Software Co-Design
- 5 IC Technology
- 6 Low Power CMOS VLSI Circuit Design
- 7 Micro-Electro-Mechanical Systems (MEMS)
- 8 RF Microelectronics
- 9 System on Chip Design
- 10 VLSI Digital Signal Processing System

Minor Program: Entrepreneurship

- 1 Corporate Entrepreneurship
- 2 Family Business Dynamics
- 3 Social Entrepreneurship
- 4 Managing Technology and Innovation
- 5 Business Model and Intellectual Property
- 6 New Venture Funding
- 7 SME Financing
- 8 Legal Aspects of Venturing
- 9 Applied Project

Syllabus
of
B. Tech. - Computer Science & Engineering

JOY OF ENGINEERING-1	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

This course is spread over two semesters. The aim of JOE-I is to get the students to experience the joy of creativity within engineering. Learning will be evaluated through development of innovative solutions by students, mentored by faculty. Students will be exposed to emerging technologies such as Artificial Intelligence, Machine Learning, Internet of Things, Robotics and Augmented Reality through invited lectures and lectures by faculty. However, the focus will be on design for purpose, providing students with opportunities to create innovative solutions to given theme problems. Students have to ensure that their final choice of outcome of their project is demonstrable and is functioning i.e. a working physical prototype of a product or a working software solution or working mobile app etc. Students will be expected to choose their projects during Semester 1. The instructor will propose the themes for student projects. The themes are representing broad areas. It is for the students to create concrete proposals through interactions with mentor faculty within the themes. Develop Ideas and Design Concepts: The students will be given the opportunity to work in teams to develop ideas and design concepts and propose solutions for specific design theme projects.

COMMUNICATION SKILLS	L	D	P	Credits
	0	0	2	1

COURSE CONTENTS

What is communication? Understanding the process/cycle of Communication; Verbal and Non-Verbal communication; Barriers of communication; Fundamentals of Effective Speaking1 (Style); Fundamentals of Effective Speaking 2 (Tone); Building Advanced Vocabulary; Effective Presentation Strategies /Dynamics of Professional Presentations; Techniques of Reading Comprehension; Basics/Techniques of writing.

ENGINEERING ETHICS	L	D	P	Credits
	0	1	0	1

COURSE CONTENTS

Ethical theories, Geo-engineering, bio-engineering, genetic engineering, environmental ethics, Kohlberg Theory, Heinz's Dilemma, Ethics and Programming, Ethics of Social Media platforms, Ethics of data collection and data sharing, Ethics and AI, Industrial Revolution 4.0, Future of AI and Technological unemployment.

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

DC Circuits: Electric charge and current, active and passive two terminal elements, Ohm's laws, series and parallel reduction of resistive circuits, star-delta transformation, current and voltage independent and dependent sources, voltage division rule and current division rule, source transformation, Kirchhoff's laws – KCL and KVL, Mesh (Loop) analysis and Nodal analysis. DC Network Theorems: Superposition Theorem, Thevenin's Theorem, Norton's theorem, Maximum Power Transfer theorem. AC Circuits: Introduction to alternating quantities – average and effective or rms values, form and peak factors, phasor representation of sinusoidal quantity, AC series circuit containing R, L, C, R-L, R-C, and R-L-C elements, impedance triangle, Instantaneous power, apparent power, power factor, power triangle, Series-Parallel R-L-C circuits. Introduction to Semiconductor devices: P-N junction, forward and reverse biasing, volt ampere characteristics of p-n junction, Zener diode, Schottky diode, applications of diode: rectifiers, clippers and clampers, other types of diodes, BJT as a switch. OP-AMP: Inverting, Non-inverting amplifier, adder, subtractor, integrator, differentiator. Design of active filters Low pass, High Pass and Band Pass. Introduction: Bipolar Junction Transistors (BJT) and DC Biasing: Familiar with Transistor fundamentals- Basic Operation and symbol Representation, Transistor configuration (CE, CB, CC), Transistor characteristics.

MATHEMATICS FOR ENGINEERS- I	L	D	P	Credits
	2	0	0	2

COURSE CONTENTS

Function of several variables, Limits & Continuity in higher dimension, Partial derivatives, Applications of Partial derivatives in Maxima and Minima, Lagrange's method, Taylor's expansion for functions of two variables, Double and triple integrals: Change of order of integration, change of coordinates, Cylindrical coordinates and Spherical polar coordinates, Change of variables, Jacobian of transformation. Matrices, Row Reduced Echelon form of a matrix, Linear equations and their solutions, Vector spaces, subspaces, linear dependence and independence of vectors, basis and dimension of a vector space, null space, range spaces, finite dimensional vector space and its applications, Linear transformation, Diagonalization, Eigen values and Eigen vectors, its applications in Markov chain and dynamical systems.

ENGINEERING CHEMISTRY	L	D	P	Credits
	1	0	0	1

COURSE CONTENTS

Chemical kinetics: Reaction rates and rate law, reaction in liquid solutions, catalysis, adsorption of gases on solids;

Quantum Theory-Basics: Schrodinger Equation, Particle in a 1D box, UV-Vis spectroscopy; Polymer chemistry: Free radical chain growth polymerization, Emulsion Polymerization, Cationic polymerization, Anionic polymerization, Insertion polymerization, characterization of polymers

PHYSICS FOR ENGINEERS	L	D	P	Credits
	2	0	0	2

COURSE CONTENTS

Engineering Optics: Basics of Interference, Diffraction and Polarization, Lasers and characteristics, Einstein's coefficients, He-Ne laser, semiconductor lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibre in industry and communication. Quantum Mechanics: Basics of quantum mechanics, De-Broglie's hypothesis, Uncertainty principle, Probability and Wave function, Postulates of quantum mechanics, Time dependent and Time-independent Schrodinger wave equation, Particle in a box. Solid State Physics: Space Lattice, unit cell and translation vectors; Miller indices, Simple and close-packed crystal structures with examples, Origin of energy bands, Kronig Penney Model (qualitative), E-K diagram, Brillouin Zones, Concept of effective mass and holes, Classification into metals, Semiconductors and insulators, Liquid crystals, Hall effect.

