Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Master of Technology

in

Computer Engineering

First Year Scheme & Syllabus

(As per AICTE guidelines, with effect from the Academic Year 2026-27)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Therefore, autonomy for Vidyalankar Institute of Technology is not merely a transition from pre-cooked syllabi to self-designed curriculum. Autonomy curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability, problem-solving approach and research ability which leads to improving competency level of learners with diverse strengths. In line with this, the curriculum framework designed is **Choice-Based Credit and Grading System (CBCGS)**. Number of credits for courses learnt by learners, internships and dissertation is finalized considering the scope of study and the ability that a learner should gain through the programme.

The curriculum has core courses of engineering, specific to the branch. These courses are completed in first year of the engineering programme that enables learners to work on their chosen dissertation topic during their final year. The curriculum planned by the Institute offer flexibility and diversity to learners to choose any set of courses from a basket of professional electives. Learner can also choose to specialize in a domain as per their field of interest. The selection of unique specialization tracks based on recent developments and industrial requirements is a salient feature of this curricula ensuring employability. Each specialization track has mandatory courses positioned and sequenced to achieve sequential and integral learning for the required depth of the specific domain. Learner can choose to complete these courses in first year of the engineering program that enables him/her to prepare for research during their final year. Credits additional to core and professional elective courses, include dissertation, internships, advanced courses in the field of computer engineering, multi- disciplinary courses, special skill development courses and similar knowledge that make learner capable to do further research or work in industrial environment.

Thus, the academic plan of VIT envisages a shift from summative to formative and competency-based learning system which will enhance learner's ability towards higher education, employability and entrepreneurship.

Chairman, Board of Studies
Department of Computer Engineering
Vidyalankar Institute of Technology

Chairman, Academic Council
Vidyalankar Institute of Technology

First Year M. Tech. Computer Engineering **Semester: I**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
CE63	Advanced Data Structure and Algorithms	Theory+ Practical	4	40	20	40	25	125
CE88	Applied Probability and Statistical Analysis	Theory+ Tutorial	4	40	20	40	25	125
CEXX	Professional Elective-1	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-2	Theory+ Practical	4	40	20	40	25	125
OEXX*	Open Elective-1	As per the list below						

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

*Refer to Appendix B for the list of Open Elective (OE) courses. Selection will be based on the subset of OE courses made available by the Institute for the semester.

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	
OE04	Sustainability Management	Theory	4	40	30	50	120
OE05	Operation Research	Theory	4	40	30	50	120
OE06	IPR and Patenting	Theory	4	40	30	50	120
OE07	Research Methodology	Theory	4	40	30	50	120
OE15	Teaching Pedagogy & Educational Technology	Theory	4	40	20	40	100
OE13*	Online Course 1 (MOOC)	Theory	2	25	-	25	050

OE14*	Online Course 2 (MOOC)	Theory	2	25	-	25	050

*Online Courses (MOOC) of 2 credits are equivalent to 30 hours course.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Refer Appendix-A for guidelines on Professional Elective Courses and Specialization Certificate

Professional Elective-1 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE67	Building Blocks of Artificial Intelligence	Artificial Intelligence and Machine Learning (AIML)
CE91	Data Engineering and Big Data systems	Data Science (DS)
CE75	Smart Sensors and Internet of Things	Internet of Things (IoT)
CE80	Ethical Hacking and Digital Forensics	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-2 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE68	Machine Learning and Pattern Recognition	Artificial Intelligence and Machine Learning (AIML)
CE92	Data Preparation and Feature Engineering	Data Science (DS)
CE76	IoT - Application and Communication Protocol	Internet of Things (IoT)
CE81	Database Security and Access control	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

First Year M. Tech. Computer Engineering **Semester: II**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
CE89	High-Performance Computing and Parallel Algorithms	Theory+ Practical	4	40	20	40	25	125
CE66	Computational Intelligence	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-3	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-4	Theory+ Practical	4	40	20	40	25	125
OEXX	Open Elective-2	As per the list below						

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*Refer to Appendix B for the list of Open Elective (OE) courses. Selection will be based on the subset of OE courses made available by the Institute for the semester.

Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	
OE04	Sustainability Management	Theory	4	40	30	50	120
OE05	Operation Research	Theory	4	40	30	50	120
OE06	IPR and Patenting	Theory	4	40	30	50	120
OE07	Research Methodology	Theory	4	40	30	50	120
OE15	Teaching Pedagogy & Educational Technology	Theory	4	40	20	40	100
OE13*	Online Course 1 (MOOC)	Theory	2	25	-	25	050
OE14*	Online Course 2 (MOOC)	Theory	2	25	-	25	050

*Online Courses (MOOC) of 2 credits are equivalent to 30 hours course.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Professional Elective-3 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE69	Deep and Reinforcement Learning	Artificial Intelligence and Machine Learning (AIML)
CE93	Business Intelligence and Visual Analytics	Data Science (DS)
CE77	Wireless Access Technologies	Internet of Things (IoT)
CE95	Blockchain Security and Privacy	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-4 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE90	Natural Language Processing with Large Language Models	Artificial Intelligence and Machine Learning (AIML)
CE94	Data Governance , Privacy and Ethics	Data Science (DS)
CE78	IoT and Smart Cities	Internet of Things (IoT)
CE82	Intrusion Detection and Prevention	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Detailed syllabus of First Year Semester-I

Course Name: Advanced Data Structure and Algorithms

Course Code: CE63

Category: Core

Preamble:

This course introduces different Advanced Data Structures and aims to provide Mathematical Approach for Analysing the Complexities of Algorithms with their real-life applications.

Pre-requisites:

1. Data Structures
2. Analysis of Algorithms

Course Objective:

- To provide mathematical approach for Analysis of Algorithms.
- To understand advanced data structures and its operations.
- To solve complex problems in real life applications.

Course Outcome:

Learner will be able to:
CO1: Describe analysis techniques for algorithms.
CO2: Appreciate the role of probability and randomization in the analysis of algorithm.
CO3: Identify appropriate data structure and design techniques for different problems.
CO4: Identify appropriate algorithm to be applied for the various application like Max Flow, Linear programming etc.
CO5: Understand Approximation and Optimization Algorithms.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be

approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Fundamental of Algorithms	Complexity: Finding complexity by tree method, master method, proving technique (contradiction, mathematical induction). Amortized analysis- aggregate analysis, accounting analysis, potential analysis dynamic tables	6
2	Probabilistic Analysis and Randomized Algorithm	The hiring problem Indicator random variables, Randomized algorithms Probabilistic analysis and further uses of indicator random variable	6
3	Advanced Data Structure	Introduction to trees and heap Red-Black Trees: properties of red-black trees, Operations on Red-black trees Binomial Heaps: Binomial trees and binomial heaps, Operation on Binomial heaps Analysis of all above operations	12
4	Flow N/W Maximum Flow	Shortest Path, The Floyd - Warshall Algorithm, Johnson's Algorithm for sparse graphs, Flow Networks, The Ford-Fulkerson method, Maximum bipartite matching, Push relabel algorithms, The relabel-to-front algorithm.	10
5	Linear Programming	An Introduction to Linear Programming, Flows in networks, Bipartite matching, Duality, Zero- sum games, The simplex algorithm, Post script: circuit evaluation	5
6	Approximation & Optimization Algorithms	Approximation Algorithms: The vertex - cover problem, the travelling salesman problem, the set- covering problem, Randomization and linear programming, The subset- sum problem. Optimization Algorithms: Genetic Algorithm, K- means Algorithm	6
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Programs on Solving Hiring problem.
2.	Program to implement operations on Red black Tree.
3.	Program to implement operations on Red black Tree.
4.	Program on Floyd-Warshall Algorithm for shortest path

Sr No.	Suggested Topic(s)
5.	Program on Johnson's Algorithm for sparse graphs
6.	Program on The Ford-Fulkerson method to determine Maximum Flow.
7.	Program to implement Maximum bipartite matching
8.	Program to implement Simplex Algorithm
9.	Program to implement subset sum problem using Randomization
10.	Program to implement K-Means Algorithm for Optimization.

Text Books:

1. 1.Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithm" PHI, India Second Edition.
2. Horowitz, Sahani and Rajsekaran, "Fundamentals of Computer Algorithm", Galgotia.
3. Harsh Bhasin, "Algorithms – Design and Analysis", Oxford, 2015.

Reference Books:

1. Rajeev Motwani, Prabhakar Raghavan," Randomized Algorithm", Cambridge University
2. S. K. Basu," Design Methods and Analysis of Algorithm", PHI
3. Vijay V. Vajirani," Approximation Algorithms", Springer.

Course Name: Applied Probability & Statistical Analysis

Course Code: CE88

Category: Core

Preamble:

This course introduces the fundamental concepts of Probability Theory and Statistical Analysis, aiming to equip learners with mathematical tools for modelling uncertainty and analyzing data. It covers probability distributions, statistical inference, regression analysis, sampling theory, hypothesis testing, and time series analysis with real-life engineering and research applications.

Pre-requisites:

- Basic Mathematics / Engineering Mathematics
- Linear Algebra

Course Objective:

- To provide a strong foundation in probability theory and random variables.
- To understand and apply various probability distributions to real-world problems.
- To develop skills in correlation, regression, and multivariate data analysis.
- To introduce sampling theory and the principles of statistical hypothesis testing.
- To analyse time series data and apply forecasting techniques including ARIMA models.

Course Outcome:

Learner will be able to:

CO1: Explain fundamental concepts of probability including conditional probability, Bayes' theorem, and independence of events.

CO2: Define and analyse discrete and continuous random variables using PMF, PDF, CDF, expectation, and variance.

CO3: Apply standard probability distributions (Binomial, Poisson, Normal) and techniques of linear algebra such as SVD to engineering problems.

CO4: Perform correlation and regression analysis, including simple and multiple regression, and interpret results for estimation and prediction.

CO5: Apply sampling theory, hypothesis testing (Z-test, t-test, Chi-Square test) and time series analysis including ARIMA models for data-driven decision making.

Course Scheme:

Contact Hours		**Credits Assigned**
Theory	**Tutorial**	**Theory + Tutorial**
3	1	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Tutorial	Total
Theory + tutorial	40	20	40	25	125

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ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Linear Algebra	Eigen values and Eigen Vectors, Diagonalizable matrix, Derogatory and Non-derogatory matrix, Singular Value Decomposition (SVD).	6
2	Probability Theory & Distributions	Fundamentals of Probability: Random Experiments and Sample Spaces, Events and Probability Axioms, Conditional Probability, Bayes' Theorem, Independence of Events. Random Variables: Discrete and Continuous Random Variables, Probability Mass Function (PMF), Probability Density Function (PDF), Cumulative Distribution Function (CDF), Expectation and Variance. Probability Distributions: Discrete and Continuous distributions, Binomial Distribution, Poisson Distribution & Normal Distribution.	10
3	Correlation & Regression	Introduction to Correlation and Covariance, Karl Pearson's Correlation Coefficient, Spearman's Rank Correlation, Interpretation and applications of correlation coefficients. Regression Analysis: Regression Coefficients and properties, Simple Linear Regression, Lines of Regression, Multiple Regression Model, Estimation and prediction using regression equations.	8
4	Sampling Theory	Population and Sample, Sampling Distribution, Test of Hypothesis, Null and Alternative Hypothesis, Level of Significance, Critical Region, One-Tailed Test, Two-Tailed Test, Degree of Freedom, Interval Estimation of Population Parameters. Test of Significance of Mean, Test of Significance of Difference Between Means, Large sample test (Z-test), Small Sample Tests (t-Test).	8
5	Hypothesis Testing	Developing Null and Alternative Hypothesis, Type I and Type II Errors, Population mean and variance, Level of Significance, Tests of Goodness of Fit and Independence, Chi-Square Test.	7

6	Time Series Analysis	Definition and applications, Components of Time Series, Forecasting Techniques, ARIMA Models.	6
Total			**45**

Suggested List of Tutorials:

Sr No.	Suggested Topic(s)
1.	Tutorial on computation of Eigen values, Eigen Vectors and Singular Value Decomposition (SVD).
2.	Tutorial on Conditional Probability and verify Bayes' Theorem.
3.	Tutorial on plot PMF, PDF, and CDF for discrete and continuous random variables.
4.	Tutorial on Binomial, Poisson and Normal Distributions.
5.	Tutorial on Karl Pearson's and Spearman's Rank Correlation Coefficients.
6.	Tutorial on Simple Linear Regression and Multiple Regression Analysis.
7.	Tutorial on Large Sample Test (Z-test) on given data.
8.	Tutorial on Small Sample Test (t-Test) on given data.
9.	Tutorial on Chi-Square Test for Goodness of Fit and Independence.
10.	Tutorial on ARIMA Model for Time Series Forecasting.

Text Books:

- Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Elsevier Academic Press, 5th Edition.
- S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, 12th Edition.
- Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th Edition.

Reference Books:

- Jay L. Devore, "Probability and Statistics for Engineering and the Sciences", Cengage Learning, 8th Edition.
- Montgomery, D.C. and Runger, G.C., "Applied Statistics and Probability for Engineers", Wiley, 6th Edition.
- George E. P. Box, Gwilym M. Jenkins, "Time Series Analysis: Forecasting and Control", Wiley, 5th Edition.

Course Name: Building Blocks of Artificial Intelligence

Course Code: CE67

Category: AI ML Track

Preamble:

Artificial Intelligence (AI) is transforming industries by enabling machines to perform tasks that traditionally required human intelligence. This course, provides a structured approach to understanding the fundamental concepts, techniques, and applications of AI. The syllabus is designed to progressively build expertise—starting with introductory concepts, moving to intermediate AI techniques, and culminating in real-world applications. Students will gain hands-on experience through programming assignments, case studies, and projects, preparing them for advanced research and industry applications in AI.

Pre-requisites: Machine Learning.

Course Objectives:

- Understand the foundational principles of AI, including problem-solving, search algorithms, and knowledge representation.
- Analyze and implement key machine learning and deep learning techniques for AI applications.
- Evaluate different AI paradigms, including rule-based systems, probabilistic reasoning, and neural networks.
- Apply AI techniques to real-world problems in domains such as computer vision, natural language processing, and robotics.

Course Outcomes:

Learner will be able to:

CO1: Explain the core concepts of AI, including search algorithms, logic, and reasoning techniques.

