DEPARTMENT OF COMPUTER ENGINEERING

M. TECH. COMPUTER ENGINEERING

Curriculum Structure

(w.e.f. Academic Year 2025-26)

PREAMBLE

The Computer Engineering programme, designed under the autonomous framework and aligned with the principles of National Education Policy 2020 and outcome-based education, aims to build a strong foundation in computing while keeping learning flexible and relevant. It blends core subjects like programming, data structures, and computer systems with modern areas such as artificial intelligence, data science, and cybersecurity. The program focuses on practical learning, projects, and real-world applications to help students develop problem-solving skills, creativity, and industry readiness. At the same time, it encourages continuous learning, ethical practices, and a sense of responsibility towards society, preparing graduates to adapt and succeed in a rapidly changing technological world.

DEPARTMENT OF COMPUTER ENGINEERING

NEP 2020 Compliant Curriculum Structure

FIRST YEAR M. TECH. COMPUTER ENGINEERING

Curriculum Structure (w.e.f. Academic Year 2025-26)

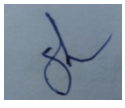
Semester - I			Teaching Scheme (Hours/Week)				Credits					Examination / Evaluation Scheme and Marks				
Course Type	Course Code	Course Title	L	T	P	SS	L	T	P	SS	Total	CCE [50]	ESE [50]	TW	PR / OR	Total
PSMC	CE-PSMC-M01-01	Probability and Statistics for Research	3	1	0	0	3	1	0	0	4	50	50	-	-	100
PSBC	CE-PSBC-M01-02	Applied Algorithms	3	0	0	0	3	0	0	0	3	50	50	-	-	100
PCC	CE-PCC-M01-03	Advanced Database Management Systems	4	0	0	0	4	0	0	0	4	50	50	-	-	100
PCC	CE-PCC-M01-04	Advanced Computer Networks	3	0	0	0	3	0	0	0	3	50	50	-	-	100
PEC	CE-PEC-M01-05	Elective I	3	1	0	0	3	1	0	0	4	50	50	-	-	100
PCC	CE-PCC-M01-06	Laboratory I	0	0	4	0	0	0	2	0	2	-	-	25	50	75
ELC	CE-ELC-M01-07	Laboratory II	0	0	4	0	0	0	2	0	2	-	-	25	50	75
AEC	CE-AEC-M01-08	Personality Development and Life Skills	0	2	0	0	0	2	0	0	2	-	-	50	-	50
AC	CE-AC-M01-09	Audit Course – Human Rights-I	0	0	0	2	0	0	0	0	0	-	-	-	-	-
Total			**30**				**24**					250	250	100	100	**700**

Elective I
CE- PEC-M01-05(A) – Artificial Computational Intelligence
CE- PEC-M01-05(B) – Big Data Technologies

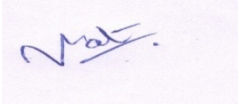
Semester - II			Teaching Scheme (Hours/Week)				Credits					Examination / Evaluation Scheme and Marks				
Course Type	Course Code	Course Title	L	T	P	SS	L	T	P	SS	Total	CCE [50]	ESE [50]	TW	PR / OR	Total
MLC	CE-MLC-M01-10	Research Methodology	3	1	0	0	3	1	0	0	4	50	50	25	-	125
PCC	CE-PCC-M01-11	Information and Cyber Security	4	0	0	0	4	0	0	0	4	50	50	-	-	100
PCC	CE-PCC-M01-12	Quantum Computing	3	0	0	0	3	0	0	0	3	50	50	-	-	100
PEC	CE-PEC-M01-13	Elective II	3	0	0	0	3	0	0	0	3	50	50	-	-	100
PEC	CE-PEC-M01-14	Elective III	3	0	0	0	3	0	0	0	3	50	50	-	-	100
ELC	CE-ELC-M01-15	Laboratory III	0	0	4	0	0	0	2	0	2	-	-	25	50	75
SLC	CE-SLC-M01-16	Seminar	0	0	4	0	0	0	2	0	2	-	-	50	-	50
CEC	CE-CEC-M01-17	Liberal Learning Course	0	1	0	0	0	1	0	0	1	-	-	25	-	25
AEC	CE-AEC-M01-18	Research Ethics and Values	0	2	0	0	0	2	0	0	2	-	-	25	-	25
AC	CE-AC-M01-19	Audit Course – Human Rights-II	0	0	0	2	0	0	0	0	0	-	-	-	-	-
Total			**30**				**24**					**250**	**250**	**150**	**50**	**700**

Elective II	Elective III
CE- PEC-M01-13(A) – AI for Visual Analysis	CE- PEC-M01-14(A) – Advanced NLP & Prompt Engineering
CE- PEC-M01-13(B) – Multimodal Information Retrieval	CE- PEC-M01-14(B) – Advanced Data Analysis & Visualization

# **L** = Lecture **P** = Practical **T** = Tutorial **SS** = Self Study
CCE = Continuous and Comprehensive Evaluation **ESE** = End Semester Examination **TW** = Term work **PR/OR** = Practical/Oral



Head of the Department CE, I²IT



Principal, I²IT

SEMESTER - I

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26
Semester – I

Probability and Statistics for Research (CE-PSMC-M01-01)

Teaching Scheme:	**Credits:** 04	**Examination Scheme:**
Lecture: 03 Hrs/ Week		**CCE:** 50 Marks
Tutorial: 01 Hr/ Week		**ESE:** 50 Marks

Course Introduction:

Computational statistics is a branch of mathematical sciences concerned with efficient methods for obtaining numerical solutions to statistically formulated problems. This course will introduce students to a variety of computationally intensive statistical techniques and the role of computation as a tool of discovery.

Prerequisites:

- Knowledge of statistics & probability
- Discrete Mathematics

Course Objectives:

- To equip students with fundamental and advanced statistical concepts required for data analysis and decision-making.
- To enable students to apply statistical models and inferential techniques to analyze complex datasets.
- To enhance critical thinking and problem-solving skills in statistical and computational methodologies for research and professional applications.

Course Outcomes:

On completion of the course, students will be able to–
PSMC-CO-M01.1: Apply foundational concepts of probability to model uncertainty
PSMC-CO-M01.2: Apply apply major probability distributions and foundational theorems to model, analyze, and interpret random variables and statistical behaviour.
PSMC-CO-M01.3: Apply statistical inference methods to derive meaningful conclusions from data in various domains.
PSMC-CO-M01.4: Develop and evaluate regression and time series models to analyze relationships, measure errors, and perform reliable forecasting.
PSMC-CO-M01.5: Apply advanced statistical methods and validation techniques for modeling while integrating decision theory and ethical practices across diverse real-world application domains.

Course Contents

Unit I	**Foundations of Probability**	**08 Hours**

Role of probability in engineering research, Random experiments, events, sample space, conditional probability, Bayes' theorem and applications in AI/ML research, Random variables: discrete and continuous, Expectation, variance, covariance, moment generating functions

Unit II	**Probability Distributions**	**08 Hours**

Discrete distributions: Bernoulli, Binomial, Poisson, Geometric, Continuous distributions: Uniform, Normal, Exponential, Gamma, Joint, marginal, and conditional distributions, Transformation of random variables, Law of large numbers & Central Limit Theorem

Unit III	Statistical Inference	08 Hours

Estimation: point and interval estimators, properties (bias, consistency, efficiency), Hypothesis testing framework: null & alternative, significance level, power of test, Parametric tests: t-test, z-test, chi-square, ANOVA
Non-parametric tests: Mann–Whitney, Wilcoxon signed-rank, Research design: sample size determination, Type I & II errors

Unit IV	Regression & Multivariate Analysis	08 Hours

Correlation vs causation, Pearson/Spearman correlation, Linear regression: simple & multiple regression models, Logistic regression for categorical outcomes, Multivariate methods: MANOVA, PCA, clustering basics, Resampling methods: bootstrap, cross-validation for research validation
Time Series Analysis introduction, Components of Time Series, Moving Average, Weighted moving average, Linear and non-linear trends, Forecasting methods (ARIMA, Exponential Smoothing)

Unit V	Methods and Applications	08 Hours

Feature Scaling, Min-Max scaling, Bias, Variance, Regularization, Ridge Regression, Lasso Regression, Cross Validation Techniques- K-fold, LOOCV, Stratified K-fold, Grid Search CV, CV Error
Applications of Statistical Computing: Elements of Decision Theory, Ethical considerations in statistical computing, Applications in finance and economics, Applications in social media analysis, Applications in healthcare and marketing

Learning Resources

Textbooks

1. Introduction to Probability and Statistics for Engineers and Scientists by Sheldon M. Ross (Academic Press, 2020, 6th Edition)
2. Statistical Techniques in Business and Economics by Douglas A. Lind, William G. Marchal, Samuel A. Wathen, 15th Edition McGraw-Hill Publications
3. Elementary Statistics Picturing The World, Ron Larson, Betsy Farber 5th Edition Prentice Hall Publications ISBN 10: 0-321-69362-0

Reference Books

1. Allen B. Downey, "Think Stats", Second Edition, O'Reilly Media, ISBN: 978-1-491-90733-7
2. Peter Bruce and Andrew Bruce, "Practical Statistics for Data Scientists", First Edition, O'Reilly Media, ISBN-978-1-491-95296-2

Web Resources

1. https://statquest.org/
2. https://www.openintro.org/book/os/
3. MIT Open Courseware –Probability and Statistics https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/

Massive Open Online Courses (MOOCs)

1. https://www.coursera.org/learn/statistical-inference
2. https://nptel.ac.in/courses/111102160
3. https://nptel.ac.in/courses/111106112

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PSMC-CO-M01.1	2	1	2	3	1	2
PSMC-CO-M01.2	1	1	2	3	1	2
PSMC-CO-M01.3	2	1	3	3	1	2
PSMC-CO-M01.4	3	2	3	3	2	3
PSMC-CO-M01.5	3	3	3	3	2	3

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Applied Algorithms (CE-PSBC-M01-02)

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction:

The course emphasizes problem-solving strategies using advanced algorithms in areas such as graph theory, dynamic programming, computational geometry, string processing, and optimization. Students will learn how to analyze algorithmic complexity and apply suitable techniques to domains.

Prerequisites:

- Data Structures and Algorithms
- Discrete Mathematics, Mathematical Foundations for Computer Science

Course Objectives:

- To develop a deep understanding of algorithmic principles and their applications in solving complex computational problems.
- To analyze the efficiency of algorithms using asymptotic notations, recurrence relations, and amortized analysis.
- To study advanced graph and greedy algorithms
- To solve different problems using dynamic programming and approximation algorithms
- Understand the principles of parallel algorithms, deterministic and non-deterministic computation.

Course Outcomes:

On completion of the course, students will be able to–
PSBC-CO-M02.1: Evaluate the efficiency of algorithms using asymptotic notations, recurrence relations to optimize performance.
PSBC-CO-M02.2: Design and implement advanced graph and greedy algorithms.
PSBC-CO-M02.3: Apply Dynamic Programming and approximation algorithms concept to solve various problems.
PSBC-CO-M02.4: Utilize randomized techniques to solve the problem.
PSBC-CO-M02.5: Analyze and design parallel algorithms using computation models and evaluate performance analysis methods

Course Contents

Unit I	**Foundations of Algorithm Analysis**	**08 Hours**

Review of algorithmic strategies, Necessity of time and space requirement analysis of algorithms, Asymptotic analysis: upper and lower complexity bounds, Big O, little o, Omega, and Theta notations, Time, and space trade-offs in algorithms. Recurrence: Analysing recursive algorithms using recurrence relations. The recurrence – tree method, The master method; Amortized Analysis: Aggregate, Accounting and Potential Methods.

Case Study Title: Algorithmic Efficiency in Large-Scale Recommendation Systems

Unit II	Graph Algorithms and Greedy Algorithm	08 Hours

Graph Algorithms: Graph traversal Techniques, **Minimum Spanning Tree**: Prim's and Kruskal's Algorithm, **Shortest Paths**: Bellman-Ford Algorithm, Single Source Shortest Paths in DAG, Johnson's Algorithm.

Greedy Algorithm: Steps and strategy, fractional knapsack problem, Huffman codes

Case Study: Optimizing Network Design and Data Compression using Graph and Greedy Algorithms

Unit III	Dynamic programming and Approximation Algorithms	08 Hours

Dynamic Programming: Elements of Dynamic programming, OBST, longest-common subsequence problem

Approximation Algorithms: Introduction, Absolute approximation, Epsilon approximation, Polynomial time Approximation schemes, probabilistically good algorithms. Approximation Algorithms: Vertex Cover, Set Cover, Traveling Salesman Problem (TSP)

Case Study: Approximation Algorithms in Large-Scale AI Model Training

Unit IV	Randomized Algorithms	08 Hours

Randomized Algorithms: Introduction to Monte Carlo & Las Vegas algorithms, their characteristics, and applications.

Probabilistic Counting & Bloom Filters: Space-efficient data structures for approximate counting and membership testing, with applications in databases and network security.

Case Study: Randomized Algorithms in Load Balancing (Monte Carlo & Las Vegas).

Unit V	Parallel Algorithms and Computational Complexity analysis	08 Hours

Parallel Algorithm: Introduction, Models, Structures, Design Techniques, Applications (Sorting, Matrix multiplications etc)

Computational Complexity Analysis : Polynomial and Non-polynomial problems, deterministic and non-deterministic algorithms, P-class problems, NP-class of problems, Polynomial problem reduction NP complete problems- vertex cover and 3-SAT and NP hard problem - Hamiltonian cycle.