FUNDAMENTALS OF DATA SCIENCE	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Fundamentals of Data Science: What is data science, Various types and levels of data, Data science life cycle, etc. Data Science Toolbox: Introduction to Python-Jupyter Notebook, Pandas, and NumPy. Data Handling and Statistics: Data collection and preparation, Missing value handling, Data scrubbing, Data transformation, Feature Engineering, Population and sample, Moments and generating functions- bias and variance, Measure of Variability, Hypothesis Testing, Probability Distributions- Uniform, Normal Poisson. Basic and Specialized Visualization Tools: Matplotlib (area plot, scatter plot, line plot, histogram, bar charts, box plot, heat map, faceting, pairplot), seaborn, ggplot2. Exploratory Data Analytics: Dimension reduction- PCA, Factor analysis. Regression Linear Model: Linear regression, logistic regression. Project in Data Science: Model Definition and Training, Model Evaluation, Model Deployment, Final presentation.

OBJECT ORIENTED PROGRAMMING USING C++	L	D	P	Credits
	2	0	4	4

COURSE CONTENTS

Evolution of Programming methodologies, Introduction to OOP and its basic features, Basic components of a Program and program structure, Compiling and Executing, Selection control statements. Data types, Expression and control statements, Iteration statements, Introduction to Arrays, Multidimensional Arrays, Strings and String related Library Functions, Standard input and output operations. Functions, Structures, this Pointer, Friend Functions and Classes, Static variable and functions. Constructors and Destructors, Static variables and Functions in class Operator Overloading, Overloading Unary Operators, Overloading binary operators. Inheritance, Types of Inheritance, Virtual Functions, Overriding, Abstract classes. Pointers, Objects and Pointers, Command Line Arguments. File handling, Exception handling.

JOY OF ENGINEERING - II	L	D	P	Credits
	1	0	4	3

COURSE CONTENTS

In continuation of the selected projects in the first semester, the students will perform the following: Product Development Process: Students will be given the space to enhance creativity and experience fundamental aspects of the product development process, including determining needs, brainstorming, estimation, sketching, sketch modelling, concept development, design aesthetics, detailed design, prototyping and manufacturing. The course shall also provide a platform to develop written, visual, and oral communication as teams will be required to present their ideas and product to “stakeholders”. Prototype Creation: Students will work on at least one idea from each theme and in the fabrication stage they will work on any one idea of their choice.

ENVIRONMENTAL STUDIES	L	D	P	Credits
	1	1	0	2

COURSE CONTENTS

Introduction to Environmental Studies, Biodiversity, Ecological footprint, wetlands, Field trip to Yamuna Bio-diversity park, Food-chains, Alternate energy scenario in India, Water Pollution, Sewage treatment, Air pollution, CO2 emission, Green-house effects, UNFCCC, Clean Air act, Global Warming, Environmental policy making, Race to bottom, Pollution Haven, Global South, Air pollution in emerging economies like India and China, Disaster Management, SDGs.

TECHNICAL REPORT WRITING	L	D	P	Credits
	1	0	2	2

COURSE CONTENTS

What is Technical Communication; Difference between General and Technical Communication; Types of Motivation in writing Technical documents; Fundamentals of Effective Writing 1 (Style); Fundamentals of Effective Writing 2 (Tone); Building Advanced Vocabulary; Effective Writing Strategies; Office Correspondence; Memo, Agenda and Minutes of meeting, Circular and Notice; Writing a Technical Proposal; Fundamentals of Technical Report Writing; Writing a Technical Report; Dynamics of Professional Report Presentations.

MATHEMATICS FOR ENGINEERS - II	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Sample Space, Dependent and Independent Events, Conditional Probability, Bayes' Rule; Random Variables, discrete and continuous random variables, Probability distribution functions, Joint probability distribution, Conditional probability distribution, Marginal probability distribution, Statistical independence, Mathematical Expectation, Variance, covariance, Mean/expected value of a random variable, Bernoulli, Binomial, Geometric, Poisson, Uniform, Normal distributions, Random sampling, estimation of population parameters, confidence interval, prediction interval and tolerance interval, testing of hypotheses, t- Distribution, F-Distribution.

FUNDAMENTALS OF DIGITAL LOGIC	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction to Digital Systems: Number Systems, Real Number Representation, Conversions, Complement of Number, Binary Arithmetic, Binary Codes. Boolean Algebra: Introduction, Basic Theorems, Properties of Boolean Algebra, Boolean Functions, Canonical forms, Standard forms, DeMorgan's Theorem, Principle of Duality, Sum of Minterms and Product of Maxterms. Logic Gates and Gate level Minimization: Binary logic, Digital Logic Gates, Universal Gates: NAND Gate, NOR Gate, Exclusive OR (XOR) Gate, Exclusive NOR (XNOR) Gate, Sum of Products, Product of Sums, Universal Buildings blocks and Karnaugh Map: Two variable, Three variable, Four Variable, Don't Care Conditions. Combinational Logic: Introduction, Combinational Circuits, Analysis Procedure, Design Procedure, Adder Circuits, Subtractor Circuits, Multiplexer, Types of Multiplexers, Demultiplexer and its types, Decoders (2 to 4, 3 to 8), Encoders (Octal to binary, Decimal to BCD). Flip Flops: Introduction, RS Flip Flop, Clocked Flip Flops, D Flip Flop, JK Flip Flop, Master Slave JK Flip Flop, T Flip Flop and Applications of Flip Flop, Conversion. Counters: Introduction, Types of Counters. Synchronous Sequential Circuits: Introduction, Classification of Sequential circuits, Analysis of Synchronous Circuits. Introduction of Asynchronous Sequential Circuits, Modes of Asynchronous Sequential circuits.

DATA STRUCTURES AND ALGORITHMS

L	D	P	Credits
2	0	2	3

COURSE CONTENTS

Introduction: Elementary Data types, Abstract data types (ADT), Basic concepts and Definition of data structures, The need for data structures, classification of data structures. Brief idea of algorithms: Asymptotic notations and algorithm analysis; notion of time and space complexity. ADT array: Multi-Dimensional Arrays, Row-major and column-major indexing, Address calculations. Basic operations in array – linear search, binary search. Main memory and comparison based elementary sorting. Performance analysis of sorting algorithms, Notion of non-comparison-based sorting. Asymptotically Faster Sorting Techniques. Performance analysis of sorting algorithms. ADT Sparse matrix. ADT List: singly, doubly, circular, doubly circular linked list, various operations on linked list, applications of linked lists in polynomial representation, sparse matrices representation, etc. ADT Stack: Implementations using array and linked list, various operations, applications. ADT Queue: Implementations using array and linked list, various operations, applications. ADT binary tree and ADT binary search tree: various terms, representation using array and linked list, various operations, traversal, applications. Binary heap, heap sort. Balanced binary search trees - AVL Trees, operations, applications. B-trees and its variations, operations, applications. ADT Graphs: Basic terminology, modeling with graph, graph representation in computer, various operations, traversal, applications. ADT Dictionary: Implementation, Hash Tables, hash function, properties of good hash functions, Hashing techniques, collision resolution techniques, insertions, deletions, and searching operations in a Hash table, Brief idea of perfect hash function, re-hashing and double hashing, applications of hashing.