CO2: Implement and compare different machine learning models for classification, regression, and clustering tasks.

CO3: Design rule-based and probabilistic AI systems for decision-making.

CO4: Apply AI techniques to solve problems in robotics, gaming, and automation.

CO5: Critically analyze ethical considerations and limitations of AI systems.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	4	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Lab Work	Total
Theory	40	20	40	25	125

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Introduction to Artificial Intelligence	Definition, history, and scope of AI Strong AI vs. Weak AI Turing Test and AI ethics Applications of AI in industry and research	6
2	Problem-Solving and Search Algorithms	Problem-solving agents Uninformed search (BFS, DFS, Uniform Cost Search) Informed search (A*, Greedy Best-First Search) Adversarial search (Minimax, Alpha-Beta Pruning) Constraint Satisfaction Problems (CSP)	7
3	Knowledge Representation and Reasoning	Propositional and First-Order Logic Rule-based systems and expert systems Probabilistic reasoning (Bayesian Networks, Markov Models) Fuzzy logic and its applications	8
4	Machine Learning Fundamentals	Supervised vs. Unsupervised Learning Linear Regression, Logistic Regression Decision Trees, Random Forests Support Vector Machines (SVM) Clustering (K-Means, Hierarchical)	8
5	Evolutionary Algorithms and Swarm Intelligence	Genetic Algorithms (GA) Particle Swarm Optimization (PSO) Ant Colony Optimization (ACO) Applications in optimization and robotics	8
6	AI Applications and Emerging Trends	AI in Game Playing (Chess, Go) AI in Robotics (Path Planning, SLAM) Natural Language Processing (NLP) Basics Ethical AI and Bias Mitigation	8
Total			**45**

Suggested List of Practical's:

Sr No.	Suggested Topic(s)
1.	Implementation of Search Algorithms Task: Implement Breadth-First Search (BFS), Depth-First Search (DFS), and A* algorithm to solve a pathfinding problem (e.g., maze navigation). Expected Outcome: Understand how different search strategies work. Compare efficiency (time and space complexity) of BFS, DFS, and A*.
2.	Solving N-Queens Problem using Constraint Satisfaction Task: Use backtracking and constraint propagation to solve the N-Queens problem. Expected Outcome: • Learn how constraint satisfaction problems (CSPs) work. • Analyze the impact of heuristics (e.g., minimum remaining values) on performance.
3.	Building a Rule-Based Expert System Task: Create a simple expert system (e.g., medical diagnosis or troubleshooting assistant) using if-thenrules. Expected Outcome: • Understand rule-based reasoning in AI. • Experience designing a basic knowledge-based system.
4.	Bayesian Network for Probabilistic Reasoning Task: Implement a Bayesian Network (e.g., disease diagnosis based on symptoms) and performinference. Expected Outcome: • Learn probabilistic reasoning in AI. • Use Bayes' theorem to compute conditional probabilities.
5.	Fuzzy Logic Controller for a Simple System Task: Design a fuzzy logic system (e.g., temperature control or obstacle avoidance). Expected Outcome: • Understand fuzzy logic and its role in AI. • Implement a basic fuzzy inference system.
6.	Supervised Learning: Classification with Decision Trees & SVM Task: Train Decision Trees and SVM classifiers on a dataset (e.g., Iris or Titanic dataset). Expected Outcome: • Compare accuracy and decision boundaries of different classifiers. • Learn feature importance and model interpretability.
7.	Unsupervised Learning: Clustering with K-Means & Hierarchical Clustering Task: Apply clustering algorithms to group data (e.g., customer segmentation). Expected Outcome: • Understand how unsupervised learning works. • Evaluate clustering performance using metrics like silhouette score.
8	Genetic Algorithm for Optimization Task: Solve an optimization problem (e.g., Traveling Salesman Problem or function optimization) using Genetic Algorithms (GA). Expected Outcome: • Learn evolutionary computation techniques.

	• Observe how selection, crossover, and mutation affect convergence.
9	Swarm Intelligence: Particle Swarm Optimization (PSO) Task: Implement PSO to optimize a mathematical function (e.g., Rosenbrock function). Expected Outcome: • Understand swarm intelligence principles. • Compare PSO with GA in terms of convergence speed.
10	AI in Game Playing: Minimax Algorithm for Tic-Tac-Toe Task: Develop an AI agent that plays Tic-Tac-Toe using Minimax with Alpha-Beta pruning. Expected Outcome: • Learn adversarial search techniques. • Analyze how pruning improves computational efficiency.

Text Books:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson.
2. Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer.
3. Elaine Rich & Kevin Knight, *Artificial Intelligence*, McGraw-Hill.
4. Melanie Mitchell, *An Introduction to Genetic Algorithms*, MIT Press.

Reference Books:

1. Nils J. Nilsson, *Principles of Artificial Intelligence*, Morgan Kaufmann.
2. Tom M. Mitchell, *Machine Learning*, McGraw-Hill.
3. George F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, Pearson.
4. Ethem Alpaydin, *Introduction to Machine Learning*, MIT Press.

Course Name: Data Engineering and Big Data systems

Course Code: CE91

Category: Professional Elective

Preamble:

In today's data-driven world, the ability to process and analyze vast amounts of data efficiently is crucial for organizations. This course on Big Data Analytics aims to provide students with a comprehensive understanding of Big Data technologies and tools. Through a combination of theoretical concepts and practical hands-on exercises, participants will learn about various components of the Hadoop ecosystem, including HDFS, MapReduce, Apache Sqoop, NoSQL databases like HBase, Apache Hive, and Apache Spark.

Pre-requisites:

1. Data Structures
2. Analysis of Algorithms

Course Objective:

- To introduce the fundamental concepts and characteristics of Big Data
- To provide an in-depth understanding of Hadoop Distributed File System (HDFS)
- To explore the MapReduce programming model for distributed computing
- To enable students to work with Apache Sqoop, HBase and Hive tools.
- To provide hands-on experience with Apache Spark for fast and efficient data processing

Course Outcome:

Learner will be able to:
CO1: Understand the challenges and characteristics of Big Data and Describe the architecture and components of Hadoop.
CO2: Implement and optimize MapReduce programs to perform distributed computing tasks.
CO3: Use Apache Sqoop for importing and exporting data between Hadoop and relational databases.
CO4: Design and work with NoSQL databases, particularly HBase, for storing and retrieving Big Data efficiently.
CO5: Query and analyze Big Data using Apache Hive, leveraging its SQL-like language (HQL).
CO6: Utilize Apache Spark for processing large-scale data in-memory, enabling faster and more efficient analytics.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

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Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Big Data	1.1 Understanding the concept of Big Data Characteristics and challenges of Big Data 1.2 Introduction to Hadoop and its ecosystem 1.3 Limitation of Hadoop	6
2	HDFS & MapReduce	2.1 Hadoop Distributed File System (HDFS) architecture 2.2 Components of HDFS 2.3 Introduction to MapReduce programming model 2.4 MapReduce workflow and phases.	10
3	Apache Sqoop	3.1 Importing and exporting data between Hadoop and relational databases 3.2 Incremental data imports and data transformations 3.3 Integration of Sqoop with other Hadoop ecosystem tools	5
4	NoSQL databases - HBase	4.1 Overview of HBase architecture and data model 4.2 CRUD operations and data manipulation in HBase 4.3 HBase schema design and best practices	6
5	Apache Hive	5.1 Hive data model and schema design 5.2 Hive Query Language (HQL) for data querying and analysis 5.3 Working with partitions, buckets, and external tables in Hive 5.4 Hive Optimazation	8
6	Apache Spark	6.1 Spark architecture and components 6.2 Spark RDD (Resilient Distributed Datasets) and transformations 6.3 Spark SQL for structured data processing	10
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Set up a Hadoop cluster and verify its functionality.
2.	Create directories and files in HDFS and perform read/write operations.
3.	Develop and execute a simple MapReduce program to count word occurrences in a text file.
4.	Import data from a relational database into HDFS using Sqoop.
5.	Export data from HDFS to a relational database using Sqoop.
6.	Perform incremental data imports and data transformations using Sqoop.
7.	Install and configure HBase on a Hadoop cluster.
8.	Create HBase tables and perform CRUD operations on them.
9.	Design an HBase schema for a given use case and perform queries and scans on the HBase table.
10.	Create a Hive table, load data into it, and define partitions and buckets for efficient storage.
11.	Write and execute HQL queries for data querying and analysis on Hive tables.
12.	Optimize Hive queries using techniques such as indexing, partitioning, and performance tuning.
13.	Create and manipulate RDDs using Spark.
14.	Use Spark SQL to process structured data and perform SQL-like queries on Spark DataFrames.

Textbooks:

1. "Hadoop: The Definitive Guide" by Tom White
2. "Data-Intensive Text Processing with MapReduce" by Jimmy Lin and Chris Dyer
3. "Learning Spark: Lightning-Fast Data Analytics" by Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia

Reference Books:

1. Hadoop MapReduce Cookbook" by Srinath Perera and Thilina Gunarathne
2. "Apache Hive Cookbook" by Hanish Bansal and Saurabh Chauha "Mastering Apache Spark" by Mike Frampton and Aurobindo Sarkar

Course Name: Smart Sensors and Internet of Things

Course Code: CE75

Category: Professional Elective

Preamble:

This course introduces learners an overview of concepts, main trends and challenges of Internet of Things. Develop the ability to use Internet of Things related software and hardware technologies. And provide the knowledge of data management business processes and analytics of IoT

Pre-requisites:

1. Basic programming knowledge
2. Basics of wireless networks

Course Objectives:

- To provide knowledge on Sensor Principles.
- To provide familiarity with different sensors and their application in real life.
- To develop necessary technical skill to select suitable smart sensors, components of IOTs with associated knowledge of interface electronics and signal conditioning

Course Outcome:

Learners will be able to:
CO1: Ability to identify, formulate suitable sensors for engineering applications
CO2: Explain and interpret the Internet of Things concepts and challenges.
CO3: Experiment with the software and hardware IoT Technologies.
CO4: Understand data management and business processes and analytics of IoT
CO5: Design and develop small IoT applications to create smart objects

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to Internet of Things and smart sensors	IoT Paradigm, IoT Architecture – State of the Art, IoT Protocols, IoT Communication Models, IoT in Global Context, Cloud Computing, Big Data Analytics, Concepts of Web of Things, Concept of Cloud of Things with emphasis on Mobile Cloud Computing, Smart Objects.	10
2	Open – Source Prototyping Platforms for IoT	Basic Arduino Programming Extended Arduino Libraries, Arduino – Based Internet Communication, Raspberry PI, Sensors and Interfacing.	6
3	IoT Technology	RFID + NFC, Wireless Networks + WSN, RTLS + GPS, Agents + Multi – Agent Systems, Composition Models for the Web of Things and resources on the Web, Discovery, Search, IoT Mashups and Others.	7
4	Wireless Sensor Networks	History and Context, The Node, Connecting Nodes, Networking Nodes, Secured Communication for IoT	6
5	Data Management, Business Process and Analytics	Data Management, Business Process in IoT, IoT Analytics, Creative Thinking Techniques, Modification, Combination Scenarios, Decentralized and Interoperable Approaches, Object – Information Distribution Architecture, Object Naming Service (ONS), Service Oriented Architecture, Network of Information, Etc.	12
6	Application and Use Cases	Concrete Applications and Use – Cases of Web Enabled Things: Energy Management and Smart Homes, Ambient Assisted Living, Intelligent Transport, Etc. M2M, Industrial IoT Applications.	4
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Starting Raspbian OS, Familiarising with Raspberry Pi Components and interface, Connecting to ethernet, Monitor, USB.

Sr No.	Suggested Topic(s)
2.	Displaying different LED patterns with Raspberry Pi.
3.	Displaying Time over 4-Digit 7-Segment Display using Raspberry Pi
4.	Raspberry Pi Based Oscilloscope
5.	Controlling Raspberry Pi with WhatsApp.
6.	Setting up Wireless Access Point using Raspberry Pi
7.	Fingerprint Sensor interfacing with Raspberry Pi
8.	Raspberry Pi GPS Module Interfacing
9.	IoT based Web Controlled Home Automation using Raspberry Pi
10.	Visitor Monitoring with Raspberry Pi and Pi Camera
11	Interfacing Raspberry Pi with RFID.
12	Building Google Assistant with Raspberry Pi.
13	Installing Windows 10 IoT Core on Raspberry Pi

Text Books:

1. The Internet of Things (MIT Press) by Samuel Greengard.
2. The Internet of Things (Connecting objects to the web) by Hakima Chaouchi ,Wiley .
3. Internet of Things (A Hands-on-Approach) by Arshdeep Bhaga and Vijay Madisetti

Reference Books:

1. The Internet of Things Key applications and Protocols, 2nd Edition, (Wiley Publication) by Olivier Hersent, David Boswarthick and Omar Elloumi.
2. IoT –From Research and Innovation to Market development, River Publication by Ovidiu Vermesan and Peter Friess.

Course Name: Ethical Hacking and Digital Forensics

Course Code: CE80

Category: Professional Elective

Preamble:

Ethical hacking and Digital evidence feature in just about every part of our personal and business lives. Legal and business decisions hinge on having timely data about what people have done. This course provides understanding of how to conduct investigations to correctly gather, analyse and present digital evidence to both business and legal audiences. It also outlines the tools to locate and analyse digital evidence on a variety of devices, how to keep up to date with changing technologies, and laws and regulations in digital forensics.

Pre-requisites:

1. System security

Course Objectives:

- Understand the concepts of Ethical Hacking and Digital Forensics, various tools and methodologies used in Digital Forensics and concepts of Mobile Forensics.
- Apply Digital Forensics tools to generate Forensic report which can be used for legal or administrative cases.