Case study: Algorithms for Parallel Computers CRCW algorithms and EREW algorithms

Learning Resources

Textbooks

1. Kishore S. Trivedi, "Probability & Statistics with Reliability, Queuing, and Computer Science publications" PHI
2. Cormen, Leiserson, Rivest, "Algorithms", PHI
3. Bressard, "Fundamentals of Algorithms", PHI
4. Horowitz, Sahni, "Fundamentals of Computer Algorithm", Galgotia

Reference Books

1. S. Baase, S and A. Van Gelder, "Computer Algorithms: Introduction to Design and Analysis", 3rd edition. Addison Wesley, 2000
2. Aho, Hopcraft, Ullman, "The Design and Analysis of Computer Algorithms", Addison Wesley
3. Knuth, "Art of Programming", Addison Wesley
4. C Papadimitriou and K Steiglitz, "Combinatorial Optimization", PHI
5. Knuth, "Art of Programming", Addison Wesley

E-Books

1."Introduction to Algorithms" by Cormen, Leiserson, Rivest, and Stein
https://dl.ebooksworld.ir/books/Introduction.to.Algorithms.4th.Leiserson.Stein.Rivest.Cormen.MIT.Press.9780262046305.EBooksWorld.ir.pdf
2.Fundamentals of Computer Algorithms" by Ellis Horowitz and Sartaj Sahni
https://kailash392.wordpress.com/wp-content/uploads/2019/02/fundamentalsof-computer-algorithms-by-ellis-horowitz.pdf

Massive Open Online Courses (MOOCs)

1. NPTEL Course: https://onlinecourses.nptel.ac.in/noc25_cs90/preview
2. NPTEL Course: https://onlinecourses.nptel.ac.in/noc25_cs124/preview
3. NPTEL Course: https://onlinecourses.nptel.ac.in/noc25_cs153/preview

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PSBC-CO-M02.1	2	1	3	2	2	1-
PSBC-CO-M02.2	2	1	3	2	2	1
PSBC-CO-M02.3	2	1	3	2	2	1
PSBC-CO-M02.4	2	1	3	2	2	2
PSBC-CO-M02.5	2	1	3	2	2	2

Hope Foundation's International Institute of Information Technology (I²IT), Pune

M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Advanced Database Management Systems (CE-PCC-M01-03)

Teaching Scheme:	**Credits: 04**	**Examination Scheme:**
Lectures: 04 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction:

This course provides an in-depth study of advanced database concepts including relational and object-oriented models, parallel and distributed databases, Query Processing and Optimization, NoSQL systems. It prepares students to work with modern data systems, analyze large datasets, and design advanced data-driven application

Prerequisites:

- Database Management Systems
- Relational Database Management Systems (RDBMS)
- Data Structures and Algorithms
- Programming experience with SQL and basic scripting

Course Objectives:

- To understand the fundamental concepts of Relational and Object-oriented databases.
- To develop skills for efficient database query processing and optimization.
- To learn and understand various Parallel and Distributed Database Architectures and applications.
- To understand and apply the basic concepts, categories and tools of NoSQL Database.
- Develop skills for creating high-performance, standardized, secure distributed applications.

Course Outcomes:

On completion of the course, students will be able to–
PCC-CO-M03.1: Differentiate relational and object-oriented databases.
PCC-CO-M03.2: Enhance database performance through efficient query processing and optimization techniques.
PCC-CO-M03.3: Illustrate parallel and distributed database architectures.
PCC-CO-M03.4: Apply concepts of NoSQL Databases
PCC-CO-M03.5: Design and optimize high-performance, standardized, and secure distributed applications.

Course Contents

Unit I	**Relational Data Model and Relational Database Constraints**	**08 Hours**

Relational model concepts, Relational model constraints and relational database schemas, Update operations, anomalies, dealing with constraint violations, Types and violations.
Overview of Object-Oriented Concepts – Objects, Basic properties. Advantages, examples, Abstract data types, Encapsulation, class hierarchies, polymorphism examples.

Unit II	**Query Processing and Query Optimization**	**08 Hours**

Query Processing - Measures of Query Cost, Selection Operation, Sorting, Query Processing in Memory. Query Optimization- Overview , Transformation of Relational Expressions, Estimating Statistics of

Expression Results, Choice of Evaluation Plans , Materialized Views ,Advanced Topics in Query Optimization		
Unit III	**Parallel and Distributed Databases**	**08 Hours**
Introduction to Parallel and Distributed Databases: Understand centralized, parallel, and distributed databases, parallelism types, and system architectures. Data Partitioning, Replication, and Query Management: Learn fragmentation, data allocation, replication models, consistency, query decomposition, planning, and parallel execution. Distributed Transaction Management: Study ACID properties, commit protocols (2PC/3PC), concurrency control, and deadlock handling in distributed environments.		
Unit IV	**NOSQL Databases**	**08 Hours**
Introduction, Overview, and History of NoSQL Databases- The definition of Four Types of No SQL Databases. NoSQL Key/Value Database: MongoDB, Column-Oriented Database: Apache Cassandra, Comparison of Relational and NoSQL databases, NoSQL database Development Tools (Map Reduce/Hive) and Programming Languages (XML/JSON)		
Unit V	**Advanced Application Development**	**08 Hours**
Performance Tuning , Performance Benchmarks, Other Issues in Application Development , Standardization , Distributed Directory Systems.		

Learning Resources

Textbooks

1. Silberschatz A., Korth H., Sudarshan S, Database System Concepts, McGraw Hill Publication, ISBN-0-07-120413-X, Seventh Edition.
2. S. K. Singh, Database Systems: Concepts, Design and Application, Pearson Publication, ISBN-978-81-317-6092-5.

Reference Books

1.Kristina Chodorow, Michael Dirolf, "MongoDB: The Definitive Guide", O'Reilly Publications
2. Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining: Concepts and Techniques", Elsevier
3. Mario Piattini, Oscar Diaz "Advanced Database Technology and Design"- online book.
4. M. Tamer Özsu, Patrick Valduriez, "Principles of Distributed Database Systems" Prentice Hall,1999.
5. Ramez Elmasri and Shamkant B. Navathe "Fundamentals of Database System"

Web Resources

1. https://www.mongodb.com/
2. https://docs.oracle.com/en/database/
3. https://nosql-database.org/

Massive Open Online Courses (MOOCs)

1. https://onlinecourses.nptel.ac.in/noc22_cs91/preview
2. https://www.coursera.org/learn/cpsc-6620-database-management-systems
3. https://www.udemy.com/course/relational-database-management-systemrdbms-complete-pack/

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PCC-CO-M03.1	2	2	2	2	1	1
PCC-CO-M03.2	3	2	3	3	2	2
PCC-CO-M03.3	2	2	3	3	3	3
PCC-CO-M03.4	2	2	2	2	2	2
PCC-CO-M03.5	3	2	3	3	3	3

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Advanced Computer Networks (CE-PCC-M01-04)

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction :

This course covers advanced networking across OSI layers, including IPv4/IPv6, routing, congestion control, virtualization, and security protocols. It also explores modern topics such as data center networking, overlay systems, and delay-tolerant networks.

Prerequisites:

- Basic knowledge of computer systems and architecture
- Java, Data Structures and Algorithms

Course Objectives:

- To develop a strong foundation of network and link layer concepts
- To understand wireless and multimedia networking technologies
- To analyze the principles, challenges, and protocols of ad-hoc wireless networks
- To acquire knowledge of network management frameworks and tools
- To explore the evolution and applications of Software Defined Networks (SDN)

Course Outcomes:

On completion of the course, students will be able to–

PCC-CO-M04.1: Explain network and link layer concepts including IP, routing, switching, and virtualization.

PCC-CO-M04.2: Explain wireless architecture, mobility management, and multimedia protocols with their impact on networks.

PCC-CO-M04.3: Explain MAC, routing, transport, and security protocols in ad-hoc wireless networks and Internet.

PCC-CO-M04.4: Describe SNMP versions, models, and tools for efficient network management and system engineering.

PCC-CO-M04.5: Explain SDN architecture, operation, controllers, and applications with implications for networking research and innovation.

Course Contents

Unit I	**Network and Link Layer**	**08 Hours**

The Network Layer, Virtual Circuit and Datagram Networks, What's Inside a Router, The Internet Protocol, Routing Algorithms, Routing in The Internet, Broadcast and Multicast Routing Introduction to link layer, Error Detection and Correction techniques, Multiple Access Links and Protocols, Switched LANs, Link Virtualization :- A Network as Link Layer, &, Data Center Networking, Retrospective: A Day in life of a Web Page Request

Unit II	**Wireless Networks and Multimedia Networking**	**08 Hours**

Introduction, Wireless Link and Network Characteristics, Wireless LAN Architecture, Wifi:802.11 Wireless LANs, Cellular Internet Access, Mobility Management: Principles, Mobile IP, Managing Mobility in Cellular Networks, Wireless and Mobility: impact on Higher level Protocols, Multimedia Networking: Applications, Streaming Stored Videos, VOIP, Protocols For Real Time Conversational Applications, Network Support for Multimedia		
Unit III	**Ad-hoc Wireless Network**	**08 Hours**
Introduction, Issues in Ad-hoc Wireless Network, Ad-hoc Wireless Internet, MAC Protocols for Ad Hoc Wireless Networks, Routing Protocols for Ad Hoc Wireless Networks, Multicast routing in Ad Hoc Wireless Networks, Transport Layer and Security Protocols for Ad Hoc Wireless Networks		
Unit IV	**Network Management**	**08 Hours**
SNMP Network Management: Basic Foundations, SNMPv1 Network Management: Organization and Information Models, Communication and Functional Models, SNMPv2, SNMPv3, Network Management Tools, Tools System and Engineering		
Unit V	**Software Defined Networks**	**08 Hours**
Introduction -Traditional Switch Architecture, Autonomous and Dynamic Forwarding Table, Why SDN?- Evolution of Switches and Control Planes, Cost, SDN Implications for Research and Innovation, Data Center Innovation, Data Center Needs, Genesis of SDN-The Evolution of Networking Technology, Forerunners of SDN , How SDN Works -Fundamental Characteristics of SDN, SDN Operation. SDN Devices Controller, SDN Applications, Alternate SDN Methods		

Learning Resources

Textbooks:

1. Computer Networking: A Top-Down Approach Featuring the Internet, James F. Kurose, Keith W. Ross, Third Edition, Pearson Education, 2007
2. C. Siva Ram Murthy, B.S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall, 2004
3. Mani Subramanian, Timothy A. Gonsalves, N. Usha Rani; Network Management: Principles and Practice; Pearson Education India, 2010
4. Goransson P, Black C, Culver T. Software Defined Networks: a Comprehensive Approach. Morgan Kaufmann; 2014

Reference Books:

1. Edition, Morgan Kaufmann, Elsevier, 2012. 2. Behrouz A. Forouzan, Data Communications and Networking, McGraw Hill, Fifth Edition, 2017
2. Computer Networks, Andrew S. Tanenbaum, Fourth Edition, Prentice Hall. 6. The Internet and Its Protocols, A. Farrel, Elsevier.
3. Chwan-Hwa (John) Wu, J. David Irwin, Introduction to Computer Networks and Cyber Security, CRC press, Taylor & Francis Group,2014
4. Larry L. Peterson and Bruce S. Davie, Computer Networks: A System Approach, Fifth
5. Java Network Programming, 3rd edition" by Elliotte Rusty Harold

Web Resources:

1. https://www.dreamtechpress.com/product/advanced-computer-networks/
2. https://www.wireshark.org/
3. https://www.netacad.com/courses/exploring-networking-cisco-packet-tracer?courseLang=en-US
4. https://www.cloudflare.com/en-gb/learning/ssl/what-is-ssl/

Massive Open Online Courses (MOOCs)

1. https://onlinecourses.swayam2.ac.in/ntr25_ed100/preview
2. https://www.coursera.org/learn/computer-networking
3. https://onlinecourses.nptel.ac.in/noc23_cs73/preview
4. https://www.udemy.com/course/java-network-programming/?couponCode=MT180825B

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PCC-CO-M04.1	2	2	--	2	2	--
PCC-CO-M04.2	1	2	--	1	2	--
PCC-CO-M04.3	2	2	1	1	1	2
PCC-CO-M04.4	--	1	2	--	1	1
PCC-CO-M04.5	1	2	2	1	1	1

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Elective I – Artificial Computational Intelligence (CE-PEC-M01-05(A))

Teaching Scheme:	**Credits: 04**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks
Tutorial: 01 Hr/Week		**ESE:** 50 Marks

Course Introduction :

Artificial Computational Intelligence is an advanced course that explores the theoretical foundations, computational models, and modern approaches in Artificial Intelligence (AI). It focuses on how intelligent agents can perceive, reason, and act to solve complex problems under certainty and uncertainty. The course covers classical AI methods such as search and logic-based reasoning, along with modern approaches including probabilistic models and explainable AI.

Prerequisites:

- Statistics and Computational Analysis

Course Objectives:

- Develop the ability to design problem-solving agents using search and optimization techniques.
- Explore AI approaches for adversarial and stochastic game-playing environments.
- Provide knowledge of formal logic-based methods and ontologies for representing and reasoning with knowledge.
- Apply probabilistic frameworks to handle uncertainty in decision-making and reasoning.
- Introduce the concepts and techniques of explainable AI, emphasizing transparency, trust, and ethical aspects of intelligent systems.

Course Outcomes:

On completion of the course, students will be able to–
PEC-COM05A.1: Implement intelligent agents for problem solving using search strategies.
PEC-COM05A.2: Apply AI algorithms for adversarial and stochastic game playing.
PEC-COM05A.3: Represent and reason with knowledge using logical and probabilistic frameworks.
PEC-COM05A.4: Demonstrate understanding of explainable AI and address ethical implications.

