DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

SCHEME FOR

MASTER OF TECHNOLOGY (M. Tech)

COMPUTER SCIENCE & ENGINEERING

(Artificial Intelligence & Machine Learning)

(1_{st} to 4_{th} Semester)

Graduation Batch: 2026-2028

Dayananda Sagar University
APPROVED COPY

SCHEME - M. TECH – 2026-28

I SEM – CSE (ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

SL.NO	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PCC	26AM5101	Mathematics for Machine Learning	3	1	0	0	60	40	100	04
2	IPCC	26AM5102	Advanced Networking & Security	3	0	2	0	60	40	100	04
3	IPCC	26AM5103	Advanced Machine Learning	2	0	2	2	60	40	100	04
4	IPCC	26AM5104	Advanced Algorithms	3	0	2	0	60	40	100	04
5	PCC	26AM5105	Responsible AI	3	0	0	0	60	40	100	03
6	PCC	26AM5106	Research Methodology & IPR	3	0	0	0	100	--	100	03
7	PrSI	26AM5107	Seminar-I	0	0	0	4	100	--	100	02
			Total	17	01	06	06				24

IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, PrSI- Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J –Project, C – No. Of Credits

DAYANANDA SAGAR UNIVERSITY Harohalli 562 112

II SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	IPCC	26AM5201	Image Processing and Computer Vision	3	0	2	-	60	40	100	04
2	IPCC	26AM5202	Deep Learning	2	0	2	2	60	40	100	04
3	IPCC	26AM5203	Generative-AI	3	0	2	-	60	40	100	04
4	IPCC	26AM5204	MLOPS for Enterprises	3	0	2	-	60	40	100	04
5	PEC	26AM52XX	Professional Elective-I*	2	0	0	2	100	--	100	03
6	PEC	26AM52XX	Professional Elective-II*	2	0	0	2	100	--	100	03
7	PrSI	26AM5205	Seminar-II	-	-	-	4	100	--	100	02
			Total	15	00	08	10				24

IPCC-Integrated Professional Core Course, PEC-Professional Elective Courses, PrSI- Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J– Project, C – No. Of Credits

*indicates students need to carry out a mini project in the subject.

DEVANGA SAGAR UNIVERSITY Harohalli 562 112

Professional Elective Courses –I (PEC-I) Domain											
Sl.No	Course Type	Course Code	Course Name	Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PEC	26AM5206	Natural Language Models	2	0	0	2	100	--	100	03
2	PEC	26AM5207	Large Language Models	2	0	0	2	100	--	100	03
3	PEC	26AM5208	Social Media Analytics	2	0	0	2	100	--	100	03
4	PEC	26AM5209	Text and Speech Generation using Advanced Models	2	0	0	2	100	--	100	03
5	PEC	26AM5210	Computational Models	2	0	0	2	100	--	100	03
6	PEC	26AM5211	Cognitive Linguistics	2	0	0	2	100	--	100	03

Professional Elective Courses –II (PEC-II) Domain											
Sl. No	Course Type	Course Code	Course Name	Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PEC	26AM5212	Accelerated Computing	2	0	0	2	100	--	100	**03**
2	PEC	26AM5213	Multi-Agent AI Systems	2	0	0	2	100	--	100	**03**
3	PEC	26AM5214	Visual Computing and Graphics	2	0	0	2	100	--	100	**03**
4	PEC	26AM5215	Robot Operating Systems (ROS)	2	0	0	2	100	--	100	**03**
5	PEC	26AM5216	AI for Autonomous Vehicles & Smart Mobility	2	0	0	2	100	--	100	**03**
6	PEC	26AM5217	Conversational AI and Spoken Language Understanding	2	0	0	2	100	--	100	**03**

KAVIKULAGURU KALIDASA SAGAR UNIVERSITY Harohalli 562 112

III SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Sl.No	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PrSI	26AM6301	Capstone Project-I	-	-	-	12	60	40	100	06
2	PEC	26AM63XX	Professional Elective-III*	3	0	0	2	100	--	100	04
3	PEC	26AM63XX	Professional Elective-IV*	3	0	0	2	100	--	100	04
			Total	6	0	0	16				14

PrSI-Project Seminar and Internship, PEC-Professional Elective Courses, L – Lecture, T – Tutorial, P – Practical, J-Project, C – No. of Credits

*indicates students need to carry out a mini project in the subject.



Professional Elective Courses –III (PEC-III) Domain											
Sl. No	Course Type	Course Code	Course Name	Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PEC	26AM6302	Edge AI and Robotics	3	0	0	2	100	--	100	04
2	PEC	26AM6303	Autonomous Planning and Reasoning Agents	3	0	0	2	100	--	100	04
3	PEC	26AM6304	Intelligent Computational Imaging and Reconstruction	3	0	0	2	100	--	100	04
4	PEC	26AM6305	Autonomous Robotic Systems	3	0	0	2	100	--	100	04
5	PEC	26AM6306	AI for Agriculture	3	0	0	2	100	--	100	04
6	PEC	26AM6307	Building AI Applications with Large Language Models	3	0	0	2	100	--	100	04

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Professional Elective Courses –IV (PEC-IV) Domain											
Sl. No	Course Type	Course Code	Course Name	Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PEC	26AM6308	Deep Learning for Science and Engineering	3	0	0	2	100	--	100	04
2	PEC	26AM6309	Ethics, Safety & Governance of Agentic AI	3	0	0	2	100	--	100	04
3	PEC	26AM6310	Intelligent Video Surveillance Systems	3	0	0	2	100	--	100	04
4	PEC	26AM6311	Foundation Models for Robotics	3	0	0	2	100	--	100	04
5	PEC	26AM6312	Blockchain for Data Security	3	0	0	2	100	--	100	04
6	PEC	26AM6313	Multi modal and Multi lingual Language Perception	3	0	0	2	100	--	100	04

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IV SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PrSI	26AM6401	Capstone Project-II	-	-	-	28	60	40	100	14
2	PrSI	26AM6402	Industry/Research Internship	-	-	-	8	100	-	100	04
			Total	-	-	-	36				**18**

PrSI-Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J – Project, C – No. Of Credits



DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING



SCHEME & SYLLABUS FOR

MASTER OF TECHNOLOGY (M. Tech)

COMPUTER SCIENCE & ENGINEERING

(Artificial Intelligence & Machine Learning)

(1st to 4th Semester)

Graduation Batch: 2026-2028

SCHEME - M. TECH – 2026-28

I SEM – CSE (ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

SL.NO	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PCC	26AM5101	Mathematics for Machine Learning	3	1	0	0	60	40	100	04
2	IPCC	26AM5102	Advanced Networking & Security	3	0	2	0	60	40	100	04
3	IPCC	26AM5103	Advanced Machine Learning	2	0	2	2	60	40	100	04
4	IPCC	26AM5104	Advanced Algorithms	3	0	2	0	60	40	100	04
5	PCC	26AM5105	Responsible AI	3	0	0	0	60	40	100	03
6	PCC	26AM5106	Research Methodology & IPR	3	0	0	0	100	--	100	03
7	PrSI	26AM5107	Seminar-I	0	0	0	4	100	--	100	02
			Total	17	01	06	06				24

IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, PrSI- Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J –Project, C – No. Of Credits

MATHEMATICS FOR MACHINE LEARNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	: 26AM5101	**Credits**:	4
Hours/Week	: 04 Hours	**Total Hours**:	60 Hours
L–T–P-J	: 3–1–0-0	**CIA+SEE:**	60+40

Prerequisites:

- Basic calculus and linear algebra
- Programming (Python preferred)
- Basic probability concepts

Course Learning Objectives:

This course will enable students to:

1. Master linear algebra concepts including vector spaces, matrix decompositions, and eigen analysis for ML applications.
2. Apply calculus, gradients, and optimization techniques for training machine learning models.
3. Understand probability, distributions, and statistical inference for probabilistic modeling.
4. Derive and implement key ML algorithms from mathematical foundations.
5. Develop computational proficiency through Python/MATLAB implementations.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
2. ***Interactive Teaching***: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	13 Hours
LINEAR ALGEBRA FUNDAMENTALS: Systems of linear equations and Gaussian elimination; Vector spaces, linear independence, basis, rank, and norms; Inner products, orthogonality, and projections; Matrix operations, determinants, trace, and inverse; Linear transformations and their representations; Eigenvalues, eigenvectors, and diagonalization; Spectral theorem for symmetric matrices.	
UNIT – II	**12 Hours**
MATRIX DECOMPOSITIONS: LU decomposition; QR decomposition and Gram-Schmidt process; Cholesky decomposition; Singular Value Decomposition (SVD): theory and computation; Low-rank approximation and matrix reconstruction; Applications: dimensionality reduction, image compression, recommender systems.	
UNIT – III	**12 Hours**
CALCULUS AND OPTIMIZATION: Partial derivatives, gradients, and directional derivatives; Jacobian and Hessian matrices; Chain rule and automatic differentiation (forward/backward mode); Taylor series for multivariate functions; Gradient descent and variants (SGD, momentum); Newton's method and quasi-Newton methods; Convex functions, convex sets, and optimality conditions; Constrained optimization: Lagrange multipliers and KKT conditions.	
UNIT – IV	**11 Hours**
PROBABILITY AND STATISTICS: Probability axioms, conditional probability, and Bayes' theorem; Random variables: discrete and continuous; Common distributions: Bernoulli, Gaussian, Exponential, Multinomial; Joint, marginal, and conditional distributions; Expectation, variance, covariance, and correlation; Maximum Likelihood Estimation (MLE); Maximum A Posteriori (MAP) estimation; Change of variables technique.	
UNIT – V	**12 Hours**
ML ALGORITHMS AND MATHEMATICAL FOUNDATIONS: **Ordinary least squares:** Closed-form solution, Probabilistic interpretation and MLE, Regularization: Ridge (L2) and Lasso (L1); Gradient descent for regression **Principal Component Analysis (PCA)**: maximum variance and projection perspectives, Eigen decomposition approach to PCA **Density Estimation**: Gaussian Mixture Models (GMMs), Expectation-Maximization (EM) algorithm **Classification**: Support Vector Machines (SVM): margin maximization, Kernel methods and the kernel trick, Dual formulation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Apply linear algebra and matrix decompositions to analyze data in ML contexts	L3
2	Implement optimization algorithms using calculus and automatic differentiation for model training	L3
3	Apply probability theory and statistical inference for probabilistic modeling and decision-making	L3
4	Derive core ML algorithms (regression, PCA, GMM, SVM) from mathematical principles	L4
5	Implement mathematical concepts computationally using Python/MATLAB	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	2	1	2	-	-	-	1	-	-	3	2
CO2	3	3	3	2	3	-	-	-	1	-	-	3	3
CO3	3	3	2	2	2	-	-	-	1	-	-	3	2
CO4	3	3	3	3	3	-	-	-	2	-	-	3	3
CO5	3	2	3	2	3	-	-	-	2	-	-	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, *"Mathematics for Machine Learning"*, Cambridge University Press, 2020.
2. Gilbert Strang, *"Linear Algebra and Learning from Data"*, Wellesley-Cambridge Press, 2019.
3. Stephen Boyd and Lieven Vandenberghe, *"Introduction to Applied Linear Algebra"*, Cambridge University Press, 2018.

REFERENCE BOOKS:

1. Christopher M. Bishop, *"Pattern Recognition and Machine Learning"*, Springer, 2006.
2. Stephen Boyd and Lieven Vandenberghe, *"Convex Optimization"*, Cambridge University Press, 2004.
3. Sheldon M. Ross, *"A First Course in Probability"*, 9th Edition, Pearson, 2014.
4. Gilbert Strang, *"Introduction to Linear Algebra"*, 5th Edition, Wellesley-Cambridge Press, 2016.

E-Resources:

1. Mathematics for Machine Learning book website: https://mml-book.com
2. MIT OpenCourseWare - Linear Algebra (Prof. Gilbert Strang)
3. Imperial College London - Mathematics for Machine Learning (Coursera)
4. 3Blue1Brown - Essence of Linear Algebra (YouTube)
5. Stanford CS229 - Machine Learning Math Review

ADVANCED NETWORKING AND SECURITY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	:	26AM5102	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	75 Hours
L–T–P-J	:	3-0-2-0	**CIA+SEE**	:	60+40

Prerequisites:

Proficiency in C programming language.

Course Objectives:

This course will enable students to:

1. To understand the fundamental principles of computer networks and analyze the design and functionality of application layer protocols including HTTP, DNS, SMTP, and modern content delivery mechanisms.
2. To examine transport layer protocols, congestion control mechanisms, and their role in supporting reliable data transfer and multimedia applications.
3. To analyze network layer operations including IP addressing, routing protocols (OSPF, BGP), and the evolution to software-defined networking architectures.
4. To investigate link layer technologies, error detection mechanisms, and the architecture of wireless and mobile networks including WiFi and cellular systems.
5. To critically assess modern network security frameworks including Zero Trust Architecture, cloud security, and security challenges in emerging network paradigms.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
2. ***Interactive Teaching***: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.

7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

NETWORK FUNDAMENTALS AND APPLICATION LAYER:

Computer Networks and the Internet – Network Edge and Core – Packet and Circuit Switching – Delay, Loss, Throughput – Protocol Layers and Service Models – Encapsulation – Application Layer Principles – Web and HTTP (HTTP/1.1, HTTP/2, HTTP/3) – Cookies and Web Caching – Electronic Mail (SMTP, POP3, IMAP) – DNS and DNSSEC – Peer-to-Peer Applications – Video Streaming and CDNs (DASH, Netflix, YouTube) – Socket Programming with UDP and TCP

UNIT – II	**09 Hours**

TRANSPORT LAYER AND MULTIMEDIA NETWORKING:

Transport Layer Overview – UDP Protocol – TCP: Segment Structure, Connection Management, Flow Control, RTT Estimation – TCP Congestion Control (Slow Start, Congestion Avoidance, Fast Retransmit, Fast Recovery) – ECN – Multimedia Networking: Properties of Video and Audio – Streaming Stored Video – Voice-over-IP – RTP and RTCP – SIP – QoS: Diffserv and IntServ

UNIT – III	**09 Hours**

NETWORK LAYER:

Router Architecture (Input/Output Processing, Switching, Queuing Basics) – IPv4: Datagram Format, Fragmentation, Addressing, Subnetting, CIDR, NAT – IPv6: Features and Datagram Format – Routing Algorithms: Link-State (OSPF) and Distance-Vector Basics – OSPF: Hierarchical Structure – BGP: Role, Route Advertisement, Path Attributes, Route Selection – SDN: Match-plus-Action, OpenFlow, Controller Concepts – ICMP Overview

UNIT – IV	**09 Hours**

LINK LAYER, WIRELESS, AND MOBILE NETWORKS:

Link Layer Services – Error Detection and Correction (Parity, Checksum, CRC) – Multiple Access Protocols (Channel Partitioning, Random Access, CSMA, CSMA/CD, CSMA/CA) –

Ethernet and Switches – ARP – VLANs – MPLS – Data Center Networking: Topologies, Fat-Tree, Load Balancing – Wireless Links and Characteristics – WiFi: 802.11 Architecture, MAC Protocol, CSMA/CA, Frame Format, Mobility Support – Bluetooth and Zigbee – Cellular Networks: 2G to 5G Architecture, LTE, 5G Core and RAN – Mobility Management: Mobile IP, Handoffs – Impact of Wireless on Higher-Layer Protocols

UNIT – V	**09 Hours**

ADVANCED NETWORK SECURITY:

Zero Trust Architecture and Software-Defined Perimeter – Secure Access Service Edge (SASE) – Cloud Security and CASB – Network Function Virtualization (NFV) Security and Service Function Chaining – SD-WAN Architecture and Security – Infrastructure Security: Device Hardening, Security Baselines, Secure Topology – 5G Security Architecture – IoT Security Protocols and Threats – AI/ML for Network Anomaly Detection and Threat Hunting – Blockchain for Network Security and Identity Management – Post-Quantum Cryptography Overview – Cyber Deception and Honeynets – Network Security Automation – Threat Intelligence and Supply Chain Security

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Analyze application layer protocols and implement client-server communication using socket programming.	L4
2	Evaluate TCP congestion control algorithms and analyze QoS mechanisms for multimedia streaming.	L5
3	Compare routing protocols and demonstrate understanding of SDN and OpenFlow concepts.	L4
4	Analyze link layer protocols and examine mobility management in wireless networks.	L4
5	Evaluate contemporary security architectures and design solutions for IoT, SD-WAN, and 5G networks.	L5

Table: Mapping Levels of COs to POs / PSOs													
COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	2	2	1	-	-	-	-	-	-	3	2
CO2	2	3	2	2	-	-	-	-	-	-	-	3	3
CO3	2	2	3	2	3	-	-	-	-	-	-	3	2
CO4	2	2	3	3	3	-	-	-	2	-	-	3	3
CO5	2	3	3	3	2	1	-	-	2	2	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. James F. Kurose & Keith W. Ross, Computer Networking: A Top-Down Approach, 7/E. Pearson Education India, 2017.
2. Sabu M. Thampi, Tony Thomas, Preetam Mukherjee," Securing the connected world: Exploring emerging Threats and Innovative solutions", Springer Nature Switzerland,1st Edition 2025.

REFERENCE BOOKS:

1. Goransson, P., Black, C., & Culver, T. Software defined networks: a comprehensive approach. Morgan Kaufmann,2016.
2. ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach, Universities Press, 2015.

LABORATORY EXPERIMENTS

1. Analysis of Application Layer Protocols (HTTP, DNS, SMTP) using Packet Sniffing Tools.
2. Design and Deployment of RESTful APIs with Secure Communication (HTTPS & TLS).
3. Performance Evaluation of TCP Variants (Tahoe, Reno, Cubic) using Network Simulators (NS3/Mininet).
4. Implementation of Congestion Control Mechanisms and Throughput Analysis.
5. Simulation of Multimedia Streaming over UDP and QoS Evaluation (Latency, Jitter, Packet Loss).
6. Implementation and Analysis of Routing Algorithms (Dijkstra, Distance Vector) in Simulated Networks.
7. Software-Defined Networking (SDN) based Routing using Mininet and OpenFlow Controller.

8. Performance Analysis of Error Detection and Correction Techniques (CRC, Hamming Code).
9. MAC Protocol Simulation and Collision Analysis (CSMA/CD, CSMA/CA).
10. Simulation of Wireless Network Performance (Wi-Fi vs LTE/5G) using NS3.
11. Mobility Management and Handover Analysis in Mobile Networks.
12. Implementation of Zero Trust Architecture using Software-Defined Perimeter (SDP) Concepts.
13. AI/ML-Based Network Intrusion Detection System (IDS) for Anomaly Detection.

ADVANCED MACHINE LEARNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	:	26AM5103	**Credits**	:	4
Hours/Week	:	06 Hours	**Total Hours**	:	90 Hours
L–T–P-J	:	2-0-2-2	**CIA+SEE**	:	60+40

Prerequisites:

Familiarity with basics in linear algebra, probability, and analysis of algorithms.

Course Objectives:

After completing this course, students will be able to:

1. Apply supervised and unsupervised learning algorithms such as Naive Bayes, KNN, SVM, PCA, LDA, and clustering techniques to real-world datasets.
2. Interpret learning theory concepts including hypothesis spaces, estimators, and loss functions.
3. Analyse optimization, regularization, and learning dynamics in deep neural networks.
4. Analyze various regularization techniques such as L1, L2, dropout, and sparse representations for improving model performance.
5. Evaluate optimization challenges such as vanishing/exploding gradients and convergence behavior in deep learning models.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

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2. ***Interactive Teaching***: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
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7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.

8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**06 Hours**
INTRODUCTION TO MACHINE LEARNING: Foundations of machine learning – Training, Validation and Testing, Problem of Overfitting & Underfitting, Bias vs Variance, supervised learning – Naive Bayes, Bayesian Belief Network, K-Nearest Neighbor, Support vector machines, Unsupervised Learning- Dimensionality Reduction Techniques, Principal component analysis, Linear Discriminant Analysis Clustering: K-means, Hierarchical, Spectral, subspace clustering	
UNIT – II	**06 Hours**
LEARNING THEORY & FOUNDATIONS: Introduction to advanced machine learning paradigms, learning problems and hypothesis spaces, Capacity, bias–variance trade-off, Overfitting and underfitting, Estimators and loss functions, Maximum Likelihood Estimation (MLE), Empirical Risk Minimization (ERM), Stochastic Gradient Descent (SGD), Generalization concepts	
UNIT – III	**06 Hours**
DEEP FEEDFORWARD NETWORKS & BACKPROPAGATION: Review of Artificial Neural Networks, Deep feedforward networks, Learning XOR problem, Hidden units and representation learning, Network architecture design principles, Backpropagation algorithm (derivation & intuition), Loss functions and activation functions, training deep networks using SGD	
UNIT – IV	**06 Hours**
REGULARIZATION, ROBUSTNESS & REPRESENTATION: Regularization techniques, L1 and L2 regularization, Noise robustness, Semi-supervised learning, Parameter tying and sharing, Sparse representations, Dropout and ensemble regularization, Stability and generalization	
UNIT – V	**06 Hours**

OPTIMIZATION FOR NEURAL NETWORKS:

Optimization challenges in neural networks, Vanishing and exploding gradients, Parameter initialization strategies, Adaptive learning rate methods, Optimization algorithms: Momentum, RMSProp, Adam, Convergence behavior

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the theoretical foundations, learning paradigms, and generalization principles of advanced machine learning models.	L2
2	Apply deep learning architectures and learning algorithms to solve complex classification and regression problems.	L3
3	Analyze optimization techniques, regularization strategies, and training dynamics in deep neural networks.	L4
4	Analyze convolutional and recurrent neural network architectures for structured and sequential data applications.	L4
5	Evaluate the advanced machine learning models using theoretical bounds, performance metrics and experimental validation	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	2	1	2	-	-	-	1	-	1	2	-
CO2	2	3	2	-	2	-	-	2	2	-	-	2	2
CO3	-	2	3	2	-	2	-	3	3	-	2	3	2
CO4	2	2	3	-	3	-	-	3	-	-	2	2	3
CO5	-	2	3	-	2	2	-	3	-	-	3	3	2

3: Substantial (High) 2: Moderate (Medium) 1: Poor (Low)

TEXTBOOKS (TB):

1. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, *Foundations of Machine Learning*, MIT Press, 2018.
2. Shai Shalev-Shwartz, Shai Ben-David, *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press, 2014.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville,*Deep Learning*, MIT Press, 2016.

REFERENCE BOOKS:

1. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements of Statistical Learning*, Springer, 2009.
3. Richard S. Sutton, Andrew G. Barto, *Reinforcement Learning: An Introduction*, MIT Press, 2018.