Course Outcome:

Learners will be able to:
CO1: Understand the fundamentals of Ethical Hacking.
CO2: Understand the fundamentals of Digital Forensics.
CO3: Achieve adequate perspectives of digital forensic investigation in various applications /devices like Windows/Unix system, mobile, email etc.
CO4: Investigate attacks, IDS, technical exploits and router attacks and "Trap and Trace" computer networks.
CO5: Investigate attacks on Mobile devices.
CO6: Apply digital forensic knowledge to use computer forensic tools and investigation report writing.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Ethical Hacking Methodology	Introduction, Steps of Ethical Hacking: Planning, Reconnaissance, Scanning, Exploitation, post exploitation and result reporting. Ethical Hacking Tool: Metasploit	6
2	Introduction to computer forensics and Digital Forensics	Computer Forensics Fundamentals, Types of Computer Forensics Technology – Types of Computer Forensics Systems-Data Recovery and Evidence Collection– Forensic duplication and preservation of DE, Understanding Computer Investigation. Digital Forensic, Rules for Digital Forensic The Need for Digital Forensics, Types of Digital Forensics, Ethics in Digital Forensics	9
3	Computer Forensics Tools	Evaluating Computer Forensics Tool Needs, Types of Computer Forensics Tools, Tasks Performed by Computer Forensics Tools, Tool Comparisons, Other Considerations for Tools, Computer Forensics Software Tools, Command-Line Forensics Tools, UNIX/Linux Forensics Tools, Other GUI Forensics Tools, Computer Forensics Hardware Tools, Forensic Workstations, Using a Write-Blocker.	9
4	Network Forensics	Technical Exploits and Password Cracking, Introduction to Intrusion Detection systems, Types of IDS Understanding Network intrusion and attacks, Analysing Network Traffic, Collecting Network based evidence, Evidence Handling. Investigating Routers, Handling Router Table Manipulation Incidents, Using Routers as Response Tools	9
5	Mobile Device Forensics	Crime and mobile phones, evidence, forensic procedures, files present in SIM cards, device data, external memory dump, and evidence in memory card, operator's networks.	6
6	Forensic Investigation	Report: Goals of Report, Layout of an Investigative Report, Guidelines for Writing a Report, sample for	6

Module No.	Module name	Content	No. of Hours
	Report and Forensic Tools	writing a forensic report. Computer Forensic Tools: need and types of computer forensic tools, task performed by computer forensic tools. Study of open-source Tools like SFIT, Autopsy etc. to acquire, search, analyse and store digital evidence	
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Vulnerability scanning using namp, Nessus, Nikto.
2.	Performing a penetration testing using Metasploit.
3.	Analysing Digital Evidences Using Win Hex/ helix3pro.
4.	Exploring Router and VLAN security, setting up access lists using Cisco Packet tracer(student edition)
5.	Exploring VPN security using Cisco Packet tracer(student edition)
6.	Analysis of network traffic using open source tools like Snort
7.	Install and use a security app on an Android mobile (e.g. Droidcrypt)
8.	Explore forensics tools in Kali Linux for acquiring, analyzing and duplicating data: dd, dcfldd, foremost, scalpel, debugfs, wireshark, tcptrace, tcpflow
9.	Analysis of forensic images using open source tools like Autopsy, like SIFT, FKT Imager
10.	Use Password cracking using tools like John the Ripper/Cain and Abel/ Ophcrack to detect weak passwords.

Text Books:

1. Jason Luttgens, Matthew Pepe, Kevin Mandia, “Incident Response and computer forensics”,3rd Edition Tata McGraw Hill, 2014.
2. Nilakshi Jain, Dhananjay Kalbande, ”Digital Forensic : The fascinating world of Digital Evidences” Wiley India Pvt Ltd 2017.

Reference Books:

1. Cory Altheide, Harlan Carvey ”Digital forensics with open source tools “Syngress Publishing, Inc. 2011.
2. Chris McNab, Network Security Assessment, By O’Reily.

3. Clint P Garrison "Digital Forensics for Network, Internet, and Cloud Computing A forensic evidence guide for moving targets and data , Syngress Publishing, Inc. 2010
4. Bill Nelson,Amelia Phillips,Christopher Steuart, "Guide to Computer Forensics and Investigations". Cengage Learning, 2014
5. Debra Littlejohn Shinder Michael Cross "Scene of the Cybercrime: Computer Forensics Handbook", 2nd Edition Syngress Publishing, Inc.2008.
6. Marjie T. Britz, Computer Forensics and Cyber Crime, Pearson, Third Edition.

Course Name: Machine Learning and Pattern Recognition

Course Code: CE68

Category: AI ML Track

Preamble:

Machine Learning (ML) and Pattern Recognition (PR) form the backbone of modern artificial intelligence systems, enabling computers to learn from data and make intelligent decisions. This course provides a comprehensive exploration of fundamental ML concepts, statistical pattern recognition techniques, and their practical applications. Structured across six modules, the syllabus progresses from introductory concepts to intermediate algorithms and real-world applications. Through a combination of theoretical foundations, mathematical formulations, and hands-on implementations, students will gain expertise in designing and evaluating ML systems for diverse domains.

Pre-requisites: Machine Learning.

Course Objectives:

- Master the mathematical underpinnings of modern machine learning algorithms.
- Design and implement advanced pattern recognition systems.
- Optimize models for performance, scalability, and interpretability.
- Solve domain-specific problems using tailored ML/PR approaches.

Course Outcomes:

Learner will be able to:

CO1: Derive and implement core ML algorithms from scratch.

CO2: Engineer features for high-dimensional pattern recognition tasks.

CO3: Diagnose and mitigate model limitations (overfitting, bias, concept drift).

CO4: Deploy ML solutions with consideration for computational constraints.

CO5: Critique and adapt published ML research for novel applications.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	4	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Lab Work	Total
Theory	40	20	40	25	125

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Optimization Foundations for ML	Convex vs. non-convex optimization in ML Gradient descent variants (SGD, Adam, RMSProp) Constrained optimization (Lagrange multipliers)	6
2	Advanced Linear Models	Kernelized regression (Ridge, Lasso path algorithms) Bayesian linear regression Generalized Linear Models (GLMs)	7
3	Modern Classification Paradigms	Margin-based classifiers (SVMs with custom kernels) Calibration of probabilistic classifiers Multiclass and multilabel strategies	8
4	Feature Learning Systems	Manifold learning (Isomap, LLE) Sparse coding and dictionary learning Automated feature engineering (TPOT, FeatureTools)	8
5	Structured Prediction	Conditional Random Fields (CRFs) Structured SVM Factor graphs and message passing	8
6	Robust ML Systems	Adversarial robustness Model monitoring and drift detection Federated learning constraints	8
Total			**45**

Suggested List of Practical's:

Sr No.	Suggested Topic(s)
1.	**Optimization Benchmarking** **Task:** Implement SGD, Adam, and L-BFGS optimizers from scratch to train logistic regression. **Outcome:** • Compare convergence rates on different loss landscapes • Understand optimizer hyperparameter sensitivity
2.	**Bayesian Linear Regression** **Task:** Develop Bayesian linear regression with evidence approximation. **Outcome:** • Generate predictive uncertainty intervals • Demonstrate automatic relevance determination (ARD)
3.	**Custom Kernel SVM** **Task:** Design domain-specific kernels (e.g., string kernels for text). **Outcome:** • Benchmark against RBF kernel • Visualize kernel-induced feature spaces
4.	**Manifold Learning for Sensor Data** **Task:** Apply Isomap/LLE to wearable device time-series. **Outcome:** • Recover latent movement patterns • Compare with PCA reconstruction error
5.	**Sparse Coding for Images** **Task:** Learn dictionary atoms from natural images. **Outcome:** • Reconstruct images with varying sparsity • Visualize learned Gabor-like filters
6.	**CRF for Document Analysis** **Task:** Implement linear-chain CRF for receipt parsing. **Outcome:** • Achieve >90% F1 on field extraction • Analyze label transition probabilities
7.	Generate FGSM/PGD attacks on CNN classifiers. **Outcome:** • Quantify accuracy drop under attack • Implement defensive distillation
8	**Concept Drift Detection** Task: **Build drift detectors for streaming data.** Outcome: **Detect simulated drift in financial data** **Compare Page-Hinkley vs ADWIN methods**
9	**Federated Learning Simulation** **Task:** Train CNN across distributed medical datasets. **Outcome:**

	• Analyze accuracy vs privacy tradeoffs • Implement secure aggregation
10	**Production ML Pipeline** **Task:** Containerize model serving with monitoring. **Outcome:** • Deploy as microservice with Prometheus • Log drift metrics over simulated months

Text Books:

1. Kevin P. Murphy, *Probabilistic Machine Learning: An Introduction*, MIT Press.
2. Mehryar Mohri, Afshin Rostamizadeh & Ameet Talwalkar, *Foundations of Machine Learning*, MIT Press.
3. Bernhard Schölkopf & Alexander J. Smola, *Learning with Kernels: Support Vector Machines, Regularization, Optimization, and Beyond*, MIT Press.
4. David Barber, *Bayesian Reasoning and Machine Learning*, Cambridge University Press.

Reference Books:

1. Shai Shalev-Shwartz & Shai Ben-David, *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press.
2. Trevor Hastie, Robert Tibshirani & Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer.
3. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer.
4. Richard O. Duda, Peter E. Hart & David G. Stork, *Pattern Classification*, Wiley-Interscience

Course Name: Data Preparation and Feature Engineering

Course Code: CE92

Category: Professional Elective

Preamble:

This course provides a comprehensive foundation in the principles and practices of data preparation and feature engineering for machine learning and data science applications. It equips learners with systematic techniques to acquire, clean, transform, and explore data, while developing high-quality features that enhance model performance. Emphasis is placed on both theoretical understanding and practical implementation using industry-standard tools and frameworks.

Pre-requisites:

- Programming with Python
- Introduction to Machine Learning

Course Objective:

- To develop a systematic understanding of data quality assessment, cleaning, and transformation techniques.
- To apply exploratory data analysis methods for meaningful insights from raw datasets.
- To design and implement feature engineering strategies for improving machine learning model performance.
- To build scalable and automated data preparation pipelines for real-world applications.

Course Outcome:

Learner will be able to:

CO1: Assess data quality and apply appropriate data acquisition and profiling techniques for diverse data sources.

CO2: Apply data cleaning, preprocessing, and transformation methods to handle real-world messy data.

CO3: Perform exploratory data analysis and derive meaningful statistical insights from datasets.

CO4: Design and implement effective feature engineering strategies including feature construction, selection, and extraction.

CO5: Build scalable and automated feature engineering pipelines considering fairness, bias, and data leakage issues.

Course Scheme:

Contact Hours		**Credits Assigned**
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	**ISA***	**MSE**	**ESE**	**Lab Work**	**Total**
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

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Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	**Data Acquisition and Quality Assessment**	Types of Data: Structured, Semi-Structured, and Unstructured; Data Sources: Files, Databases, APIs, IoT and Streaming Data; Data Collection and Ingestion Techniques; Data Profiling and Data Auditing; Data Quality Dimensions (Accuracy, Completeness, Consistency, Timeliness); Metadata Management and Data Dictionaries	8
2	**Data Cleaning and Preprocessing**	Missing Data Analysis and Imputation Techniques; Detection and Treatment of Outliers; Duplicate Detection and Data Deduplication; Handling Inconsistent, Noisy and Erroneous Data; Data Wrangling for Text, Date-Time and Categorical Data; Handling Class Imbalance (Oversampling, Undersampling, SMOTE)	8
3	**Data Transformation and Integration**	Data Normalization and Standardization; Data Encoding Techniques; Data Aggregation, Discretization and Reshaping; Data Integration and Data Fusion; Schema Matching and Entity Resolution; ETL and ELT Frameworks	7
4	**Exploratory Data Analysis and Data Understanding**	Descriptive and Inferential Statistics; Exploratory Data Analysis (EDA); Data Visualization for Data Understanding; Correlation, Covariance and Association Analysis; Multivariate Data Analysis; Pattern Discovery and Anomaly Detection	8
5	**Feature Engineering Techniques**	Feature Construction and Feature Generation; Feature Extraction Techniques; Feature Selection Methods; Dimensionality Reduction Concepts; Domain-Specific Feature Engineering; Time-Series, Text and Categorical Feature Engineering	8
6	**Automated and Scalable Feature Engineering**	Automated Feature Engineering (AutoFE); Feature Stores and Feature Management; Scalable Data Preparation Pipelines; Feature Engineering on Distributed Platforms; Data Leakage, Bias and Fairness Considerations; Industrial Case Studies and Best Practices	6
Total			**45**

Suggested List of Practical's:

Sr No.	Suggested Topic(s)
1.	Program to explore and profile a dataset to assess data quality dimensions (completeness, accuracy, consistency).
2.	Program to implement various missing data imputation techniques (mean, median, KNN, regression imputation).
3.	Program to detect and treat outliers using IQR, Z-score, and Isolation Forest methods.
4.	Program to perform data normalization, standardization, and encoding of categorical variables.
5.	Program to implement ETL pipeline for data integration from multiple heterogeneous sources.
6.	Program to perform Exploratory Data Analysis (EDA) with statistical summaries and visualization.
7.	Program to implement feature selection using filter, wrapper, and embedded methods.
8.	Program to apply dimensionality reduction techniques (PCA, LDA, t-SNE) for feature extraction.
9.	Program to perform time-series feature engineering and text feature extraction using NLP techniques.
10.	Program to build a scalable data preparation pipeline using distributed computing frameworks (e.g., PySpark).

Text Books:

- Zheng, A., & Casari, A. (2018). Feature Engineering for Machine Learning: Principles and Techniques for Data Scientists. O'Reilly Media.
- Kuhn, M., & Johnson, K. (2019). Feature Engineering and Selection: A Practical Approach for Predictive Models. CRC Press.
- Wickham, H., & Grolemund, G. (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly Media.

Reference Books:

- McKinney, W. (2022). Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter. 3rd Edition, O'Reilly Media.
- Grus, J. (2019). Data Science from Scratch: First Principles with Python. 2nd Edition, O'Reilly Media.
- Ozdemir, S. (2022). Feature Engineering Bookcamp. Manning Publications.

Course Name: IoT- Application and Communication Protocol

Course Code: CE76

Category: Professional Elective

Preamble:

The Internet of Things (IoT) is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The purpose of this course is to impart knowledge on IoT Architecture and various protocols, study their implementations and applications.