Course Contents

Unit I	**Overview of AI and Searching Techniques**	**08 Hours**

Foundation of AI and history of AI, Intelligent Agents: Types and Architectures,
Problem Formulation: State Space, Initial State, Goal Test, and Actions, **Uninformed Search:** BFS, DFS, Depth-limited, Iterative Deepening, **Informed Search:** Greedy, A*, Memory-bounded searches, **Heuristics:** Designing and Evaluating Heuristics, **Local Search and Optimization:** Hill Climbing, Simulated Annealing, Genetic Algorithms, Constraint Satisfaction Problems (CSPs) and Constraint Propagation

Unit II	**Game Playing**	**08 Hours**

Games as Search Problems, Minimax Algorithm and Variants, Alpha–Beta Pruning, Evaluation Functions, **Stochastic Games:** Expectimax, Markov Decision Processes (MDPs), Reinforcement Learning Basics for Game Playing
Case Studies: Chess, Go, Atari Games

Unit III	Knowledge Representation using Logics	08 Hours

Importance of Knowledge Representation (KR), Propositional Logic: Syntax, Semantics, Inference, First Order Logic (FOL): Syntax, Semantics, Unification, Resolution
Knowledge Engineering in FOL, Ontologies and Semantic Networks, Description Logics and Knowledge Graphs, Reasoning Systems and Automated Theorem Proving

Unit IV	Probabilistic Representation and Reasoning	08 Hours

Uncertainty in AI, Probability Theory and Bayes Theorem, Bayesian Networks: Representation, Inference, Learning, Markov Models and Hidden Markov Models (HMMs), Probabilistic Reasoning over Time

Unit V	Modern AI Trends	08 Hours

AI Paradigms: Reactive, Deliberative, Hybrid, and Learning Agents, **Emerging Trends:** Cognitive AI, Neuromorphic AI, Generative AI
Explainable AI (XAI): Need and Importance, Techniques for Explainability: LIME, SHAP, Rule-based Explanations
Ethical and Trustworthy AI: Fairness, Transparency, Accountability

Learning Resources

Textbooks

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson.
2. Deepak Khemani, A First Course in Artificial Intelligence, McGraw Hill.
3. Artificial Intelligence, Kevin Knight, Elaine Rich, B. Shivashankar Nair, 3rd Edition,2008

Reference Books

1. Wolfgang Ertel, Introduction to Artificial Intelligence, Springer.
2. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, Pearson.

Web Resources

1. Stanford AI Lab: https://ai.stanford.edu/
2. Berkeley Artificial Intelligence Research (BAIR) Lab: https://bair.berkeley.edu/
3. Wikipedia's AI Search Algorithms Section: https://en.wikipedia.org/wiki/Search_algorithm
4. OpenAI Spinning Up in Deep RL: https://spinningup.openai.com/
5. DARPA XAI Program: https://www.darpa.mil/program/explainable-artificial-intelligence
6. IBM AI Explainability 360 Toolkit: https://aix360.mybluemix.net/

Massive Open Online Courses (MOOCs)

1. AI for Everyone (Coursera, Andrew Ng) https://onlinecourses.nptel.ac.in/noc22_cs56/preview

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-COM05A.1	2	1	2	3	2	2
PEC-COM05A.2	2	1	3	3	2	2
PEC-COM05A.3	3	2	3	3	2	3
PEC-COM05A.4	2	3	3	2	3	2

Hope Foundation's International Institute of Information Technology (I²IT), Pune

M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Elective I – Big Data Technologies (CE- PEC-M01-05(B))

Teaching Scheme:	**Credits: 04**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks
Tutorial: 01 Hr/Week		**ESE:** 50 Marks

Course Introduction :

This course introduces the fundamental concepts, architectures, and tools of Big Data Technologies. Students will learn the principles of distributed storage and computation, explore the Hadoop and Spark ecosystems, understand data ingestion and processing frameworks, and gain insights into emerging trends such as real-time analytics, cloud-native big data, and AI-driven data engineering.

Prerequisites:

- Foundation in Distributed systems, Programming, Databases
- Statistics and basic linear algebra
- Cloud Basics

Course Objectives:

- To understand the fundamentals and challenges of Big Data in modern computing.
- To explore distributed systems for storage and large-scale data processing.
- To gain hands-on experience with Hadoop, Spark, and associated ecosystems.
- To learn big data ingestion, stream processing, and workflow management tools.
- To examine recent advancements and current trends in big data technologies.

Course Outcomes:

On completion of the course, students will be able to–
PEC-COM05B.1: Explain the principles and challenges of Big Data systems.
PEC-COM05B.2: Apply Hadoop and Spark frameworks for large-scale data storage and processing.
PEC-COM05B.3: Design and implement data pipelines for batch and real-time processing.
PEC-COM05B.4: Evaluate and compare big data frameworks across on-premise and cloud platforms.
PEC-COM05B.5: Analyze emerging trends and apply best practices in Big Data technologies.

Course Contents

Unit I	Foundations of Big Data	08 Hours

Introduction to Big Data: Characteristics (3Vs → 5Vs), challenges, and opportunities
Big Data ecosystem overview and its relevance in data engineering, **Distributed systems principles:** CAP theorem, consistency vs availability, scalability, **Storage systems:** HDFS, NoSQL databases (MongoDB, Cassandra, HBase)

Case studies: Big Data applications in industry (finance, healthcare, IoT, AI)

Unit II	Hadoop Ecosystem for Big Data	08 Hours

Hadoop architecture: HDFS, YARN, MapReduce programming model, Data ingestion: Sqoop, Flume, Kafka basics Hive and Pig for data warehousing and high-level query abstraction, Limitations of Hadoop and motivation for next-gen frameworks **Case studies**: Installing Hadoop, running MapReduce and Hive jobs		
Unit III	**Apache Spark and Advanced Processing**	**08 Hours**
Introduction to Apache Spark: architecture, RDDs, DataFrames, SparkSQL, Transformations and actions; Spark's DAG execution engine, Advanced Spark components: Spark Streaming, MLlib, GraphX, Performance tuning and optimizations in Spark, Batch and streaming data processing using Spark		
Unit IV	**Data Ingestion, Workflow, and Stream Processing**	**08 Hours**
Message queues and data pipelines: Kafka, Pulsar basics, ETL tools and workflow orchestration: Apache NiFi, Airflow, Oozie Real-time analytics: Storm, Flink, Structured Streaming in Spark, Lambda and Kappa architectures for real-time big data processing **Case studies**:: Simple pipeline with Kafka + Spark Streaming		
Unit V	**Big Data in Cloud and Emerging Trends**	**08 Hours**
Cloud-native big data: AWS EMR, Google BigQuery, Azure HDInsight, Containerized big data: Kubernetes, Docker integration with Spark/Hadoop, Lakehouse architectures: Delta Lake, Apache Iceberg, Databricks model Big Data and AI convergence: feature stores, data-centric AI, MLOps integration, Security, privacy, and governance in big data ecosystems (GDPR, Data lineage), Current research and future directions in big data technologies		

Learning Resources

Textbooks

1. Tom White — Hadoop: The Definitive Guide (O'Reilly, 4th Edition)
2. Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia — Learning Spark: Lightning-Fast Data Analytics (O'Reilly, 2nd Edition)

Reference Books

1. Rajkumar Buyya, Rodrigo N. Calheiros, Amir Vahid Dastjerdi — Big Data: Principles and Paradigms (Elsevier)
2. Martin Kleppmann — Designing Data-Intensive Applications (O'Reilly, 2017)
3. Bill Chambers, Matei Zaharia — Spark: The Definitive Guide (O'Reilly, 2018)
4. Nathan Marz, James Warren — Big Data: Principles and Best Practices of Scalable Real-Time Data Systems (Manning Publications)

Web Resources

1. Apache Hadoop Official Project: https://hadoop.apache.org/
2. Apache Spark Official Project: https://spark.apache.org/
3. Apache Kafka Official Project: https://kafka.apache.org/
4. Apache Airflow Official Site: https://airflow.apache.org/
5. Google Cloud Big Data Solutions: https://cloud.google.com/big-data
6. AWS Big Data Solutions: https://aws.amazon.com/big-data/

Massive Open Online Courses (MOOCs)

1. R. Misra, Big Data Computing, NPTEL, IIT Patna. [Online]. Available:

https://nptel.ac.in/courses/106104189
Big Data Specialization, Coursera. [Online]. Available:
https://www.coursera.org/specializations/bigdata

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-COM05B.1	2	2	2	3	2	2
PEC-COM05B.2	2	1	3	3	2	2
PEC-COM05B.3	3	2	3	3	3	3
PEC-COM05B.4	2	2	3	3	3	2
PEC-COM05B.5	2	3	3	2	3	3

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Laboratory I (CE-PCC-M01-06)

Teaching Scheme:	**Credits: 02**	**Examination Scheme:**
Practical: 04 Hrs/ Week		**Term work:** 25 Marks **Oral:** 50 Marks

Course Introduction :

This laboratory course integrates practical aspects of two core subjects: Applied Algorithms and Advanced Database Management Systems. The course emphasizes problem-solving techniques, application development using modern database technologies, and the implementation of algorithmic solutions in various real-world scenarios.

Prerequisites:

- Design and Analysis of Algorithms
- Database Management Systems

Course Objectives:

- To apply advanced algorithmic strategies and database concepts to real-world problems.
- To design, develop, and analyze algorithms and database systems using open-source technologies such as MongoDB.
- To build problem-solving skills and practical knowledge in advanced databases and algorithmic design.

Course Outcomes:

On completion of the course, students will be able to–

PCC-COM06.1: Design and implement efficient algorithms and optimize them for real-world applications.

PCC-COM06.2: Develop applications using NoSQL databases like MongoDB, perform CRUD operations, and design efficient database schemas.

PCC-COM06.3: Analyze and evaluate the performance of algorithms and database systems through case studies and mini-projects.

List of Assignments

Part I : Course I (Applied Algorithms)

1. Solve recursive algorithms using Recurrence Tree and Master Theorem and validate results through implementation.
2. Implement Fast Fourier Transform (FFT) for polynomial multiplication and verify its correctness with sample polynomials.
3. Implement Euclidean GCD algorithm and Chinese Remainder Theorem for solving modular equations.
4. Implement a polynomial-time approximation algorithm for the Travelling Salesman Problem (TSP) using the Nearest Neighbor Heuristic.
5. Implement Convex Hull algorithms (Graham Scan & Jarvis March) for a given set of 2D points.

Part II: Course II (Advanced Database Management Systems)

1. Advanced SQL functions for data transformation and reporting.
2. Implement Queries based on FLOWER expressions and joins using XQuery.
3. Design and develop MongoDB queries and schema for an e-commerce platform.
4. Implement MongoDB aggregation pipelines for sales analysis.
5. Use $lookup to join product and order data in MongoDB.

Mini Project Applied Algorithms(Any One)

1. Design and implement an efficient recommendation system for e-commerce or entertainment platforms focusing on algorithmic efficiency (Big-O evaluation).
2. Develop a real-world route optimization system for city transport using Dijkstra's or Johnson's algorithm, integrated with a graphical interface (small-scale city map simulation).
3. Create an image compression utility using FFT to reduce the size of gray-scale images while maintaining quality.
4. Build a Monte Carlo-based server load balancing simulation to distribute workload across multiple virtual servers.
5. Develop an application that formulates and solves resource allocation problems (like diet planning or manufacturing optimization) using the Simplex method.

Mini Project Advanced Database Management Systems (Any One)

1. NoSQL-based social media data analysis system.
2. IoT data collection and monitoring using MongoDB.
3. Design a database that processes and stores real-time data from different,sources and allows for efficient querying and analytics..
4. Develop an e-commerce platform that supports product catalogs, customer, orders, payment processing, and inventory management.
5. Healthcare management system using NoSQL database.

Learning Resources

Textbooks

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", PHI.
2. Silberschatz A., Korth H., Sudarshan S., "Database System Concepts", 6th Edition, McGraw Hill.

Reference Books

1. Horowitz, Sahni, "Fundamentals of Computer Algorithm", Galgotia.
2. Kristina Chodorow, "MongoDB: The Definitive Guide", O'Reilly Publications, 2nd Edition.
3. Jiawei Han, MichelineKamber, Jian Pei, "Data Mining: Concepts and Techniques", Elsevier.
4. Elmasri and Navathe, "Fundamentals of Database Systems", Pearson, 7th Edition.

Web Resources

1. https://nosql-database.org/
2. https://www.mongodb.com/
3. https://www.geeksforgeeks.org/fundamentals-of-algorithms/

Massive Open Online Courses (MOOCs)

1. NPTEL Online Course on "Design and Analysis of Algorithms"
2. MongoDB University Free Online Courses

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PCC-COM06.1	3	1	3	3	2	2
PCC-COM06.2	1	3	3	3	3	1
PCC-COM06.3	3	2	3	3	2	3

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Laboratory II (CE-ELC-M01-07)

Teaching Scheme:	Credits:	Examination Scheme:
Practical: 04 Hrs/ Week	**02**	**Term work:** 25 Marks **Oral:** 50 Marks

Course Introduction :

This course is designed to integrate advanced concepts from Computer Networks, Artificial Computational Intelligence, and Big Data Technologies through hands-on assignments and experiments. The course emphasizes practical learning by exposing students to simulation platforms, programming environments, big data ecosystems, and AI frameworks. Students will gain experience in configuring and evaluating network systems, implementing intelligent computational models, and designing scalable big data pipelines for real-world problem domains.

Prerequisites:

- Python, Foundations of linear algebra, probability, and statistics,
- Basic understanding of algorithms and data structures
- NumPy, Pandas, and basic data visualization libraries, Understanding of relational databases and SQL, Familiarity with data formats (e.g., CSV, JSON, Parquet) and basic scripting for automation.

Course Objectives:

- Develop technical proficiency by applying simulation tools, programming platforms, and frameworks for advanced networking, artificial intelligence, and big data applications.
- Foster problem-solving and analytical skills through the design, implementation, and evaluation of real-world networking solutions, AI models, and big data pipelines.
- Encourage innovation and interdisciplinary integration by combining concepts from communication systems, intelligent computation, and scalable data processing.
- Enhance research and experimentation skills by analyzing performance, limitations, and ethical implications of emerging computational technologies.
- Prepare students for industry and research applications by equipping them with practical expertise in modern platforms such as Hadoop, Spark, AI toolkits, and network simulation environments

Course Outcomes:

On completion of the course, students will be able to–

Advanced Computer Networks
ELC-CO-M07.1: Apply network analysis tools, simulation platforms, and socket programming to configure, monitor, and evaluate performance of advanced computer networks.
ELC-CO-M07.2: Design, implement, and test real-world networking solutions demonstrating problem-solving, analytical, and innovation skills in modern communication systems.