APPLIED DATA SCIENCE

L	D	P	Credits
1	0	2	2

COURSE CONTENTS

Quick review on Data Science concepts with hands on: (data acquisition, pre-processing – data cleaning – handling missing values). Various Outlier detection Techniques such as Z Score, Local Outlier Factor, Isolation Forest, Outlier Detection using In-degree Number (ODIN). Hypothesis Testing, T-test, P-value test, F-test, Type 1 and Type 2 Error, Confusion Matrix, A/B Testing. Importance of proper visualization, qualities of a great visualization. Data visualization toolkits - matplotlib, seaborn, interactive plot with plotly and cufflinks, geographical plotting with choropleth maps. Supervised regression –Regularized Regression. Supervised classification – Introduction to Training-Testing, Partition, Validation Set, Naïve Bayes, KNN. Unsupervised techniques – K mean clustering, Fuzzy -C means clustering, Hierarchical clustering. Dimension reduction with PCA. Factor Analysis. Feature Engineering. LDA. Performance matrix and Model Evaluation.

ETIQUETTES AND CONVERSATIONAL SKILLS	L	D	P	Credits
	1	1	0	2

COURSE CONTENTS

Understand why good speaking skills are important to be a good professional. Learn strong, professional social skills. Effective introductions. Creating a good first impression. Attitude and team building. Minimize nervousness in social situations. Enumerate the 4 levels of conversation. Physical grooming and body language. Understand place settings, napkin etiquette & basic table manners Master professional office conduct including: etiquette in relation to open plan & cubicle environments Do's and don'ts in meetings. Acquire telephone and E mail etiquette skills. Learn how to dress for success. Gain valuable insight into international etiquette. Interview facing skills.

SOFTWARE ENGINEERING	L	D	P	Credits
	1	0	2	2

COURSE CONTENTS

Introduction and overview of SE: Concepts about Software, SE activities, Issues of professional responsibility, key challenges facing SW engineering, Software Engineering methods Software Development Life Cycle (SDLC): Process Models – their advantages and disadvantages, Agile development, Requirement Phase: Elicitation, Analysis, Specification and Validation, Studying feasibility of requirements – operational, technical and economic, Requirements Prioritization. Design Phase: Differences between requirement analysis and design Activities, important desirable characteristics of a good software design, Coding and Testing: Coding standards and coding guidelines, code reviews and inspections, various types of testing Software Project Management: Software project monitoring and control, critical Path, PERT Chart, Gantt Chart Software Quality and Reliability: Software Quality control and Quality assurance, Reliability issues and metrics Software Maintenance: Necessity of software maintenance, the types of software maintenance, software reverse engineering.

DESIGN AND ANALYSIS OF ALGORITHMS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Preliminaries: Algorithms, Analyzing algorithms - problems and instances; efficiency-average and worst-case analysis; elementary operations. Complexity of algorithms, Growth of functions and Asymptotic notations, Performance measurements, pseudo code, RAM model Quick Review of Data Structures: Stack, Queue, Linked List, BST, Disjoint-set data structures. Concept of Heap and Heap sort, Comparison of sorting algorithms, Sorting in linear time. Divide and Conquer: Recurrence relations, Masters method, Merge sort, Quick sort, Matrix multiplication. Decrease and conquer – Binary search. Greedy Methods: Introduction to greedy algorithms – examples such as Fractional Knapsack problem, Minimum Spanning Trees – Prim's and Kruskal's algorithms, Single source shortest paths - Dijkstra's algorithm, Huffman coding. Dynamic Programming: Matrix-chain multiplication problem; Longest common subsequence

problem; 0/1-Kanpsack problem, Single source shortest paths - Bellman Ford algorithm. All pair shortest paths – Floyd-Warshall algorithm. String/Pattern Matching: Brute force method for string matching, Boyer-Moore algorithm, KMP algorithm Correctness of Algorithms: Loop invariant technique and induction. Intractable problems - Backtracking with examples such as N-Queens problem, Branch and Bound. Introduction to Non-deterministic algorithms, NP-Completeness and NP-Hard problems with discussions on Travelling Salesman problem, 3-SAT, Graph Coloring, Hamiltonian Cycles and Sum of Subsets, Cook’s Theorem. Undecidable problem: Halting problem.

DATABASE MANAGEMENT SYSTEM	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction: Understand the application of DBMS, difference between traditional file systems and DBMS, Views of DBMS and data Independence. Architecture of database: (2-Tier and 3-Tier Architecture) and users of database. Designing the conceptual model i.e. E-R Model (Entity set, attributes and their types), relationship constraints (participation constraints and cardinality ratio). Various keys: Primary key, foreign key, super key, candidate key etc. and constraints used in relational database model including integrity constraints. Relational algebra: Relational operators (projection, selection, union, intersection, division, cross product etc.). Apply the concepts using MySQL. Join operators: Inner join, outer join, natural join, equi-join, self-join, complete set of relational algebra operations. Normalization: Normalizing the data and applying functional dependencies like fully functional dependency, partial FD, trivial and non-trivial FD, normalization: 1NF, 2NF, 3NF, BCNF, 4NF and 5NF, Denormalization. Stored procedures, triggers and query optimization. Hashing: Methods to generate hash functions, collision and how to resolve collision, indexing and type of indexes and B-Tree with examples. Transaction processing: ACID Properties, Problems associated with concurrency (Inconsistent Read, Lost Update Problem etc.). Concurrency control mechanisms: Serializability (Conflict and view), two phase locking protocol (Strict and rigorous 2 phase locking, basic concept of deadlock (detection, recovery etc.). Database back-up and Recovery mechanisms: Log and check point-based recovery. Overview of Distributed database system.