Pre-requisites:

1. Wireless sensor network
2. Mobile computing

Course Objectives:

- To equip learners with the fundamental knowledge and basic technical competence in the field of Internet of Things (IoT)
- Introduce multiple way of data communication and networking.
- Identify the IoT networking components with respect to OSI layer

Course Outcome:

Learners will be able to:
CO1: Understand the basics of IoT and communication protocols
CO2: Understand design methodology and hardware platforms involved in IoT
CO3: Understand the different Data link and network layer protocols involved in IoT
CO4: Understand the different transport and session protocols involved in IoT
CO5: Design of Secured IoT applications
CO6: Design IoT Applications using appropriate protocols.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction	IoT architecture outline, standards - IoT Technology Fundamentals- Devices and gateways, IoT Sensors, Sensors for IoT Applications, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics. Sensors for IoT Applications	6
2	IoT Reference Architecture	Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints	8
3	IoT Data link layer and Network layer protocols	PHY/MAC Lay'er(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4,IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP	12
4	IoT Transport layer and session layer protocols	Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT	8
5	IoT service layer protocol and security protocol	Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC802.15.4 , 6LoWPAN, RPL, Application Layer	6
6	Application in IoT	IOT Applications. IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipment's, Industry 4.0 concepts. Case study on: Lighting as a service, Intelligent Traffic systems, Smart Parking and Smart water management.	5
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Study of various development boards, concepts & pin configurations
2.	Switch based LED counter using Tinkercad simulation tool.

Sr No.	Suggested Topic(s)
3.	Obstacle detection using IR sensor using Tinkercad simulation tool.
4.	Write a program on arduino or raspberry pi to subscribe to MQTT broker for temperature data and print it
5.	Write a program on arduino/Raspberry pi to send data to thingspeak
6.	To interface bluetooth with arduino/raspberry pi and write a program to send sensor data to smartphone using bluetooth
7.	Smart Environment System simulation using MATLAB and SIMULINK
8.	Smart Liquid Level Detector simulation and analysis of data using MATLAB and SIMULINK
9.	Smart Wall Socket Simulation using MATLAB and SIMULINK

Text Books:

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The EvolvingWorld of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications ,2016
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, "From Machine-to-Machine to the Internet ofThings: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2015.

Reference Books:

1. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things",ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer, 2016.
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014

Course Name: Database security and access control

Course Code: CE81

Category: Professional Elective

Preamble:

This course aims to provide students with a comprehensive understanding of the principles, techniques, and best practices related to securing and controlling access to databases. Students will gain knowledge and skills in designing secure database systems, implementing access control mechanisms, detecting, and preventing security breaches, and managing user privileges

Pre-requisites:

1. DBMS

Course Objective:

- To introduce the fundamental concepts and principles of database security.
- To explore different types of security threats and vulnerabilities in database systems.
- To examine access control models and mechanisms for protecting data in databases.
- To understand encryption techniques for securing data at rest and in transit.
- To learn about authentication and authorization mechanisms in database systems
- To study techniques for auditing and monitoring database activities to detect security breaches.

Course Outcome:

Learner will be able to:
CO1: Understand the fundamental concepts and principles of database security and access control.
CO2: Understand the access control model.
CO3: Apply appropriate access control mechanisms to protect sensitive data and prevent unauthorized access.
CO4: Identify potential security threats and vulnerabilities in database systems.
CO5: Use tools and techniques for auditing and monitoring database activities to detect and respond to security incidents.
CO6: Evaluate and select appropriate encryption and authentication mechanisms for securing data.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Database Security	Overview of database security, Importance of database security, Threats and vulnerabilities in database systems, Security goals: confidentiality, integrity, and availability	6
2	Access Control Models and Mechanisms	Discretionary access control (DAC), Mandatory access control (MAC), Role-based access control (RBAC), Attribute-based access control (ABAC), Access control lists (ACLs), Privileges and permissions.	8
3	Authentication and Authorization	User authentication techniques, Password policies and management, multi-factor authentication, Single sign-on (SSO), Authorization and access rights, Role-based authorization	8
4	Encryption and Data Protection	Encryption concepts and algorithms, Symmetric and asymmetric encryption, Secure key management, Database-level encryption, Transparent data encryption (TDE), Secure Socket Layer/Transport Layer Security (SSL/TLS)	10
5	Auditing and Monitoring	Auditing and logging concepts, Audit trails and log management, Database activity monitoring (DAM), Intrusion detection and prevention systems (IDPS), Security Information and Event Management (SIEM)	8
6	Security Best Practices and Standards	Secure database design principles, Secure coding practices for databases, Patch management and vulnerability assessment, Database hardening techniques, Compliance with relevant security standards.	5
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Setting Up Secure Database Environment

Sr No.	Suggested Topic(s)
2.	Creating and managing user roles and permissions
3.	Configuring audit policies and rules
4.	Detecting and investigating suspicious activities.
5.	Configuring secure communication protocols (SSL).
6.	Conducting vulnerability assessments for databases.
7.	Managing encryption keys and certificate
8.	Implementing strong user authentication mechanisms.
9.	Case Study: Identifty database attacks and prevention technique

Textbooks:

1. William Stallings and Lawrie Brown, “Computer Security: Principles and Practice” pearson

Reference Books:

1. Hassan A. Afyouni, “Database Security and Auditing: Protecting Data Integrity and Accessibility"”, Cengage Learning

2. Tom Slodichak, Himanshu Gupta “Database Security and Encryption: A Practical Approach", CRC Press.

Detailed syllabus of First Year Semester-II

Course Name: High-Performance Computing and Parallel Algorithms

Course Code: CE89

Category: Core

Preamble:

This course provides an in-depth understanding of High-Performance Computing (HPC), Parallel Computing, and Distributed Computing paradigms used to solve computationally intensive problems. The course covers parallel architectures, parallel algorithm design, distributed memory and shared memory programming models, performance optimization techniques, and modern HPC frameworks. Learners will gain practical experience in developing scalable parallel applications using industry-standard tools and technologies for scientific, engineering, AI, and big-data workloads.

Pre-requisites:
1. Operating Systems
2. Computer Networks

Course Objective:
- Understand principles and architectures of High-Performance Computing systems.
- Analyze parallelism and scalability in computational problems.
- Design and implement efficient parallel and distributed algorithms.
- Utilize modern HPC frameworks such as OpenMP, MPI, CUDA, and MapReduce.
- Evaluate performance, fault tolerance, and resource utilization in large-scale computing environments.

Course Outcome:

Learner will be able to:
CO1: Analyze HPC architectures, parallel processing models, and distributed computing systems.
CO2: Design parallel algorithms using decomposition, synchronization, and communication techniques.
CO3: Develop shared-memory and distributed-memory applications using OpenMP and MPI.
CO4: Apply GPU computing and accelerator-based programming for computationally intensive applications.
CO5: Evaluate scalability, performance, load balancing, and fault tolerance of HPC applications.
CO6: Design distributed and cloud-enabled parallel solutions for real-world scientific, AI, and big-data applications.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	5

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to HPC and Parallel Computing	Evolution of HPC, Need for HPC, Flynn's Taxonomy, Parallel Processing Models, Shared Memory and Distributed Memory Architectures, Multicore and Manycore Systems, Cluster Computing, Supercomputing Fundamentals, Performance Metrics, Speedup, Efficiency, Scalability, Amdahl's Law and Gustafson's Law.	8
2	Parallel Algorithm Design Techniques	Parallelism Concepts, Task and Data Parallelism, Dependency Analysis, Parallel Algorithm Design Methodologies, Divide-and-Conquer, Pipeline Parallelism, Work Pool Model, Master-Worker Model, Synchronization Mechanisms, Parallel Sorting, Parallel Searching, Parallel Matrix Operations.	8
3	Shared Memory Programming	Threads and Processes, POSIX Threads, OpenMP Architecture, OpenMP Directives, Parallel Regions, Work Sharing Constructs, Synchronization, Critical Sections, Reduction Operations, Scheduling Policies, Performance Analysis and Optimization.	8
4	Distributed Memory Computing and MPI	Message Passing Paradigm, MPI Architecture, Point-to-Point Communication, Collective Communication, Communicators and Groups, Virtual Topologies, Parallel Matrix Multiplication, Distributed Sorting, Distributed Graph Processing, MPI Performance Optimization.	8
5	GPU Computing and Accelerator Architectures	GPU Architecture, CUDA Programming Model, Threads, Blocks and Grids, Memory Hierarchy, Kernel Programming, GPU Optimization Techniques, Heterogeneous Computing, OpenCL Overview, AI and Scientific Computing Applications on GPUs.	7

6	Distributed Computing, Big Data and Cloud-based HPC	Distributed Computing Models, Distributed File Systems, MapReduce Paradigm, Hadoop Ecosystem, Spark Fundamentals, Cloud-based HPC, Resource Scheduling, Load Balancing, Fault Tolerance, Containerized HPC using Docker and Kubernetes, Applications in AI, Deep Learning, Scientific Simulations and Big Data Analytics.	6
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1	Study and benchmarking of multicore processor performance.
2	Implementation of Amdahl's Law and scalability analysis.
3	Parallel matrix multiplication using OpenMP.
4	Parallel sorting algorithms using OpenMP.
5	MPI program for distributed matrix operations.
6	MPI-based parallel reduction and collective communication.
7	Implementation of distributed shortest path algorithm using MPI.
8	CUDA program for vector addition and matrix multiplication.
9	Hadoop MapReduce application for large-scale data processing.
10	Mini Project: Design and implementation of an HPC solution for AI, scientific computing, graph analytics, or big-data processing.

Text Books:

1. Introduction to Parallel Computing – Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, Addison-Wesley/Pearson, 2nd Edition.
2. Using MPI: Portable Parallel Programming with the Message Passing Interface – William Gropp, Ewing Lusk, and Anthony Skjellum, MIT Press, 3rd Edition.\
3. Using OpenMP: Portable Shared Memory Parallel Programming – Barbara Chapman, Gabriele Jost, and Ruud van der Pas, MIT Press.
4. Programming Massively Parallel Processors: A Hands-on Approach – David B. Kirk and Wen-mei W. Hwu, Morgan Kaufmann, 4th Edition.
5. Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers – Barry Wilkinson and Michael Allen, Pearson Education, 2nd Edition.

Reference Books:

1. Parallel Programming in C with MPI and OpenMP – Michael J. Quinn, McGraw-Hill Education.
2. Distributed Systems: Concepts and Design – George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, Pearson Education, 5th Edition.
3. Distributed Algorithms – Nancy A. Lynch, Morgan Kaufmann.

4. CUDA by Example: An Introduction to General-Purpose GPU Programming – Jason Sanders and Edward Kandrot, Addison-Wesley Professional.
5. Computer Architecture: A Quantitative Approach – John L. Hennessy and David A. Patterson, Morgan Kaufmann, 6th Edition.

Course Name: Computational Intelligence

Course Code: CE66

Category: Core

Preamble:

This course introduces learners to various computational intelligence techniques. Learners will become familiarized with Neural Network, Fuzzy logic & Evolutionary techniques. Course will also offer in- depth understanding to apply computational Intelligence to different applications.

Pre-requisites:

1. Soft Computing
2. Mathematics
3. Artificial Intelligence

Course Objectives:

- To explore the various computational intelligence techniques
- To become familiarize with Neural Network, Fuzzy Logic and Evolutionary techniques.
- To learn to apply computational intelligence to different applications.

Course Outcome:

Learner will be able to:

CO1: Understand the importance of computational Intelligence.
CO2: Examine the nature of problem and find suitable Artificial Neural Network techniques to solve it.
CO3: Understand operations and properties of Fuzzy Sets.
CO4: Compare and contrast traditional algorithms with nature inspired algorithms.
CO5: To apply the concepts of natural immune system using rule-based machine learning and develop artificial immune system.
CO6: Design and implement various intelligent systems.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to Computational Intelligence paradigms	Artificial Neural Networks, Fuzzy Systems, Genetic Algorithms, Swarm Intelligence, Artificial Immune System, Applications.	6
2	Artificial Neural Networks	Basic models of ANN: NN Architecture, MP Neuron, Linear separability, activation functions, types of learning. Learning Rules: Hebbian, Perceptron, Delta, Winner- take all. Supervised NN: Perceptron Network: SDPTA, SCPTA, MCPTA, Adaline networks.	12
3	Fuzzy Logic & Rough Set Theory	Fuzzy Relations and Fuzzy Rules Fuzzy Rules, Modus Ponens and Inference Defuzzification and its Types Fuzzy Inference Systems & Design of Fuzzy Controller Introduction to Rough Sets	11
4	Optimization	GA: Selection, Encoding, Crossover, Mutation, Examples. Swarm Intelligence: Single Solution Particle Swarm Optimization: Guaranteed Convergence PSO, Social-Based Particle Swarm Optimization, Hybrid Algorithms, Sub-Swarm Based PSO, Multi-Start PSO Algorithms, Repelling Methods, Binary PSO. Ant Algorithm: Simple Ant Colony Optimization	10
5	Applications	Typical applications of Fuzzy Inference system, Character Recognition, Colour Recipe prediction- Single MLP approach, ANT algorithm/Swarm Intelligence – TSP, Best path Finding	6
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Create a perceptron with appropriate number of inputs and outputs. Train it using fixed increment learning algorithm until no change in weights is required. Output the final weights
2.	Write a program to implement artificial neural network without back propagation. Write a program to implement artificial neural network with back propagation.
3.	Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relation by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.
4.	Implement travelling salesperson problem (TSP) using genetic algorithms.
5.	Implement Particle Swarm Optimization algorithm for given initial positions, velocity and best positions of all particles
6.	To do comparative study of all the variants of Particle Swarm Optimization algorithms.
7.	To do case study of Vehicle routing problem with pick-up and delivery (VRPPD) based on Ant colony optimization algorithm.
8.	To do case study of Natural immune system and Artificial Immune Models
9.	To do the case study of Optimization using Clonal Selection Algorithm.

Text Books:

1. Andries P. Engelbrecht, Computational Intelligence - An Introduction, John Wiley pub
2. J.S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
3. Samir Roy, Udit Chakraborty "Introduction to Soft Computing" Pearson Education India.
4. Jacek.M.Zurada "Introduction to Artificial Neural Sytems" Jaico Publishing House
5. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
6. S. Rajasekaran and G.A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.

References:

1. Fuzzy sets, fuzzy membership functions, fuzzy characteristics, fuzzy operations (D'Morgans Theorem) be quickly revised from [5]-2.2,2.3(Transformation excluded), 2.4.
   See NPTEL Video lectures of Prof. Laxmidhar Behra on Intelligent Systems and Control – Module 2.
2. http://www.eecs.ceas.uc.edu/~mazlack/dbm.w2011/Komorowski.RoughSets.tutor.pdf

Course Name: Deep and Reinforcement Learning

Course Code: CE69

Category: Elective

Preamble:

The recent advancements in artificial intelligence have positioned Deep Learning and Reinforcement Learning as core technologies powering innovations across domains such as robotics, healthcare, autonomous systems, and game AI. This course aims to build foundational understanding and practical proficiency in both deep and reinforcement learning. It begins with fundamental concepts of neural networks, progresses through advanced architectures and learning algorithms, and culminates in real-world applications and case studies. With a balanced focus on theory, mathematics, coding, and use-case integration, the course prepares students to engage in advanced AI research or apply these techniques in industry settings.