Artificial Computational Intelligence
ELC-CO-M07.1: Implement and evaluate classical and modern AI techniques such as search strategies, game playing algorithms, knowledge representation methods, probabilistic reasoning, and explainable AI models.

ELC-CO-M07.2: Analyze, compare, and interpret the performance, strengths, limitations, and ethical implications of AI techniques through practical experimentation and case studies.

Big Data Technologies
ELC-CO-M07.1: Apply Hadoop, Spark, and related ecosystems to design and implement batch and real-time data processing pipelines using structured and unstructured datasets.
ELC-CO-M07.2: Develop scalable big data solutions by integrating data ingestion, workflow orchestration, and stream processing tools for practical domains such as healthcare, retail, IoT, and social media analytics.

List of Assignments

Part I : Course I (Advanced Computer Networks) Any 5

1. Capture live traffic for a web browsing session using Wireshark.
2. Simulate a small network using NS2/NS3 to compare Distance Vector vs. Link State routing.
3. Simulate an ad-hoc wireless network of 10–15 nodes using NS2/NS3. Compare performance of AODV vs. DSR routing protocols.
4. Configure FTP Server on a Linux/Windows machine using a FTP client/SFTP client. Characterize file transfer rate for a cluster of small files 100k each and a video file of 700mb.Use a TFTP client and repeat the experiment.
5. Configure a new VLAN on one VTP server and distribute it through all switches on the domain.
6. Implement various Routing Protocols and compare the performance.
7. Configure different application servers such as web server, DNS servers, and email server, and secure using firewall rules

Part II: Course II (Elective – I Artificial Computational Intelligence)

1. Implement uninformed search (BFS, DFS) and informed search (Greedy, A*) for solving the classic 8-Puzzle problem or a maze navigation task.
2. Design and test heuristics for solving the N-Queens problem using Hill Climbing and Simulated Annealing.
3. Implement the Minimax algorithm with Alpha-Beta Pruning for a two-player game (e.g., Tic-Tac-Toe, Connect Four).
4. Implement the Expectimax algorithm for a stochastic game (e.g., simplified dice-based game).
5. Train a simple classifier (e.g., decision tree, logistic regression, or neural network) on a dataset. Apply explainability techniques (LIME, SHAP, or rule-based methods) to interpret predictions.

Part II: Course II (Elective – I Big Data Technologies)

1. Write and execute a MapReduce program (e.g., word count, log file analysis) using Hadoop.
2. Load structured/unstructured data into Hive tables. Perform data analysis using HiveQL queries (aggregation, joins, partitioning).
3. Write Spark programs using RDDs and DataFrames. Implement transformations and actions (filter, map, reduce, join). Execute a batch job (e.g., customer purchase analysis from e-commerce data).
4. Set up a Kafka producer-consumer pipeline. Integrate Kafka with Spark Streaming.
5. Explore AWS EMR / Google BigQuery. Run a distributed query or Spark job in the cloud environment.

Mini Project (Any One) Course II (Elective – I Artificial Computational Intelligence)

1. Intelligent Path Finder for Campus Navigation: Design an AI agent that uses search algorithms (A*, Iterative Deepening, etc.) to compute the shortest or most efficient paths across a campus or city map. Incorporate heuristics for avoiding blocked roads or high-traffic areas.
2. AI Game Agent for Connect Four / Othello: Build an intelligent game agent that plays Connect Four or Othello using Minimax with Alpha-Beta Pruning.
3. Smart Sudoku Solver using Constraint Satisfaction: Implement a CSP-based Sudoku solver using backtracking with constraint propagation and heuristics (e.g., MRV, forward checking). Compare performance with a local search approach (hill climbing / simulated annealing).
4. Chatbot with Logic-Based Reasoning: Build a simple rule-based chatbot that uses First-Order Logic for answering queries in a restricted domain (e.g., university course advising, travel planning).

Mini Project (Any One) Course II (Elective – I Big Data Technologies)

1. Large-scale web server/application logs analysis using Hadoop.
2. Build a Hive-based data warehouse for retail transactions. Use HiveQL queries for customer segmentation, sales trends, and seasonal demand forecasting. Apply Pig scripts to preprocess raw purchase logs before loading into Hive.
3. Movie Recommendation System with Spark: Use a MovieLens dataset (or similar). Implement collaborative filtering with Spark's MLlib to recommend movies.
4. Real-Time Social Media Sentiment Analysis: Stream live tweets or social media posts using Kafka + Spark Streaming. Perform sentiment analysis in real time (positive, negative, neutral).
5. Deploy a Spark job on AWS EMR / Google BigQuery / Azure HDInsight. Process a large open dataset (e.g., NYC taxi data, COVID-19 cases).

Learning Resources

Textbooks

1. Russell, S., & Norvig, P. (2020). Artificial Intelligence: A Modern Approach (4th ed.). Pearson. ISBN: 9780134610993Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
2. Wickham, H., & Grolemund, G. (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly Media .
3. Gates, B., & McKinney, W. (2022). Streaming Data: Understanding the Real-Time Pipeline. O'Reilly Media

Reference Books

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press. ISBN: 9780262035613
2. Kleppmann, M. (2017). Designing Data-Intensive Applications. O'Reilly Media.An essential book on building reliable, scalable distributed systems ISBN: 9781449373320
3. White, T. (2015). Hadoop: The Definitive Guide (4th ed.). O'Reilly Media ISBN: 9781491901632
4. Karau, H., Warren, R., & Zaharia, M. (2015). Learning Spark: Lightning-Fast Big Data Analysis. O'Reilly Media ISBN: 9781449358624

Web Resources

1. https://www.deeplearning.ai
2. https://www.kaggle.com
3. https://www.tensorflow.org
4. https://dataeng.io
5. https://github.com/DataTalksClub

Massive Open Online Courses (MOOCs)

1. https://www.coursera.org/courses?query=artificial%20intelligence
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2020/

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
ACN- ELC-CO-M07.1	2	2	3	2	2	2
ACN- ELC-CO-M07.2	2	3	3	3	2	2
ACI- ELC-CO-M07.1	2	3	3	2	2	2
ACI- ELC-CO-M07.2	3	3	2	2	3	3
BDT- ELC-CO-M07.1	2	3	3	3	2	2
BDT- ELC-CO-M07.2	2	3	3	3	3	2

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Personality Development and Life Skills (CE-AEC-M01-08)

Teaching Scheme:	**Credits:**	**Examination Scheme:**
Tutorial: 02 Hrs/ Week	**02**	**Term work:** 50 Marks

Course Introduction :

This course equips students with essential life skills to enhance self-awareness, emotional intelligence, communication, and decision-making. Through practical activities and reflections, learners develop a well-rounded personality, preparing them for personal effectiveness, professional success, and value-based leadership.

Course Objectives:

- Understand and apply essential life skills for personal and professional development.
- Cultivate emotional intelligence, communication, and interpersonal abilities.
- Enhance self-awareness, confidence, and decision-making aligned with values.

Course Outcomes:

On completion of the course, students will be able to–

AEC-CO-M08.1: Demonstrate enhanced self-awareness and develop a personal action plan for self-improvement.

AEC-CO-M08.2: Apply emotional intelligence and stress management techniques in daily and professional life

AEC-CO-M08.3: Communicate effectively and collaborate constructively in academic and professional settings

AEC-CO-M08.4: Make sound, ethical decisions through critical thinking and structured reasoning.

AEC-CO-M08.5: Exhibit leadership behaviors, personal responsibility, and professionalism rooted in strong values

Course Contents

Unit I	**Self-Awareness and Personal Growth**	**06 Hours**

- Understanding self: Values, strengths, weaknesses
- Self-image and identity
- Goal setting and self-motivation
- Growth mindset vs fixed mindset

Activities:

1. Johari Window Exercise
2. Personal SWOT analysis
3. Vision board creation

Unit II	**Emotional Intelligence and Stress Management**	**06 Hours**

- Components of Emotional Intelligence (Daniel Goleman model)
- Identifying and managing emotions
- Empathy and emotional regulation
- Stress: Causes, effects, coping strategies

Activities:

1. Emotional journaling
2. Guided meditation and breathing exercises
3. Case studies on emotional responses

Unit III	Communication and Interpersonal Skills	06 Hours

- Verbal and non-verbal communication
- Listening and feedback
- Conflict resolution and assertiveness
- Teamwork and collaboration

Activities:

1. Role-playing and group discussions
2. Assertive vs aggressive communication drills
3. Peer feedback sessions

Unit IV	Critical Thinking and Decision-Making	08 Hours

- Logical reasoning and argumentation
- Problem-solving models (e.g., PDCA, 6 Thinking Hats)
- Decision-making under uncertainty
- Ethical and value-based decision making

Activities:

1. Group decision-making tasks
2. Case analysis and debate
3. Reflective journaling on dilemmas

Unit V	Leadership, Values, and Professionalism	08 Hours

- Leadership styles and qualities
- Accountability and responsibility
- Time management and work ethics
- Aligning actions with core values

Activities:

1. Leadership style self-assessment
2. Time audit activity

Learning Resources

Textbooks

1. Emotional Intelligence by Daniel Goleman
2. 7 Habits of Highly Effective People by Stephen R. Covey
3. Man's Search for Meaning by Viktor Frankl

Massive Open Online Courses (MOOCs)

1. Coursera: The Science of Well-Being (Yale University) https://www.coursera.org/learn/the-science-of-well-being
2. edX: Soft Skills for Professionals https://www.edx.org/learn/soft-skills

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
AEC-CO-M08.1	2	1	2	1	2	2
AEC-CO-M08.2	2	1	2	1	3	2
AEC-CO-M08.3	2	3	2	2	3	1
AEC-CO-M08.4	3	2	3	2	2	3
AEC-CO-M08.5	2	2	3	2	3	3

SEMESTER - II

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26
Semester II

Research Methodology (CE-MLC-M01-10)

Teaching Scheme:	**Credits: 04**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks
Tutorial: 01 Hr/Week		**ESE:** 50 Marks
		TW: 25 Marks

Course Introduction:

This course is designed to equip postgraduate students with essential knowledge and practical skills to undertake systematic and ethical research. It introduces learners to various types of research methodologies, the process of formulating research problems, data collection techniques, and both qualitative and quantitative analysis methods.

Prerequisites:

- Basic Statistics and Probability
- Fundamentals of Academic Writing
- Foundation Courses in Computer Engineering domain

Course Objectives:

- Understand and apply various research methodologies suitable for academic, scientific, or professional inquiry.
- Design and conduct ethical research, including data collection, analysis, and interpretation
- Communicate research findings effectively through academic writing and formal presentations.

Course Outcomes:

On completion of the course, students will be able to–

MLC-CO-M10.1: Identify and differentiate various research paradigms, approaches, and problem formulation techniques

MLC-CO-M10.2: Design an appropriate research framework and critically review existing literature to identify research gaps and formulate focused research questions

MLC-CO-M10.3: Select and apply suitable data collection methods and perform basic analysis using relevant tools

MLC-CO-M10.4: Prepare structured research reports or papers and communicate findings effectively through academic writing and presentations

MLC-CO-M10.5: Apply ethical principles and intellectual property rights in the conduct, reporting, and dissemination of research

Course Contents

Unit I	**Foundations of Research**	**08 Hours**

Meaning, Objectives, and Importance of Research, Types of Research (Basic, Applied, Qualitative, Quantitative, Exploratory, Descriptive, Analytical, Empirical), Research Process & Research Cycle, Criteria of Good Research, Research Problem Identification and Formulation

Unit II	**Research Design & Literature Review**	**08 Hours**

Meaning and Purpose of Research Design, Types of Research Design (Experimental, Correlational, Longitudinal, Cross-sectional, etc.)
Definition and Purpose of a Literature Review, Role of literature review in research design, Process of Conducting a Literature Review, Search Strategies and Tools for Literature Review, Critical Analysis, Synthesis & Gap Identification, Formulation of Research Questions

Unit III	**Data Collection and Analysis**	**08 Hours**

Collection of Primary Data, Tools of Data Collection (Questionnaires, Interviews, Observations, Documents)
Quantitative Data Analysis: Descriptive and Inferential Statistics,
Qualitative Data Analysis: Coding, Thematic Analysis, Content Analysis
Data Sampling, Testing of Hypotheses (Parametric or Standard Tests of Hypotheses)

Unit IV	**Research Writing and Research Dissemination**	**08 Hours**

Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report, Communicating research findings to different audiences, Choosing Journals (SCI, Scopus), Peer Review Process, Research Metrics and Scholarly Impact Indicators: h-index, i10 index, impact factor, cite score, citations, quartiles (Q1, Q2, Q3, Q4)

Unit V	**Research Ethics and Intellectual Property Rights**	**08 Hours**

Research Ethics: Principles, Informed Consent, Confidentiality, Academic Integrity and Misconduct (Fabrication, Falsification, Plagiarism)
Types of Intellectual Properties- Copyrights, Trademark, Patents, Traditional Knowledge, Geographical Indications, Trade Secrets, Types Patents, Design and Utility Patent, Procedures for Patenting, Patent Licensing and commercialization

Suggested List of Activities for Tutorial

1. **Literature Search & Database Usage:** Search and list at least 15 recent scholarly articles related to a chosen research topic using databases like IEEE Xplore, Scopus, or Google Scholar
2. **Bibliography and Reference Management:** Create a properly formatted reference list using Zotero, Mendeley, or EndNote in IEEE/APA/MLA style.
3. **Gap Identification from Literature Review:** Write a brief synthesis (500–700 words) identifying research gaps from reviewed literature.
4. **Formulation of Research Problem & Objectives:** Frame a concise research problem statement, research objectives, and at least one hypothesis.
5. **Research Design Planning:** Choose a qualitative, quantitative, or mixed research design and justify its selection for the research problem.
6. **Plagiarism Check & Report Writing:** Write a 2-page abstract or introduction on your topic and check it using plagiarism software (e.g., Turnitin, Grammarly) and revise if needed.