WEB PROGRAMMING	L	D	P	Credits
	1	0	2	2

COURSE CONTENTS

Introduction to CSS, Basic selectors, formatting, integrating CSS , In-line Styles, Embedded Style sheets, Imported Style Sheet, Classes, Ids. JavaScript: Data Types, Primitive Types, Statements, Keywords, Operators, JavaScript Conditional Statements Function, Parameters, Function Return Types, Arrays, JavaScript Objects, Window Objects, Document Object, Object Creation, Adding Methods of Objects, JavaScript Loops & Iteration, Adding Properties of Objects, Event Handling, Enumerating Properties, Callbacks, JSON. Building scalable Web Apps with Server-Side JavaScript: generating dynamic content on the server using Node.js (creating the HTTP server, handlebars, template engines); storing and retrieving data in MongoDB

JAVA PROGRAMMING	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction to object oriented concepts - objects - classes - abstraction and encapsulation - inheritance - polymorphism. Comparison between Procedure Oriented Programming and Object Oriented Programming. Applications of Object Oriented Programming. Introduction to Java language: JVM, JRE, Constant, variable, data types; operators and expressions; decision making, branching and looping. Object Oriented concepts using Java: access specifiers—default, private and public, Methods - invoking methods, Passing parameters to methods, Returning values from methods, Method overloading, methods with variable arguments, Classes and Objects, Constructors, Abstraction and Encapsulation, static members, nesting of methods, constructor Overloading, Garbage Collection, Finalize Method Command line arguments, Array, String, StringBuffer, StringBuilder, StringTokenizer classes Inheritance – single and multi-level inheritance, protected access specifier, multiple inheritance – defining and extending and implementing interface; final variable, method and class; abstract methods and classes; Method overriding and runtime polymorphism, polymorphism in multilevel inheritance hierarchy Package – putting classes together, creating and accessing packages, adding class to a package, hiding classes Managing Errors and Exceptions: Exception handling for managing runtime errors – try and catch blocks, finally block, Throwing an exception, Throws clause, Rethrowing an exception, Checked and unchecked exception, User defined exceptions I/O Files in Java: Concept of streams, Stream classes, Byte stream and Character stream classes, other I/O classes, reading/writing bytes and characters. Handling primitive data types, Random Access files, Serialization and deserialization. Multithreaded Programming: Creating a thread-Thread class and Runnable Interface, Life-cycle of a thread, Thread priority, Synchronization.

OPERATING SYSTEM	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction to Operating Systems, Concept of batch-processing, multi-programming, time sharing, real time operations, Process Management : Scheduling, Threads, concept of semaphore, Process Synchronization, Deadlock; Memory management: partitioning, fragmentation, paging segmentation, swapping, virtual memory, demand paging, page size, page table, page replacement algorithms; File Management, disk , Protection and Security; Case Studies.

GLOBAL ENERGY: POLITICS, MARKETS AND POLICY	L	D	P	Credits
	0	1	0	1

COURSE CONTENTS

Overview of Energy Issues; Fundamentals of Energy Systems; brief history of Global Energy; Role of Technology in energy transformation; Stakeholders in Energy Regimes; Energy Economics; Oil politics in Middle-East; Geo-politics of

Asian Energy: Russia, China, Korea, India; Selected National Strategies: Japan, China, India, Australia; Future of Energy and SDGs.

DESIGN THINKING	L	D	P	Credits
	0.5	1	1	2

COURSE CONTENTS

Design Thinking: What is design thinking? What design thinking is not? Applications of design thinking in industries. Benefits of design thinking. Case studies of design thinking. People centered design thinking. Understanding Design Thinking through a case Framing the problem statement – what really is the issue? What-Why-How-Whom. Observation Methods. Interviewing and Storytelling skills. Immersion. Empathy Canvas. Identifying Personas & Patterns . Discussion, Group Exercise. Define - Point of view, how might we, stakeholder map, customer journeys, context map and opportunity map. Creativity and Ideation ADRAI . Discussion, Group Exercise. Prototyping & Experimentation. Physical/ digital prototypes, wireframes, and storyboards. Discussion, Group Exercise.

MACHINE LEARNING	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction: Goals and applications of machine learning. Aspects of developing a learning system: training data, concept representation, function approximation. Regression and goodness of fit test. *Supervised classification:* SVM, Decision Tree classifier, Ensemble techniques – Random Forest, Bagging, Boosting. *Clustering and Unsupervised Learning:* Learning from unclassified data. Clustering. Hierarchical Agglomerative Clustering. k-means partitional clustering. Mixture of Gaussians, Expectation maximization (EM) for soft clustering. Semi-supervised learning with EM using labeled and unlabeled data. Dimension reduction with PCA, LDA, MDS. *Reinforcement Learning:* Fundamentals (Learning Agents, Dynamic Systems, Systemic Machine Learning (Model, Behind Math's, impact Function, Adaptive Learning, Multi-perspective Learning, Whole System Learning, Knowledge Representation, Building your own system *Neural Network and Perceptron Learning:* Motivation of Neural Networks, Multi-Layer Perceptron (MLP), MLP as Approximator, Autoencoder, Artificial Neural Network, Recurrent Neural Networks, Long short-term memory (LSTM). *Experimental Evaluation of Learning Algorithms:* Measuring the accuracy of learned hypotheses. Comparing learning algorithms: Over and Under -fitting, Cross-Validation, learning curves, and statistical hypothesis testing.

COMPUTER ORGANIZATION & ARCHITECTURE	L	D	P	Credits
	2	1	0	3

COURSE CONTENTS

Module 1- Introduction: Function and structure of a computer, Functional components of a computer, Interconnection of components, Performance of a computer. Number representation: fixed and floating-point number representation, IEEE standard for floating point representation. Module 2- Instruction Set Architecture: Representation of Instructions:

Machine instructions, Operands, Addressing modes, Instruction formats, Instruction sets: Register, bus and memory transfer, Instruction set architectures - CISC and RISC architectures (Difference). Module 3- Processing Unit: Addition and subtraction of signed numbers, look ahead carry adders. Multiplication: Signed operand multiplication, Booths algorithm and array multiplier. Division and logic operations. Floating point arithmetic operation. Organization of a processor - Registers, ALU and Control unit, Data path in a CPU, Instruction cycle, Organization of a control unit - Operations of a control unit, Hardwired control unit, Microprogrammed control unit, Introduction to parallel processing systems, Flynn's classifications, pipeline processing, Instruction pipelining, pipeline stages and Pipeline hazards. Module 4- Memory Subsystem: Semiconductor memories, RAM Memory cells - SRAM and DRAM cells, Internal Organization of a memory chip, Organization of a memory unit, Error correction memories, Interleaved memories, Cache memory unit - Concept of cache memory, Mapping methods, Organization of a cache memory unit, Fetch and write mechanisms, Memory management unit - Concept of virtual memory, Address translation, Hardware support for memory management.