Pre-requisites:

3. Artificial Intelligence

4. Machine Learning

Course Objective:

By the end of the course, students will be able to:

1. Understand the fundamental concepts, mathematics, and building blocks of deep learning and reinforcement learning.
2. Design and implement various deep learning architectures and optimization strategies.
3. Apply reinforcement learning algorithms to sequential decision-making problems.
4. Evaluate and deploy deep RL systems in practical applications such as robotics, NLP, and gaming.

Course Outcome:

Upon successful completion of this course, students will be able to:

1. Analyze and explain the working principles of neural networks and deep learning models.
2. Implement and optimize convolutional, recurrent, and transformer-based architectures.
3. Apply value-based and policy-based reinforcement learning techniques to solve complex tasks.
4. Develop and test deep RL agents using simulation environments like OpenAI Gym or Unity ML-Agents.
5. Integrate deep learning and reinforcement learning in application domains like computer vision, natural language processing, and robotics.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Foundations of Deep Learning	▪ Introduction to AI, ML, and Deep Learning ▪ Biological neuron vs. artificial neuron ▪ Perceptron and multi-layer perceptron ▪ Activation functions (ReLU, Sigmoid, Tanh, Softmax) ▪ Loss functions and backpropagation ▪ Gradient descent and optimization basics ▪ Overfitting, underfitting, bias-variance tradeoff ▪ Regularization (Dropout, L1/L2)	7
2	Deep Neural Network Architectures	▪ Convolutional Neural Networks (CNNs) • Convolution, pooling, padding • CNN applications in image classification ▪ Recurrent Neural Networks (RNNs) • RNNs, vanishing gradient problem • LSTM and GRU ▪ Batch normalization and residual connections ▪ Introduction to frameworks (TensorFlow, PyTorch)	7

3	Reinforcement Learning Fundamentals	• Overview of RL and Markov Decision Processes (MDPs) • Agent-environment interface • Reward signal, policy, value functions • Monte Carlo methods • Temporal Difference (TD) learning • Dynamic programming approaches • Exploration vs. exploitation strategies (ε-greedy, UCB)	8
4	Deep Reinforcement Learning	· Q-Learning and Deep Q Networks (DQN) · Experience replay and target networks · Policy gradient methods · Actor-Critic architectures · Proximal Policy Optimization (PPO), A3C · Stability and convergence issues · Tools and platforms (OpenAI Gym, Stable Baselines)	8
5	Applications of Deep Learning	· NLP applications: • Word embeddings (Word2Vec, GloVe) • Transformers, BERT, GPT overview · Computer Vision applications: • Object detection (YOLO, Faster R-CNN) • Image segmentation (U-Net, Mask R-CNN) · Autoencoders and generative models (GANs, VAEs)	7
6	Applications of Reinforcement Learning	· Game playing agents (Atari, AlphaGo overview) · Robotics: • Motion planning • Reward shaping and safety · Finance: portfolio optimization · Healthcare: personalized treatment plans · Case studies and recent research trends in Deep RL · Project planning and presentation on real-world RL tasks	8
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	**Implement a Multilayer Perceptron (MLP)** using NumPy or PyTorch for classification on MNIST or Iris dataset.
2.	**Build and train a Convolutional Neural Network (CNN)** for image classification using the CIFAR-10 or Fashion-MNIST dataset.
3.	**Text Sentiment Classification using LSTM/RNN** on the IMDB or Twitter dataset using TensorFlow/Keras.
4.	**Apply Transfer Learning using Pre-trained Models (e.g., VGG16, ResNet)** for a custom image classification task.
5.	**Implement Q-Learning** on a simple environment like FrozenLake using OpenAI Gym.
6.	**Train a Deep Q-Network (DQN)** on CartPole or MountainCar environment using PyTorch and experience replay.
7.	**Implement Policy Gradient (REINFORCE) Algorithm** for learning a policy in the LunarLander environment.
8.	**Train an Actor-Critic agent using Proximal Policy Optimization (PPO)** on BipedalWalker or Pendulum.
9.	**Develop a Generative Adversarial Network (GAN)** to generate images using MNIST or Fashion-MNIST dataset.
10.	**Mini Project / Case Study** combining deep learning and reinforcement learning on a real-world application (e.g., robotics simulation, stock trading, or game AI).

Text Books:

1. **Ian Goodfellow, Yoshua Bengio, Aaron Courville** – *Deep Learning*, MIT Press
2. **Richard S. Sutton and Andrew G. Barto** – *Reinforcement Learning: An Introduction* (Second Edition), MIT Press

Reference Books:

1. **Francois Chollet** – *Deep Learning with Python*, Manning
2. **Sebastian Raschka, Yuxi Liu, Vahid Mirjalili** – *Deep Learning with PyTorch*, Packt Publishing
3. **Maxim Lapan** – *Deep Reinforcement Learning Hands-On*, Packt
4. **Nikhil Buduma and Nicholas Locascio** – *Fundamentals of Deep Learning*, O'Reilly
5. **Alexander Zai and Brandon Brown** – *Deep Reinforcement Learning in Action*, Manning
6. **Aurélien Géron** – *Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow*, O'Reilly

Course Name: Business Intelligence and Visual Analytics

Course Code: CE93

Category: Professional Elective

Preamble:

This course provides learners with a thorough understanding of Business Intelligence (BI) concepts, data warehousing architectures, and visual analytics techniques. It bridges the gap between raw organizational data and actionable business insights by equipping learners with skills in data modeling, BI tool usage, dashboard design, and advanced visualization. The course further explores emerging trends including cloud BI, AI-augmented analytics, and real-time streaming analytics, preparing learners for data-driven decision-making roles in industry.

Pre-requisites:

- Database Management Systems
- Data Warehousing Concepts
- Basic Statistics and Data Analysis

Course Objective:

- To understand the foundations, architecture, and evolution of Business Intelligence systems and their role in organizational decision-making.
- To design and implement data warehouses and multidimensional data models using standard schemas and OLAP operations.
- To develop interactive dashboards and reports using industry-standard BI tools such as Power BI and Tableau.
- To apply visual analytics principles and advanced visualization techniques for effective communication of business insights.
- To explore modern BI architectures including cloud-based, self-service, AI-augmented, and real-time analytics systems.

Course Outcome:

Learner will be able to:

CO1: Explain the concepts, architecture, and applications of Business Intelligence systems and differentiate BI from related paradigms.

CO2: Design multidimensional data models, data warehouse schemas, and implement ETL processes for structured analytical processing.

CO3: Build professional interactive dashboards and KPI reports using BI tools following best practices in dashboard design.

CO4: Apply principles of visual analytics, human perception, and advanced visualization techniques to represent data effectively.

CO5: Evaluate modern BI architectures and emerging trends including cloud BI, AI-augmented analytics, and real-time streaming data systems.

Course Scheme:

Contact Hours		**Credits Assigned**
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	**Foundations of Business Intelligence**	Introduction to Business Intelligence (BI): Concepts, Evolution and Architecture; BI vs Data Science vs Decision Support Systems (DSS); Business Metrics and Key Performance Indicators (KPIs); Performance Management and Decision Support; Applications of BI in Various Industries	7
2	**Data Warehousing and Multidimensional Data Modeling**	Data Warehousing Concepts and Architecture; ETL (Extract, Transform, Load) Process; Data Warehouse Schemas: Star and Snowflake; OLTP and OLAP Systems; Multidimensional Data Model: Facts, Dimensions, Measures and Hierarchies; OLAP Operations: Slice, Dice, Roll-up, Drill-down and Pivot	8
3	**BI Tools and Dashboard Design**	Overview of BI Tools: Power BI, Tableau and Similar Platforms; Data Import, Transformation and Modeling; Relationships, Calculated Columns and Measures; Dashboard Design Principles and Best Practices; KPI Reporting and Business Scorecards; Mobile and Responsive Dashboard Design	8
4	**Visual Analytics and Data Visualization Principles**	Role of Visual Analytics in Decision Making; Descriptive and Inferential Statistics for Analytics; Human Perception and Cognition in Visualization; Pre-attentive Attributes and Gestalt Principles; Selecting Appropriate Visualizations for Different Data Types; Advanced Visualizations: Heat Maps, Tree Maps, Sankey Diagrams and Geographic Maps; Color Theory and Effective Use of Visual Encoding	7
5	**Interactive and Exploratory Visual Analytics**	Exploratory Data Analysis (EDA); Interactive Visualization Concepts; Filtering, Sorting and Dynamic Queries; Brushing, Linking, Zooming and Panning; Drill-down and	7

		Drill-through Analysis; Storytelling with Data and Dashboards; Operational Dashboards vs Analytical Dashboards	
6	**Modern BI Architectures and Emerging Trends**	Big Data Analytics and BI Architecture; Cloud-Based Business Intelligence; Self-Service BI; Mobile BI and Embedded Analytics; AI-Augmented Analytics and Intelligent Dashboards; Real-Time Analytics and Streaming Data; Industry Case Studies and Emerging Trends in BI	8
		Total	**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Design and implement a Star Schema and Snowflake Schema for a given business scenario using a data warehousing tool.
2.	Build an ETL pipeline to extract data from multiple sources, transform it, and load it into a data warehouse.
3.	Perform OLAP operations (Slice, Dice, Roll-up, Drill-down, Pivot) on a multidimensional dataset.
4.	Create interactive dashboards with KPIs and business scorecards using Power BI or Tableau.
5.	Implement calculated columns, measures and relationships in a BI tool for business reporting.
6.	Design advanced visualizations (Heat Maps, Tree Maps, Sankey Diagrams, Geographic Maps) for a business dataset.
7.	Perform Exploratory Data Analysis (EDA) with interactive filters, brushing, linking and drill-through on a real-world dataset.
8.	Build a data storytelling report or narrative dashboard to present business insights to stakeholders.
9.	Implement a real-time analytics dashboard using streaming data and a cloud-based BI platform.
10.	Case study: End-to-end BI solution design — from data ingestion and warehousing to visual reporting for a chosen industry domain.

Text Books:

- Larson, B. (2020). Delivering Business Intelligence with Microsoft SQL Server and Power BI. 4th Edition, McGraw-Hill Education.
- Few, S. (2013). Information Dashboard Design: Displaying Data for At-a-Glance Monitoring. 2nd Edition, Analytics Press.
- Turban, E., Sharda, R., & Delen, D. (2014). Business Intelligence and Analytics: Systems for Decision Support. 10th Edition, Pearson Education.

Reference Books:

- Knaflic, C. N. (2015). Storytelling with Data: A Data Visualization Guide for Business Professionals. Wiley.
- Kimball, R., & Ross, M. (2013). The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling. 3rd Edition, Wiley.
- Murray, S. (2017). Interactive Data Visualization for the Web: An Introduction to Designing with D3. 2nd Edition, O'Reilly Media.

Course Name: Wireless Access Technologies

Course Code: CE77

Category: Professional Elective

Preamble:

In an era where wireless communication has become ubiquitous, powering everything from personal devices to critical infrastructure, understanding the intricacies of wireless access technologies is paramount. This graduate-level course is designed to delve into the advanced principles, latest standards, and cutting-edge technologies that define today's wireless access networks. It aims to equip students with both the theoretical foundations and practical skills necessary to innovate and excel in the fast-evolving field of wireless communications.

Pre-requisites:

- Signals and systems
- Digital communications
- Wireless communications

Course Objective:

- To understand the fundamental concepts related to access technologies.
- To understand the current and emerging wired and wireless access technologies.
- To understand the knowledge about the cable modems.
- To study and exposure to different systems standards for next generation access
- technologies.
- To study about the broadband wireless technologies

Course Outcome:

Learner will be able to:
CO1: To be able to explore the fundamental concepts and emerging broadband technologies.
CO2: To be able to design the systems meeting out the requirements of the recent standards.
CO3: To be able to design the cable modem in next generation Access technologies.
CO4: To be able to analyze the systems standards for next generation access technologies.
CO5: To be able to explore the various services of wireless broadband technologies.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Review Of Access Technologies	Phone-Line modem, cable-access, ISDN, Emerging Broad band Technologies, Cable DSL, Fiber and Wireless, Standards for access network.	9
2	Digital Subscriber Lines	Asymmetric Digital subscriber lines (ADSL) – Rate Adaptive subscriber line (RADSL)-ISDN Digital subscriber line (IDSL) - High bit rate DSL (HDSL)-Single line DSL (SDSL) - very high bit rate DSL (VDSL) - Standards for XDSL & Comparison	9
3	Cable MODEM	Cable Modem, DOCSIS – Physical Cabling, Dual Modem Operation, Hub Restriction, Upstream Operation – Downstream operation – Access control – framing Security sub layer – Data link layer – LLC & Higher layers – ATM centric VS IP – centric cable modem.	9
4	Fiber Access Technologies	Optical Fiber in access networks, Architecture and Technologies- Hybrid fiber – Coax (HFC) system, Switched Digital Video (SDV) – Passive optical networks (PON) – FTTX (FTTH, FTTB, FTTC, FTT cab) comparison.	9
5	Broadband Wireless	Fixed Wireless, Direct Broadcast Satellite (DBS), Multi channel multi point distribution services (MMDS), Local multi point distribution services (LMDS), and Wideband integrated Digital Interactive Services (WIDIS).	9
Total			**45**

Text and References books:

1. Niel Ransom and Albert A. Azzam, “Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.
2. Glen Carty, "Broadband Networking",Mc Graw Hill,2002.
3. Steven Gorshe, Arvind Raghavan, Thomas Starr, Stefano Galli, "Broadband Access: Wireline and Wireless - Alternatives for Internet Services", John Wiley & Sons, 2014.
4. Gilbert Held, “Next Generation Modems: A Professional Guide to DSL and Cable Modems”, John Wiley & Sons, 2000.
5. Walter J Woralski, “ADSL and DSL Technologies”, McGraw Hill Computer Communication Series, Second Edition Oct 2001

Course Name: Blockchain Security and Privacy

Course Code: CE95

Category: Professional Elective Courses

Preamble:

This course introduces the fundamental concepts of blockchain technology with a focus on security, privacy, and trust mechanisms in decentralized systems. It covers cryptographic foundations, blockchain architecture, consensus protocols, smart contract security, privacy-preserving techniques, attack vectors, and emerging security challenges in blockchain-based applications. The course aims to equip learners with the knowledge required to analyze, design, and secure blockchain systems for real-world applications..