E-Resources:

1. https://youtu.be/TIFFfLejkcA?si=HTvJqMYoWHntgYRK
2. https://youtu.be/AASR9rOzhhA?si=o9eY9DXkczUV_FgU
3. https://youtu.be/lg4OLAjxRcQ?si=D12r6GBPJ028CpO9

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis
2. Group discussions
3. Project / seminar
4. Paper Reading & Technical Discussion

Lab experiments

1. Implement and analyze Support Vector Machine classifiers using different kernel functions such as linear, polynomial and RBF and evaluate their performance on a real-world dataset.
2. Develop a program to implement Principal Component Analysis (PCA) for reducing the dimensionality of the Iris dataset from 4 features to 2.
3. Develop a program to demonstrate the working of the decision tree algorithm. Use Breast Cancer Data set for building the decision tree and apply this knowledge to classify a new sample.
4. Develop a program to implement k-means clustering using Wisconsin Breast Cancer data set and visualize the clustering result.
5. Implement KNN classification and analyze the effect of different values of K on model performance
6. Develop a program to create histograms for all numerical features and analyze the

distribution of each feature. Generate box plots for all numerical features and identify any outliers. (Use California Housing dataset)

7. Develop a program to implement the Naive Bayesian classifier considering Olivetti Face Data set for training. Compute the accuracy of the classifier, considering a few test data sets.
8. Write a program to implement the Overfitting and Underfitting Using Polynomial Regression by generating synthetic data.
9. Write a program to perform an empirical analysis of the Bias–Variance Trade-off Using Bootstrap Sampling on synthetic data.
10. Write a program for deriving and implementing Maximum Likelihood Estimation for Statistical Distributions and Regression Models.
11. Write a program to implement a Feedforward Neural Network with Backpropagation to Solve the XOR Problem.
12. Write a program for comparative analysis of L1, L2 Regularization and Dropout for Controlling Overfitting.
13. Write a program for investigating Vanishing/Exploding Gradients problem.

ADVANCED ALGORITHMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	:	26AM5104	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	75 Hours
L–T–P-J	:	3-0-2-0	**CIA+SEE**	:	60+40

Prerequisites:

Proficiency in a C programming language.

Course Objectives:

This course will enable students to:

1. Understand the advanced methods of designing and analyzing algorithms
2. Apply various algorithm design techniques for solving problems
3. Ability to choose appropriate algorithms and use it for a specific problem
4. To introduce methods for coping with NP-hard problems.
5. Introduce the students to recent developments in the area of algorithmic design

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
2. ***Interactive Teaching***: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**09 Hours**

INTRODUCTION, SORTING, TREES AND GRAPHS:

Asymptotic notations, time complexity, space complexity, Review of various sorting algorithms, topological sorting, Trees and its representation-avl tree- red-black tree, Graph algorithms – graph traversal, single- source shortest paths, all pairs shortest paths, depth first search, breadth first search and their applications.

UNIT – II	**09 Hours**

MATROIDS:

Matroids: A Generic Optimization Problem, Motivating the Definition, Examples of Matroids, Scheduling with Deadlines.

Graph Matching: Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.

UNIT – III	**09 Hours**

FLOW NETWORKS, DYNAMIC PROGRAMMING:

Maximum Flows: Flows, Cuts, Maxflow-Mincut, Augmenting Paths, Bipartite Matchings, Other Settings

Dynamic Programming: Dynamic Programming: Longest Increasing Subsequence, Edit Distance, Subset Sum, Optimal BSTs.

UNIT – IV	**09 Hours**

APPROXIMATION ALGORITHMS, EXACT ALGORITHMS:

Approximation Algorithms: Introduction to Approximation Frameworks, Vertex Cover via Maximal Matchings, Vertex Cover via LP rounding, TSP, Set Cover

Exact Algorithms – Branch and Bound, An Inclusion-Exclusion approach to Hamiltonian Path, Local Search.

UNIT – V	**09 Hours**

LINEAR PROGRAMMING, NP-COMPLETENESS:

Linear Programming: Geometry of the feasibility region and Simplex algorithm,

NP-completeness: Examples, proof of NP-hardness and NP-completeness.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the complexity/performance of different algorithms.	L4
2	Categorize the different problems in various classes according to their complexity.	L4
3	Determine the appropriate data structure for solving a particular set of problems	L3
4	Use effectively the various algorithms for applications involving probability and statistics in computing	L3
5	Design and build solutions for a real-world problem by applying relevant distributions	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	1	-	-	2	-	-	1	2	1	2	2	1
CO2	3	3	2	2	3	-	-	2	3	2	3	3	2
CO3	2	3	3	3	3	-	-	2	3	3	2	3	3
CO4	2	2	3	3	3	1	-	2	2	3	2	3	2
CO5	1	2	2	3	3	2	1	3	2	2	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. David P. Williamson and David B. Shmoys, The Design of Approximation Algorithms, Cambridge university press, 2011.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.

REFERENCE BOOKS:

1. Alfred V. Aho, John Hopcroft, "The Design and Analysis of Computer Algorithms", Pearson Education India, 1974.

2. Jon Kleinberg and Eva Tardos, "Algorithm Design", Pearson Education India, 2006.
3. R. K. Ahuja, T. L. Magnanti and J. B. Orlin, “Network flows: Theory, Algorithms, and Applications”, Prentice Hall Englewood Cliffs, NJ, 1994.

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Demonstration of solution to a problem through programming.
3. Flip class activity

LABORATORY EXPERIMENTS

1. Implementation and Comparative Analysis of Basic Sorting Algorithms (Bubble, Selection, and Insertion Sort).
2. Implementation and Performance Evaluation of Advanced Sorting Techniques (Shell Sort and Heap Sort).
3. Implementation of Non-Comparison Sorting Algorithm: Radix Sort with Complexity Analysis.
4. Implementation and Performance Comparison of Linear Search and Binary Search Techniques.
5. Implementation and Comparative Study of Divide and Conquer Sorting Algorithms (Merge Sort and Quick Sort).
6. Implementation of Optimal Binary Search Tree (OBST) using Dynamic Programming.
7. Computation of Binomial Coefficients using Dynamic Programming and Memoisation Techniques.
8. Implementation of Greedy Strategy for Fractional Knapsack Problem with Performance Analysis.
9. Implementation of Huffman Coding for Data Compression and Efficiency Evaluation.
10. Implementation of Single Source Shortest Path using Dijkstra’s Algorithm.
11. Implementation of All-Pairs Shortest Path using Floyd–Warshall Algorithm.
12. Implementation and Comparative Analysis of Minimum Spanning Tree Algorithms (Kruskal’s and Prim’s Algorithms).
13. Implementation and Performance Comparison of String Matching Algorithms (Naïve and Knuth–Morris–Pratt).

RESPONSIBLE AI

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	:	26AM5105	**Credits**	:	3
Hours/Week	:	03 Hours	**Total Hours**	:	45 Hours
L–T–P-J	:	3-0-0-0	**CIA+SEE**	:	60+40

Prerequisites:

- Intro to AI/ML (classification, regression, basic DL)
- Probability & Statistics; basic optimization.

Course Objectives:

The course will enable students to:

1. To develop a deep understanding of ethical theories, Responsible AI principles, and societal impacts relevant to advanced AI & ML systems.
2. To enable students to identify, quantify, and mitigate bias, unfairness, and discrimination in data and models using formal metrics and toolkits.
3. To train students to design AI systems that are transparent and explainable, and to critically evaluate the quality and limitations of explanation methods.
4. To build competency in addressing privacy, security, robustness, and safety risks in AI pipelines through appropriate technical and governance mechanisms.
5. To prepare students to align AI solutions with legal, regulatory, and organizational frameworks and to document and deploy end to end Responsible AI systems in real world domains.

Teaching-Learning Process (General Instructions)

1. Interactive lectures and short case discussions to introduce core ethical concepts, regulations, and Responsible AI principles, linked to current real world AI deployments.
2. Hands on sessions using toolkits (AIF360, Fairlearn, SHAP/LIME, DP libraries) where students audit, debug, and improve real ML models for fairness, explainability, privacy, and robustness.
3. Weekly reading seminars on benchmark papers, guidelines, and standards (EU AI Act, NIST AI RMF, IEEE, OECD) with student led presentations and critical reflection notes.
4. Structured group activities—debates, role plays, and stakeholder mapping exercises—to explore societal, legal, and policy tensions around AI in domains such as healthcare, finance, governance, and labour.
5. A semester long mini project where student teams design and implement an end-to-end AI/ML system embedding Responsible AI practices, culminating in a demo, technical report, and model card/risk assessment.

UNIT – I	**08 Hours**

FOUNDATIONS OF AI ETHICS & RESPONSIBLE AI:

Historical evolution of AI and key ethical questions (autonomy vs. control, agency vs. intelligence); Normative ethics for AI: consequentialism, deontology, virtue ethics, care ethics; how they inform AI decision making; Responsible AI principles: fairness, accountability, transparency, privacy, robustness, safety, human centred design; Global AI ethics guidelines (OECD, UNESCO, EU High Level Expert Group, NIST AI RMF, industry principles).

TB1: Ch1, Ch2

UNIT – II	**10 Hours**

FAIRNESS, BIAS, AND NON-DISCRIMINATION:

Sources of bias: historical bias, measurement bias, sampling bias, label bias, feedback loops, Group vs. individual fairness; formal metrics: statistical parity, disparate impact, equalized odds, equal opportunity, calibration, Fairness in supervised learning: classification vs. ranking; tradeoffs between fairness and accuracy, Bias mitigation techniques: Pre-processing: reweighing, disparate impact remover, representation learning, In processing: adversarial debiasing, fairness constraints and Post processing: threshold adjustment, reject option classification.

TB2: Ch4

UNIT – III	**09 Hours**

TRANSPARENCY, EXPLAINABILITY, AND ACCOUNTABILITY:

Opacity of black box models: epistemic opacity, algorithmic accountability, right to explanation, Intrinsic interpretability: linear models, decision trees, rule lists, GAMs; Post hoc explanations: feature importance, partial dependence plots, SHAP, LIME, counterfactuals; human-centred XAI: cognitive aspects, explanation usefulness, pitfalls of explanations; Documentation: model cards, datasheets for datasets, accountability frameworks.

TB1: Ch3, Ch5

UNIT – IV	**09 Hours**

PRIVACY, SECURITY, AND ROBUSTNESS IN AI SYSTEMS:

Privacy threats in AI: membership inference, model inversion, linkage attacks; overview of India's DPDP Act, GDPR constraints; Privacy preserving ML: anonymization limits; federated learning, differential privacy, secure aggregation; Adversarial examples and robustness: evasion attacks, poisoning attacks; defense strategies (adversarial training, certified

robustness); Safety and reliability: distribution shift, out of distribution detection, monitoring and incident response for AI services. TB2: Ch3, Ch7; TB1: Ch5, Ch6

UNIT – V	**09 Hours**
GOVERNANCE, LAW, AND POLICY FOR AI: Overview of AI governance: organizational processes, risk registers, RAI boards, ethics review; Legal frameworks: EU AI Act categories (unacceptable, high risk, limited risk systems), NIST AI Risk Management Framework, India specific context: DPDP Act, sectoral guidelines (RBI, health, telecom), Liability and accountability: product liability, negligence, human in the loop requirements, auditability, Standards: ISO/IEC AI standards, IEEE Ethically Aligned Design. TB2: Ch3; TB3: Ch6	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	**Explain** major ethical theories and Responsible AI principles and relate them to AI design and deployment decisions.	L2
2	**Identify**, measure, and mitigate bias, unfairness, and discrimination in datasets and ML models using quantitative metrics and toolkits.	L3
3	**Design** interpretable and explainable AI models and critically evaluate post-hoc explanation methods.	L5
4	**Analyze** privacy, security, robustness, and safety concerns in AI systems and apply appropriate technical safeguards (e.g., DP, FL, adversarial robustness).	L4
5	**Evaluate** AI systems against relevant legal and governance frameworks, and draft Responsible AI documentation such as model cards and risk assessments.	L5

Table: Mapping Levels of COs to POs / PSOs													
COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	1	-	2	1	3	1	1	-	2	2
CO2	2	3	2	-	-	2	1	2	-	-	-	2	3
CO3	2	2	3	2	2	-	-	2	-	-	-	2	2
CO4	3	3	3	2	3	3	2	3	1	1	-	2	2
CO5	2	2	2	2	2	3	2	3	1	3	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Mark Coeckelbergh, *AI Ethics*, MIT Press, 2020 – accessible yet rigorous coverage of privacy, responsibility, transparency, bias, future of work, and policy.
2. Luciano Floridi, *The Ethics of Artificial Intelligence: Principles, Challenges, and Opportunities*, Oxford University Press, 2023 – deep philosophical and governance perspective, including AI4SG and soft ethics.
3. Olivia Gambelin, *Responsible AI: How to Build AI That Works for Everyone*, Kogan Page, 2025 – practical guidance for operationalizing Responsible AI in organizations (people, process, technology).

REFERENCE BOOKS:

1. R. Benjamins, Best Practices for Creating Trustworthy AI Systems, Springer, 2023 – Engineering focused patterns for fairness, explainability, robustness, and governance in real ML pipelines.
2. S. Müller, "Ethics of Artificial Intelligence and Robotics," Stanford Encyclopedia of Philosophy, 2020 – Authoritative reference on conceptual foundations and major debates in AI ethics.
3. The Cambridge Handbook of the Law, Ethics and Policy of Artificial Intelligence, Cambridge University Press, esp. Ch. 3 "Ethics of AI" – Legal and policy framing for AI governance.

E-Resources:

1. Coursera, "Responsible AI: Transparency & Ethics," 2025 – modules on AI Fairness 360, SHAP, LIME, NIST AI RMF, model cards.
2. Fractal Analytics, "Responsible AI – Principles and Ethical Considerations," Coursera, 2024.
3. UC San Diego Extended Studies, "Responsible AI: Transparency, Accountability, Explainability and Privacy," 2024.

4. CSE IIT Kharagpur, “CS60016: AI and Ethics,” 2022 – course outline focusing on bias, fairness, and societal implications.
5. Carnegie Mellon ExecEd, “Responsible Artificial Intelligence,” course modules on explainability, robustness, privacy, fairness.

Activity Based Learning (Suggested Activities in Class)

1. Bias auditing of real datasets using fairness toolkits.
2. Role play of an AI ethics review board for a controversial system.
3. Model card and datasheet creation for existing ML models.
4. Red teaming and defense of an AI model for robustness and privacy.
5. Field or industry mini project applying a Responsible AI checklist.

RESEARCH METHODOLOGY & IPR

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	:	26AM5106	**Credits**	:	3
Hours/Week	:	03 Hours	**Total Hours**	:	45 Hours
L–T–P-J	:	3-0-0-0	**CIA**	:	100

Course Objectives:

The course will enable students to:

1. Understand the fundamentals of research and formulation of problem statement.
2. Develop skills to conduct systematic literature surveys and analyze the relevant research papers in respective domains.
3. Analyze patent documents and technology disclosures to assess novelty, prior art, and commercialization potential of research outcomes.
4. Write and present research papers by effectively communicating research findings through well-structured manuscripts and oral presentations, suitable for peer-reviewed journals and reputed national/international conferences.
5. Prepare high-quality research proposals and technical reports suitable for funding agencies and institutional review committees.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
2. ***Interactive Teaching***: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.

8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

INTRODUCTION:

Meaning of Research, Concepts and Objectives of Research, Motivation in Research, Types of Research, Research Gaps Identification, Research Question Formulation, Problem Identification, Qualitative vs quantitative research, Ethical aspects and Plagiarism detection tools.

UNIT – II	**10 Hours**

LITERATURE REVIEW & TECHNICAL WRITING:

Research design process, Need and types of research design, Literature survey, Use of advanced search techniques, Popular databases Web of Science, Scopus and Google Scholar, Indexing, Impact of Title and Keywords, Citations, Styles for Citations, Acknowledgment, Importance of Bibliography, Tools for Bibliography (Mendeley etc.), Report Writing.

UNIT – III	**09 Hours**

HYPOTHESIS TESTING AND RESEARCH METHODOLOGY:

Quantitative techniques, sampling fundamentals, Type of hypothesis, Introduction and applications of Binomial, normal and Poisson distributions, Statistical tests: Chisquared test, t-test, f-test etc., Multivariate analysis, Introduction to various statistical analysis techniques and software, Data Collection Methods, Meaning and Importance of Data, Sources of Data, Use of Secondary Data

UNIT – IV	**09 Hours**

INTELLECTUAL PROPERTY RIGHTS (IPR):

Introduction to IPR, Patents, copyrights, trademarks, Patent search and analysis, IPR in software, AI algorithms, datasets, Role of WIPO and WTO in IPR establishments, Process of Patenting, Common rules of IPR practices, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Technology transfer and commercialization, Major Amendments in IP Laws and Acts in India.

UNIT – V	09 Hours
RESEARCH PROPOSAL & PUBLICATION: Research proposal contents, Research proposal writing, Funding agencies (DST, SERB, MeitY – overview), Budget formation, TRL Levels, Gantt Chart, Project Outcomes, Paper formulation, Abstract formation, Journal and conference selection, Peer review process, Paper presentation and review responses, Submission to Journal/Conferences, Preparation of Response to Reviewers, Track Change Mode in Word.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	**Identify** and formulate feasible and clear research problems in AI/ML domains using appropriate research methodologies.	L4
2	**Conduct** systematic literature reviews and critically evaluate the publications in the AI/ML domains.	L5
3	**Analyze** patent documents and assess the novelty and patentability of AI-based solutions.	L4
4	**Write** and present research papers by effectively communicating research findings through well-structured manuscripts and oral presentations	L6
5	**Evaluate** high-quality research proposals and technical reports in compliance with the guidelines of funding agencies and institutional review committees.	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	1	-	-	3	1	3	-	-	-	2	1
CO2	2	3	2	2	-	3	2	3	-	-	-	2	1
CO3	3	3	2	2	3	3	1	3	1	-	-	2	1
CO4	2	3	2	2	2	3	2	3	1	-	-	2	2

CO5	3	2	3	3	3	3	2	3	2	-	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. C.R. Kothari - Research Methodology: Methods and Techniques, New Age International, 5th Edition 2024, ISBN: 9789389802559.
2. Stuart Melville and Wayne Goddard - Research Methodology: An Introduction for Science & Engineering Students, Juta and Company Ltd, 2nd Edition 2001.
3. B. L. Wadehra - Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indicators, Universal Law Publishing, 3rd Edition 2004.
4. Ranjit Kumar - Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications, 4th Edition 2024.

REFERENCE BOOKS:

1. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, University of Chicago Press, 5th Edition 2024.
2. Research Methods for Engineers by David V. Thiel, 1st Edition, Cambridge University Press, 2014.
3. Research methodology: an introduction for science & engineering students by Stuart Melville and Wayne Goddard, 2nd Edition 2001.

E-Resources:

1. https://onlinecourses.swayam2.ac.in/ntr25_ed93/preview

Activity Based Learning (Suggested Activities in Class)

1. Quizzes
2. Assignments
3. Seminars

SEMINAR-I
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Course Code	:	26AM5107	**Credits**	:	2
Hours/Week	:	04 Hours	**Total Hours**	:	60 Hours
L–T–P-J	:	0-0-0-4	**CIA**	:	100

Prerequisites:

Proficiency in Artificial Intelligence.

Course Objectives:

1. Identify and select an appropriate seminar topic based on recent advancements in engineering, technology, and research domains.
2. Explore and understand fundamental and advanced Artificial Intelligence techniques including Machine Learning, Deep Learning, Natural Language Processing, and Computer Vision.
3. Study and examine diverse applications of Artificial Intelligence in areas such as healthcare, robotics, education, and industrial systems.To critically analyze AI research papers and case studies.
4. Critically analyze research papers, technical articles, and real-world case studies related to Artificial Intelligence to understand current trends and challenges.
5. Foster collaborative learning and knowledge sharing through discussions, peer interactions, and seminar presentations.

Teaching-Learning Process (General Instructions)

1. Interactive Lectures: Engage students with theoretical explanations followed by Q&A.
2. Hands-on Sessions: Practical coding exercises, AI model development, and experimentation.
3. Case Studies: Real-world AI applications in healthcare, robotics, and smart systems.
4. Problem-Solving & Mini Projects: Encourage analytical thinking and problem-solving skills.
5. Group Discussions & Seminars: Foster collaborative learning and knowledge sharing.

Guidelines:

1. The seminar topic proposed by the student shall be approved by the concerned faculty guide and the Department Chairman before proceeding further.
2. Seminar topics should preferably be aligned with current research trends, emerging technologies, industrial practices, or interdisciplinary applications, and may be motivated by recent journal articles, conference papers, white papers, or industrial case studies.

3. The selected seminar topic should be focused, research-oriented, and feasible to be completed within the semester, enabling in-depth study, critical analysis, and technical understanding.
4. Each seminar will be closely supervised by the Seminar Guide, who will provide continuous feedback and guidance during topic selection, literature survey, report preparation, and presentation stages.

EVALUATION (SEMINAR):

1. The seminar topic approved initially shall be pursued throughout the semester with emphasis on literature review, conceptual understanding, and critical analysis.
2. The evaluation will comprise:
    - Depth of technical content
    - Quality of literature survey
    - Understanding of the topic
    - Presentation skills and clarity
    - Ability to answer questions during reviews
3. Each student is required to submit a seminar report following the prescribed format and may be encouraged to base the seminar on recent IEEE / Scopus-indexed journal or conference papers.
4. Continuous Internal Assessment (CIA) will be conducted through seminar reviews by a committee of senior faculty members of the department.
5. The topic of seminar can be any AI applications domain mentioned below but not limited to Deep Learning, Computer Vision, Large Language Model, Advanced AI Applications, Ethical & Societal Implications, Robotics, Emerging Technologies.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Identify a suitable seminar topic related to recent advancements in AI, ML, and Deep Learning.	L2
2	Explain core concepts and demonstrate the techniques of Artificial Intelligence.	L3
3	Apply the Artificial Intelligence in healthcare, robotics, education, and industrial environments.	L3

4	Analyze and interpret AI research papers and case studies to evaluate methodologies, results, and practical relevance.	L4
5	Demonstrate effective communication, teamwork, and knowledge-sharing skills during seminar presentations and discussions.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	1	0	0	1	1	1	2	2	1	2	2	3	3
CO2	3	3	1	3	3	3	3	2	2	2	3	3	3
CO3	3	3	1	3	2	2	2	2	2	2	2	2	3
CO4	3	3	2	3	3	3	3	2	2	2	3	3	3
CO5	3	3	1	3	3	3	3	2	2	2	3	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson, 2020.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press, 2016.
3. Daniel Jurafsky and James H. Martin, *Speech and Language Processing*, 3rd Edition, Pearson, 2023.R. Szeliski, *Computer Vision: Algorithms and Applications,* 2nd Edition, 2022.
4. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning,* 2016.
5. Richard Hartley & Andrew Zisserman, *Multiple View Geometry in Computer Vision,* 2nd Edition, 2004.

II SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	IPCC	26AM5201	Image Processing and Computer Vision	3	0	2	-	60	40	100	04
2	IPCC	26AM5202	Deep Learning	2	0	2	2	60	40	100	04
3	IPCC	26AM5203	Generative-AI	3	0	2	-	60	40	100	04
4	IPCC	26AM5204	MLOPS for Enterprises	3	0	2	-	60	40	100	04
5	PEC	26AM52XX	Professional Elective-I*	2	0	0	2	100	--	100	03
6	PEC	26AM52XX	Professional Elective-II*	2	0	0	2	100	--	100	03
7	PrSI	26AM5205	Seminar-II	-	-	-	4	100	--	100	02
			Total	15	00	08	10				24

IPCC-Integrated Professional Core Course, PEC-Professional Elective Courses, PrSI- Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J– Project, C – No. Of Credits

*indicates students need to carry out a mini project in the subject.

Professional Elective Courses –I (PEC-I) Domain										
Sl.No	**Course Type**	**Course Name**	**Lecture**	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credit**
			L	**T**	**P**	**J**				
1	PEC	Natural Language Models	2	0	0	2	100	--	100	**03**
2	PEC	Large Language Models	2	0	0	2	100	--	100	**03**
3	PEC	Social Media Analytics	2	0	0	2	100	--	100	**03**
4	PEC	Text and Speech Generation using Advanced Models	2	0	0	2	100	--	100	**03**
5	PEC	Computational Models	2	0	0	2	100	--	100	**03**
6	PEC	Cognitive Linguistics	2	0	0	2	100	--	100	**03**

Professional Elective Courses –II (PEC-II) Domain										
Sl. No	**Course Type**	**Course Name**	**Lecture**	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credit**
			L	**T**	**P**	**J**				
1	PEC	Accelerated Computing	2	0	0	2	100	--	100	**03**
2	PEC	Multi-Agent AI Systems	2	0	0	2	100	--	100	**03**
3	PEC	Visual Computing and Graphics	2	0	0	2	100	--	100	**03**
4	PEC	Robot Operating Systems (ROS)	2	0	0	2	100	--	100	**03**
5	PEC	AI for Autonomous Vehicles & Smart Mobility	2	0	0	2	100	--	100	**03**
6	PEC	Conversational AI and Spoken Language Understanding	2	0	0	2	100	--	100	**03**

IMAGE PROCESSING AND COMPUTER VISION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5201	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	75 Hours
L–T–P-J	:	3–0–2-0	**CIA+SEE**	:	60+40

Prerequisites:

Proficiency in a Python programming language and probability concepts.

Course Learning Objectives:

This course will enable students to:

1. To understand advanced concepts of digital image formation, representation, sampling, quantization, and perceptual models in image processing.
2. To analyze and implement spatial and frequency domain techniques, including advanced filtering, transform-domain methods, and image enhancement approaches.
3. To study and apply advanced image segmentation, morphological processing, and feature extraction techniques for effective image representation and analysis.
4. To explore geometric computer vision concepts, including camera models, projection geometry, feature detection, and multi-view vision.
5. To develop and implement computer vision solutions using modern techniques and tools (MATLAB/Python/OpenCV), and apply them to real-world problems such as object detection, recognition, and 3D vision.

Teaching-Learning Process (General Instructions)

1. **Lecture Method:** Traditional and innovative teaching methods adopted to develop course outcomes.
2. **Interactive Teaching:** Active learning including brainstorming, discussing, group work, focused listening, formulating questions, and roleplaying.
3. **Visual Learning:** Show video/animation films to explain the functioning of various concepts.
4. **Collaborative Learning:** Encourage Group Learning in the class.
5. **Critical Thinking:** Ask at least three Higher-order Thinking questions in the class.
6. **Real-World Context:** Discuss how every concept can be applied to the real world to improve student understanding.

UNIT – I	**08 Hours**

ADVANCED IMAGE PROCESSING FUNDAMENTALS AND TRANSFORM TECHNIQUES:

Advanced Digital Image Processing Fundamentals: Image formation and acquisition models, Human visual perception and psychovisual redundancy, Advanced sampling and quantization (aliasing, Moiré effects), Color science and perceptual color models (CIELAB, YCbCr).
Advanced Spatial Domain Processing: Non-linear gray level transformations, Adaptive histogram equalization (CLAHE), Edge-preserving smoothing (bilateral filtering), Advanced sharpening (high-boost filtering).
Frequency Domain Analysis: 2D Fourier Transform and properties, Discrete Cosine Transform (DCT), Frequency domain filtering and hybrid approaches.

(TEXT1: CHAPTERS 1, 2, 3)

UNIT – II	**10 Hours**

ADVANCED IMAGE SEGMENTATION AND COLOR ANALYSIS:

Advanced Image Segmentation: Edge-based segmentation with optimization, Region-based segmentation with energy minimization, Clustering-based segmentation (K-means, Mean Shift), Graph-based segmentation techniques.
Modern Segmentation Techniques: Active contour models (Snakes), Watershed segmentation, Introduction to deep learning-based segmentation (U-Net concept).
Advanced Color Image Processing: Color constancy and correction, Color-based object tracking, Multichannel image filtering.

(TB1: Chapters 6, 10)

UNIT – III	**09 Hours**

MATHEMATICAL MORPHOLOGY, FEATURE ENGINEERING AND IMAGE COMPRESSION:

Mathematical Morphology & Structural Analysis: Set-theoretic formulation of morphology, Morphological reconstruction, Skeletonization and shape representation.
Advanced Feature Extraction: Texture analysis (GLCM, LBP), Shape descriptors (Fourier descriptors, moments), Feature selection and dimensionality reduction (PCA).
Image Compression (Advanced): Transform coding (DCT, Wavelets), JPEG/JPEG2000 standards, Rate-distortion optimization

(**TB2: Chapters 9, 8, 5)**

UNIT – IV	**09 Hours**

GEOMETRIC COMPUTER VISION AND CAMERA MODELING:

Computer Vision & Geometric Modeling: Imaging geometry and camera calibration, Multi-view geometry fundamentals, Projective transformations and homography. **Advanced Feature Detection:** Scale-space theory, Harris, Hessian, LoG, DoG with mathematical formulation, Feature matching and invariance properties. **TB3: Chapters 1, 4, 5, 8** **TB4: Chapter 4**	
UNIT – V	**09 Hours**
STEREO VISION & ADVANCED DESCRIPTORS: **Stereo Vision:** Epipolar Geometry, Rectification and Issues related to Stereo. **Advanced Features:** SIFT, PCA-SIFT, SURF, HOG. **Applications:** Image segmentation in computer vision contexts. **TB3: Chapters 11, 15** **TB4: Chapters 5, 8, 12**	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Comprehend different image representations such as grayscale, RGB, and HSV.	L2
2	Apply Image Enhancement Techniques including histogram equalization, contrast stretching, and sharpening filters.	L3
3	Implement spatial domain operations like convolution smoothing filters and edge detection.	L4
4	Apply image segmentation techniques like thresholding, region growing, and edge-based segmentation.	L3
5	Evaluate real-world applications including medical imaging, satellite imagery, face recognition, and video processing.	L5

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	-	-	-	-	-	-	1	1	-	2	-
CO2	3	3	2	-	2	-	-	-	-	2	2	2	2
CO3	3	3	-	2	2	-	-	2	2	-	-	2	2
CO4	3	3	2	2	2	-	-	3	2	-	2	2	2
CO5	3	3	3	2	3	-	-	2	2	2	3	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS

1. **Richard Szeliski**, "Computer Vision: Algorithms and Applications", Springer, 2nd Edition, 2022.
2. **Manas Kamal Bhuyan**, "Computer Vision and Image Processing Fundamentals and Applications", Taylor & Francis Group, 2020.

REFERENCE BOOKS

1. **Tekalp A.M.**, "Digital Video Processing", Prentice Hall (1995).
2. **Simon Prince**, "Computer Vision: Models, Learning, and Inference", 2012.
3. **Gonzalez, R.C., and Woods, R.E.**, "Digital Image Processing", 4th Edition, Pearson Education (2017).
4. **Jain A.K.**, "Fundamentals of Digital Image Processing", Prentice Hall (2015).
5. **David Forsyth, Jean Ponce**, "Computer Vision: A Modern Approach", 2015.

Activity-Based Learning

1. **Group Discussion:** The Applications of Computer Vision.
2. **Collaborative Activity:** Minor project development with a team of 4 students.

LABORATORY EXPERIMENTS

1. Write a program to perform gray-level transformations (log, power-law), image negative, and contrast enhancement using histogram equalization and adaptive histogram equalization (CLAHE).
2. Implement image sampling and quantization. Convert images between RGB, HSV, and CIELAB color spaces and analyze the effect on image quality.

3. Implement smoothing filters (mean, Gaussian, bilateral) and sharpening techniques (Laplacian, high-boost filtering). Compare their performance on noisy images.
4. Compute the Fourier Transform of an image and implement frequency domain filtering (low-pass, high-pass, band-pass). Analyze results in spatial vs frequency domain.
5. Implement threshold-based (global, adaptive), edge-based (Sobel/Canny), and clustering-based segmentation (K-means).
6. Implement region growing, watershed segmentation, and Hough transform for line detection.
7. Implement erosion, dilation, opening, closing, and morphological reconstruction. Apply connected component analysis and skeletonization.
8. Extract texture features (GLCM/LBP), shape features, and color features. Apply dimensionality reduction using PCA.
9. Implement Harris Corner Detector (without inbuilt functions) and compute feature descriptors using SIFT/SURF/ORB. Perform feature matching between images.
10. Implement Huffman Coding and transform-based compression (DCT). Compare compression ratio and reconstruction quality.
11. Mini Project – I: Develop a system for object detection using HOG features and a machine learning classifier (SVM). Evaluate performance under variations such as noise, scale, and illumination.
12. Mini Project – II: Develop a system to detect and segment objects (e.g., hand/skin region) using HSV/CIELAB color space. Extract contours and implement basic tracking across frames or images.

DEEP LEARNING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5202	**Credits**	:	4
Hours/Week	:	06 Hours	**Total Hours**	:	90 Hours
L–T–P-J	:	2–0–2-2	**CIA+SEE**	:	60+40

Prerequisites:

Machine Learning

Course Objectives:

1. To introduce the fundamental concepts of biologically inspired computing and the mathematical foundations of neural networks, including learning rules, activation functions, optimization techniques, and training challenges.
2. To provide in-depth knowledge of convolutional neural networks, their architectures, regularization methods, and transfer learning techniques for image-based applications.
3. To develop an understanding of recurrent neural network architectures and sequence learning methods for modeling temporal and sequential data.
4. To expose students to advanced deep learning models, generative techniques, and reinforcement learning, focusing on training difficulties and probabilistic learning frameworks.
5. To familiarize students with real-world applications of deep learning in image localization, segmentation, object detection, and medical image analysis.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Real-World Examples: Incorporate real-world examples and case studies that demonstrate the relevance and application of automata theory in areas such as natural language processing, compilers, and pattern recognition.
2. Problem-Solving Sessions: Organize problem-solving sessions where students can work through challenging problems together.
3. Reflective Learning: Encourage students to reflect on their problem-solving approaches and discuss the reasoning behind their solutions.

UNIT – I	**06 Hours**

IINTRODUCTION:

Biologically inspired computing, Perceptron Learning rule, Multi-layer Perceptron model, Activation Functions, Loss functions. Backpropagation, Optimization: Gradient descent

methods, Momentum, RMSprop, Adam, batch normalization, dropout, hyper parameter optimization, model ensembles	
UNIT – II	**06 Hours**
CONVOLUTIONAL NEURAL NETWORKS: Introduction, Data Augmentation – zooming, rotation, cropping, blurring, noise addition, self-supervision techniques, CNN architecture, convolution, pooling, padding, Regularization Techniques, variants of CNN - AlexNet, VGG, GoogLeNet, ResNet, InceptionNet, EfficientNet, Transfer Learning	
UNIT – III	**06 Hours**
RECURRENT NEURAL NETWORKS: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs	
UNIT – IV	**06 Hours**
ADVANCED DL MODELS: Generative models - Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines. Auto Encoders, parameterization, Deep Reinforcement Learning	
UNIT – V	**06 Hours**
APPLICATION: Image Localization, Image segmentation architectures – Unet, VNet, UNet++, Object Detection –YOLO, BiFPN layers, Centre Net, EfficientDet, Case study – RoI cropping in CT images and Cervical Images.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		

1	Understand the fundamental concepts of neural networks, activation functions, and optimization techniques used in deep learning.	L2
2	Apply convolutional neural network architectures and data augmentation techniques for image-based tasks.	L3
3	Analyze sequential data using recurrent neural networks and their variants such as LSTM and GRU.	L4
4	Evaluate advanced deep learning models including generative models, autoencoders, and reinforcement learning approaches.	L5
5	Design and implement deep learning solutions for real-world applications such as image segmentation and object detection.	L6

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	-	1	1	1	-	-	-	-	3	3
CO2	3	2	-	-	3	-	-	-	2	-	2	2	2
CO3	3	3	2	2	-	-	-	2	3	-	2	2	2
CO4	3	2	3	2	-	3	2	3	3	3	2	3	3
CO5	3	3	3	-	2	2	2	-	3	3	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Goodfellow, I., Bengio, Y, and Courville, A., Deep Learning, MIT Press, 2016.
2. Bishop, C., M., Pattern Recognition and Machine Learning, Springer, 2006.

REFERENCE BOOKS:

1. Y. Bengio, I. Goodfellow and A. Courville, Deep Learning, 1st ed MIT Press, 2016.
2. Bishop C. M., Pattern Recognition and Machine Learning, 1st ed Springer, 2006.

3. Geoffrey E. Hinton, Neural network architectures for artificial intelligence, 1st ed American Association for Artificial Intelligence Menlo Park, 1988, ISBN:0-929280-15-6.
4. Adrian Rosebrock, Deep Learning for Computer Vision with Python, E-Book, 1st ed, September 2017.
5. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
6. Golub, G., H., and Van Loan, C., F., Matrix Computations, JHU Press, 2013.
7. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.

Project Based Learning (Suggested Activities in Class)

1. Identify a real-world problem and explore suitable datasets for deep learning applications.
2. Perform data preprocessing, normalization, and augmentation for image or sequential datasets.
3. Select appropriate deep learning models and design suitable architectures based on the problem.
4. Implement deep learning models using frameworks such as TensorFlow or PyTorch.
5. Perform hyperparameter tuning and apply optimization techniques to improve model performance.
6. Evaluate and compare model performance using appropriate metrics such as accuracy, precision, recall, and IoU.
7. Apply transfer learning techniques and fine-tune pretrained models for improved results.
8. Visualize feature representations and interpret model results using appropriate tools and techniques.
9. Deploy the trained model using a simple interface or web-based application.
10. Document and present the project findings including methodology, results, and challenges.

LABORATORY EXPERIMENTS

1. Design and Implementation of Perceptron Learning Algorithm for Binary Classification and Analysis of Decision Boundaries.
2. Development of Multi-Layer Perceptron (MLP) with Comparative Analysis of Activation Functions and Optimization Techniques.
3. Design and Implementation of Convolutional Neural Network (CNN) for Image Classification with Analysis of Convolution and Pooling Operations.
4. Implementation and Performance Evaluation of Data Augmentation Techniques for Improving CNN Generalization.
5. Implementation of Transfer Learning Using Pretrained CNN Models for Custom Image Classification Tasks.
6. Implementation of Recurrent Neural Network (RNN) for Sequence Prediction and Temporal Pattern Analysis.
7. Comparative Implementation of LSTM and GRU Networks for Efficient Sequence Modeling and Vanishing Gradient Analysis.
8. Design and Implementation of Autoencoders for Feature Extraction and Dimensionality Reduction.
9. Implementation of Restricted Boltzmann Machine (RBM) with Gibbs Sampling for Probabilistic Representation Learning.
10. Implementation of U-Net Architecture for Image Segmentation and Performance Evaluation.
11. Design and Implementation of YOLO-Based Object Detection Model for Real-Time Applications.
12. Development of Deep Learning-Based Medical Image Analysis System for ROI Extraction and Classification in CT and Cervical Images.

GENERATIVE-AI

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5203	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	75 Hours
L–T–P-J	:	3–0–2-0	**CIA+SEE**	:	60+40

Prerequisites:

Artificial Intelligence, Machine Learning, Deep Learning, Natural Language Processing, Computer Vision

Course Objectives:

1. Provide foundations of Generative AI in healthcare
2. Understand prompt engineering for clinical context
3. Apply LLMs, multimodal GenAI and agents in healthcare
4. Design agent workflows for medical applications.
5. Address ethical and regulatory challenges

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Real-World Examples: Incorporate real-world examples and case studies that demonstrate the relevance and application of automata theory in areas such as natural language processing, compilers, and pattern recognition.
2. Problem-Solving Sessions: Organize problem-solving sessions where students can work through challenging problems together.
3. Reflective Learning: Encourage students to reflect on their problem-solving approaches and discuss the reasoning behind their solutions.

UNIT – I	**08 Hours**

INTRODUCTION:

Introduction to Generative AI, Definition and scope of Generative AI, Hierarchy of Generative AI, Overview of generative models and their applications, Importance of Generative AI in various domains, Ethical considerations and challenges - bias amplification, deepfakes, intellectual property, environmental cost of training.

UNIT – II	**10 Hours**

PROMPT ENGINEERING: Synthesis and critique of prompt engineering techniques: classroom discussion focuses on when prompt engineering reaches its limits versus when fine-tuning or architectural changes are needed; defensive prompting, prompt injection, jailbreaking awareness; security and safety considerations

UNIT – III	**09 Hours**
GENERATIVE AI ARCHITECTURES — TRANSFORMERS, GPT, DIFFUSION: Encoder/decoder architectures; latent space in generative models; transformer architectures and self-attention mechanism; multi-head attention and positional encoding; conditional generative models; GPT architecture (pre-training, fine-tuning, inference); encoder-only (BERT), decoder-only (GPT), encoder-decoder (T5) comparison; denoising diffusion models for text-to-image pipelines; introduction to retrieval-augmented generation.	

UNIT – IV	**09 Hours**
LANGUAGE MODELS AND LLM ARCHITECTURES: Language models and tokenization fundamentals; LLM training and inference at a conceptual level; LLMs vs traditional Generative AI; examples of leading LLMs (GPT-4, Claude, LLaMA, Gemini); fine-tuning vs prompt engineering vs RAG — decision framework; model evaluation metrics (perplexity, BLEU, ROUGE, human evaluation); inference sizing and optimization.	

UNIT – V	**09 Hours**
AI AGENTS & AGENTIC WORKFLOWS: AI agents and autonomous systems overview; core components of intelligent agents — Planning, Memory, Tool Use, Goal-directed behavior; agent taxonomies (Reflex, Goal-based, Utility-based, Learning); agent orchestration frameworks (LangChain, LangGraph, CrewAI, AutoGen); RAG agents; Chain-of-thought multi-step reasoning; NVIDIA NIM for agent deployment (hands-on via DLI); agent deployment strategies and monitoring.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		

CO1	Explain the fundamental concepts, hierarchy, and applications of Generative AI across modalities.	L2
CO2	Apply prompt engineering strategies (zero-shot, few-shot, chain-of-thought) for effective interaction with generative models.	L4
CO3	Analyze generative model architectures including transformers, GPT, BERT, T5, and diffusion models.	L4
CO4	Evaluate different large language models on standardized tasks using perplexity, BLEU, ROUGE, and human evaluation.	L3
CO5	Design AI agent workflows with planning, memory, and tool use for autonomous task execution using LangChain/CrewAI.	L5

COs COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	2	1	2	3	2	–	2	–	2	1	–	2	1
CO2	3	2	–	2	3	3	–	3	–	3	–	3	2
CO3	3	2	3	3	2	–	–	–	–	3	2	3	3
CO4	3	2	–	–	3	2	1	3	–	3	2	3	3
CO5	3	2	3	2	3	–	3	–	2	1	–	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. David Foster, *Generative Deep Learning*, 2nd Edition, O'Reilly, 2023.
2. James Phoenix & Mike Taylor, *Prompt Engineering for Generative AI*, O'Reilly, 2024.

REFERENCE BOOKS:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson

2. Patterson, *Introduction to Artificial Intelligence & Expert Systems*, PHI.

E-Resources:

1. https://www.datacamp.com/blog/what-is-prompt-engineering-the-future-of-ai-communication

2. https://www.promptengineering4u.com/learning/techniques/template-based-prompting#h.2n56pv37pv0c

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis
2. Group discussions
3. Mini-project / seminar
4. Quiz

LABORATORY EXPERIMENTS

1. Installation and Configuration of Generative AI Development Environment.
2. Implementation of Prompt Engineering Techniques for Healthcare Applications.
3. Evaluation and Optimization of Large Language Model Outputs.
4. Exploration of Transformer Architecture and Attention Mechanism.
5. Text Generation and Summarization using Pretrained Language Models.
6. Fine-Tuning Large Language Models for Domain-Specific Medical Data.
7. Implementation of Retrieval Augmented Generation (RAG) Systems.
8. Design and Development of LLM-based Intelligent Agents.
9. Multimodal Generative AI for Text-to-Image and Image Captioning Tasks.
10. Implementation of Generative Adversarial Networks (GANs) for Image Generation.
11. Development of a Generative AI-based Healthcare Chatbot.
12. Evaluation of Ethical, Safety, and Bias Issues in Generative AI Systems.
13. Mini Project: Design and Implementation of a Generative AI Healthcare Application.

MLOPS FOR ENTERPRISES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	:	26AM5204	**Credits**:	4
Hours/Week	:	05 Hours	**Total Hours**:	75 Hours
L–T–P-J	:	3–0–2-0	**CIA+SEE:**	60+40

Course Learning Objectives:

This course will enable students to:

1. To impart knowledge on production-level challenges of ML models.
2. To provide comprehension of various activities involved in the development, deployment, and monitoring of ML models.
3. To familiarize the principles of MLOps and different platforms.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only the traditional lecture method but a different *type of teaching method* that may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Show ***Video/animation*** clips to explain the functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher-order Thinking questions in the class.
6. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the student's understanding.

UNIT – I	**08 Hours**

INTRODUCTION TO DEVOPS:

SDLC, Virtualization: Containers, Container Orchestration Systems, Cloud platforms, CI/CD: Continuous Integration – Configuration Management, Deployment and Delivery phases, Continuous monitoring, Continuous Testing, GitOps and Declarative Infrastructure for ML Systems, Progressive Delivery: Blue–Green, Canary and Shadow Deployments

UNIT – II	**10 Hours**

BASIC CONCEPTS:

Evolution of MLOps, Data-centric AI, ML Development Lifecycle, MLOps Approach, Features of MLOps, ML Data Lifecycle in Production, MLOps maturity levels and Lifecycle concepts, ML artifacts, MLOps workflows, Feature Stores and Data-Centric Infrastructure, MLOps Maturity Models and Capability Assessment, Model Risk Management (MRM) and Governance Foundations.