Research proposal: Generate a novel research proposal based on an existing published journal paper. Use LATEX for preparing Report and Presentation Slides.

Learning Resources

Textbooks

1. C.R. Kothari & Gaurav Garg – Research Methodology: Methods and Techniques, New Age International Publishers, ISBN: 9789386649225
2. Ranjit Kumar – Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications ISBN: 9781526449900

Reference Books

1. John W. Creswell & J.D. Creswell – Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE Publications ISBN: 9781506386706
2. Uma Sekaran & Roger Bougie – Research Methods for Business: A Skill-Building Approach, Wiley Publications, ISBN: 9781119561224

Web Resources

1. https://research-methodology.net/research-methodology/research-process/
2. https://research-methodology.net/research-philosophy/
3. https://research-methodology.net/research-methods/
4. https://www.niehs.nih.gov/research/resources/bioethics
5. https://www.scribbr.com/wp-content/uploads/2022/09/thesis-structure.png

Massive Open Online Courses (MOOCs)

1. NPTEL- Research Methodology By Prof. Soumitro Banerjee, IISER Kolkata https://onlinecourses.nptel.ac.in/noc22_ge08/preview
2. NPTEL - Research Methodology, By Prof. Edamana Prasad, Prof. Prathap Haridoss IIT Madras https://onlinecourses.nptel.ac.in/noc23_ge36/preview
3. Coursera - Research Methodologies by Athanasia Lampraki https://www.coursera.org/learn/research-methodologies

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
MLC-CO-M10.1	3	2	3	2	1	3
MLC-CO-M10.2	3	2	3	2	2	3
MLC-CO-M10.3	3	1	3	3	2	3
MLC-CO-M10.4	2	3	2	2	2	2
MLC-CO-M10.5	2	2	2	1	2	3

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Information and Cyber Security (CE-PCC-M01-11)

Teaching Scheme: 04 Hrs/ Week	**Credits:** 04	**Examination Scheme:** **CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction:

The basic ideas and procedures for defending computer networks, systems, and data against online threats and illegal access are covered in a cybersecurity course. These courses are designed to give people the information and abilities they need to protect their critical infrastructure, organizational data, and personal information against online attacks.

Prerequisites:

- Understanding operating systems (Windows, Linux, macOS), file systems, and how software applications work is essential.
- Knowledge of network protocols (TCP/IP, DNS, etc.), topologies, and security protocols is crucial for understanding how systems communicate and how to secure them.
- Cybersecurity requires a strong foundation in computer science, networking principles, and security ideas. Strong analytical and problem-solving abilities are also very helpful, as is familiarity with programming and scripting languages.

Course Objectives:

- To provide foundational knowledge of cryptography, security principles, and classical encryption techniques for secure communication.
- To impart knowledge of symmetric key cryptography concepts, algorithms, modes, and key management for ensuring data confidentiality.
- To impart knowledge of number theory, asymmetric key cryptography, and authentication techniques for ensuring secure data communication.
- To impart fundamental knowledge of cybersecurity concepts, threats, attacks, and policies for protecting digital assets and infrastructure.
- To impart knowledge of web application security concepts, vulnerabilities, mitigation techniques, and advanced mechanisms for ensuring secure and private digital interactions.

Course Outcomes:

On completion of the course, students will be able to–

PCC-CO-M11.1: Design and evaluate secure communication systems by applying advanced cryptographic methods and security architectures.

PCC-CO-M11.2: Design and evaluate advanced symmetric key cryptographic systems and key management strategies to ensure data confidentiality and secure communication.

PCC-CO-M11.3: Explain advanced concepts of number theory, asymmetric key cryptography, and authentication mechanisms for secure digital communication.

PCC-CO-M11.4: Explain advanced cyber security concepts, threats, and policies to assess and address modern digital security challenges.

PCC-CO-M11.5: Analyze web application security threats, vulnerabilities, and defenses to evaluate and apply advanced security mechanisms across diverse platforms.

Course Contents

Unit I	Introduction to Information Security	08 Hours

Overview - Cryptography and modern cryptography, Need of security, Services, Mechanism and Attacks, The OSI security Architecture, Security Attacks, Security Services, Security Mechanisms, A model for Network security, Classical Encryption techniques – Symmetric Cipher model, Substitution techniques, Transposition techniques, Steganography.

Unit II	Symmetric Key Cryptography	08 Hours

Symmetric Key Cryptography: Block Cipher and Data Encryption Standard - Simplified DES, Block cipher principles, The Data Encryption Standard, The strength of DES, Differential and Linear Cryptanalysis, Block Cipher Design Principles, Block cipher modes of operations, Introduction to AES Multiple Encryption and Triple DES, Block Cipher Modes of Operation, Stream Ciphers and RC4,Confidentiality Using Symmetric Encryption, Placement of Encryption Function, Traffic Confidentiality, Key Distribution, Random Number Generation

Unit III	Number Theory and Asymmetric Key Cryptography	08 Hours

Number Theory and Asymmetric Key Cryptography: Prime Number, relatively prime numbers, Modular Arithmetic, Fermat's and Euler's Theorem, The Chinese Remainder Theorem, Discrete logarithms, Public Key Cryptography and RSA - Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Diffie-Hellman Key Exchange, Elliptic Curve Arithmetic, Elliptic Curve Cryptography, Message Authentication and Hash Functions , Authentication Requirements, Authentication Functions, Message Authentication Codes ,Hash Functions, Security of Hash Functions and Macs

Unit IV	Introduction to Cyber Security	08 Hours

Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, CIA Triad, Assets and Threat, motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., Comprehensive Cyber Security Policy.

Unit V	Web application security	08 Hours

Introduction to web application security: Attacks, vulnerabilities and mitigation, Client-side security, Server-side security, Application security: HTTPS, HSTS etc., Security engineering: Passwords and their limitations, Attacks on passwords: CAPTCHA, OTP. Advanced security topics: Secure email systems: PGP, SMIME, DKIM, DMARC, DNSSec, SMTP STS etc., Privacy and security for online social networks, Database security, Browser security, Mobile device security

Learning Resources

Textbooks

1. Cryptography and Network Security : William Stallings, Pearson Education, 4th Edition
2. Principles of Information Security : Michael E. Whitman, Herbert J. Mattord, CENGAGE Learning, 4th Edition.
3. Hossein, "Handbook of Information Security, Threats, Vulnerabilities, Prevention, Detection, and Management", Wiley, Volume 3 edition, ISBN-13: 978-0470323069.

Reference Books

1. Georgia Weidman, "Penetration testing: A Hands-On Introduction to Hacking", No Starch Press, 2014, ISBN-13: 978-1593275648.
2. Michael Sikorski and Andrew Honig, "Practical Malware Analysis", No Starch Press, 1st Edition, 2012, ISBN-13: 978-1593272906
3. Cryptography and Network Security : Forouzan Mukhopadhyay, Mc Graw Hill, 2nd Edition

Web Resources

1. https://www.cisa.gov/resources-tools/resources/free-cybersecurity-services-and-tools
2. https://www.edx.org/learn/cybersecurity
3. https://attack.mitre.org/

Massive Open Online Courses (MOOCs)

1. https://onlinecourses.nptel.ac.in/noc23_cs127/preview
2. https://www.coursera.org/learn/packt-cybersecurity-foundations-threat-mitigation-abiab

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PCC-CO-M11.1	2	1	2	2	2	2
PCC-CO-M11.2	2	1	2	2	2	2
PCC-CO-M11.3	2	2	2	2	-	3
PCC-CO-M11.4	2	3	3	2	2	2
PCC-CO-M11.5	3	2	3	3	3	2

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With effect from A.Y. 2025-26

Quantum Computing (CE-PCC-M01-12)

Teaching Scheme:	**Credits:** 03	**Examination Scheme:**
03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction :
This course provides a comprehensive foundation in quantum theory for computing, quantum circuits, and algorithms, along with exposure to quantum error correction, hardware platforms, and modern applications in cryptography, optimization, and machine learning.

Prerequisites:
- Linear Algebra, Probability & Statistics
- Basics of Quantum Mechanics / Engineering Physics
- Classical Cryptography and Machine Learning

Course Objectives:
- Understand the principles of quantum mechanics relevant to computing.
- Apply quantum gates and build simple circuits.
- Learn foundational quantum algorithms and their computational advantage.
- Understand noise challenges and error correction techniques.
- Explore real-world applications and current research trends of quantum computing.

Course Outcomes:
On completion of the course, students will be able to–
PCC-CO-M12.1: Have strong theoretical foundation in quantum mechanics applied to computing.
PCC-CO-M12.2: Design and simulate quantum circuits.
PCC-CO-M12.3: Understand important quantum algorithms and their impact.
PCC-CO-M12.4: Gain familiarity with quantum programming tools and applications.
PCC-CO-M12.5: Develop research or advanced projects in quantum computing.

Course Contents

Unit I	**Fundamental of Quantum Computation**	**08 Hours**

Introduction to Quantum Computing: Motivation and applications, Comparison with classical computing.
Basics of Quantum Mechanics for Computing: Qubits, Superposition, Entanglement, Measurement, Bloch sphere representation, Linear Algebra & Dirac Notation, Postulates of Quantum Mechanics

Unit II	**Quantum Architecture, Gates and Circuits**	**08 Hours**

Quantum Architectures: Harmonic oscillator quantum computer, Optical photon quantum computer, Optical cavity quantum electrodynamics
Quantum Gates: Single-Qubit Gates (Pauli, Hadamard, Phase, Rotation gates), Multi-Qubit Gates(CNOT, SWAP, Toffoli)
Quantum Circuits: Representation & Simulation, Reversibility and Unitarity, Quantum Circuit simulation using IBM Qiskit

Unit III	Quantum Algorithms	08 Hours

Deutsch-Jozsa Algorithm, Grover's Search Algorithm, Quantum Fourier Transform (QFT), Shor's Factoring Algorithm, Introduction to Variational Quantum Algorithms: VQE, QAOA

Unit IV	Quantum Noise and Error Correction	08 Hours

Sources of Noise and Decoherence, Quantum Error Correction Basics: Bit-flip, Phase-flip, Shor's Code Fault-Tolerant Quantum Computation, Quantum Hardware Implementations, Superconducting qubits: Trapped ions, Photonic systems, Scalability challenges

Unit V	Quantum Applications and Tools	08 Hours

Quantum Machine Learning (QML), Quantum Cryptography & Post-Quantum Cryptography, Quantum Natural Language Processing (QNLP), Applications in Optimization, Chemistry, and AI, Quantum Programming Tools: Qiskit, Cirq, Pennylane

Learning Resources

Textbooks

1. Nielsen, M. A., & Chuang, I. L. (2010). Quantum Computation and Quantum Information. Cambridge University Press.
2. Eleanor Rieffel and Wolfgang Polak, "Quantum Computing: A Gentle Introduction," The MIT Press, 2011, ISBN 978-0-262-01506-6

Reference Books

1. Benenti, G., Casati, G., & Strini, G. (2007). Principles of Quantum Computation and Information. World Scientific.
2. Kaye, P., Laflamme, R., & Mosca, M. (2007). An Introduction to Quantum Computing. Oxford University Press.
3. Preskill, J. (2018). Lecture Notes on Quantum Computation (freely available online).

Web Resources

1. Qiskit Textbook (Open-Source): https://qiskit.org/textbook/
2. Quantum Algorithm Zoo: https://quantumalgorithmzoo.org/
3. IBM Quantum Experience: https://quantum-computing.ibm.com
4. Microsoft Quantum Development Kit (Q#): https://learn.microsoft.com/en-us/azure/quantum/
5. Google Cirq: https://quantumai.google/cirq

Massive Open Online Courses (MOOCs)

1. Coursera – Quantum Mechanics for Scientists and Engineers (Stanford Univ.)
2. edX – Quantum Computing Fundamentals (MIT xPro)

Udemy – Quantum Computing for Everyone (with Qiskit & Python)

CO PO Mapping						
CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PCC-CO-M12.1	2	1	2	2	2	2
PCC-CO-M12.2	2	1	2	2	2	2
PCC-CO-M12.3	2	2	2	2	-	3
PCC-CO-M12.4	2	3	3	2	2	2
PCC-CO-M12.5	3	2	3	3	3	2

Hope Foundation's International Institute of Information Technology (I²IT), Pune

M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Elective II - AI for Visual Analysis (CE- PEC-M01-13(A))

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction :

This course provides a structured pathway from the fundamentals of computer vision to advanced AI-driven visual understanding. Students will first learn classical vision methods, then explore deep learning architectures for vision, and finally study cutting-edge techniques such as object detection, segmentation, vision transformers, and generative models.

Prerequisites:

- Basics of Artificial Intelligence
- Basics of Image Processing
- Basics of Machine Learning

Course Objectives:

- Introduce fundamental concepts and techniques of computer vision for visual data processing.
- Develop an understanding of deep learning methods applied to image and video analysis.
- Apply AI techniques to tasks such as object detection, segmentation, and video understanding.
- Explore emerging trends such as self-supervised learning, vision transformers, and generative models in visual analysis.

Course Outcomes:

On completion of the course, students will be able to–

PEC-CO-M13A.1: Explain the principles of image formation, representation, and classical computer vision techniques.

PEC-CO-M13A.2: Implement and experiment with deep learning architectures for image classification and feature learning.

PEC-CO-M13A.3: Apply AI models for object detection, semantic segmentation, and video analysis.