Pre-requisites:

1. Computer Networks
2. Cryptography and Network Security
3. Database Management Systems

Course Objective:

- To understand the architecture, components, and functioning of blockchain systems.
- To study cryptographic techniques used for ensuring security and integrity in blockchain networks.
- To analyze security vulnerabilities, attacks, and threats in blockchain platforms and smart contracts.
- To explore privacy-preserving mechanisms and advanced cryptographic protocols used in blockchain systems.
- To evaluate blockchain security solutions and their applications in various domains..

Course Outcome:

Learner will be able to:
CO1: Explain blockchain fundamentals, cryptographic primitives, consensus mechanisms, and decentralized trust models.
CO2: Analyze the security properties, vulnerabilities, and attack vectors associated with blockchain networks and distributed ledger technologies.
CO3: Evaluate smart contract security issues and apply appropriate techniques for secure smart contract design and auditing.
CO4: Apply privacy-preserving mechanisms such as anonymity, pseudonymity, zero-knowledge proofs, and secure multi-party computation in blockchain-based systems.
CO5: Assess emerging blockchain security and privacy challenges, regulatory considerations, and propose suitable solutions for real-world decentralized applications.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Blockchain Fundamentals	Introduction to Blockchain: Evolution of Distributed Ledger Technologies (DLT), Blockchain Architecture, Components and Characteristics, Public, Private and Consortium Blockchains, Blockchain Layers. Cryptographic Foundations: Hash Functions, Merkle Trees, Digital Signatures, Public Key Infrastructure (PKI), Elliptic Curve Cryptography (ECC), Wallets and Key Management. Security Principles in Decentralized Systems: Integrity, Availability, Non-repudiation and Trust Models	8
2	Consensus Mechanisms and Blockchain Network Security	Consensus Fundamentals, Byzantine Generals Problem, Byzantine Fault Tolerance (BFT). Consensus Algorithms: Proof of Work (PoW), Proof of Stake (PoS), Delegated PoS, PBFT, Proof of Authority (PoA). Blockchain Network Security Threats: Double Spending Attack, 51% Attack, Sybil Attack, Eclipse Attack, Routing Attack, Selfish Mining. Security Analysis of Bitcoin and Ethereum Networks.	8
3	Smart Contract Security	Introduction to Smart Contracts, Ethereum Virtual Machine (EVM), Solidity Fundamentals. Smart Contract Lifecycle and Deployment. Common Smart Contract Vulnerabilities: Reentrancy Attack, Integer Overflow/Underflow, Timestamp Dependency, Denial of Service (DoS), Front Running, Access Control Vulnerabilities. Smart Contract Security Best Practices, Auditing Tools and Techniques, Case Studies of DAO Hack, Parity Wallet Attack and Recent DeFi Exploits	8
4	Privacy-Preserving Techniques in Blockchain	Privacy Challenges in Public Blockchains. Anonymity, Pseudonymity and Confidentiality. Privacy-Enhancing Technologies: Coin Mixing, Ring Signatures, Stealth Addresses, Confidential Transactions. Zero-Knowledge Proofs (ZKP), zk-SNARKs, zk-STARKs. Secure Multi-Party Computation (SMPC),	7

		Homomorphic Encryption, Privacy-Preserving Identity Management and Decentralized Identity (DID)	
5	Blockchain Security Frameworks and Applications	Security Architecture for Blockchain Systems. Identity and Access Management in Blockchain. Blockchain Security in Financial Systems, Supply Chain, Healthcare, IoT and Smart Cities. Security Considerations in DeFi, NFTs and Web3 Ecosystems. Enterprise Blockchain Platforms: Hyperledger Fabric Security, Quorum Security Features. Blockchain Forensics and Incident Investigation	7
6	Emerging Trends, Governance and Regulatory Challenges	Blockchain Governance Models, Security Standards and Compliance Requirements. Regulatory Frameworks, Data Protection and Privacy Laws. Security Challenges in Cross-Chain and Interoperable Blockchains. Quantum Computing Threats to Blockchain Security. AI and Blockchain Security Integration. Future Trends: Zero-Trust Blockchain Systems, Privacy-Preserving DeFi, Decentralized Autonomous Organizations (DAOs), Blockchain Security Research Directions	7
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1	Installation and configuration of a Blockchain Development Environment (Ethereum/Hyperledger), creation of wallets, and key pair generation.
2	Implementation of cryptographic primitives used in blockchain: SHA-256 hashing, Merkle Tree construction, and Digital Signature generation/verification.
3	Simulation and analysis of blockchain transactions, block creation, validation, and chain verification.
4	Study and implementation of consensus mechanisms such as Proof of Work (PoW) and Proof of Stake (PoS) in a simulated blockchain environment.
5	Development and deployment of a basic Smart Contract using Solidity on Ethereum test network.
6	Identification and demonstration of common Smart Contract vulnerabilities such as Reentrancy, Integer Overflow/Underflow, and Access Control issues.
7	Smart Contract security auditing using tools such as Remix Analyzer, Mythril, Slither, or Oyente.
8	Implementation and demonstration of privacy-preserving techniques such as Ring Signatures, Coin Mixing concepts, or Confidential Transactions.
9	Blockchain forensic analysis: tracing blockchain transactions and investigating suspicious wallet activities using blockchain explorers and forensic tools.
10	Mini Project: Design and implementation of a secure blockchain-based application (e.g., Supply Chain Tracking, Digital Identity Management, E-Voting, Healthcare Records, or Asset

	Management System) incorporating security and privacy features.

Textbooks:

1. Imran Bashir, Mastering Blockchain, 5th Edition, Packt Publishing, 2023.
2. Andreas M. Antonopoulos and Gavin Wood, Mastering Ethereum: Building Smart Contracts and DApps, O'Reilly Media, 2019.
3. Daniel Drescher, Blockchain Basics: A Non-Technical Introduction in 25 Steps, Apress, 2020.

Reference Books:

1. William Stallings, Cryptography and Network Security: Principles and Practice, 8th Edition, Pearson, 2024.
2. Arshdeep Bahga and Vijay Madisetti, Blockchain Applications: A Hands-On Approach, VPT Publications.
3. Pedro Franco, Understanding Bitcoin: Cryptography, Engineering and Economics, Wiley.
4. Rui Zhang, Rui Xue, Ling Liu, Security and Privacy on Blockchain, ACM Computing Surveys.
5. Joseph Bonneau et al., SoK: Research Perspectives and Challenges for Bitcoin and Cryptocurrencies, IEEE Security & Privacy.
6. Andreas M. Antonopoulos, Mastering Bitcoin: Programming the Open Blockchain, O'Reilly Media.

Course Name: Natural Language Processing with Large Language Models

Course Code: CE90

Category: Professional Elective

Preamble:

This course introduces learners to various techniques for natural language processing. Learners will become familiarized with Morphological analysis, syntactic and semantic analysis of text. Course will also offer in-depth understanding of Natural language processing applications like Machine translation, Question answering system, etc.

Pre-requisites:

1. Theory of Computer Science
2. Compiler Construction
3. Machine Learning

Course Objective:

- To provide students with a strong foundation in Natural Language Processing techniques, including text representation, linguistic analysis, and deep learning methods for language understanding.
- To enable students to design, develop, and evaluate intelligent language applications using Transformer architectures, Large Language Models (LLMs), prompt engineering, and Retrieval-Augmented Generation (RAG) techniques.

Course Outcome:

Learner will be able to:
CO1: Apply NLP preprocessing and linguistic analysis techniques to textual data.
CO2: Develop deep learning-based NLP models using embeddings and sequence learning architectures.
CO3: Explain Transformer architectures
CO4: Understand the working principles of Large Language Models.
CO5: Design effective prompts and Retrieval-Augmented Generation pipelines for domain-specific applications.
CO6: Develop and evaluate intelligent NLP applications using modern LLM frameworks and tools.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Foundations of Natural Language Processing	**Introduction to NLP** • Overview of NLP and Applications • Challenges in Natural Language Understanding • NLP Pipeline • NLP in Industry and Research **Text Preprocessing and Linguistic Analysis** • Tokenization • Stemming and Lemmatization • Part-of-Speech Tagging • Named Entity Recognition • Dependency Parsing **Statistical NLP** • N-Gram Models • TF-IDF • Language Modeling • Text Classification Fundamentals	09
2	Word Representation and Deep Learning for NLP	**Word Embeddings** • One-Hot Encoding • Word2Vec • GloVe • FastText • Contextual Embeddings **Neural Networks for NLP** • Feedforward Networks • Recurrent Neural Networks • LSTM and GRU Architectures • Sequence-to-Sequence Models • Attention Mechanism	09
3	Transformers	**Transformer Architecture** • Self-Attention • Multi-Head Attention • Positional Encoding • Encoder-Decoder Architecture	06

4	Large Language Models	**Large Language Models** • Foundation Models • Pre-training and Fine-tuning • Instruction Tuning • Tokenization and Embeddings in LLMs • GPT, Gemini, Llama and Open-Source LLMs	09
5	Prompt Engineering and Retrieval-Augmented Generation	**Prompt Engineering** • Zero-Shot Prompting • Few-Shot Prompting • Chain-of-Thought Prompting • Role-Based Prompting • Structured Prompt Design **Retrieval-Augmented Generation (RAG)** • Motivation for RAG • Embedding Models • Vector Databases • Similarity Search • RAG Architecture • Knowledge Retrieval Pipelines	06
6	NLP Applications using LLMs	• Question Answering Systems • Conversational AI • Text Summarization • Information Extraction • Sentiment Analysis • Domain-Specific Assistants **LLM Evaluation and Deployment** • Evaluation Metrics • Hallucination Analysis • Response Quality Assessment	06
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Text preprocessing using NLTK and spaCy.
2.	Sentiment analysis using machine learning models.
3.	Word embedding generation using Word2Vec.
4.	Text classification using deep learning.
5.	Prompt engineering using LLM APIs.
6.	Building a chatbot using Gemini/OpenAI APIs.
7.	Creating embeddings and vector databases.
8.	Implementing a Retrieval-Augmented Generation (RAG) system.
9.	Document summarization using LLMs.
10.	Mini-project: Domain-specific intelligent assistant.

Text Books:

1. Daniel Jurafsky and James H Martin, "Speech and Language Processing", 3e, Pearson Education, 2018
2. Jacob Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019
3. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta and Harshit Surana, Practical Natural Language Processing, O'Reilly Media, 2020.

Reference Books:

1. Lewis Tunstall, Leandro von Werra and Thomas Wolf, Natural Language Processing with Transformers, O'Reilly Media, 2022
2. Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications, 2024.
3. M. H. Houshmand, Generative AI and Large Language Models: Architecture, Applications and Prompt Engineering, Wiley, 2024.

Course Name: Data Governance, Privacy and Ethics

Course Code: CE94

Category: Program Elective

Preamble:

This course introduces the foundational principles and practices of Data Governance, Privacy, and Ethics in the context of modern data-driven organizations. It equips learners with the essential frameworks for managing data assets responsibly, understanding global regulatory requirements, and applying ethical considerations in data collection, storage, processing, and sharing. The course blends technical, legal, and organizational perspectives to prepare students for real-world data stewardship and compliance roles.

Pre-requisites:

Database Management Systems
Fundamentals of Data Analytics

Course Objective:

- To understand the principles, frameworks, and practices of data governance in organizations.
- To familiarize learners with global data privacy laws and compliance requirements.
- To develop ethical awareness in handling, processing, and sharing data responsibly.
- To introduce techniques for data quality management, metadata management, and master data management.
- To prepare learners to design and implement data governance strategies for real-world scenarios.

Course Outcome:
Learner will be able to:
CO1: Describe the key concepts, frameworks, and stakeholders involved in data governance.
CO2: Appreciate the role of data privacy regulations (GDPR, CCPA, PDPA) in shaping organizational data practices.
CO3: Identify and address ethical issues arising from algorithmic bias, surveillance, and data-driven decision-making.
CO4: Design and apply appropriate data governance policies including data classification, lineage, quality management, and stewardship.
CO5: Understand data governance tools and emerging trends such as DataOps, data mesh, and cloud data governance.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Data Governance	Data Governance overview and importance; Data Governance frameworks: DAMA-DMBOK, IBM, COBIT; Key roles: Data Owners, Stewards, Custodians; Data Governance Council structure; Policies, standards, and procedures; Business drivers and value of data governance.	6
2	Data Privacy Laws and Regulations	Overview of global data protection laws: GDPR, CCPA, PDPA, HIPAA; Principles of data privacy: lawfulness, transparency, purpose limitation, data minimization; Rights of data subjects: access, rectification, erasure, portability; Data breach notification and compliance; Cross-border data transfer regulations.	8
3	Ethics in Data and AI	Ethical principles in data collection and usage; Algorithmic bias and fairness: types, causes, and mitigation; Transparency, explainability, and accountability in AI; Surveillance, profiling, and consent challenges; Ethical frameworks: deontology, utilitarianism, virtue ethics; Case studies on responsible AI.	8
4	Data Quality and Metadata Management	Dimensions of data quality: accuracy, completeness, consistency, timeliness; Data quality assessment, profiling, and remediation; Metadata types: technical, business, operational; Metadata management tools and repositories; Data lineage: definition, importance, and implementation; Data cataloging.	8
5	Master Data Management and Data Stewardship	Concept and importance of Master Data Management (MDM); MDM architecture styles: registry, consolidation, coexistence, centralized; Data stewardship roles and lifecycle management; Data classification and sensitivity levels; Implementing data governance policies; Reference data management.	8
6	Data Governance Implementation and Compliance	Building a data governance roadmap and maturity model; Data governance tools: Collibra, Informatica, Alation; Risk management in data governance: identification, assessment, mitigation; Auditing and monitoring compliance; Privacy-by-Design and Security-by-Design principles; Emerging trends: DataOps, data mesh, cloud data governance.	7
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Implement a data governance policy document for a hypothetical organization including roles, responsibilities, and data classification standards.
2.	Analyze a GDPR compliance case study: identify violations, data subject rights issues, and propose remediation steps.
3.	Perform data quality profiling on a given dataset, measure dimensions (completeness, accuracy, consistency), and produce a quality report.
4.	Implement data lineage tracking using Apache Atlas or equivalent; trace data flow from source to consumption.
5.	Build a data catalog for a sample database schema with business, technical, and operational metadata annotations.
6.	Develop a Master Data Management (MDM) plan for a sample enterprise scenario including architecture selection and entity resolution.
7.	Identify and mitigate algorithmic bias in a machine learning dataset using fairness metrics and bias mitigation techniques.
8.	Design a Privacy Impact Assessment (PIA) for a data collection scenario involving personal data.
9.	Implement Role-Based Access Control (RBAC) policies for a data warehouse ensuring least-privilege access.
10.	Create a data governance compliance dashboard using a BI tool to monitor KPIs such as data quality scores and policy adherence.