UNIT – III	**09 Hours**

MACHINE LEARNING PIPELINES AND AUTOMATION: CI/CD for Machine Learning, ML model serving, Data pipelines, Data drift, ML pipelines: Data ingestion, Feature engineering, Hyperparameter optimization, testing and packaging. Advanced Pipeline Orchestration (Airflow, Kubeflow, Prefect), Data and ML Pipeline Testing & Validation, CI/CD/CT Patterns.	
UNIT – IV	**09 Hours**
MODELLING IN MLOPS: Model management: Model deployment and monitoring, feedback, orchestration pipelines for ML workflows, ML security, Real-time Streaming ML models, Deployment on edge devices, Automated ML. Model Management and Registries, Model Serving Patterns	
UNIT -V	**09 Hours**
CASE STUDIES ON MLOPS BEST PRACTICES: Case Study 1: Netflix – End-to-end recommendation MLOps platform (experimentation, A/B testing, monitoring). Case Study 2: Uber Michelangelo – Centralized ML & LLMOps platform (feature store, CI/CD, artifact management). Case Study 3: Deep Learning in Production – Governance, compliance, and real-time personalization. Best practices: Technical debt, observability, governance, organizational patterns in MLOps.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain and assess the effectiveness and scalability of an end-to-end machine learning system in a real-world scenario.	L2
2	Recall various metrics used to evaluate machine learning model performance	L2
3	Design and integrate comprehensive automated systems that encompass ML pipelines, CI/CD, data processing, model serving, and drift detection.	L4
4	Analyse the challenges and benefits of implementing MLOps in an organization.	L4
5	Evaluate the applicability and effectiveness of MLOps best practices from case studies in your own or another organization.	L5

Mapping Levels of COs to POs / PSOs													
Cos				Program Outcomes (POs)								PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2	2	2	2	-	2	-	-	2	1	-	2	2
CO2	2	2	2	2	-	2	-	2	2	1	-	2	2
CO3	2	2	2	2	2	2	-	2	2	1	3	2	2
CO4	2	2	2	2	2	2	-	3	2	1	3	2	2
CO5	2	1	-	2	3	-	-	2	-	1	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Carl Osipov – MLOps Engineering at Scale, Manning Publications, 1st Edition 2022.
2. Noah Gift, Alfredo Deza – Practical MLOps: Operationalizing Machine Learning Models, O'Reilly Media, 1st Edition 2021.
3. Mark Treveil et al. – Introducing MLOps: How to Scale Machine Learning in the Enterprise, O'Reilly Media, 1st Edition 2021.
4. Emmanuel Ameisen – Building Machine Learning Powered Applications, O'Reilly Media, 1st Edition 2020.

REFERENCE BOOKS:

1. Andriy Burkov – Machine Learning Engineering, True Positive Inc., 1st Edition 2020.
2. Valliappa Lakshmanan et al. – Machine Learning Design Patterns, O'Reilly Media, 1st Edition 2020.
3. Databricks - The Big Book of MLOPs, 1st Edition 2023 (eBook).

Activity Based Learning (Suggested Activities in Class)

1. Assignments (in writing and doing forms on the aspects of syllabus content and outside the syllabus content. Shall be individual and challenging)
2. Student seminars (on topics of the syllabus and related aspects (individual activity)
3. Quiz (on topics where the content can be compiled by smaller aspects and data (Individuals or groups as teams))
4. Study projects (by very small groups of students on selected local real-time problems pertaining to syllabus or related areas. The individual participation and contribution of students shall be ensured (team activity).

LABORATORY EXPERIMENTS

1. Setting up an End-to-End MLOps Development Environment using Python, Docker, Git, and MLflow.
2. Implementing Data Version Control for Machine Learning Pipelines using DVC and Git.
3. Automating Exploratory Data Analysis and Data Validation using Pandas Profiling and Great Expectations.
4. Designing a Reproducible Feature Engineering Pipeline using Scikit-Learn Pipelines.
5. Tracking and Comparing Machine Learning Experiments using MLflow Tracking Server.
6. Implementing Model Versioning and Model Registry using MLflow Model Registry.
7. Containerizing a Machine Learning Model for Production Deployment using Docker.
8. Developing and Deploying a Machine Learning Model as a REST API using FastAPI.
9. Implementing Continuous Integration and Continuous Deployment (CI/CD) Pipeline for Machine Learning using GitHub Actions.
10. Designing an Automated Machine Learning Workflow using Apache Airflow.
11. Real-Time Model Serving and Inference using TensorFlow Serving or TorchServe.
12. Monitoring Model Performance, Data Drift, and Prediction Drift using Evidently AI.
13. Designing an Automated Model Retraining Pipeline Triggered by Data Drift.
14. Designing MLOps Pipeline for Cancer Gene Expression Analysis.
15. MLOps Pipeline for Monitoring Responsible AI & Bias in ML Models.

NATURAL LANGUAGE MODELS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5206	**Credits**	:	3
Hours / Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA**	:	100

Prerequisites:

Proficiency in Deep Learning

Course Objectives:

1. Understand the basics of NLP and apply text processing techniques like tokenization and word embeddings.
2. Build and fine-tune Transformer models for tasks such as Sentiment Analysis and Named Entity Recognition.
3. Develop Natural Language Generation systems, including RAG and multimodal applications.
4. Learn advanced model optimization techniques, including in-context learning, prompt engineering, and parameter-efficient fine-tuning.
5. Evaluate NLP models using metrics like BLEU and ROUGE, and apply explainability and ethical AI practices.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Case Studies:** Use real-world applications of neural language models such as machine translation, chatbots, text summarization, and sentiment analysis to illustrate the practical relevance of language modeling techniques.
2. **Problem-Solving and Design Exercises:** Conduct problem-solving and design-oriented sessions where students analyze neural language model architectures, embedding techniques, loss functions, and evaluation metrics such as perplexity.
3. **Hands-on Learning:** Organize laboratory sessions and guided experiments involving the implementation, training, and evaluation of neural language models using deep learning frameworks.
4. **Reflective and Research-Based Learning:** Encourage students to study and discuss recent research papers on neural language models and large language models, and reflect on model performance, limitations, and architectural choices through presentations and discussions.

UNIT – I	**09 Hours**

NLP FOUNDATIONS & STATISTICAL LANGUAGE MODELING:

Fundamentals for NLP; Text Processing pipelines: Tokenization (Byte Pair Encoding, Word Piece tokenization, Sentence Piece tokenisation), Normalization, Stop word removal, Stemming, Lemmatization, Regular expressions in information extraction

Statistical Language Modeling: N-grams (Unigram, Bigram, Trigram), Language Modeling basics, Smoothing techniques (Laplace, Good-Turing). String Processing & Similarity: Edit Distance Algorithms (Levenshtein Distance), Spell Correction	
UNIT – II	**09 Hours**
LINGUISTIC PROCESSING, SEQUENCE MODELING & SEMANTIC ANALYSIS: Part-of-Speech Tagging, Named Entity Recognition, Relation Extraction; Hidden Markov Models, Conditional Random Fields, BiLSTM-CRF. Semantic Analysis: Semantic Similarity, WordNet, Latent Semantic Analysis (LSA), Semantic Role Labeling and knowledge graph-based representations.	
UNIT – III	**09 Hours**
WORD EMBEDDINGS AND NEURAL SEQUENCE MODELS: Word Embeddings: Bag of Words, TF-IDF, Word2Vec (Continuous Bag of Words, Skip-Gram), GloVe, FastText, Contextual Embeddings (ELMo, BERT), Subword Modeling. Neural Sequence Models: RNNs, LSTMs, GRUs, Bidirectional RNNs.	
UNIT – IV	**09 Hours**
SEQUENCE-TO-SEQUENCE LEARNING, ATTENTION, SEQUENCE TAGGING AND EVALUATION: Encoder-Decoder (Seq2Seq) frameworks for machine translation and summarization, Training and Decoding strategies (teacher forcing, beam search), Attention Mechanisms including Bahdanau, Luong, self-attention and positional encoding in transformers. **Sequence Tagging**: BiLSTM-CRF for POS Tagging and Named Entity Recognition (NER); Transformer-based tagging using pretrained models such as BERT, fine-tuning for downstream tasks. **Performance Evaluation**: BLEU, ROUGE, BERT Score; Perplexity, METEOR; Precision, Recall, F1-score, Exact Match (EM);	
UNIT – V	**09 Hours**
RESPONSIBLE AI, EXPLAINABILITY AND NLM APPLICATIONS: **Responsible AI:** Bias mitigation, toxicity detection, and privacy; Explainability: Model **Explainability:** Attention maps, Attention-flow/rollout, Integrated gradients; Industry	

Applications: Recommendation Systems (LLM-based), Twitter/X tagging, and Extractive vs. Abstractive Summarization; chatbots and conversational AI, domain-specific NLM applications (Healthcare, Legal).

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	Apply text preprocessing and statistical language modeling techniques for NLP tasks.	L3
CO2	Analyze linguistic structures using POS tagging, NER, and sequence models such as HMM, CRF, and BiLSTM-CRF.	L4
CO3	Implement word embedding methods and neural sequence models (RNN, LSTM, GRU) for language representation.	L3
CO4	Apply Seq2Seq models with attention and transformer-based approaches and Evaluate NLM techniques using appropriate metrics	L3
CO5	Apply responsible AI principles including bias mitigation, explainability, and domain-specific applications.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	1	1	1	-	1	-	-	-	-	-	1	3	1
CO2	3	2	1	1	2	-	-	-	-	-	1	3	2
CO3	3	1	1	-	2	-	-	-	-	-	2	3	3
CO4	2	2	1	1	2	-	-	-	-	-	2	3	3
CO5	1	1	1	-	2	-	-	-	-	-	3	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Jurafsky, D. & Martin, J. H. — Speech and Language Processing, 3rd Edition, Pearson, 2023.
2. Jacob Eisenstein — Introduction to Natural Language Processing, MIT Press in 2019.
3. Lewis Tunstall et al. - Natural Language Processing with Transformers, 1st Edition, O'Reilly, 2022.

REFERENCE BOOKS:

1. Christopher Manning - Foundations of Statistical Natural Language Processing, 1st Edition, MIT Press, 1999.
2. Yoav Goldberg - Neural Network Methods for Natural Language Processing, 1st Edition, Morgan & Claypool Publishers, 2017.

E-Resources:

1. **Hugging Face LLM & NLP Course** — free interactive course covering transformers and LLMs: https://huggingface.co/learn/llm-course/en/chapter1/1 Hugging Face
2. **Stanford CS224N: NLP with Deep Learning (Lecture Series)** — classic NLP deep learning lectures: https://web.stanford.edu/class/archive/cs/cs224n/cs224n.1204/ Stanford University
3. **Natural Language Processing Tutorial (TutorialsPoint)** — step-by-step beginner to intermediate guide: https://www.tutorialspoint.com/natural_language_processing/index.htm tutorialspoint.com
4. **Advanced spaCy NLP Course** — hands-on NLP techniques with spaCy: https://course.spacy.io/en/ Advanced NLP with spaCy
5. **NLP Full Course (YouTube)** — video tutorial covering NLP basics and coding: https://www.youtube.com/watch?v=M7SWr5xObkA YouTube
6. **Free NLP Course (MyGreatLearning)** — free foundational NLP course: https://www.mygreatlearning.com/academy/learn-for-free/courses/introduction-to-natural-language-processing

Activity Based Learning (Suggested Activities in Class):

1. **Real-World Problem Solving (Group Discussion):** Discuss the technical and ethical challenges of using LLMs for **Automated Fact-Checking** and **Hallucination Detection** in legal or medical documents.
2. **Role Play (The Transformer Mechanism):** Assign students roles as **Query, Key, and Value vectors**. Simulate the **Self-Attention** mechanism physically in class to demonstrate how tokens "attend" to each other based on relevance.
3. **Programming Demonstration:** Live coding of a **Streamlit application** that performs **Zero-shot Classification** using a pre-trained model from Hugging Face to categorize news headlines into domains like finance or health.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

LARGE LANGUAGE MODELS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5207	**Credits**	:	3
Hours / Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA**	:	100

Prerequisites:

- Understanding of basic machine learning and deep learning concepts
- Familiarity with neural networks and backpropagation
- Knowledge of linear algebra, calculus, and probability
- Proficiency in Python programming

Course Objectives:

1. Understand the basics of NLP and apply text processing techniques like tokenization and word embeddings.
2. Build and fine-tune Transformer models for tasks such as Sentiment Analysis and Named Entity Recognition.
3. Develop Natural Language Generation systems, including RAG and multimodal applications.
4. Learn advanced model optimization techniques, including in-context learning, prompt engineering, and parameter-efficient fine-tuning.
5. Evaluate NLP models using metrics like BLEU and ROUGE, and apply explainability and ethical AI practices.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Case Studies:** Use real-world applications of neural language models such as machine translation, chatbots, text summarization, and sentiment analysis to illustrate the practical relevance of language modeling techniques.
2. **Problem-Solving and Design Exercises:** Conduct problem-solving and design-oriented sessions where students analyze neural language model architectures, embedding techniques, loss functions, and evaluation metrics such as perplexity.
3. **Hands-on Learning:** Organize laboratory sessions and guided experiments involving the implementation, training, and evaluation of neural language models using deep learning frameworks.
4. **Reflective and Research-Based Learning:** Encourage students to study and discuss recent research papers on neural language models and large language models, and reflect on model performance, limitations, and architectural choices through presentations and discussions.

UNIT – I	8 Hours
INTRODUCTION TO AI ENGINEERING AND FOUNDATION MODELS: Evolution of AI engineering from language models to large language models and foundation models; AI vs ML engineering and the AI engineering stack. Understanding foundation models including training data, model scaling, pretraining and post-training techniques, sampling strategies, structured outputs, and probabilistic nature of AI. **TB1: CHAPTERS 1, 2**	
UNIT – II	**10 Hours**
TRANSFORMER ARCHITECTURE AND LLM FUNDAMENTALS: Working with text data including word embeddings, tokenization techniques such as byte pair encoding, token-to-ID conversion, context tokens, sliding window sampling, token embeddings, and positional encoding. Attention mechanisms including self-attention, attention weight computation, causal masking, dropout, and multi-head attention for capturing long-range dependencies	
UNIT – III	**019 Hours**
PROMPT ENGINEERING AND RETRIEVAL-AUGMENTED GENERATION: Prompt engineering concepts including zero-shot and few-shot prompting, system vs user prompts, context management, and best practices such as clear instructions, task decomposition, chain-of-thought prompting, iterative refinement, and prompt evaluation and versioning. Defensive prompting covering prompt injection, jailbreaking, information leakage risks, and mitigation strategies.	
UNIT – IV	**09 Hours**
AGENT SYSTEMS AND FINE-TUNING TECHNIQUES: Agent systems including agent architecture, agentic workflows vs traditional pipelines, use cases, and core components such as tool integration, planning strategies (ReAct, chain-of-thought, tree-of-thoughts), memory mechanisms, and orchestration frameworks; along with challenges in debugging, evaluation, and cost–latency optimization.	
UNIT – V	**09 Hours**
EVALUATION, INFERENCE OPTIMIZATION, AND PRODUCTION DEPLOYMENT:	

Evaluation of foundation models including challenges, metrics such as cross-entropy and perplexity, functional correctness, similarity measures, embeddings, and use of AI as a judge with comparative evaluation; along with evaluation criteria, benchmark analysis, and design of evaluation pipelines for model and system assessment.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
Course Outcome	**Description**	**BTL**
CO1	Explain the architecture of transformers and GPT models including attention mechanisms	**L2**
CO2	Implement prompt engineering techniques and build RAG systems with retrieval optimization	**L4**
CO3	Design and implement agentic workflows and apply parameter-efficient fine-tuning (LoRA, PEFT)	**L5**
CO4	Develop comprehensive evaluation methodologies and pipelines for AI systems	**L3**
CO5	Optimize LLM inference and deploy production-ready AI applications with monitoring	**L6**

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	3	-	-	-	-	-	-	-	-	3	1
CO2	3	3	3	2	3	-	-	-	-	-	2	3	3
CO3	3	3	3	-	3	2	-	2	-	-	2	3	3
CO4	3	3	3	3	-	-	-	-	2	-	3	3	2
CO5	3	3	2	-	3	2	-	-	3	-	3	3	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Chip Huyen, “AI Engineering: Building Applications with Foundation Models”, O'Reilly Media, Inc." 2024, ISBN: 978-1-098-16630-4.

REFERENCE BOOKS:

1. Sebastian Raschka, “Build a Large Language Model (From Scratch),” Simon and Schuster, 2024. ISBN: 978-1633437166.
2. Jay Alammar and Maarten Grootendorst, “Hands-On Large Language Models: language understanding and generation,” 2024, O’Reilly Media Inc., 2024. ISBN: 978-1098150969
3. Lewis Tunstall, Leandro von Werra, and Thomas Wolf, “Natural Language Processing with Transformers,” O’Reilly Media Inc., 2022, ISBN: 978-1098136796
4. Chip Huyen, “Designing Machine Learning Systems,” O’Reilly Media Inc., 2022. ISBN: 978-1098107963
5. Ashish Vaswani, “Attention Is All You Need. Advances in neural information processing systems,” 2017.

E-Resources:

1. Hugging Face NLP Course: https://huggingface.co/learn/nlp-course
2. DeepLearning.AI Short Courses on LLMs, RAG, and Agents
3. Stanford CS224N: Natural Language Processing with Deep Learning
4. LangChain Documentation: https://python.langchain.com/
5. OpenAI API Documentation: https://platform.openai.com/docs
6. Papers with Code - Transformers: https://paperswithcode.com/methods/category/transformers
7. AI Engineering resources: https://github.com/chiphuyen/aie-book

Activity Based Learning (Suggested Activities in Class):

1. Implement multi-head attention mechanism from scratch and visualize attention weights
2. Prompt engineering workshop: Chain-of-thought, few-shot learning, defensive prompting
3. Build a production RAG system with vector database and retrieval optimization
4. Implement an AI agent with tool-use (web search, calculator) and ReAct planning
5. Fine-tune an LLM using LoRA for text classification task
6. Design comprehensive evaluation pipeline with AI-as-judge and multiple metrics
7. Inference optimization lab: Quantization, batching, caching strategies comparison
8. Team project: End-to-end LLM application from architecture to deployment

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

SOCIAL MEDIA ANALYTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	: 26AM5208	**Credits**:	3
Hours/Week	: 04 Hours	**Total Hours**:	45 Hrs (15 Hrs Project)
L–T–P-J	: 2–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand fundamentals of social media platforms, network structures, and digital interactions.
2. Apply analytical and computational techniques to extract insights from social media data.
3. Perform text mining, sentiment analysis, topic modelling using real social datasets.
4. Analyze user behavior, influence, virality, and community structures.
5. Use tools like Python, Gephi, NetworkX, APIs for hands-on social media analytics.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Lectures:** Structured lectures are used to explain fundamental concepts of speech processing, ASR, and spoken language understanding.
2. **Interactive Learning:** Classroom discussions and question–answer sessions are conducted to enhance conceptual clarity and critical thinking.
3. **Mini-Projects/Assignments:** Students work on small projects and assignments related to intent detection, slot filling, and dialogue systems to apply theoretical knowledge.

UNIT – I	**09 Hours**

INTRODUCTION TO SOCIAL MEDIA ANALYTICS:

Evolution of social platforms, Web 2.0, user-generated content, Social media ecosystem: X/Twitter, Facebook, YouTube, Instagram, Reddit, Social media data types: Structured, Unstructured, Streaming data, Data collection via APIs (Twitter API, YouTube API), Web scraping basics, Ethical issues, Privacy, Responsible AI in analytics.

UNIT – II	**09 Hours**

NETWORK THEORY FOR SOCIAL MEDIA:

Graph basics, Directed/Undirected networks, Centrality measures: Degree, Closeness, Betweenness, Eigenvector Community detection: Louvain, Girvan–Newman Influence and diffusion: Cascade models, Viral marketing, Homophily, Link prediction, Structural holes.	
UNIT – III	**09 Hours**
TEXT ANALYTICS FOR SOCIAL MEDIA: Text preprocessing, Tokenization, POS tagging, Sentiment analysis: lexicon-based & ML-based. Topic modeling: LDA, BERTopic, Named Entity Recognition, Emotion classification, sarcasm & stance detection, Handling noisy social text (slang, emojis, short forms).	
UNIT – IV	**09 Hours**
SOCIAL MEDIA MINING & PREDICTIVE ANALYTICS: Supervised & unsupervised models for social media, Recommendation systems basics, Trend detection, anomaly detection, Bot detection & misinformation analytics, Time-series forecasting of user engagement.	
UNIT – V	**09 Hours**
TOOLS, PLATFORMS & APPLICATIONS: **Tools:** Python (Pandas, NumPy), NLP libraries: NLTK, SpaCy, HuggingFace, Network tools: Gephi, NetworkX, SNAP, Visualization tools: Tableau/Power BI, Dashboards & reporting.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
CO1	Understand the fundamentals of social media platforms and data structures	L2
CO2	Apply text mining and sentiment analysis for social data	L3
CO3	Analyze network structures, communities, and influence	L4
CO4	Build predictive models for trend, virality, and user behavior	L4
CO5	Use tools & APIs to perform end-to-end social media analytics	L3

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	1	-	1	-	-	2	-	1	1	-	2	1
CO2	3	3	2	2	2	-	-	1	-	-	1	2	2
CO3	2	3	2	2	2	-	-	-	-	-	1	3	2
CO4	2	3	2	2	3	-	-	-	1	-	2	3	3
CO5	1	2	2	3	3	-	-	-	2	1	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Zafarani, Reza, Abbasi, Mohammad, and Liu, Huan – *Social Media Mining: An Introduction*, Cambridge University Press, 2023.
2. Han, Jiawei – *Data Mining: Concepts and Techniques*, Morgan Kaufmann, 2022. https://www.elsevier.com/books/data-mining-concepts-and-techniques/han/978-0-12-811760-6
3. Russell, Matthew – *Mining the Social Web*, O'Reilly, 4th Edition, 2023.

REFERENCE BOOKS:

1. Borgatti, S.P., Everett, M.G. – *Analyzing Social Networks*, SAGE Publications.
2. Leskovec, Jure – *Mining Massive Datasets*, Cambridge University Press.
3. Rogers, Richard – *Digital Methods*, MIT Press.
4. Newman, Mark – *Networks: An Introduction*, Oxford University Press.
5. Walshe, Rory – *Applied Social Media Analytics*, Wiley.

E-Resources:

- NPTEL: *Social Networks* – IIT Kharagpur https://cse.iitkgp.ac.in/~saptarshi/courses/socomp2020a/SocialComp-00-Social-Net-Intro.pdf
- Coursera – *Social Media Data Analytics* (University of Illinois)
- MIT OpenCourseWare – Big Data & Analyticshttps://www.coursera.org/learn/social-media-data-analytics
- Kaggle Social Media Datasets https://ocw.mit.edu/courses/big-data-and-social-analytics/

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

TEXT AND SPEECH GENERATION USING ADVANCED MODELS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5209	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA:**		100

Prerequisites:

Proficiency in a C programming language.