DATA COMMUNICATIONS & COMPUTER NETWORKS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Basic concepts of networking: Internet; network edge; network core; packet vs. circuit switching; delay, loss and throughput; protocol layers; network security Application layer: basic principles of network applications; web and HTTP; Electronic Mail, DNS, Peer-to-Peer applications; Video streaming, content distribution networks Transport layer: services of transport layer; multiplexing and demultiplexing; connectionless transport using UDP; principles of reliable data transfer; connection-oriented transport using TCP; principles of congestion control; TCP congestion control Network layer: overview of forwarding, routing and network service models; router in detail; internet protocol (IP), Ipv4 and IPv6 addressing; network address translation (NAT); forwarding in SDN; routing algorithms; OSPF; BGP; SDN control plane; ICMP protocol; Network management and SNMP protocol Link layer: services of link layer; error-detection and correction techniques; multiple access links and protocols; switched local area networks; link virtualization; data center networking Wireless and mobile networks: wireless network characteristics; 802.11 wireless LANs, cellular internet access, mobility management, mobile IP. Network security: cryptography; digital signatures; authentication protocols, secure e-mails, secure TCP connections; IPsec; VPNs; secure wireless LAN; Firewalls; Intrusion Detection Multimedia networking: types and properties of multimedia network applications; stored video streaming; voice-over-IP; RTP protocol; SIP protocol; Quality-of-Service (QoS).

MOBILE APPLICATION DEVELOPMENT	L	D	P	Credits
	2	0	0	2

COURSE CONTENTS

Introduction: What is Android, Android versions and its feature set, Android Development Environment - System Requirements, Android SDK, Installing Java, Creating Android Virtual Devices (AVDs) Android Runtime - Dalvik Virtual Machine, Android Runtime –Core Libraries, Creating an Activity, Running the Application in the AVD, Stopping a

Running Application, Modifying the Example Application, Reviewing the Layout and Resource Files, Intent Overview, Implicit Intents, Creating the Implicit Intent Example Project, Explicit Intents, Creating the Explicit Intent Example Application, Intents with Activities, Designing for Different Android Devices, Views and View Groups, Android Layout Managers, Programming the display, Keyboard/ touch, accessing camera, multimedia (Audio and Video), on device sensors, Sending SMS, Sending WhatsApp, Sending email, Dialing a number, Introduction to location based service, configuring the Android Emulator for Location Based Services, Geocoding and Map-Based Activities, RecyclerView Development of application using Firebase database, Testing and deploying these applications on SDK and on the device.

HUMAN COMPUTER INTERACTION	L	D	P	Credits
	2	0	0	2

COURSE CONTENTS

Understand the foundation elements of human computer interaction, Understand the design process and various design issues, Common practices used in HCI, Creating user personas, Gather, analyze, and present data for interaction design, Using qualitative and quantitative methods in HCI research, Contextual inquiry Importance of users / talking to users, Task analysis, Prototyping (Low and high fidelity), Understanding cognitive frameworks - Mental Model, Practical processes involved in interaction design and Evaluation, Usability evaluation: think aloud, observing users, testing and modeling users, expert evaluations, Information Visualization, The pros and cons of carrying out studies in the lab versus in the field and in the wild.

INNOVATION AND ENTREPRENEURSHIP	L	D	P	Credits
	0.5	1	1	2

COURSE CONTENTS

What is Entrepreneurship? How are Entrepreneurs different from Managers? How do entrepreneurs identify opportunities? Is this external or internal to the Entrepreneur? How would you go about identifying the opportunities to start a new venture? What is Innovation? Are creativity and Innovation similar? What are the different forms and types of innovation? Interaction with an Entrepreneurs. How to evaluate the various opportunities and choose one to build the new venture? Going beyond the gut feel and using a process for this. How to give shape to the opportunity? Is the process iterative or linear? How to increase the chance of success? How to use prototypes for testing? How to prepare a Business Pitch and Business Plan? What are the elements of the two? How to capture the opportunity from the perspective of the listener? How Business Model (Osterwald) helps to capture the various elements? How to create demand for the new venture proposition? How does sales and marketing differ in new ventures vs established business? How to build a team for New Venture?

DIGITAL IMAGE PROCESSING

L	D	P	Credits
3	0	2	4

COURSE CONTENTS

Introduction: Visual Perception, Image Sensing and Acquisition, Image Sampling and Quantization, Representing Digital Images, Spatial and Intensity Resolution. Transformation and Enhancement of images: Gray level transformations and processing in spatial domain, Enhancement using arithmetic/logic operations, Image derivatives, filtering- smoothing, sharpening, convolution and correlation. Histogram processing – stretching, equalization and matching. Image interpolation. Fourier transformation and processing in frequency domain – DFT, FFT, Inverse Fourier transformation, Filtering: smoothing and sharpening in frequency domain, convolution. Image Restoration: Noise models, restoration in spatial domain, periodic noise reduction using frequency domain filtering, Inverse filtering. Colour models and transformations, Smoothing and sharpening and segmentation. Morphological operations: Dilation, Erosion, Opening, Closing, Boundary extraction, Thinning. Image compression fundamentals, Lossless compressions and Lossy compression Techniques. Segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region-based segmentation, Segmentation using morphology. Introduction to Image Representation and Description: - Chain code, Polynomial approximation, Signatures, Skeletons; Regional description – Texture -- gray-level-cooccurrence matrix.