PEC-CO-M13A.4: Analyze and compare state-of-the-art models for visual analysis, including transformers and generative approaches.

PEC-CO-M13A.5: Evaluate recent trends in AI for visual analysis, considering ethical and deployment aspects

Course Contents

Unit I	**Introduction to Computer Vision**	**08 Hours**

A brief history of computer vision, Basic Image Processing: Filtering (smoothing, sharpening), edge detection, morphological operations,
Image sensing and acquisition, A simple image formation model, Image Sampling & Quantization, basic relationships between pixels.
Image processing: Point operators, Linear filtering, More neighborhood operators, Basics of Fourier transform, Pyramids and wavelets and Geometric transformations.

Unit II	**Computer Vision Techniques**	**08 Hours**

Segmentation: Thresholding, region growing, clustering-based methods, graph-based segmentation, Object Detection & Recognition (Pre-deep learning era): HOG, Haar cascades, template matching, Motion and Tracking: Optical flow, background subtraction, Kalman filters, 3D Vision: Stereo vision, depth estimation, structure-from-motion basics, Image Matching and Registration

Unit III	Deep Learning for Visual Analysis	08 Hours

Introduction to Deep Learning for Vision, Convolutional Neural Networks (CNNs): Architectures (LeNet, AlexNet, VGG, ResNet), CNN Operations: Convolution, pooling, activation, normalization, Training and Fine-tuning Vision Models, Data Augmentation and Transfer Learning

Unit IV	AI for Visual Analysis	08 Hours

Object Detection and Localization: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD
Semantic and Instance Segmentation: FCN, U-Net, Mask R-CNN, Video Understanding: Action recognition, event detection, video summarization, Visual Question Answering (VQA) and Multimodal AI (Vision + Language), Explainability in Visual AI Models
Case Study: Training YOLO/Mask R-CNN for a custom dataset

Unit V	Emerging Trends in AI for Visual Analysis	08 Hours

Self-Supervised and Few-Shot Learning in Vision, Vision Transformers (ViT, Swin Transformer), Generative Models for Visual Analysis: GANs, diffusion models, deepfakes
AI for Medical Imaging, Remote Sensing, Autonomous Driving, Surveillance, Ethical Concerns: Bias, privacy, security in visual AI
Case Study: Implementing a Vision Transformer or GAN-based visual analysis task

Learning Resources

Textbooks

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2nd Edition, 2022.
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.
3. Adrian Rosebrock, Deep Learning for Computer Vision, PyImageSearch, 2019.

Reference Books

1. D. Forsyth and J. Ponce, Computer Vision: A Modern Approach, Pearson, 2nd Edition, 2011.
2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson, 4th Edition, 2018.
3. Reinhard Klette, Concise Computer Vision - An Introduction into Theory and Algorithms, Springer, 2014

Web Resources

1. Tutorials on computer vision and deep learning: https://www.pyimagesearch.com/
2. Stanford Vision Lab – Research papers and projects: http://vision.stanford.edu/
3. OpenCV Documentation – https://docs.opencv.org/

Massive Open Online Courses (MOOCs)

1. Convolutional Neural Networks for Visual Recognition – Stanford (Free Online) http://cs231n.stanford.edu/
2. Deep Learning for Computer Vision – Coursera (by National Research University HSE) https://www.coursera.org/learn/deep-learning-in-computer-vision

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-CO-M13A.1	2	1	2	3	1	1
PEC-CO-M13A.2	3	1	3	3	2	2
PEC-CO-M13A.3	3	1	3	3	3	3
PEC-CO-M13A.4	3	2	3	2	2	3
PEC-CO-M13A.5	3	3	3	2	2	3

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M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Elective II - Multimodal Information Retrieval (CE- PEC-M01-13(B))

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

This course will equip students with theoretical foundations and computational techniques to retrieve and analyze multimodal data effectively. This course covers representation learning, feature fusion, alignment, and deep learning methods for cross-modal retrieval, culminating in real-world applications such as search engines, recommendation systems, medical informatics, and multimedia analysis.

Prerequisites:
- Basics of information retrieval
- Basics of machine learning

Course Objectives:
- Provide a strong foundation in classical and modern information retrieval techniques.
- Explore data representation methods for text, image, audio, and video.
- Study multimodal fusion, alignment, and embedding techniques for retrieval.
- Introduce deep learning–based frameworks and state-of-the-art multimodal models.
- Analyze applications and research challenges in multimodal retrieval systems.

Course Outcomes:
On completion of the course, students will be able to–
PEC-CO-M13B.1: Explain the fundamentals of information retrieval and extend them to multimodal data.
PEC-CO-M13B.2: Represent and process multimodal data (text, image, audio, video) for retrieval tasks.
PEC-CO-M13B.3: Apply feature extraction, fusion, and alignment techniques for multimodal integration.
PEC-CO-M13B.4: Design and implement deep learning models for multimodal and cross-modal retrieval.
PEC-CO-M13B.5: Critically analyze recent research, applications, and open challenges in multimodal information retrieval.

Course Contents

Unit I	**Foundations of Information Retrieval**	**08 Hours**

Basics of Information Retrieval: models, indexing, ranking, relevance, Limitations of unimodal IR, Motivation for multimodal information retrieval, Introduction to multimodal data sources (text, image, audio, video, sensor), Evaluation metrics for IR systems (precision, recall, MAP, NDCG).

Unit II	**Representations of Multimodal Data**	**08 Hours**

Text representations: Bag-of-words, TF-IDF, word embeddings (Word2Vec, GloVe, BERT), Image representations: SIFT, HOG, CNN-based feature extraction, Audio representations: MFCC, spectrograms, audio embeddings.
Video representations: Keyframe extraction, temporal features, spatio-temporal CNNs, Introduction to multimodal datasets (MS COCO, Flickr30k, YouTube-8M)

Unit III	**Fusion and Alignment Techniques**	**08 Hours**

Feature-level fusion vs decision-level fusion, Canonical Correlation Analysis (CCA), Partial Least Squares (PLS), Joint embedding models for multimodal data, Attention mechanisms for alignment (e.g., text-image matching), Cross-modal retrieval (e.g., image-to-text, text-to-audio) **Case studies:** Image captioning, Visual Question Answering (VQA)		
Unit IV	**Deep Learning for Multimodal Retrieval**	**08 Hours**
Deep neural networks for feature learning, Multimodal autoencoders and variational autoencoders, Generative models: GANs for cross-modal synthesis (text-to-image, image-to-audio), Multimodal transformers (CLIP, ALIGN, BLIP), Contrastive learning approaches (e.g., CLIP, SimCLR extensions), Zero-shot and few-shot multimodal retrieval		
Unit V	**Applications and Trends**	**08 Hours**
Applications: Search engines (Google Images, YouTube search), Recommendation systems, Healthcare (medical imaging + text), Multimedia content analysis, Cross-lingual multimodal retrieval. Future trends: Multimodal foundation models, LLM+vision integration, prompt-based retrieval		

Learning Resources

Textbooks

1. Manning, C. D., Raghavan, P., & Schütze, H. Introduction to Information Retrieval. Cambridge University Press, 2008.
2. Sridharan, S. Multimodal Information Retrieval: Concepts and Applications. Springer, 2020.

Reference Books

1. Goodfellow, I., Bengio, Y., & Courville, A. Deep Learning. MIT Press, 2016.
2. Li, S., & Jain, A. K. Handbook of Multimedia Information Retrieval. Springer, 2017.
3. Radford, A. et al. Learning Transferable Visual Models From Natural Language Supervision (CLIP), NeurIPS 2021.
4. Xu, C., Xie, L., Yang, X., & Zhuang, Y. Multimedia Information Retrieval and Applications. Springer, 2017.

Web Resources

1. Stanford IR Book (Online Draft): https://nlp.stanford.edu/IR-book/
2. Multimodal Machine Learning Tutorial (CMU): http://multicomp.cs.cmu.edu/
3. Microsoft Research Multimodal AI: https://www.microsoft.com/en-us/research/project/multimodal/
4. Google AI Blog – Multimodal Models: https://ai.googleblog.com/
5. Hugging Face Multimodal Models Hub: https://huggingface.co/models?pipeline_tag=multimodal

Massive Open Online Courses (MOOCs)

1. Information Retrieval and Web Search Engines – Stanford University (YouTube Lectures & Resources)
2. Multimodal Machine Learning (Carnegie Mellon University, CMU) – Publicly available lecture slides/tutorials

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-CO-M13B.1	1	1	2	2	1	1
PEC-CO-M13B.2	2	1	2	3	2	2
PEC-CO-M13B.3	2	1	2	3	2	2
PEC-CO-M13B.4	3	2	3	3	3	3
PEC-CO-M13B.5	3	3	3	2	2	3

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Elective III - Advanced NLP and Prompt Engineering (CE- PEC-M01-14(A))

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction :

This course focuses on advanced concepts in NLP, including contextual text representations, structured prediction, generative models, and multimodal NLP. It further explores large language models (LLMs), their fine-tuning, alignment, and emerging practices in prompt engineering.

Prerequisites:

- Probability and Statistics
- Machine Learning / Deep Learning
- Artificial Intelligence

Course Objectives:

- To understand advanced methods of representing, analyzing, and modeling natural language.
- To apply deep learning architectures for complex NLP tasks such as structured prediction, summarization, translation, and dialogue systems.
- To explore multimodal and generative NLP techniques, including their ethical implications.
- To study the foundations and adaptation techniques of large language models (LLMs).
- To design effective prompts and leverage prompt engineering for advanced AI applications.

Course Outcomes:

On completion of the course, students will be able to–

PEC-CO-M14A.1: Apply advanced embedding techniques and sequence modeling architectures to represent and analyze text data.

PEC-CO-M14A.2: Develop and evaluate models for structured NLP tasks such as NER, summarization, translation, and discourse analysis.

PEC-CO-M14A.3: Implement multimodal and generative models for text and cross-modal tasks.

PEC-CO-M14A.4: Demonstrate the ability to fine-tune and adapt large language models for domain-specific applications.

PEC-CO-M14A.5: Design effective prompts and advanced prompting strategies for solving diverse NLP tasks with LLMs.

Course Contents

Unit I	**Text Representations & Architectures**	**08 Hours**

Word & Subword Embeddings: Word2Vec, GloVe limitations, Contextual embeddings (ELMo, Flair), Byte Pair Encoding (BPE), SentencePiece

Sequence Models: Advanced RNNs (Bi-LSTM, GRU), Hierarchical & character-level models

Transformers: Self-attention mechanism, Positional encodings & variants (relative position, rotary embeddings)

Unit II	**Advanced NLP Tasks & Applications**	**08 Hours**

Sequence Labeling & Structured Prediction, Named Entity Recognition (NER) with CRF + BiLSTM, Dependency parsing, semantic role labeling, Advanced Text Classification: Multi-label, hierarchical classification, Zero-shot & few-shot classification with transformers, Document-level NLP: Coreference resolution, Discourse analysis, Advanced Applications: Information extraction pipelines, Abstractive summarization (Pointer-Generator, Transformers), Dialogue state tracking in conversational agents		
Unit III	**Multimodal & Generative NLP**	**08 Hours**
Multimodal NLP: Vision + Language models (Image Captioning, VQA), Speech + Text (ASR, speech translation, multimodal embeddings), Generative Models for Text: Variational Autoencoders (VAEs) for text, GANs for text generation (challenges, solutions), Diffusion models for text & cross-modal tasks Advanced Machine Translation: Neural MT with transformers, Low-resource & unsupervised MT Ethical Concerns in Generative NLP: Bias, hallucination, misinformation		
Unit IV	**Large Language Models & Fine-tuning**	**08 Hours**
Foundations of LLMs: GPT, T5, BERT to GPT-4 evolution, Scaling laws & efficiency trends, Instruction tuning, alignment, RLHF, Fine-Tuning Approaches: Full fine-tuning vs. parameter-efficient methods (LoRA, adapters, prefix-tuning, p-tuning), Domain adaptation & task-specific tuning, Evaluation & Limitations: Benchmarks (MMLU, GLUE, HELM), Hallucination, robustness, interpretability		
Unit V	**Prompt Engineering & Emerging Trends**	**08 Hours**
Prompt Engineering Fundamentals: Zero-shot, one-shot, few-shot prompting, Chain-of-thought prompting, reasoning prompts, Role, style, and constraint-based prompting Advanced Prompting Techniques: Self-consistency prompting, Retrieval-augmented generation (RAG), Tool-use prompting, program-aided language models (PAL), Evaluation of Prompts: Prompt metrics, effectiveness analysis, Failure cases & error analysis, Applications & Trends: Prompting for code generation, reasoning, multimodal tasks, Guardrails, prompt security, jailbreak prevention, Autonomous agents powered by LLMs (LangChain, AutoGPT)		

Learning Resources

Textbooks

1. Jurafsky, D., & Martin, J. H. (2023). Speech and Language Processing (3rd Edition draft). Stanford University.
2. Eisenstein, J. (2019). Introduction to Natural Language Processing. MIT Press.
3. Palash Goyal, Sumit Pandey, Karan Jain (2018). Deep Learning for Natural Language Processing. Apress.

Reference Books

1. Goldberg, Y. (2017). Neural Network Methods in Natural Language Processing. Morgan & Claypool.
2. Rajalingappaa Shanmugamani (2021). Practical Natural Language Processing with Transformers. Packt.
3. Peter D. Turney & Patrick Pantel (2010). From Frequency to Meaning: Vector Space Models of Semantics. J. of AI Research.