Course Objectives:

1. **To understand the fundamentals of text and speech generation** and their role in modern artificial intelligence applications.
2. **To study advanced deep learning architectures** such as RNNs, LSTMs, and Transformer-based models for natural language and speech generation.
3. **To analyze text generation techniques** including language modeling, sequence-to-sequence learning, and contextual word prediction.
4. **To explore speech generation models** such as Text-to-Speech (TTS), neural vocoders, and end-to-end speech synthesis systems.
5. **To apply text and speech generation models** in real-world applications like chatbots, virtual assistants, accessibility tools, and customer support systems.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Lectures:** Structured lectures are used to develop conceptual understanding of text and speech generation fundamentals, advanced language models, and speech synthesis architectures, addressing CO1 and CO2**.**
2. **Interactive Learning:** Classroom discussions, model walkthroughs, and question–answer sessions promote analytical thinking and problem-solving skills, supporting CO3 by enabling students to interpret and compare advanced generation techniques.
3. **Mini-Projects / Assignments:** Hands-on mini-projects and assignments such as chatbot implementation, text generation tasks, and speech synthesis applications help students apply theoretical knowledge to real-world problems, *fulfilling CO4 and CO5.*

UNIT – I	**08 Hours**

INTRODUCTION TO TEXT AND SPEECH GENERATION:

Overview of Natural Language Processing and Speech Processing, Fundamentals of Text Generation, Basics of Speech Generation, Language Modeling Concepts, Applications of Text and Speech Generation in AI Systems. TB1: Chapter 1, 2, 3	
UNIT – II	**10 Hours**
TEXT GENERATION MODELS: Statistical Language Models, N-gram Models, Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Sequence-to-Sequence Models, Attention Mechanism, Transformer Architecture for Text Generation. TB1: Chapter 7, 8 TB3: Chapter 1, 2	
UNIT – III	**09 Hours**
ADVANCED TEXT GENERATION USING TRANSFORMERS: Pre-trained Language Models, Encoder-Decoder and Decoder-Only Architectures, Text Generation Strategies (Greedy Search, Beam Search, Sampling), Fine-Tuning and Prompt-Based Learning, Evaluation Metrics for Text Generation. TB1: Chapter 9, 10	
UNIT – IV	**09 Hours**
SPEECH GENERATION AND TEXT-TO-SPEECH SYSTEMS: Fundamentals of Speech Signals, Text-to-Speech (TTS) Pipeline, Acoustic Modeling, Neural TTS Models (Tacotron, FastSpeech), Neural Vocoders (WaveNet, WaveGlow), Evaluation of Speech Quality and Naturalness. TB2: Chapter 1, 2, 3, 4	
UNIT – V	**091 Hours**
APPLICATIONS, ETHICS, AND TRUSTWORTHY AI: Applications of Text and Speech Generation (Chatbots, Virtual Assistants, Assistive Technologies), Bias and Fairness in Generated Content, Ethical Issues and Responsible AI, Human-in-the-Loop Systems, Case Studies and Emerging Trends.	

TB1: Chapter 11		
Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	**Explain** the fundamentals of text and speech generation and their role in modern AI applications	L2
2	**Implement** advanced deep learning models for text generation and speech synthesis	L3
3	**Use** text and speech generation techniques to address practical AI application scenarios	L3
4	**Differentiate** and **analyze** advanced text and speech generation models based on performance, robustness, and ethical considerations	L4
5	**Analyze** the design of AI applications integrating text and speech generation models with respect to trust, bias, and responsibility.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	1	-	-	-	-	-	-	-	-	-	2	-
CO2	2	2	1	-	3	-	-	-	-	-	-	3	2
CO3	2	3	1	-	2	-	-	-	-	-	-	3	1
CO4	2	3	2	1	3	1	-	-	-	-	-	2	3
CO5	1	2	3	-	3	2	-	-	-	-	-	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Jurafsky, Daniel, and James H. Martin. *Speech and Language Processing*. Pearson Education, latest edition,2023.

2. Tan, Xu. *Neural Text-to-Speech Synthesis*. Springer, 2021.

3. Bird, Steven, Ewan Klein, and Edward Loper. *Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit*. O'Reilly Media, 2009.

REFERENCE BOOKS:

1. Manning, Christopher D., and Hinrich Schütze. *Foundations of Statistical Natural Language Processing*. MIT Press, 1999.

2. Rao, Delip, and Brian McMahan. *Natural Language Processing with PyTorch*. O'Reilly Media, 2019.

E-Resources:

1.Stanford CS224N – Natural Language Processing with Deep Learning https://web.stanford.edu/class/cs224n/

2. Hugging Face – Transformers Documentation and Tutorials - https://huggingface.co/docs

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

COMPUTATIONAL MODELS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5210	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA:**		100

Prerequisites:

Proficiency in at least one programming language (Python, MATLAB, or C++).

Course Objectives:

1. To introduce the fundamental concepts of computational models and formal languages used to describe computation.
2. To develop an understanding of finite automata, regular expressions, and their role in modeling and solving computational problems.
3. To explain context-free grammars and pushdown automata, and analyze their applications in language processing and compiler design.
4. To provide a comprehensive understanding of Turing machines, computability, and undecidable problems.
5. To enable students to analyze computational problems using appropriate computational models and classify them based on computability and computational complexity.

Teaching-Learning Process (General Instructions)

These pedagogical methods are intended to enhance conceptual understanding and improve the attainment of course outcomes.

1. A1 Conceptual Lectures: Classroom lectures focusing on formal definitions, theoretical foundations, and mathematical reasoning behind computational models.
2. A2 Problem-Solving Sessions: Regular problem-solving classes involving the design and analysis of finite automata, grammars, pushdown automata, and Turing machines.
3. A3 Case Studies: Discussion of real-world applications of computational models in compiler design, programming language processing, and pattern recognition.
4. A4 Interactive Learning: Encouraging student participation through quizzes, discussions, and peer instruction to strengthen conceptual clarity.
5. A5 Laboratory and Tool-Based Learning: Hands-on sessions using software tools for simulating automata, grammars, and Turing machines.

UNIT – I	08 Hours
INTRODUCTION TO COMPUTATIONAL MODELS: Introduction to computation and computational models, motivation and scope of theory of computation, mathematical preliminaries, alphabets, strings, and languages, operations on languages, formal language definition, classification of languages, Chomsky hierarchy, role of computational models in computer science applications.	
UNIT – II	**10 Hours**
FINITE AUTOMATA AND REGULAR LANGUAGES: Deterministic Finite Automata (DFA), Non-Deterministic Finite Automata (NFA), equivalence of DFA and NFA, ε–NFA, minimization of DFA, Regular Expressions, conversion between regular expressions and finite automata, pumping lemma for regular languages, applications of regular languages.	
UNIT – III	**09 Hours**
CONTEXT-FREE GRAMMARS AND PUSHDOWN AUTOMATA: Context-Free Grammars (CFG): definition and derivations, parse trees, ambiguity in grammars, normal forms (Chomsky Normal Form and Greibach Normal Form), Pushdown Automata (PDA), equivalence of PDA and CFG, pumping lemma for context-free languages, applications in syntax analysis and compiler design.	
UNIT – IV	**09 Hours**
TURING MACHINES AND COMPUTABILITY: Introduction to Turing Machines, components and operation of a TM, language recognition using Turing Machines, variants of Turing Machines, Church–Turing Thesis, recursive and recursively enumerable languages, decidable and undecidable problems, halting problem, reductions.	
UNIT – V	**09 Hours**
COMPUTATIONAL COMPLEXITY THEORY: Introduction to computational complexity, time and space complexity measures, complexity classes P, NP, NP-Complete, and NP-Hard, polynomial-time reductions, Cook's theorem (overview), examples of NP-complete problems, importance of complexity theory in modern computing.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the fundamental concepts of computational models, formal languages, and their classification.	L2
2	Design and analyze finite automata and regular expressions for modeling regular languages.	L3
3	Apply context-free grammars and pushdown automata to solve problems related to language parsing and compiler design.	L3
4	Analyze Turing machines and distinguish between decidable and undecidable computational problems.	L4
5	Classify computational problems based on time and space complexity and evaluate their computational feasibility.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	2	1	–	–	–	1	–	1	–	1	–	1	1
CO2	2	2	1	1	1	1	–	1	–	1	–	1	2
CO3	2	3	1	2	1	1	–	1	1	2	1	2	2
CO4	1	2	1	2	1	2	1	2	1	3	1	2	2
CO5	2	3	2	3	2	2	1	2	2	3	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. **Hopcroft, J.E., Motwani, R., and Ullman, J. D.**, *Introduction to Automata Theory, Languages, and Computation*, 3rd Edition, Pearson Education, 2014. *(Prescribed textbook in IIT Bombay, IIT Madras, NIT Trichy)*
2. **Michael Sipser**, *Introduction to the Theory of Computation*, 3rd Edition, Cengage Learning, 2013. *(Used in IIT Kanpur, IIIT Hyderabad)*

REFERENCE BOOKS:

1. **Kozen, D. C.**, *Automata and Computability*, Springer, 1997. *(Referenced in IIT Bombay – Theory of Computation)*
2. **Lewis, H. R., and Papadimitriou, C. H.**, *Elements of the Theory of Computation*, 2nd Edition, Pearson Education, 1998. *(Used in NIT Calicut, NIT Surathkal)*
3. **Peter Linz**, *An Introduction to Formal Languages and Automata*, 6th Edition, Jones & Bartlett Learning, 2016. *(IIIT Hyderabad curriculum)*

E-Resources:

1. (NPTEL, IIT course pages)

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Roleplay E.g., Stack, Queue, etc.,
3. Demonstration of solution to a problem through programming.
4. Flip class activity E.g., arrays, pointers, dynamic memory allocation, etc.,

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

COGNITIVE LINGUISTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5211	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA:**		100

Prerequisites:

Natural Language Processing

Course Objectives:

1. To introduce students to the historical development, core assumptions, and main schools of thought within cognitive linguistics as an alternative to formal models of language.
2. To develop students' understanding of key theoretical frameworks in cognitive linguistics, including frame semantics, construction grammar, conceptual metaphor theory, and prototype theory.
3. To enable students to analyse linguistic data using usage-based, functional, and cognitive approaches, linking grammar to cognition, categorization, and language use.
4. To train students to critically read, interpret, and discuss primary scholarly works in cognitive linguistics, fostering independent thinking and methodological awareness.
5. To cultivate students' ability to design and present small-scale research projects in cognitive linguistics, culminating in oral presentations and a written term paper.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture methods, but different *types of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
3. Show ***Video/Animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.

6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

INTRODUCTION TO COGNITIVE LINGUISTICS:

Cognitive linguistics, Scope and Need of Cognitive linguistics, Connection between language, mind, and perception, Formal, functional and cognitive linguistics, historical development and core assumptions, Comparison with formal/generative linguistics.

UNIT – II	**10 Hours**

GRAMMAR, COGNITION AND USAGE-BASED MODEL:

Overview of Cognitive Grammar, Symbolic units, Schemas and instantiations, Domains and domain matrices, Grammar and cognition; Talmy's cognitive representations. Language as human behaviour, language acquisition, language as a complex adaptive system (usage-based model), Role of frequency, repetition, and experience.

UNIT – III	**9 Hours**

FRAME SEMANTICS AND CONSTRUCTION GRAMMAR:

Frame semantics: Origin of Frame Semantics, frames and Fillmore's case grammar, Frame elements (FEs): core and peripheral roles, Frame evocation and lexical units, Introduction to FrameNet.

Construction grammar: constructions as elements of grammar; Fillmore, Langacker; construction grammar vs cognitive grammar, Difference from rule-based and generative grammar approaches.

TB2:

UNIT – IV	**9 Hours**

CONCEPTUAL METAPHOR AND CONCEPTUAL BLENDING:

Definition of metaphor in Cognitive Linguistics, Conceptual Metaphor Theory, Difference between linguistic metaphors and conceptual metaphors, Lakoff & Johnson: metaphor as a cognitive mechanism.

Conceptual Blending **-** Mental spaces and integration networks, Components of blending: Input spaces, Generic space, Blended space, Types of Conceptual Blends, conceptual blending and its applications in meaning construction.

UNIT – V	**9 Hours**

PROTOTYPE THEORY, TYPOLOGY AND APPLICATIONS:

Prototype theory: Motivation of Prototype Theory, Characteristics of Prototypes, Cognitive economy and categorization efficiency, Prototypes in lexical semantics, prototype and basic-level categories; applications in psychology, psychiatry, cultural anthropology.
Typology and cognitive linguistics: Cognitive basis of language universals, Role of cognition in shaping language structures, Typological patterns explained through cognitive principles.

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Understand the historical development and core assumptions of cognitive linguistics and distinguish it from formal and functional approaches to language.	L2
2	Apply concepts of grammar–cognition interfaces and usage-based models to analyse how language structure emerges from use and cognitive processes.	L3
3	Analyze linguistic data using frame semantics and construction grammar to identify how meaning and grammatical patterns are organised in speakers' minds.	L4
4	Analyze conceptual metaphors and conceptual blending in authentic language examples to reveal underlying cognitive mechanisms of meaning construction.	L4
5	Evaluate and design small-scale studies that use prototype theory and typological perspectives to explain categorization and linguistic universals in cognitive linguistics.	L5

Table: Mapping Levels of COs to POs / PSOs		
COs	**Program Outcomes (POs)**	**PSOs**

	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2	1	–	–	–	1	–	1	–	1	–	1	1
CO2	2	2	1	1	1	1	–	1	–	1	–	1	2
CO3	2	3	1	2	1	1	–	1	1	2	1	2	2
CO4	1	2	1	2	1	2	1	2	1	3	1	2	2
CO5	2	3	2	3	2	2	1	2	2	3	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Evans, Vyvyan, & Green, Melanie. Cognitive Linguistics.
2. Dąbrowska, Ewa, & Divjak, Dagmar (eds.). Handbook of Cognitive Linguistics. De Gruyter, 2015.
3. Dąbrowska, Ewa (ed.). The Cambridge Handbook of Cognitive Linguistics. Cambridge University Press, 2017.

REFERENCE BOOKS:

1. Tomasello, Michael. A Natural History of Human Thinking. Harvard University Press, 2014.
2. Bybee, Joan. Frequency of Use and the Organization of Language. Oxford University Press, 2006.

E-Resources:

- Language, Culture and Cognition: An Introduction (IIT Guwahati) – Introduces relations between language, cognition and culture explicitly from a cognitive linguistics perspective; videos and materials are free, exam is paid only if needed.
- Bilingualism: A Cognitive and Psycholinguistic Perspective (NPTEL) – Explores cognitive and psycholinguistic aspects of bilingualism, useful for units on cognition and categorisation.onlinecourses.
- Applied Linguistics (NPTEL) – Focus on applications of linguistic theory; relevant for connecting cognitive and applied perspectives.
- Introduction to Cognitive Psychology / Cognition and its Computation / Introduction to Basic Cognitive Processes (NPTEL) – Background on cognitive processes, attention, memory and computation supporting cognitive linguistics foundations.

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Role play E.g., Stack, Queue, etc.,
3. Demonstration of solution to a problem through programming.
4. Flip class activity E.g., arrays, pointers, dynamic memory allocation, etc.,

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

ACCELERATED COMPUTING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	: 26AM5212	**Credits**:	3
Hours/Week	: 04 Hours	**Total Hours**:	45 Hrs (15 Hrs Project)
L–T–P-J	: 2–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

- Understand GPU architecture and CUDA programming fundamentals
- Apply parallel programming concepts using CUDA APIs
- Analyze memory hierarchy and optimize data access
- Design efficient parallel algorithms and computation patterns
- Implement scalable GPU applications using advanced CUDA features

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Examples:** Incorporate real-world examples and case studies that demonstrate the relevance and application of automata theory in areas such as natural language processing, compilers, and pattern recognition.
2. **Problem-Solving Sessions:** Organize problem-solving sessions where students can work through challenging problems together.
3. **Reflective Learning**: Encourage students to reflect on their problem-solving approaches and discuss the reasoning behind their solutions**.**

UNIT – I	**08 Hours**

INTRODUCTION TO CUDA:
Introduction to Heterogeneous Parallel Computing – portability and scalability - Overview of Accelerated Computing -GPU vs CPU Architecture Introduction to CUDA Programming Model- CUDA API Basics (Host and Device Code)- CUDA Threads, Blocks, and Grids -Data Parallelism Concepts

UNIT – II	**10 Hours**

MEMORY AND DATA LOCALITY:

Memory Hierarchy in CUDA, Global Memory, Shared Memory, Registers, Memory Allocation and Data Transfer, Memory Coalescing, Data Locality Optimization Techniques, Unified Memory Concepts

UNIT – III	09 Hours
THREAD EXECUTION AND PERFORMANCE OPTIMIZATION: Thread Execution Model, Warp Execution and Divergence, Thread Scheduling, Performance Bottlenecks, Optimization Techniques, Profiling CUDA Programs	
UNIT – IV	**09 Hours**
PARALLEL COMPUTATION PATTERNS: Common Parallel Patterns, Reduction, Scan (Prefix Sum), Stencil Computations, Algorithm Design for Parallelism, Load Balancing, Synchronization Mechanisms	
UNIT – V	**09 Hours**
ADVANCED CUDA AND MULTI-GPU SYSTEMS: Efficient Host–Device Data Transfer, CUDA Streams and Asynchronous Execution, Dynamic Parallelism, Multi-GPU Programming, CUDA Libraries (cuBLAS, cuDNN, etc.), Introduction to OpenACC, MPI, OpenCL	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain the fundamentals of parallel computing, GPU architecture, and CUDA programming models.	L2
2	Apply CUDA programming and parallel algorithms to develop high-performance computing solutions.	L3
3	Analyze performance bottlenecks and optimize applications using profiling and GPU optimization techniques.	L4
4	Create scalable and efficient GPU-accelerated applications using modern C++ and parallel computing frameworks.	L5
5	Evaluate real-world problems and implement accelerated computing solutions for AI, data science, and HPC applications.	L5

Mapping Levels of COs to POs / PSOs

COs				Program Outcomes (POs)							PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	1	2	1	-	-	-	-	-	-	2	1
CO2	2	3	2	3	2	-	-	-	-	-	-	3	2
CO3	2	3	3	3	2	-	-	-	1	1	_	3	3
CO4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO5	1	2	2	3	2	1	1	3	2	2	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Yoshida, K., Miwa, S., Yamaki, H., & Honda, H. (2024). Analyzing the impact of CUDA versions on GPU applications. Parallel Computing, 120, 103081
2. Boopathi, S., Pandey, B. K., & Pandey, D. (2023). Advances in artificial intelligence for image processing: techniques, applications, and optimization. In Handbook of research on thrust technologies' effect on image processing (pp. 73-95). IGI Global Scientific Publishing.

REFERENCE BOOKS:

1. Sinadjan, L. (2025). GPU Acceleration for Faster Evolutionary Spatial Cyclic Game Systems. arXiv preprint arXiv:2508.16639.
2. Zhao, Q. (2025). Novel Profiling Techniques for Emerging Architectures and Applications. North Carolina State University.

E-Resources:

- https://developer.nvidia.com/cuda/toolkit/

  https://www.nvidia.com/en-in/training/

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

MULTI-AGENT AI SYSTEM
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	: 26AM5213	**Credits**:	3
Hours/Week	: 04 Hours	**Total Hours**:	45 Hrs (15 Hrs Project)
L–T–P-J	: 2–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understanding the principles behind intelligent agents and agent-oriented systems.
2. Knowledge of architectural models enabling autonomous agent behaviour.
3. Familiarity with cooperation, coordination, and communication in multi-agent societies.
4. Awareness of ethical implications and governance challenges of autonomous agents.
5. Capability to conceptualize and build agent-based solutions for practical problems.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Examples:** Incorporate real-world examples and case studies that demonstrate the relevance and application of automata theory in areas such as natural language processing, compilers, and pattern recognition.
2. **Problem-Solving Sessions:** Organize problem-solving sessions where students can work through challenging problems together.
3. **Reflective Learning**: Encourage students to reflect on their problem-solving approaches and discuss the reasoning behind their solutions**.**

UNIT – I	**8 Hours**

INTELLIGENT AGENTS VS CONVENTIONAL EXPERT SYSTEMS:

Agents and objects, agents versus expert systems, agents versus distributed systems, characteristics of intelligent agents, agent environments and environment properties, typical application domains of agent systems.

UNIT – II	**10 Hours**

INTELLIGENT AGENT ARCHITECTURES:

Abstract architectures for intelligent agents, task environments and agent functions, design of intelligent agents, reasoning agents and BDI architecture, reactive agents and subsumption

architecture, hybrid agents such as PRS architecture, Multi-layered agent architectures including InterRAP.

UNIT – III	**09 Hours**
MULTI-AGENT SYSTEMS AND INTERACTION MODELS: Definition and characteristics of multi-agent systems, classification of multi-agent interactions, cooperative versus non-cooperative agents, zero-sum and non-zero-sum interactions, Prisoner's Dilemma, Axelrod's experiments on cooperation, self-interested agents and strategic interaction	
UNIT – IV	**09 Hours**
AGENT AI, COMMUNICATION, COORDINATION AND ETHICS: Classical planning concepts, Plan–execute–monitor loops, Task decomposition and hierarchical planning, Reinforcement learning fundamentals for agents, Reward-driven decision making, Relationship between deep learning and agentic behavior, Handling uncertainty and constraints.	
UNIT – V	**09 Hours**
COOPERATIVE MULTI-AGENT SYSTEMS AND ETHICAL FRAMEWORK: Cooperative Distributed Problem Solving (CDPS), Partial Global Planning, coordination and coherence in agent societies, negotiation and argumentation among agents, auction-based multi-agent systems, ethical risks in multi-agent decision-making, governance and societal impact of agent-based systems, real-world applications of intelligent agents and multi-agent systems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain the concepts of intelligent agents and applications suitable for agent-oriented solutions.	L2
2	Describe agent architectures and mechanisms enabling autonomous intelligent behaviour.	L3

3	Analyze interaction and coordination strategies in multi-agent systems.	L4
4	Evaluate ethical, social, and governance challenges in agent-based systems.	L4
5	Design and develop a basic intelligent or multi-agent system for a real-world problem	L3

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	1	2	1	-	-	-	-	-	-	2	1
CO2	2	3	2	3	2	-	-	-	-	-	-	3	2
CO3	2	3	3	3	2	-	-	-	1	1	_	3	3
CO4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO5	1	2	2	3	2	1	1	3	2	2	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Michael Wooldridge, An Introduction to MultiAgent Systems, 2nd Edition, Wiley, 2009.
2. Stuart J. Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2021.

REFERENCE MATERIALS

1. François Chollet, Deep Learning with Python, 2nd Edition, Manning Publications, 2021.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.