Text Books:

1. Sunil Soares, "Big Data Governance: Modern Data Management Principles", MC Press.
2. John Ladley, "Data Governance: How to Design, Deploy and Sustain an Effective Data Governance Program", Academic Press, 2nd Edition.
3. Katharine Jarmul, "Practical Data Privacy", O'Reilly Media.

Reference Books:

1. Cathy O'Neil, "Weapons of Math Destruction", Crown Publishing Group.
2. Virginia Eubanks, "Automating Inequality", St. Martin's Press.
3. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI.

Course Name: IoT and Smart Cities

Course Code: CE78

Category: Professional Elective

Preamble:

In this course, the important sensors, associated interface electronics, signal conditioning, technology of smart sensors and IOT for the measurement and monitoring of vital environmental parameters will be studied.

Pre-requisites:

Applied Physics, Embedded System, Sensor Technology

Course objectives:

- The objective of this course is to Select the right sensor for a given application.
- To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterised, and analysed.
- Introduce evolution of internet technology and need for IoT.
- Discuss on IoT reference layer and various protocols and software
- Evaluate the wireless technologies used in IoT.

Course Outcomes:

Learner will be able to:
CO1: Create analytical design and development solutions for sensors

CO2: Select appropriate sensors for the given application development.

CO3: Evaluate performance characteristics of different types of sensors

CO4: Design and develop IoT based sensor systems

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Sensor characteristics	Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal	8
2	Physical Principle of Sensing	Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer, Optics, Fiber optics and waveguides	8
3	Sensor Interface and Applications	Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits. Case Studies: Inertial Sensors (Accelerometer & gyroscope), Healthcare Sensors (Glucometer, ECG & MRI), Smart building Sensors (Smoke & occupancy sensors)	8
4	Introduction to IoT	Introduction to Internet of Things: Characteristics of IoT, Design principles of IoT, IoT Architecture and Protocols, Enabling Technologies for IoT, IoT levels and IoT vs M2M.IoT Design Methodology: Design methodology, Challenges in IoT Design, IoT SystemManagement, IoT Servers..Basics of Arduino: Introduction to Arduino, Arduino IDE, Basic Commands for Arduino, Connecting LEDs with Arduino, Connecting LCD with Arduino.	8
5	IoT point to point communication technologies	IoT Communication Pattern, IoT protocol Architecture, Selection of Wireless technologies (6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA,Lifi,Wifi)	7
6	IoT application and its Variants	Case studies: IoT for smart cities, health care, agriculture, smart meters.M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0,IoT standards.	6
Total			**45**

Suggested list of Practicals:

1. Implementation of Signal Conditioning Circuits
2. Sensor interfacing using off-the-shelf components.
3. Performance Analysis of Optical Link with Different Detectors
4. Performance Analysis of Soliton Communication System
5. Effect of cross phase modulation on WDM system
6. Mitigation of Four wave mixing by NZ-DSF fiber
7. Performance Analysis of Optical Amplifier

8. Performance Analysis of DWDM System

Text Books:

1. Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.

2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1 st Edition, Wiley.

3. S. M. Sze, (1994), Semiconductor Sensors, 1 st Edition, Wiley.

4. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016.

5. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Aves and, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014

Reference Books:

1. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
2. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
3. John G Webster, "Measurement, Instrumentation and sensor Handbook", 2017, 2nd edition, CRC Press, Florida.

Course Name: Intrusion Detection and Prevention

Course Code: CE82

Category: Professional Elective

Preamble:

The goal of the course is to introduce the students to principles, methodologies and technologies used in intrusion detection and prevention systems. With the help of tools, it provides analysis, mitigation of intrusion and helps in preventing the same using effective strategies.

Pre-requisites:

1. Computer Network
2. Cyber Security

Course Objective:

- To understand the vulnerabilities and detection techniques of various attacks
- To understand the network intrusion detection & prevention mechanisms
- To understand the countermeasures of various information security attacks
- To design / make use of a typical intrusion detection system

Course Outcome:

Learner will be able to:
CO1: Design and implement Intrusion Detection System
CO2: Understand classes of attacks on computer systems.
CO3: Identify various types of IDS of signature based and anomaly-based techniques to solve problems related to intrusion detection and prevention.
CO4: Employ ID&PS specific feature extraction techniques.
CO5: Interpret and analyze intrusion detection and prevention logs, alerts, and reports to detect security incidents and potential vulnerabilities.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction	History of Intrusion detection, Audit, Concept and definition, Internal and external threats to data, attacks, Key functions of IDPS technologies-Common Detection methodologies-Signature & Anomaly based Detection,	4
2	Intrusion Detection Systems Principles	Stateful protocol analysis Types of IDS, Information sources Host based information sources, Network based information sources.	5
3	IDS Technologies	Components & Architecture-Typical components, Network Architectures Security capabilities - Information gathering capabilities, logging capabilities, detection & prevention capabilities. Intrusion Prevention Systems, Network protocol based IDS, Hybrid IDS, Analysis schemes, thinking about intrusion. A model for intrusion analysis, techniques Responses requirement of responses, types of responses mapping responses to policy Vulnerability analysis, credential analysis non credential analysis	9
4	Network Based IDS	Networking Overview-OSI layers. Components and Architecture - Typical components, Network architectures and sensor locations. Security capabilities Wireless IDPS-Wireless Networking overview-WLAN standards & components. Components Network Behavior analysis system.	9
5	Host Based IDS	Components and Architecture-Typical components, Network architectures, Agent locations, host architectures. Security capabilities-Logging, detection, prevention, and other capabilities. Using & Integrating multiple IDPS technologies-Need for multiple IDPS technologies, integrating different IDPS technologies-Direct & Indirect IDPS integration other technologies with IDPS capabilities. Network Forensic Analysis Tool, Anti-	9

		malware technologies, Firewalls and Routers,	
6	IDS Tool : SNORT IDS	Introduction to Snort, Working with Snort Rules, Snort configuration, Snort with MySQL, Running Snort on Multiple Network Interfaces, Snort Modes Snort Alert Modes, Snarf with Snort, Agent development for intrusion detection, Architecture models of IDS and IPS.	9
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Use of Wire shark Tool
2.	Set up Snort and study the logs.
3.	Setting up personal Firewall using iptables
4.	SQL injection attack, Cross-Cite Scripting attack simulation
5.	Case Study /Seminar: Topic beyond syllabus related to topics covered.

Text and References books:

1. Carl Endorf, Eugene Schultz and Jim Mellander —" Intrusion Detection & Prevention", 1st Edition, Tata McGraw-Hill, 2006

2. Christopher Kruegel,Fredrik Valeur, Giovanni Vigna: —Intrusion Detection and Correlation Challenges and Solutions, 1st Edition,Springer, 2005.

3. Karen Scarfone, Peter Mell," Guide to Intrusion Detection and Prevention Systems (IDPS)", NIST special publication, 2007

4. Kerry J Cox , Christopher Gerg," Managing Security with Snort and IDS Tools", O'Reilly, 2007.

5. Rafeeq Rehman : — Intrusion Detection with SNORT, Apache,MySQL, PHP and ACID,|| 1st Edition, Prentice Hall , 2003

6. Stephen Northcutt, Judy Novak : —Network Intrusion Detection||, 3rd Edition, New Riders Publishing, 2002.

Detailed syllabus of Open Elective

Course Name: Sustainability Management

Course Code: OE04

Category: Open Elective

Preamble:
This course explores corporate sustainability from the perspective of large, multinational corporations. Focus is on the management tools available to corporations and how they can drive sustainability into a company at all levels, providing a balance between environmental stewardship, social well-being, and economic prosperity.

Objectives:
1. The importance to each individual corporate entity of corporate sustainability.
2. Key drivers and inhibitors, both external and internal to the corporation, of the natural environmental and social aspects of corporate sustainability.
3. The roles of social and natural environmental risk, and product and process innovation, in developing corporate sustainability.

Course Outcome: Student will be able to:
1. Define sustainability and identify major sustainability challenges.
2. Identify, act on, and evaluate their professional and personal actions with the knowledge and appreciation of interconnections among economic, environmental, and social perspectives.
3. Recognize the global implications of their actions.
4. Apply concepts of sustainable development to address sustainability challenges in a global context.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	30	50	120

Detailed Syllabus

Module no	Module Name	Content	No of Hours
1	Introduction to Sustainability Management	Meaning, definition, dimensions of sustainability, value of sustainability, framework for business sustainability Understanding the Sustainability Challenge- The Systemic Level and Business Level, Their Implications for business.	12

Module no	Module Name	Content	No of Hours
2	Importance of Corporate Sustainability	Assessing the Strategic Opportunity, Managing Sustainability Transitions across Business Functions, successful cases of organizations focusing on a business model designed around sustainability principles and mind-sets.	12
3	Seizing the Strategic Opportunity	Managing Sustainability Transitions across Business Functions, the challenges related to the management of the integration of sustainability-related processes in business organizations.	12
4	Stakeholder Engagement	Multilateral engagement, Government engagement, NGO's – influence and engagement, Trade associations (WBCSD), Stakeholder interests and engagement	12
5	Transitioning Organizations to Sustainable Enterprises	Developing the Road-Map, Approach the challenge of developing a roadmap to realize the stakeholder value creation potential in sustainability transitions at three different levels, initiatives related to transformational change in the organizations.	12
Total			**60**

Textbooks:

1. Corporate Sustainability in Practice: A Guide for Strategy Development and Implementation by Paolo Taticchi, Melissa Demartini
2. Corporate Sustainability, Social Responsibility and Environmental Management: An Introduction to Theory and Practice with Case Studies by Mark Anthony Camilleri.

Reference-Books:

1. How to Succeed as an Independent Consultant by Holtz, Herman.
2. Strategy for Sustainability: A Business Manifest by Adam Werbach.

E- Resources:

1. Global Journal of Management and Business Research: D Accounting and Auditing
2. Indian Journal of Finance - http://www.indianjournaloffinance.co.in/
3. IVEY Business Journal- https://iveybusinessjournal.com/publication/corporate-sustainability-what-is-it-and-where-does-it-come-from/

OE14:

1. https://www.coursera.org/learn/corp-
2. https://www.edx.org/course/introduction-to-corporate-sustainability-social-in
3. https://www.classcentral.com/course/corp-sustainability-10667

Course Name: Operation Research

Course Code: OE05

Category: Open Elective

Pre-requisites:

- Mathematics

Course Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Course Outcome:

- Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems. Understand the applications of integer programming and a queuing model and compute important performance measures.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	30	50	120

Detailed Syllabus

Module	Detailed Content	Hours
1	**Introduction to Operations Research** • Introduction, , Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming** • Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, SimplexMethod	13

	Penalty Cost Method or Big M-method, Two Phase Method,Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem** • Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the steppingstone method and MODI method. **Assignment Problem** • Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines	
	Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem** • Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	05
2	**Queuing models** • Queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	09
3	**Simulation** • Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	10
4	**Dynamic programming** • Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	08
5	**Game Theory** • Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	10
6	**Inventory Models** • Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05
	Total	**60**

Textbooks and References:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Name: IPR and Patenting

Course Code: OE06

Category: Open Elective

Preamble: This course aims to help learners understand IPR and its management. It will introduce the learners to different types of IPR and patenting processes for innovation and commercialization of the IPR. The learners will also learn about the various strategies to manage and protect the IPR.

Course Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as international treaty procedures
- To get acquainted with Patent search and patent filing procedures and applications.
- To familiarize with the IPR Management and Commercialization Process.

Course Outcome:

- Understand Intellectual Property assets
- Assist individuals and organizations in capacity-building
- Work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting
- Apply the IPR understanding in policy design, NDA Forms, Contributing to Standards and other processes.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

ISA	MSE	ESE	Total
40	30	50	120

Detailed Syllabus

Module	Detailed Content	Hours
1	**Importance of IPR in Modern Global Economic Environment** • Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	5
2	**Enforcement of Intellectual Property Rights** • Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement **Indian Scenario of IPR** • Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	10
3	**Emerging Issues in IPR** • Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	5
4	**Basics of Patents** • Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	10
5	**Patent Rules** • Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treatieswhere India is a member (TRIPS agreement, Paris convention	10

	etc.) **Procedure for Filing a Patent (National and International)** • Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases** Important websites, Searching international databases	
6	**IPR Management** • IPR management Strategies, IPR Commercialization Strategies • IPR Dispute and Negotiation strategies • Participation in Standards and Public Funding • IPR Policymaking and developing innovation eco-system	5
Total		**45**

Guidelines to conduct practical/home assignment sessions:

- An individual or a group of two students will conduct the capstone project.
- To encourage project-based learning in the curriculum, students may select one of the subjects of their choice after the subject in charge reviews and approves it.
- Each individual l/team will conduct a rigorous literature survey of the IPR Subject by reading and understanding at least 3-5 Patent/IPR papers from current, high-quality national/international Patents/IPR search engines. The list of documents surveyed must be documented.
- The project assessment for term work will be done at least twice a semester, and it will involve giving a presentation to the faculty in charge or a panel of expert members.