ARTIFICIAL INTELLIGENCE

L	D	P	Credits
2	0	2	3

COURSE CONTENTS

Introduction: Understand what is Artificial Intelligence and why is there so much focus on AI these days? Turing test, Practical impact of AI including some early applications of AI. Modern AI applications. State-space Search: State-space problems, Uninformed Search – BFS, DFS, IDS, Uniform Cost Search, Avoiding Repeated States in search; Informed Search: Heuristic Function – admissible and dominating heuristic, A* algorithm, optimality. Adversarial Search and Game Playing: Understand and applying Mini-max, Reducing search space with Alpha-Beta Pruning. Constraint Satisfaction Problem (CSP): Defining CSP, discussion on various heuristics for variable and value selection; Reducing Backtracking in DFS Tree - Forward Checking and Constraint Propagation. Knowledge representation and Reasoning: Propositional logic, First order logic, Inference in First order logic, Forward & Backward chaining, Resolution Refutation. Intelligent Agents: PEAS, Rational agent, Types of Agents – simple reflex agent, mode-based reflex agent, goal-based agent, utility-based agent, learning agent. Planning: Generic Search vs. Planning Problem, Planning with State Space Search, Partial order planning. Dealing with Uncertainty and Imprecision: Fuzzy sets and Fuzzy Logic, Fuzzy Inference Systems.

DISCRETE MATHEMATICS	L	D	P	Credits
	2	1	0	3

COURSE CONTENTS

Sets, Relation and Function, Operations and laws of sets, Size of a Set, Finite and infinite sets, Cartesian products, Functions, Image of a Set, Bijective functions, Inverse and composite function, Binary relation, Partial ordering relation, Equivalence relation, Countable and uncountable sets, The Power Set theorem, Schroeder-Bernstein theorem. The Well-Ordering Principle, Recursive definition, Recurrence Relations & Generating functions. Number Theory: Division algorithm, Greatest Common Divisor, Euclidean Algorithm, The Prime Numbers, Fundamental Theorem of Arithmetic, Distribution of primes, Modulo Arithmetic, Applications of modulo arithmetic, Chinese remainder theorem. Logic: Basic Connectives and Truth Tables, Logical Equivalence: The Laws of Logic, Logical Implication, Rules of Inference, Validity of Arguments, The use of Quantifiers, Predicate Logic, Arguments in Predicate Logic. Proof Techniques: Proof Methods and Strategies, Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. Combinatorics: Counting Principles, Functions and Counting, Pigeonhole Principle, Permutations and Combinations, Combinatorial Arguments. Algebraic Structures: Algebraic Structures with one binary operation: Semi Groups, Monoids, Groups, Cyclic Groups, Permutation Groups, Normal Subgroups. Algebraic Structures with two Binary Operation: Rings, Integral Domain and Fields. Boolean algebra and Boolean Ring, Identities of Boolean algebra, Duality, Representation of Boolean Function, Disjunctive and Conjunctive Normal Form.

NETWORK SECURITY	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction: Attack, Services and Mechanism, Model for Internetwork Security. Cryptography, Notion of Plain Text, Encryption, Key, Cipher Text, Decryption and Cryptanalysis, Public Key Encryption, Digital Signatures and Authentication. Network Security: Authentication Application, Kerberos, X.509, Directory Authentication Service, Pretty Good Privacy, S/MIME. IP Security Architecture: Overview, Authentication header, Encapsulating Security Payload combining Security Associations, Key Management. Web Security: Requirement: Secure Sockets Layer, Transport Layer Security, Secure Electronic Transactions. Network Management Security: Overview of SNMP Architecture- SNMPV1 Communication Facility, SNMPV3. System Security: Intruders, Viruses and Related Threats, Firewall Design Principles, Comprehensive examples using available software platforms/case tools, Configuration Management.

IOT SENSORS, PERIPHERALS AND PROCESSORS	L	D	P	Credits
	1	0	2	2

COURSE CONTENTS

Introduction to various types of sensors: LDR, photo diodes, motion sensors, ultrasonic sensors, hall sensors, temperature, and humidity sensors etc., Sensor signal conditioning: Basics and types of signal conditioning e.g., Analog

signal conditioning (amplification, level shifting, voltage to current and current to voltage conversion, filtering), Digital signal conditioning (noise removal, analog to digital conversion, isolation using opto-couplers), Laboratory power supplies: unregulated power supply, DC voltage regulators, output current limiting, variable power supply, power supply performance and its applications, etc., Actuators: Relay, DC motor and its drivers, servo motor, stepper motor, etc., Microcontroller development boards: Arduino, NODEMCU, Raspberry Pi, etc., Sensor interfacing with Arduino, NODEMCU, and Raspberry Pi. ADC, timer, interrupt programming.

THEORY OF COMPUTATION	L	D	P	Credits
	2	1	0	3

COURSE CONTENTS

Introduction to fundamental concepts in automata theory and formal languages, Alphabet, Languages and grammars, productions and derivations, Chomsky hierarchy of languages, Finite State Machine, Deterministic finite automata (DFA), Non-Deterministic Finite Automata (NFA), Mealy machine, Moore Machine, Regular Expression, Pumping Lemma for regular sets, Context Free Grammar (CFG), Pumping Lemma for CFG, Pushdown Automata (PDA), Turing Machine, Properties of recursive and recursive enumerable languages.

IOT NETWORKS, ARCHITECTURES AND APPLICATIONS	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

What is IoT and Why is IoT, applications of IoT, Potential and challenges, IoT architecture, OSI and TCP/IP model, Architectures of IoT two layer and three layer, Circuits: overview of circuits used in IoT, battery current, and wireless links, digital computing and analog to digital interfaces, Embedded systems: internet connectivity and MGC architecture, Cortex M and BLE, Type of communication: M2M, machine to cloud, etc. Network protocols and standards for internet of things, Interfacing the SPISS memory of NODEMCU and its related theory, Multi Hop communication and interfacing of Bluetooth, RF module, etc. HTML, CSS, JavaScript, HTTP, MQTT protocol, HTTP Webserver, MQTT Publish and subscriber, Web socket programming, IoT case study e.g. voice activated control, home automation, industrial automation, smart grid, smart cities etc. Setup open source IoT platform e.g. Things speak, yenen cloud, Adafruit cloud server etc.

CRYPTOGRAPHY	L	D	P	Credits
	2	0	0	2

COURSE CONTENTS

Introduction to Security attacks, services and mechanism; Cryptography: basic concepts, cryptanalytic attacks, classical techniques and cryptanalysis; Cryptography: symmetric algorithms, basic concepts and principles, block cipher modes of operation, DES, AES; Introduction to number theory; Cryptography: asymmetric algorithms (public-key cryptography), basic concepts and principles, RSA; Key management; Message Authentication, Hash function and MAC Algorithm; Digital signature, DSS. Certificates, certificate authority; Email and Web Security; Wireless Security, Passwords, Viruses.