E-RESOURCES:

- FIPA Agent Standards : https://www.fipa.org
- MIT OpenCourseWare – Multi-Agent Systems : https://ocw.mit.edu

- NVIDIA AI Resources: https://developer.nvidia.com/ai
- Coursera – Multi-Agent Systems & AI Courses: https://www.coursera.org

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

VISUAL COMPUTING AND GRAPHICS
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER - II

Subject Code	: 26AM5214	**Credits**:	3
Hours/Week	: 04 Hours	**Total Hours**:	45 Hrs (15 Hrs Project)
L–T–P-J	: 2–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand core concepts of computer graphics and rendering pipelines
2. Analyze geometric transformations and GPU-based rendering techniques
3. Explore lighting, shading, and material models for realistic rendering
4. Evaluate real-time ray tracing and optimization techniques
5. Assess integration of AI/ML in modern graphics systems.

Teaching-Learning Process (General Instructions):

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Case Studies:** Use real-world applications from robotics, game playing, resource management, and autonomous systems to demonstrate the practical relevance of planning and decision-making algorithms.
2. **Problem-Solving and Design Exercises:** Conduct problem-solving sessions where students formulate planning domains, design heuristics, and analyze algorithmic trade-offs for sequential decision problems.
3. **Hands-on Learning**: Organize laboratory sessions involving implementation and evaluation of planning algorithms, MDPs, and reinforcement learning agents in simulated environments.
4. **Reflective and Research-Based Learning:** Encourage students to study recent research papers on planning and RL, reflect on algorithmic advances, limitations, and design choices through presentations and discussions.

UNIT – I	**08 Hours**

GRAPHICS PIPELINE AND GPU FUNDAMENTALS:
Introduction to computer graphics, applications in visualization and game engines, graphics rendering pipeline, rasterization vs ray tracing, GPU architecture fundamentals, memory hierarchy, parallel processing, graphics APIs (OpenGL, Vulkan), mathematical foundations (vectors, matrices, coordinate systems).

UNIT – II	**10 Hours**
GEOMETRIC TRANSFORMATIONS AND SHADER PROGRAMMING: 2D and 3D transformations (translation, rotation, scaling), homogeneous coordinates, viewing transformations, projection systems (orthographic and perspective), camera systems, GPU pipeline execution, shader programming (vertex and fragment shaders), texture mapping basics.	
UNIT – III	**09 Hours**
LIGHTING, SHADING AND RENDERING TECHNIQUES: Lighting models (ambient, diffuse, specular), Phong and Blinn-Phong shading, physically-based rendering (PBR), normal mapping, shadow mapping, ray tracing fundamentals, BVH acceleration, global illumination basics.	
UNIT – IV	**09 Hours**
ADVANCED RENDERING AND NEURAL GRAPHICS: Real-time ray tracing, hybrid rendering, denoising techniques, rendering optimization (culling, LOD), neural rendering basics, NeRF, AI-based denoising, deep learning in graphics, 3D visualization for AI applications.	
UNIT – V	**09 Hours**
ADVANCED RENDERING AND NEURAL GRAPHICS: Real-time ray tracing, hybrid rendering, denoising techniques, rendering optimization (culling, level-of-detail), neural rendering basics, NeRF, AI-based denoising, deep learning in graphics, 3D visualization for AI applications.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain graphics pipeline and GPU architecture concepts	L3
2	Analyze transformations, viewing systems, and shader programming	L4
3	Apply lighting models and shading technique	L3

4	Evaluate real-time ray tracing and optimization methods	L5
5	Evaluate neural rendering and AI integration in graphics	L5

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	2	2	2	-	-	-	-	-	2	3	-
CO2	3	3	2	2	2	-	-	-	-	-	2	3	2
CO3	3	3	2	3	3	-	-	-	-	-	2	2	3
CO4	3	2	2	3	3	-	-	-	-	-	2	2	2
CO5	3	2	3	3	2	1	1	2	2	-	1	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Shirley, Peter, Michael Ashikhmin, and Steve Marschner. Fundamentals of Computer Graphics. 4th Edition. A K Peters/CRC Press, 2021.
2. Akenine-Möller, Tomas, Eric Haines, and Naty Hoffman. Real-Time Rendering. 4th Edition. CRC Press, 2018.
3. Shreiner, Dave and Bill Licea-Kane. OpenGL Programming Guide: The Official Guide to Learning OpenGL. 9th Edition. Addison-Wesley, 2013.

REFERENCE BOOKS:

1. Foley, James D., Andries van Dam, Steven K. Feiner, and John F. Hughes. Computer Graphics: Principles and Practice. 3rd Edition. Addison-Wesley, 2013.
2. Buss, Samuel R. 3D Computer Graphics: A Mathematical Introduction with OpenGL. 1st Edition, 2003.
3. Watt, Alan. 3D Computer Graphics. 3rd Edition. Addison-Wesley, 2000.E.

E-Resources:

- Khronos Group OpenGL Documentation: https://www.khronos.org/opengl/
- Vulkan API Specifications: https://www.khronos.org/vulkan/

- NVIDIA Developer Blog – Ray Tracing, DLSS, and Neural Rendering: https://developer.nvidia.com/blog/
- SIGGRAPH Papers and Course Materials: https://kesen.realtimerendering.com/
- High-Performance Graphics Conference: https://www.highperformancegraphics.org/
- Global Illumination Compendium: https://people.cs.kuleuven.be/~philip.dutre/GI/
- NPTEL Computer Graphics: https://nptel.ac.in/courses/106106090/

Activity Based Learning (Suggested Activities in Class):

Hands on activity, Quiz, Seminar.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

ROBOT OPERATING SYSTEMS (ROS)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	:	26AM5215	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA**	:	100

Course Learning Objectives:

This course enables students to:

1. Understand ROS architecture and communication mechanisms for robotic systems.
2. Develop ROS-based programs using nodes, topics, and services.
3. Implement sensor integration and data handling in robotic applications.
4. Analyze and debug robotic systems using ROS tools and visualization frameworks.
5. Build and simulate robotic systems using ROS and simulation environments.

Teaching-Learning Process (General Instructions)
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. **Lecture** method combining conceptual exposition with examples from AI, robotics, HCI, and neuroscience.
2. **Interactive teaching** through think–pair–share, small-group discussions on classic cognitive experiments and cognitive architectures.
3. **Demonstrations** of cognitive models (e.g., ACT-R / SOAR demos, Bayesian models, reinforcement learning agents) and HCI prototypes.
4. **Collaborative learning** via mini-projects where students implement small cognitive agents or interfaces and present findings.
5. **Critical thinking** questions connecting human cognition with AI system design, interpretability, and bias.
6. **Problem-based** learning around case studies (e.g., dialogue systems, recommender systems, assistive technologies) requiring cognitive modelling.
7. **Real-world application** discussions linking cognitive systems to domains like healthcare, education, autonomous systems, and digital therapeutics.

UNIT – I	**08 Hours**
INTRODUCTION TO ROS AND ROBOTIC MIDDLEWARE: Evolution of robotic middleware, ROS ecosystem, computation graph, nodes, topics, services, ROS architecture, ROS file system, basic ROS setup.	
UNIT – II	**10 Hours**
ROS PROGRAMMING AND COMMUNICATION:	

ROS workspace and package creation, publishing and subscribing, message types, services, ROS client libraries (Python), inter-node communication.	
UNIT – III	**09 Hours**
SENSOR INTEGRATION AND DATA HANDLING: Integration of sensors (camera, LiDAR – conceptual), data acquisition in ROS, message handling, basic data processing, introduction to sensor-based decision pipelines.	
UNIT – IV	**09 Hours**
ROS TOOLS, SIMULATION, AND SYSTEM INTEGRATION: ROS debugging tools (rosnode, rqt_graph, rosout, rqt_console), RViz visualization, rosbag data logging, introduction to Gazebo simulation, basic robot simulation, teleoperation, introduction to navigation concepts in ROS.	
UNIT – V	**09 Hours**
NVIDIA DLI: ROS 2 AND ISAAC SIM: Getting Started with Issac Sim - Building Your First Robot in Isaac Sim, Ingesting Robot Assets and Simulating Your Robot in Isaac Sim, Synthetic Data Generation for Perception Model Training in Isaac Sim, Developing Robots With Software-in-the-Loop (SIL) in Isaac Sim, Leveraging ROS 2 and Hardware-in-the-Loop in Isaac Si	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
CO1	**Understand** the fundamental concepts and interdisciplinary nature of ROS.	L2
CO2	**Analyze** and compare different ROS architecture.	L4
CO3	**Design** simple ROS system prototypes that integrate perception, reasoning, and learning components.	L4
CO4	**Apply** human-centered computing and HCI principles to design and evaluate ROS systems.	L3
CO5	**Critically** evaluate ROS systems with respect to plausibility, performance, ethics, and societal impact.	L5

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**

CO1	2	3	2	-	-	-	-	-	-	-	-	3	-
CO2	3	3	3	2	-	2	-	-	-	-	-	3	2
CO3	3	3	3	3	2	2	2	2	-	2	2	3	2
CO4	3	3	3	3	2	2	2	3	2	3	3	3	3
CO5	2	2	2	2	3	2	3	3	2	3	3	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXTBOOKS:

1. Quigley, Morgan; Gerkey, Brian; Smart, William D., Programming Robots with ROS, 1st Edition, O'Reilly Media, 2015.
2. Joseph, Lentin, Robot Operating System for Absolute Beginners, 1st Edition, Apress, 2018.

REFERENCE BOOKS:

1. Fairchild, Carol & Harman, Thomas L., ROS Robotics by Example, 2nd Edition, Packt Publishing, 2017.
2. Martinez & Fernandez, Mastering ROS for Robotics Programming, 3rd Edition, Packt, 2021.
3. Bassa, Marco Matteo, ROS2 Best Practices, 1st Edition, 2023.

E-Resources:

1. https://docs.nvidia.com/learning/physical-ai/getting-started-with-isaac-sim/latest/index.html
2. https://docs.nvidia.com/learning/physical-ai/getting-started-with-isaac-ros/latest/index.html
3. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-OV-02+V1.

Activity Based Learning (Suggested Activities in Class):

1. Future directions: Integrating large language models, multimodal models, and cognitive theories; human-in-the-loop cognitive systems.
2. Case Study Analysis: Modelling problem solving and planning in cognitive architectures, connections to agent-based models (topics in agent-based models in cognitive and behavioural science).

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

AI FOR AUTONOMOUS VEHICLES & SMART MOBILITY
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Course Code	:	26AM5216	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA**	:	100

Prerequisites:

Proficiency in a Python programming language.

Course Objectives:

1. Understand AI-driven architecture of autonomous vehicles and smart mobility systems.
2. Apply machine learning and deep learning techniques for perception, prediction, and decision-making.
3. Analyze localization, planning, and control using AI-based approaches.
4. Develop AI-enabled solutions for real-world smart mobility applications.
5. Evaluate safety, ethics, and societal impacts of AI in transportation systems.

Teaching-Learning Process (General Instructions)

1. **Case-Based Learning:** Study real failures and successes of Human–AI systems**.**
2. **Human-in-the-Loop Activities:** Simple simulations where students act as AI supervisors.
3. **Group Discussions:** Ethics, bias, trust, and responsibility in AI decisions**.**
4. **Reflective Learning:** Students reflect on when to trust AI and when not to.
5. **Mini Design Tasks:** Design a trustworthy AI workflow for a given application**.**

UNIT – I	**8 Hours**

AI IN SMART MOBILITY & AUTONOMOUS SYSTEMS:

Evolution of mobility, levels of automation, AV architecture, Role of AI & ML in daily transportation, introduction to AI in transportation, intelligent transportation systems, AI pipeline (data → model → decision).

UNIT – II	**10 Hours**

AI-BASED PERCEPTION SYSTEMS:

Sensors (Camera, LiDAR, RADAR), sensor fusion, Computer Vision basics for autonomous vehicles, image processing, Convolutional Neural Networks (CNNs), object detection (YOLO, SSD), semantic segmentation.

UNIT – III	09 Hours
AI FOR LOCALIZATION & PREDICTION: Simultaneous Localization and Mapping (SLAM), neural networks, supervised learning: regression & classification in mobility systems, time-series prediction, traffic forecasting.	
UNIT – IV	**09 Hours**
AI-BASED PLANNING, CONTROL & CONNECTIVITY: Path planning (Dijkstra, A*), reinforcement learning, decision-making models, trajectory planning, V2X communication, Edge AI in smart mobility, 5G mobility**,** Real-life examples: Smart traffic signals, emergency vehicle prioritization.	
UNIT – V	**09 Hours**
AI SAFETY, ETHICS & FUTURE MOBILITY: Safety challenges in autonomous vehicles, Explainable AI (XAI), safety in AI systems, bias in ML models, ethical decision-making, legal frameworks, sustainability. Future trends: Electric vehicles, shared mobility, AI-based smart city ecosystems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain AI-based architecture of autonomous vehicles	L2
2	Apply ML/DL models for perception and prediction tasks	L3
3	Analyze AI-driven localization and path planning techniques	L4
4	Develop intelligent mobility solutions using AI	L3
5	Analyze ethical, safety, and societal implications of AI systems	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	-	-	2	-	-	-	-	-	-	2	3

CO2	2	3	-	2	2	-	-	2	-	-	-	2	2
CO3	-	2	-	-	-	3	-	3	-	-	-	2	2
CO4	2	2	3	-	3	-	-	2	1	-	-	3	1
CO5	-	2	3	-	2	2	-	3	2	1	-	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Mahajan, Rupali A., Rajesh Dey, Parikshit N. Mahalle, and Vivek S. Deshpande, AI-Driven Transportation Systems: Real-Time Applications & Related Technologies. Springer, 2025.
2. Houbing Song, Sabina Jeschke, et al., Smart Transportation: AI Enabled Mobility and Autonomous Driving. CRC Press, 2021.

REFERENCE BOOKS:

1. Hussein T. Mouftah, Melike Erol-Kantarci, Sameh Sorour, onnected and Autonomous Vehicles in Smart Cities. CRC Press, 2020.
2. Dominique Paret and Hassina Rebaine, Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet. Wiley, 2022.

E-Resources:

- MIT OpenCourseWare – Human-Centered AI
- Stanford HAI resources
- NPTEL – Ethics in AI
- IEEE Ethically Aligned Design documents

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis
2. Group discussions
3. Role-play (Human vs AI decision-making)
4. Mini-project / seminar
5. Quiz.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30

AI-powered Assignment “Or” Mini Project*	50
Total	**100 marks**

CONVERSATIONAL AI AND SPOKEN LANGUAGE UNDERSTANDING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Course Code	:	26AM5217	**Credits**	:	3
Hours/Week	:	04 Hours	**Total Hours**	:	45 Hrs (15 Hrs Project)
L–T–P-J	:	2–0–0-2	**CIA**	:	100

Prerequisites:

Basic understanding of Artificial Intelligence, Machine Learning concepts, probability, and introductory programming (Python/C). Familiarity with data ethics and algorithmic decision-making is desirable.

Course Objectives:

This course will enable students to:

1. Understand classical and modern Conversational AI architectures, including LLM-based systems.
2. Apply NLP and deep learning techniques for language understanding and response generation.
3. Design intelligent dialogue systems using retrieval, generation, and reinforcement learning.
4. Develop, evaluate, and deploy scalable conversational AI applications.
5. Analyse ethical, societal, and research challenges in advanced conversational systems.

Teaching-Learning Process (General Instructions)

These pedagogical approaches are designed to accelerate the attainment of course learning outcomes and promote deep conceptual understanding.

1. Lecture Method: Includes structured lectures integrated with concept-driven discussions supported by contemporary research articles, global policy documents, and real-world case examples of agentic AI systems.

2. Interactive Teaching: Active learning through guided discussions, ethical dilemma analysis, and problem-solving sessions focused on safety, alignment, and decision-making challenges in autonomous AI agents.

3. Visual Learning: Use of documentaries, expert talks, system flow visualizations, and simulation videos to illustrate AI failures, governance mechanisms, and human–AI interaction dynamics.

4. Collaborative Learning: Group-based evaluation of AI governance frameworks, regulatory case studies, and comparative analysis of international AI policies and standards.

5. Critical Thinking: Faculty will pose higher-order questions encouraging students to reason about ethical trade-offs, accountability, risk mitigation, and long-term implications of agentic AI deployment.

6. Application-Oriented Learning: Continuous emphasis on applying ethical principles, safety strategies, and governance models to real-world agentic AI use cases across domains such as healthcare, transportation, and public systems.

UNIT – I	**08 Hours**

FOUNDATIONS OF CONVERSATIONAL AI:

Evolution of conversational systems, Types of conversational systems: task-oriented, open-domain, hybrid, Core components of the system, Understanding Conversational AI vs Chatbots vs Virtual Assistants, Applications of conversational systems, Challenges in conversational systems.

UNIT – II	**10 Hours**

NATURAL LANGUAGE UNDERSTANDING & REPRESENTATION LEARNING:

Text preprocessing and linguistic features, Intent classification and entity recognition, Machine learning approaches for NLU, Word embeddings: Word2Vec, GloVe, FastText, Contextual embeddings: BERT, RoBERTa, Transformer architecture for NLU, Context handling, Ambiguity resolution.

UNIT – III	**09 Hours**

DIALOGUE MANAGEMENT, GENERATION & LLMS:

Dialogue systems: task-oriented vs open-domain, Dialogue state tracking, Rule-based dialogue management, Machine learning-based dialogue management, Natural Language Generation (NLG): template based and model-based approaches, Introduction to Large Language Models, Prompt engineering and in-context learning, Retrieval-Augmented Generation (RAG) for grounded conversations, Handling errors, fallbacks and mitigation strategies

UNIT – IV	**09 Hours**

ADVANCED CONVERSATIONAL AI SYSTEMS:

Knowledge-grounded dialogue systems, Conversational Information Retrieval, Emotion-aware and empathetic conversational agents, Multimodal Conversational AI (text, speech, vision), Reinforcement Learning and RLHF for dialogue optimization, Explainable Conversational AI (XAI).

UNIT – V	09 Hours
DEPLOYMENT, EVALUATION, ETHICS & FUTURE TRENDS: Evaluation metrics, human evaluation of conversational agents, deployment architectures and APIs, MLOps for conversational AI, security issues, future research directions and open challenges.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain classical and modern conversational AI architectures	L2
2	Apply NLP and transformer-based models for language understanding	L3
3	Design dialogue systems using retrieval, generation, and RL	L4
4	Implement and evaluate conversational AI applications	L3
5	Analyze ethical, societal, and research challenges in conversational AI	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	1	2	1	-	-	-	-	-	-	2	1
CO2	2	3	2	3	2	-	-	-	-	-	-	3	2
CO3	2	3	3	3	2	-	-	-	1	1	_	3	3
CO4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO5	1	2	2	3	2	1	1	3	2	2	2	2	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Romil Rawat, Rajesh Kumar Chakrawarti, Sanjaya Kumar Sarangi, Piyush Vyas, Mary Sowjanya Alamanda, Kotagiri Srividya, Krishnan Sakthidasan Sankaran "Conversational Artificial Intelligence", Scrivener Publishing, January 2024.
2. Michael McTear , Marina Ashurkina , "Transforming Conversational AI", February 2024.

REFERENCE BOOKS:

1. O'Neil, C. Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. Crown Publishing Group, 2016.
2. Floridi, L. The Ethics of Artificial Intelligence: Principles, Challenges, and Opportunities. Oxford University Press, 2023.
3. AI Now Institute. Annual AI Impact Report. New York University, 2022.
4. Amodei, D., Olah, C., Steinhardt, J., Christiano, P., Schulman, J., & Mané, D. Concrete Problems in AI Safety. arXiv / OpenAI, 2016.
5. Mittelstadt, B., Allo, P., Taddeo, M., Wachter, S., & Floridi, L. The Ethics of Algorithms: Mapping the Debate. Big Data & Society, 2016.
6. Crawford, K. Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence. Yale University Press, 2021.
7. European Commission. Ethics Guidelines for Trustworthy AI. Publications Office of the European Union, 2019.
8. OECD. Artificial Intelligence in Society. OECD Publishing, 2019.

E-Resources:

1. https://oecd.ai
2. https://www.unesco.org/en/artificial-intelligence

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis of real-world AI failures.
2. Policy debate role-play (regulator, developer, civil society).
3. Ethical impact assessment of an agentic AI application.
4. Flipped classroom discussions on AI governance documents.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20

Mid-Semester Examination (MSE)	30
AI-powered Assignment “Or” Mini Project*	50
Total	**100 marks**

SEMINAR-II
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Course Code	:	26AM5205	**Credits**	:	2
Hours/Week	:	04 Hours	**Total Hours**	:	60 Hours
L–T–P-J	:	0–0–0-4	**CIA**	:	100

Prerequisites:

Proficiency in Artificial Intelligence

Course Objectives:

This course will enable students to:

1. Identify and select an appropriate seminar topic based on recent advancements in engineering, technology, and research domains.
2. Explore and understand fundamental and advanced Artificial Intelligence techniques including Machine Learning, Deep Learning, Natural Language Processing, and Computer Vision.
3. Study and examine diverse applications of Artificial Intelligence in areas such as healthcare, robotics, education, and industrial systems.
4. Critically analyze research papers, technical articles, and real-world case studies related to Artificial Intelligence to understand current trends and challenges.
5. Foster collaborative learning and knowledge sharing through discussions, peer interactions, and seminar presentations.

Teaching-Learning Process (General Instructions)

1. Interactive Lectures: Engage students with theoretical explanations followed by Q&A.
2. Hands-on Sessions: Practical coding exercises, AI model development, and experimentation.
3. Case Studies: Real-world AI applications in healthcare, robotics, and smart systems.
4. Problem-Solving & Mini Projects: Encourage analytical thinking and problem-solving skills.
5. Group Discussions & Seminars: Foster collaborative learning and knowledge sharing.

Guidelines:

6. The seminar topic proposed by the student shall be approved by the concerned faculty guide and the Department Chairman before proceeding further.
7. Seminar topics should preferably be aligned with current research trends, emerging technologies, industrial practices, or interdisciplinary applications, and may be motivated by recent journal articles, conference papers, white papers, or industrial case studies.

8. The selected seminar topic should be focused, research-oriented, and feasible to be completed within the semester, enabling in-depth study, critical analysis, and technical understanding.
9. Each seminar will be closely supervised by the Seminar Guide, who will provide continuous feedback and guidance during topic selection, literature survey, report preparation, and presentation stages.