Deliverables of the capstone project by the student or the group:

Sr. No	Deliverables	Hours in Practical Session	Hours as a home assignment
1	A report summarizing the findings of the literature survey.	3	3
2	Prior Artwork	3	3
3	Preparing own IPR and Other Reading Material	3	3
4	Final Draft with application	3	3
5	Detailed synopsis of the submitted application	3	3
Total		**15**	**15**

Skill Set (H, M, L)

1. Building your IPR Understanding (H)
2. Learning different tools (H)
3. Analysis of the Prior Art Work (M)

Tool Set:

1. Search Engines
2. Assessment/Feedback/Survey

Module Mapping:

Module	Skill Set	Tool Set
Module 1	1	-
Module 2	1	-
Module 3	1	-
Module 4	1,2,3	1,2
Module 5	1,2,3	1,2
Module 6	2,3	1,2

Recommended Online Courses:

1. https://l2proindia.com/index.php#item1 (GOI and Qualcomm Course)
2. https://onlinecourses.swayam2.ac.in/aic24_ge17/preview (Swayam)
3. https://welc.wipo.int/ipedu/ (WIPO Portals)
4. https://www.youtube.com/@turnipinno/videos (Turnip)

Textbooks and References:

1. Rajkumar S. Adukia, 2007, *A Handbook on Laws Relating to Intellectual PropertyRights in India*, The Institute of Chartered Accountants of India
2. Keayla B K, *Patent system and related issues at a glance*, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, *Intellectual Property Law in India*, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, *Intellectual Property and HumanDevelopment: Current Trends and Future Scenario*, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, *Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right*, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, *The enforcement of Intellactual Property Rights: A Case Book*, 3rdEdition, WIPO

7. Prabhuddha Ganguli, 2012, *Intellectual Property Rights*, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, *Intellectual Property Rights*, 1stEdition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, *Intellectual Property Rights*, 2nd Edition,Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, *Fundamentals of IPR for Engineers*, 1stEdition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, *A Manual on Intellectual Property Rights*.
12. Mathew Y Maa, 2009, *Fundamentals of Patenting and Licensing for Scientists and Engineers*, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi**,** *IPR: Drafting, Interpretationof Patent Specifications and Claims***,** New India Publishing Agency
14. Vivien Irish, 2005, *Intellectual Property Rights for Engineers*, IET
15. Howard B Rockman, 2004, *Intellectual Property Law for Engineers and scientists*,Wiley- IEEE Press
16. Mathew Y Maa, 2009, *Fundamentals of Patenting and Licensing for Scientists and Engineers*, World Scientific Publishing Company
17. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi**,** *IPR: Drafting, Interpretationof Patent Specifications and Claims***,** New India Publishing Agency
18. Vivien Irish, 2005, *Intellectual Property Rights for Engineers*, IET
19. Howard B Rockman, 2004, *Intellectual Property Law for Engineers and scientists*,Wiley-IEEE Press

Course Name: Research Methodology

Course Code: OE07

Category: Open Elective

Preamble:

This course is to make the students understand the importance of research and various methods that researcher used to investigate problems. The course will also help the students to make meaningful decisions.

Pre-requisites:

1. Quantitative Techniques
2. Operations and production management

Course Objective:

- To understand importance of research and various methods that researcher used to investigate problems.
- To write research proposals.
- To perform enriched data collection and analysis.
- To write detailed research reports.

Course Outcome:

Learner will be able to:
CO1: Understand the importance of research and various methods that researcher used to investigate problems.

CO2: Apply Modern Analytical tools for Business Management Decisions.

CO3: Derive strategies from the research.

CO4: Understand the challenges in collecting the data collection and analysis.

CO5: Interpret the data to make meaningful decisions.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Total
Theory	40	30	50	120

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Research	Meaning of research; Types of research- Exploratory research, Conclusive research; The process of research; Research applications in social and business sciences; Features of a Good research study	4
2	Research Problem and Formulation of Research Hypotheses	Defining the Research problem; Management Decision Problem vs Management Research Problem; Problem identification process; Components of the research problem; Formulating the research hypothesis- Types of Research hypothesis; Writing a research proposal- Contents of a research proposal and types of research proposals.	6
3	Research Design	Meaning of Research Designs; Nature and Classification of Research Designs; Exploratory Research Designs: Secondary Resource analysis, Case study Method, Expert opinion survey, Focus group discussions; Descriptive Research Designs: Cross sectional studies and Longitudinal studies; Experimental Designs, Errors affecting Research Design	6
4	Primary and Secondary Data	Classification of Data; Secondary Data: Uses, Advantages, Disadvantages, Types and sources; Primary Data Collection: Observation method, Focus Group Discussion, Personal Interview method	4
5	Attitude Measurement and Scaling	Types of Measurement Scales; Attitude; Classification of Scales: Single item vs Multiple Item scale, Comparative vs non-Comparative scales, Measurement Error, Criteria for Good Measurement	6
6	Questionnaire Design	Questionnaire method; Types of Questionnaires; Process of Questionnaire Designing; Advantages and Disadvantages of Questionnaire Method	4
7	Sampling and Data Processing	Sampling concepts- Sample vs Census, Sampling vs Non Sampling error; Sampling Design- Probability and Non Probability Sampling design; Determination of Sample size- Sample size for estimating population mean,	6

		Determination of sample size for estimating the population proportion Data Editing- Field Editing, Centralized in house editing; Coding- Coding Closed ended structured Questions, Coding open ended structured Questions; Classification and Tabulation of Data.	
8	Univariate and Bivariate Analysis of Data	Descriptive vs Inferential Analysis, Descriptive Analysis of Univariate data- Analysis of Nominal scale data with only one possible response, Analysis of Nominal scale data with multiple category responses, Analysis of Ordinal Scaled Questions, Measures of Central Tendency, Measures of Dispersion; Descriptive Analysis of Bivariate data	6
9	Testing of Hypotheses	Concepts in Testing of Hypothesis – Steps in testing of hypothesis, Test Statistic for testing hypothesis about population mean; Tests concerning Means- the case of single population; Tests for Difference between two population means; Tests concerning population proportion- the case of single population; Tests for difference between two population proportions.	6
10	Chi-square Analysis	Chi square test for the Goodness of Fit; Chi square test for the independence of variables; Chi square test for the equality of more than two population proportions	4
11	Analysis of Variance	Completely randomized design in a one-way ANOVA; Randomized block design in two way ANOVA; Factorial design	4
12	Research Report Writing and Ethics in research	Types of research reports – Brief reports and Detailed reports; Report writing: Structure of the research report- Preliminary section, Main report, Interpretations of Results and Suggested Recommendations; Report writing: Formulation rules for writing the report: Guidelines for presenting tabular data, Guidelines for visual Representations. Meaning of Research Ethics; Clients Ethical code; Researchers Ethical code; Ethical Codes related to respondents; Responsibility of ethics in research	4
Total			**60**

Text and References books:

1. Business Research Methods – Cooper Schindler
2. Research Methodology Methods & Techniques – C.R.Kothari
3. Statistics for Management – Richard L Levin.

Course Name: Teaching Pedagogy and Educational Technology

Course Code: OE15

Category: Open Elective

Preamble:

The rapid progress of the Internet and allied technologies, emphasis on outcome-based education, the importance of participative learning, and changing student expectations demand rapid development of engineering faculty teaching competencies. Further, the growing heterogeneous capabilities and motivations of students are giving rise to more diverse learning needs, which require changes in the existing paradigms of engineering education. Today, faculty members must adopt more flexible and student-centric paradigms and focus on developing students' attributes. We propose a four-credit course on teaching pedagogy and Educational Technology to train upcoming or budding faculty members in new and impactful education techniques.

Pre-requisites: N/A

Course Outcome:

Students will be able to:

1) Understand university teaching and its requirements.
2) Apply the different teaching strategies and develop their lesson plan.
3) Apply different ICT tools in teaching.
4) Apply different Assessment methodologies for effective education.
5) Develop their MOOC.
6) Apply gamification to education courses.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Examination Scheme:

ISA	MSE	ESE	Total
40	20	40	100

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	University Teaching	What is university teaching, and how is it different from other teaching? What are the various theories/schools of thought for Teaching? Different Taxonomies and their Applications. What is education accreditation? NEP 2020	10
2	Teaching Leadership and Strategies	Developing Lesson Plans, Setting Labs/Practicals, PBL, Developing *Course Outcomes* of a subject, Think Pair Share Flipped Classroom, Collaborative learning, TBL, etc. Career path for teaching and mentoring.	8

3	ICT Tools	Digital Teaching Techniques, Generative AI tools, Digital lab journal alternative to lab notebook, Plicker, Crossword Mobile test, Beyond classroom activities, simulation tools, open-source tools, etc.	6
4	Assessment Methods	Formative and summative assessments, Evaluation Models and Different Types of Examinations, setting up surveys, setting rubrics, designing assessment methods, Festival of examination,etc.	6
5	Designing MOOC	Introduction to MOOC, Elements of MOOC, Development of MOOC-tools,setting up a MOOC using Moodle, Develop your Open Educational Resources (OERs).	6
6	Gamification	What are gamifications? Types of games, designing principles of games, use of games in education.	4
Total			**40**

Guidelines to conduct practical/home assignment sessions:

1. The capstone project will be conducted by an individual or a group of two students.
2. To encourage project-based learning in the curriculum, students may select one of the subjects of their choice after a review and approval by the subject in charge.
3. Each team will do a rigorous literature survey of the MOOC Subject by reading and understanding at least 3-5 research papers from current good quality national/international journals/conferences. (Papers selected must be indexed by Scopus/IEEE/Springer/ACM etc.). The list of papers surveyed must be clearly documented.
4. The project assessment for term work will be done at least twice a semester by giving a presentation to the faculty in charge or a panel of expert members.

Deliverables of the capstone project by the student or the group:

Sr. No	Deliverables	Hours in Practical Session	Hours as a home assignment
1	A report summarizing the findings of the literature survey.	2	5
2	Content Development	2	5
3	Preparing Assessment and Other Reading Material	2	5
4	Final Deployment of the Course	2	10
5	Detailed synopsis of the implemented MOOC	2	5
Total		**10**	**30**

Skill Set (H, M, L)

1. Building your course (H)
2. Learning different tools (H)
3. Analysis of the Course and Feedback (M)

Tool Set

1. ICT
2. Moodle

3. Assessment/Feedback/Survey

Module Mapping

Module	Skill Set	Tool Set
Module 1	1,2	-
Module 2	1,2	-
Module 3	1.2,3	1,2,3
Module 4	1,2,3	1,2,3
Module 5	1,2,3	1,2,3
Module 6	2,3	1,3

Recommended Online Courses:

- IITBombayX Courses: https://courses.iitbombayx.in/dashboard
- University Teaching by The University of Hong Kong, Coursera.
- Assessment in Higher Education by Erasmus University Rotterdam, Coursera.

Reference Books:

1. "The Cambridge Handbook of the Learning Sciences" (2nd Edition) edited by R. Keith Sawyer. Publisher: Cambridge University Press, 2014 ISBN: 978-1107626577
2. "Design for How People Learn" by Julie Dirksen. Publisher: New Riders, 2nd Edition, 2015, ISBN: 978-0134211282
3. "E-Learning by Design" by William Horton. Publisher: Wiley, 2nd Edition, 2011 ISBN: 978-0470900024
4. "Integrating Technology in the Classroom: Tools to Meet the Need of Every Student" by Boni Hamilton. Publisher: International Society for Technology in Education, 2015,ISBN: 978-1564843642
5. "The SAGE Handbook of Digital Technology Research" edited by Sara Price, Carey Jewitt, and Barry Brown.Publisher: SAGE Publications Ltd, 2013,ISBN: 978-1446200476.

Note: This list, while comprehensive, is not exhaustive. Educational Technology is broad and constantly evolving, with new research, theories, and technologies emerging regularly. These texts provide a strong foundation, but engaging with current journals, conferences, and professional networks is essential for staying up to date.

Appendix-A

Guidelines for Professional Elective Courses and Specialization Certificate

Professional Elective courses are designed to meet industrial requirements. All learners must opt for 4 professional elective courses as a part of requirement for M.Tech. degree.

Specialization Certificate is introduced in order to build competency of learners in the chosen domain. Department of Computer Engineering offers the following specialization tracks:

1. Artificial Intelligence and Machine Learning (AIML)
2. Data Science (DS)
3. Internet of Things (IoT)
4. Computer Security (CSec)

Learners can take courses from any track. **However, if learners complete all Professional Elective Courses from the same chosen track, they will be eligible to receive a Specialization Certificate from the Institute.**

Learners who choose professional elective courses from different specialisation tracks will not be eligible for a Specialization Certificate.

It should be noted that there are no additional credit requirements for these specialisations.

AIML track: Courses to be chosen for specialization in Artificial Intelligence and Machine Learning

Preferred Semester	Course Code	Course Name
I	CE67	Building Blocks of Artificial Intelligence
I	CE68	Machine Learning and Pattern Recognition
II	CE69	Deep and Reinforcement Learning
II	CE90	Natural Language Processing with Large Language Models

DS track: Courses to be chosen for specialization in Data Science

Preferred Semester	Course Code	Course Name
I	CE91	Data Engineering and Big Data systems
I	CE92	Data Preparation and Feature Engineering
II	CE93	Business Intelligence and Visual Analytics
II	CE94	Data Governance , Privacy and Ethics

IoT track: Courses to be chosen for specialization in Internet of Things

Preferred Semester	Course Code	Course Name
I	CE75	Smart Sensors and Internet of Things
I	CE76	IoT - Application and Communication Protocol

II	CE77	Wireless Access Technologies
II	CE78	IoT and Smart Cities

CSec track: Courses to be chosen for specialization in Computer Security

Preferred Semester	Course Code	Course Name
I	CE80	Ethical Hacking and Digital Forensics
I	CE81	Database Security and Access control
II	CE95	Blockchain Security and Privacy
II	CE82	Intrusion Detection and Prevention

Appendix B

Courses under Open Elective (OE) Category

Sr. No.	Course Code	Course Name	Hours Per Week		Credits	Preferred Semester
			Theory	Practical		
1	OE04	Sustainability Management	4	-	4	-
2	OE05	Operation Research	4	-	4	-
3	OE06	IPR and Patenting	4	-	4	-
4	OE07	Research Methodology	4	-	4	-
5	OE15	Teaching Pedagogy & Educational Technology	4	-	4	-
6	OE13*	Online Course 1 (MOOC)	As per course		2	-
7	OE14*	Online Course 2 (MOOC)	As per course		2	-

*Online Courses (MOOC) of 2 credits is equivalent to 30 hours course.