Web Resources

1. Stanford NLP Group: https://nlp.stanford.edu
2. Hugging Face Resources: https://huggingface.co/transformers
3. OpenAI Research Blog: https://openai.com/research

Massive Open Online Courses (MOOCs)

1. Large Language Models (Stanford University) https://web.stanford.edu/class/cs324/
2. Natural Language Processing with Deep Learning (Stanford University) https://web.stanford.edu/class/cs224n/
3. DeepLearning.AI – Generative AI with Large Language Models (Coursera) https://www.coursera.org/learn/generative-ai-with-llms

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-CO-M14A.1	1	2	3	3	2	1
PEC-CO-M14A.2	2	3	3	3	3	2
PEC-CO-M14A.3	2	3	3	3	2	2
PEC-CO-M14A.4	1	2	3	3	2	1
PEC-CO-M14A.5	2	3	3	3	3	2

Hope Foundation's International Institute of Information Technology (I²IT), Pune
M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Elective III - Advanced Data Analysis & Visualization (CE- PEC-M01-14(B))

Teaching Scheme:	**Credits: 03**	**Examination Scheme:**
Lectures: 03 Hrs/ Week		**CCE:** 50 Marks **ESE:** 50 Marks

Course Introduction :

This course provides postgraduate students with advanced methods for analyzing data using statistical, computational, and machine learning approaches, coupled with state-of-the-art visualization techniques. It emphasizes not only technical proficiency but also the design, communication, and ethical aspects of data storytelling.

Prerequisites:

- Database Management Systems
- Data structures

Course Objectives:

- Apply advanced statistical and computational methods for data analysis.
- Design effective and perceptually sound data visualizations for complex datasets.
- Utilize modern visualization frameworks and interactive dashboard tools.
- Integrate machine learning techniques with visualization for model interpretation and decision-making.
- Critically evaluate and apply current trends, tools, and research in data analysis and visualization.

Course Outcomes:

On completion of the course, students will be able to–

PEC-CO-M14B.1: Perform advanced exploratory data analysis on large, heterogeneous datasets.
PEC-CO-M14B.2: Apply visualization principles to design effective and ethical data visualizations.
PEC-CO-M14B.3: Develop interactive, dynamic, and multi-dimensional data visualizations using modern tools.
PEC-CO-M14B.4: Employ machine learning models for data-driven insights and interpret them visually.
PEC-CO-M14B.5: Analyze recent research trends and implement cutting-edge visualization techniques such as real-time dashboards and immersive analytics.

Course Contents

Unit I	**Foundations of Data Analysis**	**08 Hours**

Introduction to Data Visualization, Definition, Role in Data Engineering, Gestalt Principles, Visual Encoding, Marks & Channels, Effectiveness, Cognitive Load & Simplicity, Data Types & Analytical Tasks, Choosing the right visualization
Data preprocessing at scale: cleaning, transformation, feature engineering
Exploratory Data Analysis (EDA): advanced statistical summaries, correlation, and outlier detection, Handling high-dimensional data (PCA, t-SNE, UMAP)

Unit II	**Data Visualization Principles & Design**	**08 Hours**

Perceptual & cognitive principles of data visualization, Chart types, design choices, and avoiding misrepresentation, Visual encoding & storytelling with data Advanced visualization libraries: Matplotlib, Seaborn, Plotly, ggplot2		
Unit III	**Advanced Visualization Techniques**	**08 Hours**
Interactive & dynamic visualizations: Multivariate data visualization: scatterplot matrices, parallel coordinates, heatmaps, Time-series, geospatial, and network visualizations, 3D visualization techniques for large-scale engineering datasets, Dashboards and reporting: Tableau, Power BI, Plotly Dash, Streamlit		
Unit IV	**Data Analysis with Machine Learning & AI**	**08 Hours**
Supervised & unsupervised learning for data analysis (classification, clustering, anomaly detection), Model interpretability & visualization (feature importance, SHAP, LIME), Visual analytics for model evaluation (ROC, confusion matrix, performance dashboards) AI-driven visualization: automated insights generation, natural language to charts		
Unit V	**Current Trends in Data Analysis & Visualization**	**08 Hours**
Big data visualization challenges (streaming data, real-time visualization), Cloud-based data visualization platforms (Google Data Studio, AWS QuickSight, Azure Power BI), Storytelling with data & narrative visualization, Visualization for explainable AI & decision support systems Recent Trends: Immersive analytics, AR/VR-based visualization, and visual analytics in human-AI collaboration		

Learning Resources

Textbooks

1. Andy Kirk – Data Visualization: A Handbook for Data-Driven Design, Sage Publications, 2016.
2. Hadley Wickham, Garrett Grolemund – R for Data Science: Import, Tidy, Transform, Visualize, and Model Data, O'Reilly, 2017.
3. Wes McKinney – Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, O'Reilly, 2022 (2nd Edition).

Reference Books

1. Tamara Munzner – Visualization Analysis and Design, CRC Press, 2014.
2. Cole Nussbaumer Knaflic – Storytelling with Data: A Data Visualization Guide for Business Professionals, Wiley, 2015.
3. Ben Fry – Visualizing Data: Exploring and Explaining Data with the Processing Environment, O'Reilly, 2008.

Web Resources

1. Data Viz Project: https://datavizproject.com
2. Information is Beautiful: https://informationisbeautiful.net
3. Observable HQ: https://observablehq.com
4. FlowingData, [Online]. Available: https://flowingdata.com
5. Nightingale (Data Visualization Society Blog): https://nightingale.house

Massive Open Online Courses (MOOCs)

1. Coursera Data Visualization Courses: https://www.coursera.org/courses?query=d6
2. edX Data Visualization Courses: https://www.edx.org/learn/data-visualization

Udacity Data Visualization Courses: https://www.udacity.com/courses/datavisualization

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
PEC-CO-M14B.1	2	2	2	3	2	2
PEC-CO-M14B.2	2	2	3	3	3	2
PEC-CO-M14B.3	3	1	3	3	3	3
PEC-CO-M14B.4	3	2	3	2	3	3
PEC-CO-M14B.5	2	2	2	3	2	2

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With effect from A.Y. 2025-26

Laboratory III (CE-ELC-M01-15)

Teaching Scheme:	Credits: 02	Examination Scheme:
Practical: 04 Hrs/ Week		**Term work:** 25 Marks **Oral:** 25 Marks

Course Introduction :

This course introduces students to hands-on experiments and mini-projects based on advanced elective subjects: Computer Vision, Natural Language Processing & Prompt Engineering, Multimodal Information Retrieval & Big Data Visualization. It emphasizes practical implementation, cross-domain integration, and real-time data processing. Students will develop prototypes, perform analytics, and deploy intelligent systems using cutting-edge tools and frameworks.

Prerequisites:

- Python, OpenCV, NumPy
- Digital Image Processing
- Data Bases, Big Data Concept

Course Objectives:

- To develop practical skills in fundamental computer vision techniques, including camera calibration, image segmentation, motion estimation, object tracking, and morphological analysis using real-time image and video data.
- To provide hands-on experience in data visualization, NoSQL databases, big data frameworks, and distributed computing models, enabling students to develop scalable data processing applications using modern technologies like Python, MongoDB, MapReduce, Spark, Hadoop, and Pig.
- To equip students with practical skills in big data technologies and tools by implementing data visualization, NoSQL operations, distributed processing using MapReduce, scalable clustering with Spark, and data storage solutions using MongoDB, Pig, Hadoop, or R.

Course Outcomes:

AI for Visual Analysis
ELC-CO-M15.1: Apply fundamental and deep learning-based techniques for visual analysis tasks such as image preprocessing, segmentation, object detection, and video understanding.
ELC-CO-M15.2: Design and implement AI-driven solutions using CNNs, object detectors, and generative models for real-world applications in domains like healthcare, surveillance, and autonomous systems.

Multimodal Information Retrieval
ELC-CO-M15.1: Apply classical and deep learning–based information retrieval techniques to process, represent, and evaluate multimodal data (text, image, audio, video).
ELC-CO-M15.2: Design and implement fusion, alignment, and cross-modal retrieval models to solve real-world multimodal search and recommendation problems.

Advanced NLP and Prompt Engineering
ELC-CO-M15.1: Apply advanced NLP architectures and embeddings (transformers, contextual models,

multimodal approaches) to analyze and model complex language tasks.
ELC-CO-M15.2: Design, fine-tune, and evaluate generative and large language models for domain-specific applications while addressing robustness, bias, and hallucination issues.
ELC-CO-M15.3: Develop effective prompt engineering strategies and autonomous agent workflows for solving real-world reasoning, summarization, translation, and code generation tasks.

Advanced Data Analysis & Visualization
ELC-CO-M15.1: Apply advanced data preprocessing, exploratory analysis, and visualization principles to extract meaningful insights from complex datasets.
ELC-CO-M15.2: Design and develop interactive dashboards and visualization systems using modern tools and libraries for effective storytelling and decision-making.

List of Assignments

Part I : Course I (AI for Visual Analysis)

1. Perform image acquisition, sampling, and quantization on sample images. Implement smoothing, sharpening, edge detection, and morphological operations using OpenCV.
2. Implement segmentation using thresholding, region growing, and clustering. Perform object detection using HOG and Haar cascades.
3. Train and evaluate CNNs (e.g., LeNet, AlexNet, ResNet) for image classification on CIFAR-10 or a custom dataset. Use transfer learning for fine-tuning.
4. Implement object detection using YOLOv5/SSD. Train a model on a custom dataset and evaluate performance.
5. Train a Vision Transformer (ViT) for image classification OR implement a GAN for generating synthetic images. Analyze performance and limitations.

Part I: Course II (Multimodal Information Retrieval)

1. Classical Information Retrieval on Text Data: Implement a simple search engine using TF-IDF and cosine similarity on a collection of news articles or research abstracts. Evaluate retrieval performance using precision, recall, MAP, and NDCG.
2. Implement keyframe extraction and compute CNN features per frame. Extend to temporal representation using an RNN/LSTM or temporal pooling.
3. Perform feature-level fusion (concatenation, weighted sum) and decision-level fusion for text + image retrieval.
4. Implement a text-image matching model with attention (e.g., for MS COCO captions). Given a text query, retrieve the most relevant image and vice versa.
5. Implement a contrastive learning model (e.g., CLIP-style) using a small dataset. Use pretrained transformers (BERT for text, ResNet for images).

Part II: Course I (Advanced NLP & Prompt Engineering)

1. Implement Word2Vec and GloVe embeddings on a text dataset, then compare them with contextual embeddings like ELMo or Flair.
2. Build a simple transformer-based model with self-attention and positional encodings.
3. Implement Named Entity Recognition (NER) using BiLSTM+CRF. Extend the experiment with a transformer-based NER model (e.g., BERT).
4. Implement a coreference resolution pipeline using Hugging Face or spaCy.
5. Fine-tune a pre-trained LLM (e.g., GPT-2, T5, or BERT variants) for a domain-specific task (e.g., medical Q&A, legal document classification).

Part II: Course II (Advanced Data Analysis & Visualization)

1. Perform large-scale data cleaning, transformation, and feature engineering. Reduce dimensionality using PCA and visualize clusters with t-SNE/UMAP.
2. Create plots using Matplotlib, Seaborn, and Plotly. Implement storytelling through multi-chart dashboards in Jupyter Notebook.
3. Implement time-series visualization and geospatial mapping (using Folium/Plotly).
4. Implement network data visualization using graph libraries (e.g., NetworkX + Plotly).
5. Build an interactive dashboard using Tableau or Power BI with multiple linked visualizations. Include filtering, drill-down, and user interaction capabilities.

Mini Project - AI for Visual Analysis (Any One)

1. Develop a preprocessing pipeline that enhances X-ray or MRI images (denoising, edge sharpening, morphological operations).
2. Classical Vision for Smart Surveillance: Build a system that detects and tracks moving objects (people/vehicles) in CCTV footage using traditional CV methods (HOG, Haar cascades, optical flow).
3. CNN-based Plant Disease Detection: Train CNN models (ResNet, VGG) on a dataset of plant leaf images to detect and classify plant diseases.
4. Object Detection for Traffic Monitoring: Use YOLO/SSD to detect and count vehicles in real-time traffic videos.
5. Generative Models for Art & Style Transfer: Implement a GAN or diffusion model to generate synthetic artwork or perform neural style transfer.

Mini Project - Multimodal Information Retrieval (Any One)

1. Domain-Specific Search Engine: Build a specialized IR system (e.g., for research papers, legal documents, or news articles)
2. Create a multimodal dataset (e.g., product descriptions + product images + reviews). Visualize modality embeddings with t-SNE and discuss semantic clustering.
3. Design a content-based video retrieval system using CNN-based keyframe extraction and temporal embeddings. Support query-by-video and query-by-text.
4. Build a text-to-image retrieval system using attention-based alignment on dataset such as MS COCO or Flickr30k (image-caption pairs).
5. Fine-tune a CLIP-like model (ResNet + Transformer) on a smaller multimodal dataset. Evaluate zero-shot retrieval performance (e.g., search images using unseen textual queries).

Mini Project - Advanced NLP & Prompt Engineering (Any One)

1. Build a classifier for sentiment/emotion detection on Twitter or Reddit posts using contextual embeddings (e.g., Flair, ELMo, or BERT). Compare performance against static embeddings (Word2Vec, GloVe).
2. Implement abstractive summarization of long legal or policy documents using transformers (BART, T5).
3. Develop an end-to-end pipeline for extracting key entities (author, method, dataset, results) from academic papers. Use BiLSTM+CRF and transformer-based NER models for comparison.
4. Fine-tune a generative model (VAE, GPT-2, or diffusion-based text generator) for story or poetry generation. Compare human evaluation of creativity vs. coherence.
5. Design advanced prompts for an autonomous agent (using LangChain or AutoGPT) to perform multi-step reasoning tasks (e.g., trip planning, research assistant, code debugging). Test different strategies: zero-shot, few-shot, chain-of-thought, retrieval-augmented generation (RAG).