EVALUATION (SEMINAR):

1. The seminar topic approved initially shall be pursued throughout the semester with emphasis on literature review, conceptual understanding, and critical analysis.
2. The evaluation will comprise:
    - Depth of technical content
    - Quality of literature survey
    - Understanding of the topic
    - Presentation skills and clarity
    - Ability to answer questions during reviews
3. Each student is required to submit a seminar report following the prescribed format and may be encouraged to base the seminar on recent IEEE / Scopus-indexed journal or conference papers.
4. Continuous Internal Assessment (CIA) will be conducted through seminar reviews by a committee of senior faculty members of the department.
5. The topic of seminar can be any AI applications domain mentioned below but not limited to Deep Learning, Computer Vision, Large Language Model, Advanced AI Applications, Ethical & Societal Implications, Robotics, Emerging Technologies.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Identify a suitable seminar topic related to recent advancements in AI, ML, and Deep Learning.	L2
2	Explain core concepts and demonstrate the techniques of Artificial Intelligence including Machine Learning, Deep Learning, NLP, and Computer Vision.	L3

3	Illustrate the applications of Artificial Intelligence in healthcare, robotics, education, and industrial environments.	L2
4	Analyze and interpret AI research papers and case studies to evaluate methodologies, results, and practical relevance.	L4
5	Demonstrate effective communication, teamwork, and knowledge-sharing skills during seminar presentations and discussions.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	1	0	0	1	1	1	2	2	1	2	2	3	3
CO2	3	3	1	3	3	3	3	2	2	2	3	3	3
CO3	3	3	1	3	2	2	2	2	2	2	2	2	3
CO4	3	3	2	3	3	3	3	2	2	2	3	3	3
CO5	3	3	1	3	3	3	3	2	2	2	3	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson, 2020.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press, 2016.
3. Daniel Jurafsky and James H. Martin, *Speech and Language Processing*, 3rd Edition, Pearson, 2023.R. Szeliski, *Computer Vision: Algorithms and Applications,* 2nd Edition, 2022.
4. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning,* 2016.
5. Richard Hartley & Andrew Zisserman, *Multiple View Geometry in Computer Vision,* 2nd Edition, 2004.

III SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Sl.No	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PrSI	26AM6301	Capstone Project-I	-	-	-	12	60	40	100	06
2	PEC	26AM6302	Professional Elective-III*	3	0	0	2	100	--	100	04
3	PEC	26AM6303	Professional Elective-IV*	3	0	0	2	100	--	100	04
			Total	6	0	0	16				14

PrSI-Project Seminar and Internship, PEC-Professional Elective Courses, L – Lecture, T – Tutorial, P – Practical, J-Project, C – No. of Credits

*indicates students need to carry out a mini project in the subject.

Professional Elective Courses –III (PEC-III) Domain										
Sl. No	**Course Type**	**Course Name**	**Lecture**	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credit**
			L	**T**	**P**	**J**				
1	PEC	Edge AI and Robotics	3	0	0	2	100	--	100	**04**
2	PEC	Autonomous Agentic AI systems	3	0	0	2	100	--	100	**04**
3	PEC	Intelligent Computational Imaging and Reconstruction	3	0	0	2	100	--	100	**04**
4	PEC	Autonomous Robotic Systems	3	0	0	2	100	--	100	**04**
5	PEC	AI for Agriculture	3	0	0	2	100	--	100	**04**
6	PEC	Building AI Applications with Large Language Models	3	0	0	2	100	--	100	**04**

Professional Elective Courses –IV (PEC-IV) Domain										
Sl. No	**Course Type**	**Course Name**	**Lecture**	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credit**
			L	**T**	**P**	**J**				
1	PEC	Deep Learning for Science and Engineering	3	0	0	2	100	--	100	**04**
2	PEC	Ethics, Safety & Governance of Agentic AI	3	0	0	2	100	--	100	**04**
3	PEC	Intelligent Video Surveillance Systems	3	0	0	2	100	--	100	**04**
4	PEC	Foundation Models for Robotics	3	0	0	2	100	--	100	**04**
5	PEC	Blockchain for Data Security	3	0	0	2	100	--	100	**04**
6	PEC	Multi modal and Multi lingual Language Perception	3	0	0	2	100	--	100	**04**

CAPSTONE PROJECT - I

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 26AM6301	**Credits**:	6
Hours/Week	: 12 Hours	**Total Hours**:	180 Hours
L–T–P–J	: 0–0–0–12	**CIA+SEE:**	60+40

Course Learning Objectives:

This course will enable students to:

1. To identify key research questions within a field to carry out research in a team.
2. To identify and summarize the literature review of the relevant field.
3. To demonstrate relevant referencing and inculcate new skills in various aspects of academic writing.
4. To demonstrate the knowledge and understanding of writing the publication/report.
5. To showcase the strong evidence on the clarity of the argument, understanding of the selected domain area and presentation of its technical information.
6. To detail description of the process of carrying out the independent research in written document along with results and conclusions with reference to the existing literature.
7. To analyze and synthesize the new research findings.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Lecture method means it includes not only the traditional lecture method but a different type of teaching method that may be adopted to develop the course outcomes.
2. Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Show Video/animation films to explain the functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, ask at least three Higher-order Thinking questions in the class.
6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.

COURSE CONTENT:

1. The research topic proposed by both the guide and the student should be approved by the department chairman to proceed further.
2. A degree of industrial or other academic institute input and involvement will be encouraged, and can be facilitated through existing academic-industrial collaborations or by addressing specific topics that are of interest to industrial/academic partners.

3. The problem statement should be big enough to be carried out in two phases over the two semesters i.e., III and IV semesters in the II year.
4. All projects will be closely supervised by the Project Guide with ongoing feedback and guidance at all stages of the project from conception to completion.
5. The following criteria will be checked by the department chairman to approve the research proposal:
   a) Department staff as project guide
      i. Ability to provide research direction to the student in the chosen field of interest
      ii. Ability to design an appropriate research strategy and methodology to carry out the research by the student
      iii. Ability to provide and evaluate a strong literature review document for the chosen research topic
      iv. Ability to train students on research paper/technical writing skills
      v. Conduct reviews in a regular time period and submit the evaluation to the department chairman
   b) Student Participation
      i. To be dedicated and committed to work on a new research topic by learning new technical skills
      ii. To have fair knowledge on what is product development or research topic
      iii. To have constant interaction with allocated guide by providing weekly updates
      iv. To be committed to complete the project and submitting the technical paper within the stipulated time framed by the university

Evaluation:

i. Phase-1 comprises of Literature Survey, Problem identification, Objectives and Methodology.
ii. There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department based on the rubrics
iii. Additionally, there will be a Semester end evaluation of the work done that would include an internal Faculty and an external academic expert

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Identify and Select an Appropriate Research Problem	L1
2	Explain and Summarize Relevant Literature	L2
3	Compare and Critically Analyze Relevant Research Papers	L3

4	Construct a Research Model and Perform Evaluation	L4
5	Create and Draft Publications or Demonstrations	L5

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	1	1	1	1	1	2	2	3	2	1
CO2	2	2	3	2	2	1	1	1	2	2	3	1	2
CO3	3	3	3	2	3	2	2	1	2	2	2	2	2
CO4	2	3	2	3	2	1	2	2	2	2	2	2	2
CO5	1	1	2	1	2	1	1	1	3	3	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

EDGE AI AND ROBOTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 26AM6302	**Credits**:	4
Hours/Week	: 05 Hours	**Total Hours**:	45 Hrs (30 Hrs Project)
L–T–P-J	: 3–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand the fundamentals of Edge AI, embedded systems, and robotics.
2. Learn sensor integration, data acquisition, and real-time decision-making at the edge.
3. Apply machine learning and computer vision techniques in robotic systems.
4. Develop autonomous robotic applications using Edge AI platforms.
5. Explore industrial and smart automation use cases using robotics and AI.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Lecture Method:** Includes traditional lectures along with concept-driven discussions supported by recent research examples.
2. **Interactive Teaching:** Active learning through problem-solving sessions, brainstorming, and guided discussions on real-world robotic scenarios.
3. **Visual Learning:** Use of videos, simulations, and demonstrations to explain robotic perception, learning, and autonomy.
4. **Collaborative Learning:** Group-based analysis of autonomous system architectures and case studies.
5. **Critical Thinking:** Faculty will pose higher-order thinking questions related to design trade-offs and system intelligence.
6. **Application-Oriented Learning:** Continuous emphasis on translating AI concepts into real-world robotic applications.

UNIT– I	**10 Hours**
INTRODUCTION TO EDGE AI: AI Introduction, AI Hardware, Introduction to Jetson Nano, Edge, AIoT, Big Data, Introduction to Parallel Programming, Machine Learning Fundamentals	
UNIT – II	**08 Hours**
VISION DEEP NEURAL NETWORKS (DNNS):	

Computer Vision, Image Classification, Object Detection, Semantic Segmentation, Pose Estimation	
UNIT – III	**09 Hours**
DIVERSITY, ETHICS, AND SECURITY: Diversity and Bias in Datasets, Ethics and Security, Fairness, Accountability, and Transparency in AI, Privacy Preservation and Data Protection, Adversarial Attacks and AI Model Robustness, Explainable AI (XAI) for Decision Making, Cybersecurity Risks in Edge Devices.	
UNIT – IV	**09 Hours**
AUTONOMOUS ROBOTICS: Agent Architectures, Teaching Machines to Act, Introduction to ROS2, Robot Navigation, Path Planning Algorithms, Obstacle Detection and Avoidance	
UNIT – V	**09 Hours**
REINFORCEMENT LEARNING: Reinforcement Learning Fundamentals, Markov Decision Process (MDP), Q-Learning and Deep Q-Networks (DQN), Reward Functions and Policy Optimization, Exploration vs Exploitation Strategies, Applications of Reinforcement Learning in Robotics.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain the concepts of Edge AI, robotics, and embedded intelligence.	L2
2	Analyze sensors, actuators, and communication systems in robotic platforms.	L3
3	Develop AI models for real-time robotic perception and control.	L4
4	Implement autonomous robotic solutions using edge devices.	L5
5	Evaluate industrial applications, ethical issues, and future trends in Edge AI robotics.	L5

Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2

CO1	3	2	-	–	2	2	–	3	–	–	2	2	1
CO2	2	3	2	–	3	2	–	2	–	–	–	3	2
CO3	2	3	3	2	3	3	–	3	–	–	–	3	3
CO4	2	3	3	3	3	3	–	3	2	–	–	3	3
CO5	2	2	-	2	2	3	–	3	2	2	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Murphy, R. R. (2019). *Introduction to AI robotics*. MIT press.
2. Vermesan, O., & Marples, D. (2024). *Advancing Edge Artificial Intelligence: System Contexts*. River Publishers.

REFERENCE BOOKS:

1. Pickover, C. A. (2024). *Artificial intelligence: an illustrated history: from medieval robots to neural networks*. Hachette UK.
2. Khang, A. (Ed.). (2024). *Medical Robotics and AI-Assisted Diagnostics for a High-Tech Healthcare Industry*. IGI global.

E-Resources:

1. https://developer.nvidia.com/edge-ai-robotics-teaching-kit-syllabus
2. https://docs.ros.org/

Activity Based Learning (Suggested Activities in Class)

1. Analysis of an autonomous robotic system architecture through group discussion.
2. Case-study-based evaluation of AI techniques used in real-world robotic platforms.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

AUTONOMOUS PLANNING AND REASONING AGENTS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	:	26AM6303	**Credits**:	4
Hours/Week	:	05 Hours	**Total Hours**:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. **Understand** the fundamental principles of classical planning, search algorithms, and heuristic design for automated problem solving.
2. **Analyze** and formulate sequential decision-making problems using Markov Decision Processes and related frameworks.
3. **Apply** dynamic programming, Monte Carlo methods, and temporal-difference learning techniques for value-based reinforcement learning.
4. **Integrate** planning and learning approaches for model-based reinforcement learning and online decision-making.
5. **Develop** policy gradient methods and actor-critic algorithms for continuous control and high-dimensional decision spaces.
6. **Evaluate** planning and decision-making systems with respect to optimality, sample efficiency, scalability, and real-world deployment considerations.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Lecture Method:** Conceptual explanation of financial systems, AI models, and FinTech architectures with real-world examples.
2. **Interactive Teaching:** Active learning through case discussions, data-driven problem solving, and scenario analysis.
3. **Visual Learning:** Use of videos, dashboards, and simulations to demonstrate financial analytics and AI pipelines.
4. **Collaborative Learning:** Group-based analysis of FinTech platforms and AI-powered financial products.
5. **Critical Thinking:** Higher-order questions focusing on risk, bias, explainability, and regulation.
6. **Application-Oriented Learning:** Continuous linkage between theoretical models and industry-scale financial use cases.

UNIT – I	**8 Hours**

CLASSICAL PLANNING & SEARCH:

Planning problem formulation: States, actions, goals, and plans. STRIPS and PDDL representation languages. State-space search: Forward and backward search. Uninformed search: BFS, DFS, iterative deepening. Informed search and heuristics: A* algorithm, greedy best-first search. Heuristic design: Relaxed planning graphs, delete-relaxation, pattern databases. Planning graphs and GraphPlan algorithm. Hierarchical Task Network (HTN) planning.

UNIT – II	**08 Hours**

MARKOV DECISION PROCESSES & DYNAMIC PROGRAMMING:

Sequential decision-making under uncertainty. Markov Decision Processes: States, actions, transition dynamics, rewards, policies. Bellman equations and optimality principles. Value iteration and policy iteration algorithms. Convergence properties and computational complexity. Partially Observable MDPs (POMDPs): Belief states and belief-space planning. Extensions: Discounting, finite vs infinite horizons, episodic vs continuing tasks.

UNIT – III	**08 Hours**

VALUE-BASED REINFORCEMENT LEARNING:

Model-free reinforcement learning framework. Monte Carlo methods: First-visit and every-visit MC, exploring starts. Temporal-Difference learning: TD(0), TD(λ), eligibility traces. Q-learning and SARSA algorithms. Function approximation in RL: Linear methods, feature engineering. Deep Q-Networks (DQN): Experience replay, target networks, double DQN. Rainbow and distributional RL. Multi-step bootstrapping and n-step methods..

UNIT – IV	**07 Hours**

POLICY GRADIENT & ACTOR-CRITIC METHODS:

Policy-based reinforcement learning. Policy gradient theorem and REINFORCE algorithm. Baseline functions and variance reduction. Actor-critic architectures: A2C, A3C. Advanced policy gradient methods: Proximal Policy Optimization (PPO), Trust Region Policy Optimization (TRPO). Deterministic policy gradients: DDPG, TD3. Soft Actor-Critic (SAC) and maximum entropy RL. Continuous action spaces and control problems

UNIT – V	**09 Hours**

MODEL-BASED RL, PLANNING & ADVANCED TOPICS:

Model-based reinforcement learning: Learning forward models, Dyna architecture. Monte Carlo Tree Search (MCTS) and AlphaGo/AlphaZero. Integrated planning and learning: Model Predictive Control with learned models. Multi-agent reinforcement learning: Nash equilibria, cooperative and competitive settings. Hierarchical reinforcement learning: Options framework, feudal networks. Exploration strategies: ε-greedy, UCB, Thompson sampling, curiosity-driven exploration. Sample efficiency, transfer learning, and sim-to-real transfer. Safety and robustness in planning and RL systems..

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Analyze planning problems and design effective heuristics for state-space search algorithms.	L3
2	Formulate and solve sequential decision problems using MDPs and dynamic programming methods.	L4
3	Implement and compare value-based reinforcement learning algorithms including deep Q-learning.	L3
4	Apply policy gradient and actor-critic methods to continuous control and high-dimensional problems.	L4
5	Critically evaluate model-based planning, exploration strategies, and deployment considerations in real-world RL systems.	L3

Mapping Levels of COs to POs / PSOs													
COs				Program Outcomes (POs)								PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	-	-	2	-	-	-	-	-	-	2	2
CO2	3	3	-	2	3	-	-	-	-	-	-	2	2
CO3	3	3	2	2	3	-	-	-	-	-	-	2	2
CO4	3	3	2	2	3	2	2	2	-	-	-	2	2
CO5	3	2	2	2	3	2	2	2	-	-	-	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, 2020.
2. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, 2018.
3. Malik Ghallab, Dana Nau, and Paolo Traverso, Automated Planning: Theory and Practice, 2004.

REFERENCE BOOKS:

1. Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, 4th Edition, 2017.
2. Csaba Szepesvári, Algorithms for Reinforcement Learning, 2010, Morgan & Claypool.
3. Mykel J. Kochenderfer, Decision Making Under Uncertainty: Theory and Application, 2015, MIT Press.

E-Resources:

1. NPTEL – Reinforcement Learning (IIT Madras) https://nptel.ac.in/courses/106106143
2. OpenAI Spinning Up in Deep RL https://spinningup.openai.com/

Activity Based Learning (Suggested Activities in Class)

1. Group-based analysis of AI-driven credit scoring or fraud detection systems.
2. Case-study discussion on ethical and regulatory challenges in AI-powered finance.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

INTELLIGENT COMPUTATIONAL IMAGING AND RECONSTRUCTION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 26AM6304	**Credits**:	4
Hours/Week	: 05 Hours	**Total Hours**:	45 Hrs (30 Hrs Project)
L–T–P-J	: 3–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand image formation and computational imaging principles.
2. Apply inverse problem solving and optimization techniques.
3. Analyze advanced imaging methods such as HDR and super-resolution.
4. Explore modern imaging modalities and sensing systems.
5. Design AI-based imaging solutions for real-world applications.

Teaching-Learning Process (General Instructions):

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Lecture Method**: This includes not only traditional lectures but also the use of conceptual diagrams, case-based explanations, and thematic presentations to help students understand AI techniques applied to agriculture.
2. **Interactive Teaching**: Adopt active-learning strategies such as brainstorming, group discussions, focused listening, questioning, and notetaking to engage students with AI–AI-agriculture problems.
3. **Use of Multimedia**: Show videos, animations, and illustrations demonstrating AI applications like crop-disease detection, drone-based monitoring, and precision farming techniques.
4. **Collaborative Learning**: Encourage group tasks where students analyse agricultural challenges and discuss how AI models can address them.
5. **Critical Thinking**: Ask higher-order thinking questions that push students to evaluate AI methods, compare models, analyse datasets conceptually, and understand limitations in agricultural environments.
6. **Problem-Based Learning**: Present real agricultural problems (e.g., yield prediction, pest detection) and encourage students to think analytically, evaluate solutions, and apply theoretical AI techniques.
7. **Multiple Solution Approaches**: Show different conceptual approaches to solve the same agricultural problem and motivate students to propose their own innovative, theory-based solutions.

8. **Real-World Integration**: Discuss how each theoretical concept (ML models, sensors, AI pipelines, image theory, etc.) relates to real-world agricultural applications to deepen understanding and relevance.	
UNIT – I	**09 Hours**
FOUNDATIONS OF COMPUTATIONAL IMAGING: Introduction to Computational Imaging, imaging system overview, image formation models, radiometry and photometry, sampling and quantization, linear shift-invariant systems, convolution and correlation operations, frequency domain analysis using the Fourier Transform	
UNIT – II	**09 Hours**
INVERSE PROBLEMS AND OPTIMIZATION IN IMAGING: Forward and inverse imaging problems, ill-posed problems and their challenges, regularization techniques such as Tikhonov Regularization, L1 regularization, and total variation, Bayesian estimation methods, Maximum A Posteriori (MAP) Estimation and Minimum Mean Square Error (MMSE) Estimation, optimization techniques including Gradient Descent, proximal methods, and Alternating Direction Method of Multipliers (ADMM)	
UNIT – III	**09 Hours**
ADVANCED COMPUTATIONAL IMAGING TECHNIQUES: Advanced techniques in Computational Imaging including computational photography, high dynamic range imaging using HDR Imaging, super-resolution imaging, image deblurring and denoising methods, compressive sensing and sparse representations, coded aperture imaging, and phase retrieval techniques.	
UNIT – IV	**09 Hours**
ADVANCED IMAGING SYSTEMS AND MODALITIES: Advanced imaging techniques in Computational Imaging including light field imaging, lensless and coded imaging systems, computational microscopy, basics of computational tomography such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), hyperspectral imaging, time-of-flight and depth imaging, and event-based cameras.	

UNIT – V	09 Hours
LEARNING-BASED COMPUTATIONAL IMAGING: Learning-based approaches in Computational Imaging, deep learning techniques for imaging, convolutional neural networks (Convolutional Neural Networks (CNNs)) for image reconstruction, plug-and-play priors, physics-informed neural networks, end-to-end imaging system design, self-supervised and unsupervised learning methods for imaging, and ethical and societal considerations in intelligent imaging systems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
CO 1	Understand image formation and computational imaging principles.	L2
CO 2	Apply inverse problem solving and optimization techniques	L4
CO 3	Analyze advanced imaging methods such as HDR and super-resolution	L4
CO 4	Explore modern imaging modalities and sensing systems.	L3
CO 5	Design AI-based imaging solutions for real-world applications.	L5

Mapping Levels of COs to POs / PSOs													
COs	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	1	-	-	-	2	-	2	2	1	3	-	-
CO2	3	3	2	2	3	-	-	2	3	2	3	2	2
CO3	2	3	3	3	3	-	-	1	3	3	2	3	3
CO4	2	2	3	2	3	2	2	2	2	3	2	3	2
CO5	1	2	2	2	1	3	3	3	1	2	1	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Veeraraghavan – Computational Imaging
2. Szeliski – Computer Vision.

REFERENCE BOOKS:

1. MIT OpenCourseWare
2. Stanford Algorithms Lectures

Activity Based Learning (Suggested Activities in Class)

1. Group-based analysis of AI-driven applications.
2. Case-study discussion on ethical and regulatory challenges in AI-powered agriculture.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

AUTONOMOUS ROBOTIC SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 26AM6305	**Credits**:	4
Hours/Week	: 05 Hours	**Total Hours**:	45 Hrs (30 Hrs Project)
L–T–P-J	: 3–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand the architecture and design principles of autonomous robotic systems.
2. Apply perception and localization techniques under real-world sensing uncertainty.
3. Analyze trade-offs between accuracy, computation, and robustness in autonomy pipelines.
4. Design planning and navigation strategies under dynamic and constrained environments.
5. Integrate multiple subsystems into a cohesive autonomous system.
6. Evaluate system performance under uncertainty, noise, and failure conditions.

Teaching-Learning Process (General Instructions):

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Real-world case studies related to cognitive science and human–AI interaction will be used to demonstrate practical applications of intelligent systems.
2. Research paper reading and discussion sessions will be conducted to expose students to recent advances in cognitive science and human-centered AI.
3. Design-oriented problem-solving activities will be included to analyze and model human–AI interaction scenarios.
4. Seminars and student presentations will be used to strengthen conceptual understanding and communication skills.
5. Activity-based learning methods will be adopted to encourage critical thinking, reflection, and collaborative learning.

UNIT – I	**8 Hours**

PERCEPTION FOR AUTONOMOUS SYSTEMS:

Sensors for robotics (LiDAR, camera, IMU), data acquisition, feature extraction, object detection (classical + deep learning overview), basic sensor fusion concepts.