Core Electives

DEEP LEARNING	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Review of Machine Learning and Introduction to Deep Learning, Feed-Forward-Artificial-Neural-Network: Multi-Layered Perceptron – Optimization with Gradient Descent and Backpropagation; Variants of Gradient Descent – batch/minibatch/stochastic-gradient-descent (SGD), Momentum, RMSProp, Adam. Using deep learning libraries – introduction to Tensorflow and Keras, Convolutional Neural Networks (CNN) – solving Binary and Multi-class Image Classification, problems; Object Detection from Images – RCNN, YOLO, SSD; Image Segmentation – Semantic, Segmentation with UNET and Instance Segmentation with Mask-RCNN. Processing sequence data with Recurrent Neural Networks (RNN), LSTM, GRU with applications to text classification. Transfer Learning – Feature extraction and Fine-tuning; Data Augmentation, Attention-based models and Transformers with applications, Autoencoders and Generative Adversarial Networks (GAN), Applications of Deep Learning to Audio, Image and Text Processing, Deployment of the Deep Learning models on cloud.

CLOUD COMPUTING	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Cloud Computing Basics- Defining Cloud Computing, Cloud Types: The NIST model, The Cloud Cube Model, Examining the Characteristics of Cloud Computing, Benefits of cloud computing, Disadvantages of cloud computing. Understanding cloud architecture- Exploring the Cloud Computing Stack, Composability, Infrastructure Platforms, Virtual Appliances, Communication Protocols Applications, Connecting to the Cloud. Hardware and Infrastructure- Clients, Security, Network, Services. Software as a Service (SaaS)- Defining Software as a Service (SaaS), SaaS characteristics, Open SaaS and SOA, Salesforce.com and CRM SaaS. Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Identity as a Service (IDaaS), Capacity Planning-Defining Baseline and Metrics Baseline measurements, System metrics, Load testing, Resource ceilings, Server and instance types, Network Capacity, Scaling, Understanding Cloud Security- Securing the Cloud The security boundary, Security service boundary Security mapping, Securing Data, Moving Applications to the Cloud, Working with Cloud Based Storage, Communicating with the Cloud, Using the Mobile Cloud, Managing cloud workloads and servicesUnderstanding workloads, looking at principle of workload management, connecting workloads in the cloud, Migrating to the Cloud-Cloud Services for Individuals, Cloud Services Aimed at the MidMarket, Enterprise-Class Cloud Offerings, and Migration. Working with Mobile Web ServicesUnderstanding Service Types, Mobile interoperability, Performing Service Discovery Context-aware services.

BIG DATA ANALYTICS	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction to Big Data and its types, Big Data technology Landscape, Life Cycle of Big data projects, Introduction to Hadoop, Hadoop Distributed File System (HDFS), Processing Data with Hadoop (MAPREDUCE), Working of Yet Another Resource Negotiator (YARN), Interacting with Hadoop Ecosystem, NoSQL databases, NewSQL, Machine Learning: Definitions and Types, Regression, Clustering, Collaborative Filtering, Association Rule Mining.

ADVANCED DATA SCIENCE	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction to Data Science: Introduction to Data Science concepts- Data pre-processing – data cleaning – handling missing values. Exploratory Data Analysis (EDA). Hypothesis Testing, Type I and Type II error, A/B Testing, Outlier detection Methods. Data Visualization: Importance of proper visualization, qualities of a great visualization. Data visualization toolkits - matplotlib, seaborn, interactive plot with plotly and cufflinks, geographical plotting with choropleth maps. Making sense of data with suitable plots like line plot, bar plot, histogram, Box plot. Applied Machine Learning, Supervised regression – Linear Regression, Multiple Linear Regression, Regularized Regression, Supervised classification – Logistic Regression, KNN, SVM, Decision Tree classifier, Ensemble techniques – Random Forest, Bagging, Boosting, Unsupervised techniques – K-means clustering, Fuzzy c-mean, Mean Shift, Mixture of Gaussians, Evaluating a Classification Model, Dimension reduction and Feature Engineering: Dimension reduction- PCA, Factor analysis, LDA, Cross validation, model overfitting, hyper-parameter tuning of a machine learning model and model persistence. Time Series Analysis: Introduction: Examples, simple descriptive techniques, trend, seasonality, the correlogram. Probability models for time series: stationarity. Moving average (MA), Autoregressive (AR), ARMA and ARIMA models. Auto correlation.

BLOCKCHAIN	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Background leading to Blockchain, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Blockchain application, Private and Public blockchain. The consensus problem - Asynchronous Byzantine Agreement - AAP protocol and its analysis - Nakamoto Consensus. Deep details of blockchain transaction ecosystem - hashing, Merkle tree, PoW etc. Crypto-currencies, wallets and crypto economy, Applications of Blockchain Ethereum - Ethereum Virtual Machine (EVM) - Wallets for Ethereum - Solidity - Smart Contracts, Basics of Solidity, Advanced Solidity, Deployment of Smart Contract, developing a DApp

using Remix, developing a DApp using Truffle, Understanding and implementing frontend (html-css-js) and backend basics (cmd node.js). Introduction Hyperledger Fabric, Hyperledger Fabric architecture.

CYBER SECURITY TOOLS AND CYBER-ATTACKS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Basics of Security: Confidentiality, Integrity, Availability, Non-repudiation, Privacy, Anonymity, Information Security, Cyber Security, Network Security. Essential Terminologies: Threats, Vulnerabilities & its types, Attacks, Exploits. Malware, Trojan, Virus, Worms. Types of Attacks: Denial-of-service (DoS) and distributed denial-of-service (DDoS) attacks, Botnets, Eavesdropping, Man-in-the-middle (MITM) attack, Phishing attacks, Password attack i.e. Brute Force Attack, Dictionary Attack, Key Logger Attack, Cross-site scripting (XSS) attack, SQL Injection attack, Types of SQL Injections. Pen testing Process: Planning and Reconnaissance, Scanning, Assessment, Exploitation, Reporting. Foot printing, Fingerprinting, Sniffing, ARP Poisoning, DNS Poisoning, Social Engineering. Introduction to Dark Web. Vulnerability assessment tools: OpenVAS, Wireshark, Aircrack-ng. Network Security: Pre-connection, Gaining attacks, post-connection attacks, Pen testing Routers, Bypassing Firewalls. Penetration Testing Wireless Networks: Network Mapping, WEP Attacks, WPA/WPA2 Network security controls for defence mechanism, DOS & DDOS Mitigation Network Défense - Tools, Secure protocols, Firewalls, types of firewalls, Intrusion Detection and filters (Host-Based IDS vs Network-Based IDS), VPN.