Mini Project - Advanced Data Analysis & Visualization (Any One)

1. Analyze a large, messy dataset (e.g., NYC Taxi data, or COVID-19 global cases) and Clean data: handle missing values, outliers, duplicates, Compute descriptive statistics and correlation matrices. Create multi-faceted visualizations: Heatmaps of correlations, Interactive scatter plots and line charts with Plotly. Faceted plots (e.g., by region/time).
2. Analyze a time series dataset (e.g., electricity consumption, stock prices): Decompose time series into trend, seasonality, residuals. Build forecasting models: ARIMA, ETS, or Prophet. Visualize components and forecast results. Create an interactive Shiny app to explore time series and forecasts.
3. Using retail or e-commerce transaction data: Perform RFM analysis to create customer value segments. Use Tableau to create dashboards with: Customer segmentation visuals (cluster maps, bar charts), Interactive filters for demographics and buying behavior, Trends and patterns analysis across segments.
4. Detect anomalies in sensor or network data: Use machine learning models (Isolation Forest, One-Class SVM). Visualize anomalies on time series charts with Matplotlib/Plotly. Create a report explaining detected anomalies and potential causes.
5. Create an interactive web-based visualization: Choose a dataset (e.g., world development indicators). Build dynamic charts (e.g., bubble charts, force-directed graphs). Add interaction:

tooltips, zoom, filter options. Publish as a mini-dashboard or storytelling page.

Learning Resources

Textbooks

1. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Publisher Prentice
2. Hall Edition 2nd Edition, 2018.
3. Manning, Christopher D., and Enrich Schütze , "Foundations of Statistical Natural Language Processing", Cambridge, MA: MIT Press, 1999, 978-0262133609
4. Lewis Tunstall, Leandro von Werra, Thomas Wolf (Hugging Face) "Natural Language Processing with Python."
5. González, R.C.; Woods, R.E. Digital image processing. 3rd ed, Harlow: Pearson Prentice Hall.2016, ISBN 9780131687288, July 2018.
6. Learning Spark: Lightning-Fast Big Data Analysis , Jules S. Damji, Brooke Wenig, Tathagata Das, Denny Lee, O'Reilly Media, 2nd Edition (Updated for Spark 3.x)
7. Big Data: Principles and Paradigms Rajkumar Buyya, Rodrigo N. Calheiros, Amir Vahid Dastjerdi, Morgan Kaufmann

Reference Books

1. Digital Image Processing and Computer Vision, R. J. Schalkoff, John Wiley & Sons Australia Edition, 2008.
2. Steven Bird, Ewan Klein, Edward Loper, "Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit", O'Reilly Publication .
3. Alexander Clark, Chris Fox, and Shalom Lappin, "The Handbook of Computational Linguistics an Natural Language Processing", Wiley Blackwell Publications .
4. Bryant, Randal E., and David Richard O'Hallaron. Computer systems: a programmer's perspective. Prentice Hall, 2011.
5. Saltzer, Jerome H., and M. Frans Kaashoek. Principles of computer system design: an introduction. Morgan Kaufmann, 2009.
6. David A. Forsyth and Jean Ponce: Computer vision: A modern approach, Prentice Hall, 2002.
7. Big Data Analytics with Spark: A Practitioner's Guide to Using Spark for Large Scale Data Analysis Mohammed Guller, Publisher: Apress.

Web Resources

1. https://www.datacamp.com/blog/what-is-computer-vision
2. Google AI Blog: http://research.google/blog/ - 2.
3. Hugging Face Blog: https://huggingface.co/blog - 3.
4. Papers with Code - Prompt Engineering: https://paperswithcode.com/task/prompt-engineering
5. https://intellipaat.com/blog/tutorial/spark-tutorial/
6. https://www.nxp.com/docs/en/preview/PREVIEW-EDGE-EBOOK.pdf
7. https://www.nxp.com/document/guide/essentials-of-edge-computing-ebook:EDGE-COMPUTING-EBOOK

Massive Open Online Courses (MOOCs)

1. https://www.coursera.org/learn/introduction-computer-vision-watson-opencv?utm_source=mobile&utm_source=link&utm_medium=page_share&utm_content=lih&utm_campaign=card_button
2. https://nptel.ac.in/courses/106101007
3. https://nptel.ac.in/courses/106106211

4. Apache Spark for Big Data Analytics and Data Processing | Udemy
5. https://www.coursera.org/learn/scala-spark-big-data

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
AIV ELC-CO-M15.1	2	3	3	2	2	2
AIVA- ELC-CO-M15.2	2	3	3	3	2	2
MIR- ELC-CO-M15.1	2	3	3	2	2	2
MIR- ELC-CO-M15.2	2	3	3	3	3	2
ANLP- ELC-CO-M15.1	2	3	3	2	2	2
ANLP- ELC-CO-M15.2	3	3	3	3	3	3
ANLP- ELC-CO-M15.3	2	3	3	3	2	2
ADAV- ELC-CO-M15.1	2	3	3	2	2	2
ADAV- ELC-CO-M15.2	2	3	3	2	2	2

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M.Tech. Computer Engineering Curriculum
With effect from A.Y. 2025-26

Seminar (CE-SLC-M01-16)

Teaching Scheme:	Credits:	Examination Scheme:
Practical: 04 Hrs/ Week	**02**	**Term work:** 50 Marks

Course Introduction :

The Seminar is designed to enhance the research aptitude, technical communication skills, and independent learning abilities of postgraduate students. It provides a platform for students to explore recent trends, emerging technologies, or specific problems within their domain of interest, and present their findings through structured reports and oral presentations. This course encourages critical thinking, peer learning, and academic discussion, fostering an environment of scholarly inquiry and professional growth.

Course Objectives:

- To enable students to explore and analyze current topics, research areas, or industrial advancements relevant to computer engineering.
- To develop effective technical writing and presentation skills for academic and professional communication.
- To encourage independent learning, literature review, and critical evaluation of scholarly articles and technology reports.

Course Outcomes:

By the end of this course, students will be able to:
SLC-CO-M16.1: Identify and investigate current trends or challenges in the field of computer engineering.
SLC-CO-M16.2: Critically review and synthesize relevant technical literature or case studies.
SLC-CO-M16.3: Deliver a well-structured seminar presentation supported by appropriate visual and written material.
SLC-CO-M16.4: Demonstrate improved communication, articulation, and questioning skills during academic discussions and Q&A sessions.

Guidelines

1. Topic Selection: Students must select a recent or emerging topic in the field of Computer Engineering (e.g., AI, Cybersecurity, Blockchain, Quantum Computing). The topic must be approved by the seminar coordinator or assigned faculty guide.
2. Supervisor Interaction: Students must consult their seminar guide weekly to discuss progress, obtain feedback, and plan next steps.
3. Literature Review: Students are expected to refer to reputed journals, conference papers, technical reports, and patents.
4. Documentation: A seminar report must be prepared following prescribed formatting guidelines (IEEE/ACM style preferred).
5. The report must include introduction, problem statement, literature survey, technical content, critical analysis, and references.

6. Presentation: Each student must deliver a presentation (~15 minutes), followed by a Q&A session. Visual aids (slides, videos, demos) must be clear and professionally designed.
7. Plagiarism Policy: Reports must be original and checked for plagiarism (as per institutional norms; typically <10%).

Suggested Seminar Activities

Week 1: Topic Identification
Week 2: Proposal Development
Week 3: Literature Review
Week 4: Planning the implementation phase
Week 5: Finalization of the literature review and research plan
Week 6: Submit literature review summary and outline of seminar content.
Week 7: Draft seminar report preparation. First internal review by guide.
Week 8: Report Preparation
Week 9: Finalization of seminar report and slides. Plagiarism check.
Week 10: Final seminar presentation and submission of report. Evaluation by review panel.

Deliverables

1. Seminar Topic Approval Form
2. Seminar Report
3. Plagiarism Check Report

Assessment

The student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordinator. The continuous assessment of the progress needs to be documented unambiguously. For standardization and documentation, follow the guidelines circulated / as in the seminar logbook approved by the department.

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
SLC-CO-M16.1	3	2	1	1	3	2
SLC-CO-M16.2	2	3	3	3	2	3
SLC-CO-M16.3	3	2	2	2	3	2
SLC-CO-M16.4	2	3	2	2	2	3

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Liberal Learning Course (CE-CEC-M01-17)

Teaching Scheme:	**Credits: 01**	**Examination Scheme:**
Tutorial: 01 Hr/Week		**Term work:** 25 Marks

Course Introduction:

This course is aimed at expanding the horizons of knowledge of students in a variety of areas beyond Engineering. It provides opportunities for students of Engineering to foray into areas of their interest, to contribute to their overall personality development.

Course Objectives:

To promote physical and mental well-being among students.
To foster self-expression, creativity, and collaboration through artistic activities.
To cultivate discipline, self-awareness, and a balanced lifestyle alongside rigorous academic pursuits.

Course Outcomes:

CEC-CO-M17.1: Demonstrate improved focus, stress management, and emotional resilience using mindfulness

CEC-CO-M17.2: Express ideas, emotions, and narratives through movement and performance, enhancing interpersonal and communication skills.

CEC-CO-M17.3: Integrate wellness routines into their daily lives, leading to better time management, self-regulation, and overall well-being.

Guidelines

- Students are expected to actively participate in sessions from one of the following domains: Yoga, Meditation, Dance, or Drama.
- These sessions will be facilitated by domain experts on or off campus and are conducted through a blend of activities, discussions, presentations, and lectures.
- Each domain includes a continuous evaluation process tailored to its specific nature, and assessment criteria may vary accordingly.
- While there is no fixed syllabus prescribed for the mentioned domains, instructors generally design and follow a structured outline to guide the sessions throughout the semester.

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
CEC-CO-M17.1	2	-	1	-	2	3
CEC-CO-M17.2	-	3	2	-	3	2
CEC-CO-M17.3	2	1	2	-	2	3

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Research Ethics and Values (CE-AEC-M01-18)

Teaching Scheme:	**Credits: 02**	**Examination Scheme:**
Tutorial: 02 Hrs/ Week		**Term work:** 25 Marks

Course Introduction :

This course provides a comprehensive understanding of ethical principles and values that underpin responsible research practices. It covers topics such as research integrity, authorship ethics, plagiarism, human and animal subject protection, data management, and intellectual property rights. Students will explore real-world ethical dilemmas and develop the ability to conduct and report research with accountability and professional integrity.

Course Objectives:

- To introduce fundamental ethical concepts and values essential in research practice.
- To enable students to recognize and analyze ethical issues across various stages of the research lifecycle.
- To promote responsible conduct of research through awareness of guidelines, policies, and professional standards.

Course Outcomes:

AEC-CO-M18.1: Identify key ethical principles and values governing research practices.
AEC-CO-M18.2: Recognize ethical issues related to data collection, authorship, peer review, and publication.
AEC-CO-M18.3: Evaluate real-world cases of research misconduct and propose ethically sound alternatives.
AEC-CO-M18.4: Demonstrate understanding of intellectual property rights and avoid plagiarism using standard tools.

Suggested List of Assignments / Activities

1. Analyze a real or hypothetical case involving research misconduct and present your ethical reasoning.
2. Summarize and compare ethical guidelines from organizations like UGC, IEEE, or Elsevier.
3. Use tools like Turnitin or Grammarly to evaluate sample content and reflect on findings.
4. Participate in a mock Institutional Ethics Committee to evaluate a research proposal.
5. Study a real-world case involving copyright or patent infringement in research and present your insights.
6. Write a personal reflection on your own values and ethical stance as a future researcher.
7. Prepare and deliver a presentation on informed consent and its challenges in digital research.
8. Ethics in AI/Data Science: Explore emerging ethical issues in AI or data-driven research.

CO PO Mapping

CO\PO	PO1	PO2	PO3	PSO1	PSO2	PSO3
AEC-CO-M18.1	2	2	1	1	1	2
AEC-CO-M18.2	3	3	2	1	2	3
AEC-CO-M18.3	3	3	2	2	2	3
AEC-CO-M18.4	2	3	2	2	3	3

PROGRAM EXIT (Post Graduate Diploma)

- Exit Course to be offered after the end of 1st year to the students opting for exit. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma
- Post graduate diploma will be awarded if a student completes 44 credits and wishes to exit after the first year of PG. A student will be allowed to enter/re-enter only at the odd semester and can only exit after the even semester.

Semester - II			Teaching Scheme (Hours/Week)				Credits					Examination / Evaluation Scheme and Marks				
Course Type	Course Code	Course Title	L	T	P	SS	L	T	P	SS	Total	CCE [50]	ESE [50]	TW	PR / OR	Total
SLC	CE-SLC-MPX-01	Program Exit Course	0	0	0	4	0	0	0	4	4	-	-	-	50	50
ELC	CE- ELC-MPX-02	Project	0	0	8	0	0	0	4	0	4	-	-	-	50	50
Total			12				08					0	0	0	100	100

Program Exit Courses	
PG Diploma in Artificial Intelligence & Machine Learning	**Affective Computing-** By Prof. Jainendra Shukla, Prof. Abhinav Dhal, IIIT Delhi https://nptel.ac.in/courses/106106244
	Deep Learning -By Prof. P.K. Biswas, IIT Kharagpur https://nptel.ac.in/courses/106105215
	Responsible & Safe AI Systems -By Prof. Ponnurangam Kumaraguru, Prof. Balaraman Ravindran, Prof. Arun Rajkumar, IIIT Hyderabad, IIT Madras https://onlinecourses.nptel.ac.in/noc25_cs118/preview
	Reinforcement Learning - By Prof. Balaraman Ravindran, IIT Madras https://onlinecourses.nptel.ac.in/noc25_cs92/preview
PG Diploma in Data Engineering	**Scalable Data Science-** By Prof. Anirban Dasgupta, Prof. Sourangshu Bhattacharya, IIT Gadhinagar, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc25_cs160/preview
	Data Analysis & Decision Making – III - By Prof. Raghunandan Sengupta, IIT Kanpur https://nptel.ac.in/courses/110104125
	Business Intelligence & Analytics – By Prof. Saji K Mathew, IIT Madras https://nptel.ac.in/courses/106106361