NATURAL LANGUAGE PROCESSING AND TEXT ANALYTICS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Basic and Advance text pre-processing: Tokenization, Stemming, Spell Correction, etc. Vectorization: Distributional Semantics, Topic Models, Subword Models, Sentence encoders, Language Modelling: N-grams, smoothing techniques, RNNs. Morphology, Parts of Speech Tagging, NER. Lexical Semantics, Word Sense Disambiguation, Linguistic Structure: Dependency Parsing. Information Extraction: Relation Extraction, Event Extraction, Contextual Word Representations, Text Classification, Sentiment Analysis, Opinion Mining, Summarization, Question Answering, Machine Translation (Seq2Seq models and Transformers), Tools for text analytics – Spacy, NLTK, Keras, and Tensorflow.

DATA SCIENCE IN FINANCIAL MARKETS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Fundamental of financial markets, Investment, Stock Exchange, Equity/Share, Debt Instrument, Derivative, Mutual Fund, Index, Securities Market, Primary Market, Market Capitalization, Initial Public Offer (IPO), Prospectus, and Secondary market. Basic returns data characteristics of financial market data, asymmetry and fat tails distribution, Autocorrelation, spectral density, autoregression, GARCH model, time-series with memory: R/S analysis and Hurst exponent, random matrix theory, and its applications, and Stock Portfolio Optimisation. Hands-on analysis of different stock markets, e.g., Standard and Poor's (S&P 500), Nikkei Stock exchange, (Nikkei 225) the Bombay Stock Exchange (BSE), and The Financial Times Stock Exchange 100 Index (FTSE-100), etc.

INFORMATION SECURITY	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction to Information Security: Core goals of information security; the CIA triad, Common information security terms and processes, Types of controls and their function are categorized. Threats and Attack Modes: Common threats and attack modes on information systems, Threats, attacks, and attack agents, and continues with a description of access control, spoofing, social engineering, application, web application, malware, and denial of service attacks. Understanding attack behaviour. Cryptographic Models: Ciphers, Symmetric, Asymmetric, Hashing. Access Control: Protect data from unauthorized disclosure, Access control models, Types of access control models, Mandatory access control (MAC), discretionary access control (DAC), role-based access control (RBAC), and rule-based access control (RB-RBAC). Identification and Authentication: Identification, types of authentication, Human authentication factors, authentication forms, authentication protocols, methods for single sign-on (SSO), and public-key infrastructure (PKI). Security Technology: Firewalls and VPNs, Security Technology: Intrusion Detection, Access Control, and Other Security Tools. Intrusion Detection and Prevention Systems, Privacy Laws, Penalties, and Privacy Issues, Electronic data privacy protection, global privacy laws, some areas and issues of online privacy, and the penalties and adverse effects of a data breach on organizations.

GEOGRAPHICAL INFORMATION SYSTEMS	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction to Geographic Information Systems, Components of GIS, Types of vector data and introduction to the concept of topology, raster data models, comparison of vectors and raster's, TIN data models, Types of non-spatial data, raster data compression techniques, spatial database systems and types, pre-processing of spatial datasets, geo-referencing, different map projections, spatial interpolation techniques, digital elevation models and types of resolutions, quality assessment of DEMs, location allocation problems, Overlay operations, Buffer operations,

classification methods, Errors in GIS and introduction to maps, Types of maps, developing maps using vectors datasets, limitations of GIS, WebGIS (hosting geospatial dataset in a website). Data acquisition using drones and integration of GIS-drone environment.

CYBER FORENSICS	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Computer Forensics Fundamentals, Types of Computer Forensics Technology, Types of Vendor and Computer Forensics Services, Data Recovery – Evidence Collection and Data Seizure, Duplication and Preservation of Digital Evidence, Computer Image Verification and Authentication, Discover of Electronic Evidence, Identification of Data, Reconstructing Past Events, Networks, Fighting against Macro Threats, Information Warfare Arsenal, Tactics of the Military, Tactics of Terrorist and Rogues – Tactics of Private Companies, Surveillance Tools – Victims and Refugees, Advanced Computer Forensics.

SOCIAL NETWORK ANALYSIS	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Introduction to social networks, Types of social networks: friend, user-generated, content, affiliation, etc. Network characteristics: Degree, paths, centrality, cliques, clustering coefficients, giant components, diameter, etc., Introduction to network plotting (using NetworkX package/Gephi), Network construction from empirical data Centrality Measures: degree, closeness, betweenness, eigenvalue, and PageRank Clustering Methods: Hierarchal and k-means, Community detection algorithms: Community Detection vs Clustering, Agglomerative Methods, and Divisive Methods, Network evolution models: Random model, small world, and preferential attachment, Hands-on tutorial with online available databases.

MALWARE ANALYSIS	L	D	P	Credits
	3	0	0	3

COURSE CONTENTS

Introduction to Malware Analysis: Static analysis, Dynamic Analysis, Code Analysis, Memory Analysis. Cyber threat intelligence: CTI types, CTI process, CTI tools for end to end security, discover and decode, reduce false positives. Threat hunting: Introduction to threat hunting, Phases of hunting, Types of hunting tools: Analysis based, Intelligence based, Situation drive.

INTERACTION DESIGN	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Brainstorming, User research, Prototyping, Workflow design, Understanding iterative processes to improve design, Persona Design, Using Design Thinking framework, Theories behind Interaction Design, Data gathering and analysis for improving the design.

DATA VISUALIZATION WITH R	L	D	P	Credits
	2	0	2	3

COURSE CONTENTS

Key R concepts: Dataframes, Vectors, Factors, Functions; Use of specialized packages. Importing Data into R from other sources, Basics of data manipulation in R using dplyr, Combining R & Python: Executing R Code blocks in Google Colab; Executing Python in RStudio, Compatible forms of dataframes between Python & R. Representing univariate data (continuous and categorical) through appropriate plots. Discerning patterns in single variables of a dataframe and linking them with key statistical measures of central tendency. Working with two variables to present linear and nonlinear relationships among continuous variables such as correlations, heatmaps etc. Use of faceting to compare patterns of continuous variables across categorical/ordinal variables. Graph Visualization. Visualizing Categorical Data for detecting deviations and showing statistical significance. Using outputs from models to visually represent results.