UNIT – II	**10 Hours**

LOCALIZATION AND MAPPING: Coordinate frames, odometry, probabilistic localization (Kalman Filter, Particle Filter concepts), mapping basics, occupancy grid maps, SLAM overview (visual and LiDAR-based).	
UNIT – III	**09 Hours**
PLANNING AND DECISION MAKING: Graph-based planning methods (A*, Dijkstra), sampling-based planning (RRT, PRM), and hierarchical decision-making frameworks incorporating cost functions and constraints.	
UNIT – IV	**09 Hours**
NAVIGATION AND EXECUTION: Navigation stack architecture (ROS-based), global vs local planning, trajectory generation, execution constraints, obstacle avoidance in dynamic environments, system limitations.	
UNIT – V	**09 Hours**
SYSTEM INTEGRATION AND EVALUATION: System-level architecture, integration of perception–localization–planning–execution, ROS pipelines, simulation-to-real transfer, evaluation metrics and benchmarking, failure case analysis, case studies (autonomous vehicles, warehouse robots).	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze and describe the architecture of autonomous robotic systems	L4
2	Apply perception techniques for environment understanding under uncertainty	L3
3	Analyze and implement localization and mapping methods	L4
4	Design planning and decision-making strategies for autonomous navigation	L6
5	Develop and evaluate an integrated autonomous robotic system	L6

Table: Mapping Levels of COs to POs / PSOs													
COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	1	2	-	-	1	-	2	-	-	2	2
CO2	3	3	2	-	-	-	1	-	-	-	3	2	2
CO3	3	3	3	2	2	-	1	1	2	2	-	3	3
CO4	3	2	3	3	2	-	-	2	2	2	2	2	3
CO5	2	2	-	-	-	3	2	3	2	2	2	2	2

3: Substantial (High) 2: Moderate (Medium) 1: Poor (Low)

TEXT BOOKS (TB):

1. 1. Thrun, S., Burgard, W., Fox, D., Probabilistic Robotics, 2005, MIT Press.
2. LaValle, S. M., Planning Algorithms, 2006, Cambridge University Press.
3. Siciliano, B., Khatib, O., Springer Handbook of Robotics, 2016, Springer.

REFERENCE BOOKS:

1. Corke, P., Robotics, Vision and Control, 2017, Springer

Activity Based Learning (Suggested Activities in Class)

Case study discussion, seminar presentation, research paper review, group discussion, design-based problem solving.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

AI FOR AGRICULTURE

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 26AM6306	**Credits**:	4
Hours/Week	: 05 Hours	**Total Hours**:	45 Hrs (30 Hrs Project)
L–T–P-J	: 3–0–0-2	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. Understand the role of Artificial Intelligence, Machine Learning, and Computer Vision in modern agriculture.
2. Apply AI techniques for crop monitoring, yield prediction, and precision farming.
3. Analyze agricultural data from sensors, drones, and weather systems for intelligent decision-making.
4. Develop AI-enabled smart farming solutions using IoT, robotics, and automation tools.
5. Evaluate sustainability, efficiency, and future opportunities of AI-driven agriculture systems.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. **Real-World Examples:** Incorporate real-world examples and case studies that demonstrate the relevance and application of blockchain deployments in cybersecurity, healthcare, and finance.
2. **Problem-Solving Sessions:** Organize problem-solving sessions where students can work through challenging problems together.
3. **Reflective Learning**: Encourage students to reflect on their problem-solving approaches and discuss the reasoning behind their solutions**.**

UNIT – I	**09 Hours**

INTRODUCTION TO AI IN AGRICULTURE:

Evolution of agriculture technology, challenges in conventional farming, need for AI in agriculture, overview of AI, ML and data analytics, smart farming concepts, digital agriculture, AI pipeline (data → model → decision).

UNIT – II	**09 Hours**

PRECISION AGRICULTURE & COMPUTER VISION: Precision agriculture concepts, Site-Specific Crop Management (SSCM), Variable Rate Technology (VRT), computer vision basics, image acquisition, crop disease detection, pest identification, weed recognition, crop maturity detection using CNN models	
UNIT – III	**09 Hours**
AI, IOT & ROBOTICS IN FARMING: IoT sensors for soil moisture, pH, temperature and humidity, sensor networks in farms, drones for surveillance and spraying, autonomous tractors, harvesting robots, robotics in greenhouse farming, AI + IoT integration	
UNIT – IV	**09 Hours**
AGRICULTURAL DATA ANALYTICS & PREDICTION: Agricultural datasets, data preprocessing, classification, clustering, regression, yield prediction models, weather forecasting, crop recommendation systems, satellite image analytics, decision support systems.	
UNIT – V	**09 Hours**
SUSTAINABILITY, FUTURE TRENDS & SMART ECOSYSTEMS: Climate-smart agriculture, sustainable farming practices, AI for water management, carbon-efficient farming, blockchain in agriculture, future of agri-tech startups, ethical issues, challenges in rural deployment, future intelligent farming ecosystems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain fundamentals of AI, ML, and computer vision in agriculture	L2
2	Apply AI models for agricultural data analysis and prediction	L3
3	Analyze crop disease, pest, and soil-health detection systems	L4
4	Develop AI-based smart farming solutions using IoT and robotics	L3

5	Analyze sustainability and efficiency of AI-enabled agriculture systems	L4

Mapping Levels of COs to POs / PSOs													
COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	1	-	-	2	-	-	2	-	-	2	1
CO2	3	3	2	-	-	-	-	-	2	-	1	3	2
CO3	3	3	3	2	2	-	-	2	-	2	1	3	3
CO4	3	2	2	3	3	-	-	2	2	-	1	2	2
CO5	3	3	3	3	3	-	-	3	-	-	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Köse, U., Prasath, V. B., Mondal, M. R. H., Podder, P., & Bharati, S. (2024). *Artificial Intelligence and Smart Agriculture Technology*. Auerbach Publications. ISBN 978-1032289069.
2. Singh, R., Gehlot, A., Prajapat, M. K., & Singh, B. (2020). *Artificial Intelligence in Agriculture*. New India Publishing Agency. ISBN 978-9389547924.

REFERENCE BOOKS:

1. Russell, S. J., & Norvig, P. (2022). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson Education India. ISBN 978-9356063570.
2. Shelke, Suresh (2025). *AI for Agriculture*. Current Publications. ISBN 978-9349728219.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30

AI-powered Assignment “Or” Mini Project*	50
Total	**100 marks**

BUILDING AI APPLICATIONS WITH LARGE LANGUAGE MODELS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6307	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

Fundamentals of Machine Learning, Probability & Statistics

Course Objectives:

This course will enable students to:

1. To understand the fundamentals of Large Language Models and transformer architectures.
2. To develop skills in prompt engineering and LLM interaction techniques.
3. To design and build real-world AI applications using LLM APIs and frameworks.
4. To apply fine-tuning, evaluation, and optimization strategies for LLMs.
5. To analyze ethical, security, and deployment challenges in AI applications.

Teaching-Learning Process (General Instructions)

1. Case-based learning
2. Demonstrations of AI tools in healthcare
3. Clinical scenario discussions
4. Assignments and quizzes
5. Mini-project / case study

UNIT – I	**8 Hours**

INTRODUCTION TO LLMS AND GENERATIVE AI:

Overview of LLM and Generative AI Evolution of AI, NLP, and Generative AI - Language Models: N-grams to Transformers - LLM Fundamentals: tokens, embeddings, context - Transformer architecture and self-attention - Overview of LLM capabilities and limitations

UNIT – II	**10 Hours**

MACHINE LEARNING FOR BEHAVIORAL ANALYSIS:

Machine learning paradigms for social and behavioral data analysis. Supervised and unsupervised learning for behavioral prediction. Feature extraction and representation of social signals. Time-series and sequential modeling of human activities. Anomaly detection and behavioral profiling.

Introduction to affective computing and emotion recognition. Evaluation metrics for behavioral models and fairness-aware machine learning.	
UNIT – III	**9 Hours**
PROMPT ENGINEERING AND INTERACTION DESIGN: Prompt design principles -Zero-shot, few-shot, chain-of-thought prompting -System prompts and role-based interaction - Prompt optimization techniques - Prompt evaluation and debugging.	
UNIT – IV	**9 Hours**
BUILDING APPLICATIONS WITH LLM APIS: Introduction to APIs (OpenAI, Hugging Face, Gemini) - Building chatbots and conversational agents -Text generation, summarization, classification -Retrieval-Augmented Generation (RAG) - Integrating LLMs into web and mobile applications Fine-tuning vs prompt tuning - Transfer learning and domain adaptation, Model evaluation metrics (accuracy, BLEU, ROUGE) - Performance optimization and cost management, Scaling laws and inference optimization	
UNIT – V	**9 Hours**
ETHICS, POLICY, AND ADVANCED APPLICATIONS: Ethical challenges in AI-driven social systems. Algorithmic bias and fairness in behavioral models. Privacy, surveillance, and data protection issues. Explainable and accountable AI for social decision-making. Applications of AI in governance, education, healthcare, and mental health. Behavioral nudging, persuasive AI, and social impact assessment. Regulatory frameworks and future directions in responsible and human-centric AI.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
CO1	Explain AI principles and architectures used in social and behavioral science applications.	L2
CO2	Analyze human behavior, social interactions, and decision-making processes using AI-driven models	L3
CO3	Apply machine learning, natural language processing, and network analysis techniques for social and behavioral data analysis.	L3

CO4	Examine social dynamics, group behavior, and collective decision-making using computational and AI-based approaches.	L4
CO5	Evaluate real-world AI-driven social systems with respect to fairness, privacy, ethical impact, and societal outcomes.	L4

COs CO's	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	–	–	2	–	–	–	–	–	–	2	1
CO2	2	3	–	2	3	–	–	–	–	–	–	3	2
CO3	–	2	3	3	2	–	–	–	–	–	–	3	3
CO4	2	2	–	–	3	2	1	3	–	–	–	2	2
CO5	–	2	3	2	3	–	–	–	2	1	–	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Salganik, M. J. Bit by Bit: Social Research in the Digital Age. Princeton University Press, 2020.
2. Generative AI with Large Language Models" – DeepLearning.AI (2024 Edition)
3. Natural Language Processing with Transformers" – Lewis Tunstall et al. (O'Reilly, 2023)

REFERENCE BOOKS:

1. Mitchell, T. M. Machine Learning. McGraw-Hill, 2017.
2. Jurafsky, D., & Martin, J. Speech and Language Processing. Pearson, 2023.
3. Aggarwal, C. C. Machine Learning for Text. Springer, 2018.

E-Resources:

1. https://www.coursera.org/specializations/computational-social-science-ucdavis
2. https://www.elementsofai.com/

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis
2. Mini-project / seminar

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

DEEP LEARNING FOR SCIENCE AND ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6308	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

Proficiency in basic programming concepts and familiarity with fundamental computer systems concepts.

Course Objectives:

This course will enable students to:

1. Understand fundamental concepts of deep learning and neural networks
2. Gain proficiency in Python and deep learning frameworks
3. Apply deep learning techniques to scientific and engineering problems
4. Explore advanced topics such as neural operators and uncertainty quantification
5. Implement scalable solutions using distributed and high-performance computing.

Teaching-Learning Process (General Instructions)

1. The course shall be delivered primarily through classroom lectures focusing on fundamental concepts and principles of Green AI and sustainable edge computing.
2. Real-world examples, simplified case studies, and practical scenarios shall be used to illustrate energy efficiency, sustainability challenges, and system-level trade-offs in AI systems.
3. Interactive discussions and short analytical exercises shall be incorporated to promote critical thinking on performance, efficiency, and environmental impact.
4. Contemporary trends and emerging practices in Green AI and edge computing shall be briefly introduced to provide industry and research context.

UNIT – I	**08 Hours**

FUNDAMENTALS OF DEEP LEARNING:

Introduction to Deep Learning, A Primer on Python, NumPy, SciPy and Jupyter Notebooks, Deep Learning Networks, A Primer on TensorFlow, PyTorch and JAX, Training and Optimization, Neural Network Architectures

UNIT – II	09 Hours
NEURAL DIFFERENTIAL EQUATIONS: Discovering Differential Equations, Physics-Informed Neural Networks (PINNs)- Part I, Physics-Informed Neural Networks (PINNs)- Part II	
UNIT – III	**09 Hours**
NEURAL OPERATORS: Introduction to Deep Neural Operators, Mathematical Foundations, Fourier Transform and Inverse Fourier Transform, Deep Operator Networks, Fourier Neural Operators, Learning Operators for Differential Equations, Implementation using Python and Deep Learning Frameworks	
UNIT – IV	**09 Hours**
DATA AND UNCERTAINTY: Introduction to Multi-Fidelity Data in Machine Learning, Multi-Fidelity Modelling Techniques, Gaussian Process Regression, Multi-Fidelity Deep Neural Networks, Introduction to Uncertainty Quantification, Bayesian Neural Networks, Neural Methods for Uncertainty Estimation.	
UNIT – V	**09 Hours**
SCALABLE SCIENTIFIC MACHINE LEARNING: Introduction to Scalable Scientific Machine Learning, Multi-GPU and Distributed Training Concepts, Message Passing Interface for Parallel Computing, Horovod for Distributed Deep Learning, Domain Decomposition Methods, NVIDIA Physics NeMo Core and Framework Overview, Physics NeMo Symbolic for Solving Differential Equations	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the fundamentals of deep learning and scientific machine learning	L2

2	Apply Python and deep learning frameworks to build models	L3
3	Analyze differential equations using PINNs and neural operators	L4
4	Evaluate model performance with uncertainty quantification methods	L5
5	Design scalable deep learning systems using distributed computing.	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	–	2	2	–	2	–	–	2	3	1
CO2	3	3	3	–	3	3	–	2	–	–	–	3	1
CO3	3	2	3	–	3	3	–	3	–	–	–	3	2
CO4	3	2	3	2	3	3	–	3	2	–	–	2	3
CO5	3	2	3	–	3	3	–	3	2	2	2	3	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville
2. Pattern Recognition and Machine Learning – Christopher M. Bishop
3. Scientific Machine Learning – Course Notes / Technical Resources.

REFERENCE BOOKS:

1. Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow – Aurélien Géron
2. Machine Learning: A Probabilistic Perspective – Kevin P. Murphy.

Evaluation Scheme:

Criteria	Weightage of Marks

Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment “Or” Mini Project*	50
Total	**100 marks**

ETHICS, SAFETY & GOVERNANCE OF AGENTIC AI

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6309	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

Basic understanding of Artificial Intelligence, Machine Learning concepts, probability, and introductory programming (Python/C). Familiarity with data ethics and algorithmic decision-making is desirable.

Course Objectives:

This course will enable students to:

1. Understand core ethical theories and principles relevant to the development and operation of agentic and autonomous AI systems.
2. Analyze safety risks, alignment challenges, and potential failure modes in intelligent agents deployed in real-world environments.
3. Evaluate global AI governance frameworks, regulatory policies, and international standards guiding responsible AI adoption.
4. Assess the societal, legal, and economic impacts of agentic AI across critical application domains.
5. Design ethically aligned, safe, and accountable agentic AI solutions incorporating transparency, human oversight, and governance mechanisms.

Teaching-Learning Process (General Instructions)

1. Lecture sessions supported by real case studies
2. Interactive and collaborative learning**.**
3. Demonstrations using open-source tools**.**
4. Mini design exercises.
5. Research paper discussions.

UNIT – I	**09 Hours**

FOUNDATIONS OF ETHICS AND AGENTIC AI:

Introduction to Agentic AI and autonomous systems; historical evolution of AI ethics; normative ethical theories (deontology, utilitarianism, virtue ethics); moral agency and responsibility in AI; human–AI interaction and value alignment; overview of ethical challenges in learning, reasoning, and acting agents.

Case Study: Autonomous Decision-Making in Healthcare Triage Systems.	
UNIT – II	**09 Hours**
SAFETY, RISK, AND ALIGNMENT IN AGENTIC SYSTEMS: AI safety fundamentals; reward hacking and specification gaming; robustness, reliability, and adversarial risks; alignment problem and value misgeneralization; interpretability and explainability for agentic models; human-in-the-loop and human-on-the-loop systems. **Case Study**: Reward Hacking in a Reinforcement Learning Trading Agent.	
UNIT – III	**09 Hours**
GOVERNANCE, LAW, AND POLICY FRAMEWORKS: Global AI governance landscape; OECD AI principles; UNESCO AI ethics recommendations; EU AI Act; US AI Bill of Rights; data protection laws (GDPR concepts); accountability, transparency, and auditability; standards bodies (ISO/IEC, IEEE). **Case Study**: Facial Recognition AI and Regulatory Conflict.	
UNIT – IV	**09 Hours**
SOCIETAL IMPACT AND RESPONSIBLE DEPLOYMENT: Bias, fairness, and discrimination in agentic AI; impact on employment and labor; AI in healthcare, finance, surveillance, and defense; misinformation and autonomous decision-making risks; sustainability and environmental cost of AI systems; cross-cultural and global south perspectives. **Case Study**: Algorithmic Hiring Agent and Workforce Discrimination	
UNIT – V	**9 Hours**
FUTURE DIRECTIONS AND TRUSTWORTHY AGENTIC AI: AI assurance and certification; ethical-by-design and safety-by-design methodologies; red-teaming and impact assessments; governance of autonomous agents and multi-agent systems; future risks (superintelligence, autonomous weapons); research frontiers and global cooperation. **Case Study**: Autonomous Weapons and Human Oversight.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain ethical theories and their application to agentic AI systems.	L2
2	Analyze safety risks and alignment challenges in autonomous AI systems	L4
3	Examine global AI governance frameworks, standards, and regulations	L4
4	Assess societal impacts and ethical trade-offs of agentic AI deployment	L3
5	Analyze approaches for responsible and trustworthy governance of agentic AI	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	-	-	2	1	-	-	2	-	1	1
CO2	3	-	-	-	2	-	-	-	2	-	2	2	2
CO3	3	1	-	1	-	1	-	-	2	-	-	2	3
CO4	3	2	2	1	2	-	-	1	-	3	2	2	3
CO5	3	1	2	1	2	-	1	-	-	2	3	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Russell, S., & Norvig, P. *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson, 2021.
2. IEEE Standards Association. *Ethically Aligned Design: A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems*. IEEE, 2019.
3. Bostrom, N. *Superintelligence: Paths, Dangers, Strategies*. Oxford University Press, 2014.

REFERENCE BOOKS:

1. O'Neil, C. Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. Crown Publishing Group, 2016.
2. Floridi, L. The Ethics of Artificial Intelligence: Principles, Challenges, and Opportunities. Oxford University Press, 2023.
3. AI Now Institute. Annual AI Impact Report. New York University, 2022.
4. Amodei, D., Olah, C., Steinhardt, J., Christiano, P., Schulman, J., & Mané, D. Concrete Problems in AI Safety. arXiv / OpenAI, 2016.

E-Resources:

1. https://oecd.ai
2. https://www.unesco.org/en/artificial-intelligence

Activity Based Learning (Suggested Activities in Class)

1. Case study analysis of real-world AI failures.
2. Policy debate role-play (regulator, developer, civil society).
3. Ethical impact assessment of an agentic AI application.
4. Flipped classroom discussions on AI governance documents.

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

INTELLIGENT VIDEO SURVEILLANCE SYSTEMS
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Course Code	:	26AM6310	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

Proficiency in a C programming language and basic linear algebra.

Course Objectives:

This course will enable students to:

1. Understand the fundamental components, processes, and architectures involved in video analytics and surveillance systems.
2. Apply various techniques for foreground extraction, background modeling, segmentation, and object tracking in video data.
3. Familiarize with different classifiers and learning methods including neural networks, deep learning models, fuzzy logic, Bayesian methods, and HMMs used for video-based analysis.
4. Explore the role of video analytics in security applications such as human action recognition, behavioral analysis, crowd monitoring, and perimeter security.
5. Examine the use of video analytics in business intelligence, traffic monitoring, and advanced driver assistance systems for decision-making and real-world deployment.

Teaching-Learning Process (General Instructions)

1. Classroom lectures with conceptual illustrations and examples.
2. Case studies and problem-based learning sessions.
3. Hands-on demonstrations using quantum simulators and cloud platforms.
4. Group discussions, assignments, and tutorials.
5. Mini-projects and student presentations.

UNIT – I	**09 Hours**

VIDEO ANALYTIC COMPONENTS:

Introduction to Video Analytics, Need for Video Analytics, Overview of video Analytics systems, Video analytics pipeline and architecture, Pre-processing Techniques, Feature space representation (PCA, FLD, SIFT, HOG), Classifier design for video data, Feature selection and dimensionality reduction

UNIT – II	**09 Hours**

FOREGROUND EXTRACTION & SEGMENTATION:
Background Modeling-Background estimation techniques, Averaging-based methods, Gaussian Mixture Model (GMM), Optical Flow-based approaches, Image Segmentation-Region-based segmentation, Region splitting and merging, Watershed segmentation, Morphological Operations- Erosion and Dilation, Advanced Tracking.

UNIT – III	**09 Hours**

CLASSIFIERS FOR VIDEO ANALYSIS:
Classical Machine Learning Approaches, Bayesian classifier, Decision trees and ensemble methods, Fuzzy Classifier, Deep Learning Approaches, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) for temporal modeling, LSTM networks, Probabilistic Models, Hidden Markov Models (HMM) based classifier, Conditional Random Fields (CRFs), Performance Evaluation

UNIT – IV	**09 Hours**

VIDEO ANALYTICS FOR SECURITY APPLICATIONS:
Object Detection and Recognition, Human behavioral analysis, Gait recognition, Human action recognition, Pose estimation, Crowd Analysis, Crowd density estimation, anomaly detection in crowds, Security Systems, Perimeter security and intrusion detection, Smart city surveillance applications.

UNIT – V	**09 Hours**

BUSINESS INTELLIGENCE, TRAFFIC MONITORING & ADVANCED TOPICS:
Business Intelligence Applications, Video Analysis for retail analytics, Customer behaviour analysis, Queue management systems, Traffic Monitoring, Traffic flow analysis, Speed estimation, Traffic violation detection, Advanced Driver Assistance Systems (ADAS), Video-based rendering and scene reconstruction, Activity recognition and summarization, 3D video surveillance, Edge computing for surveillance, Future trends: AI-powered surveillance, federated learning.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	Explain the fundamental components and processes of video analytics including pre-processing, feature extraction, and classification pipelines.	L2
CO2	Apply foreground extraction, segmentation, and tracking techniques to analyze video data effectively.	L3
CO3	Compare and use classification approaches such as neural networks, deep learning models, fuzzy logic, Bayesian methods, and HMMs for video-based analysis.	L3
CO4	Evaluate video analytics approaches to recommend suitable solutions for security, business intelligence, and traffic monitoring applications.	L3
CO5	Design and develop intelligent video surveillance systems addressing real-world challenges while considering ethical and privacy implications.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	2	-	1	1	-	-	1	2	2	2	1
CO2	3	3	3	2	-	1	1	-	-	2	-	3	2
CO3	3	3	3	3	2	-	-	1	-	-	2	3	2
CO4	3	3	3	3	3	2	2	1	-	2	2	3	3
CO5	2	2	2	2	2	1	1	1	1	2	2	2	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Patil, Lalit V., et al. – Video Analytics, Nirali Prakashan, 2023.

REFERENCE BOOKS:

1. Tekalp, A. Murat – Digital Video Processing, Pearson, 2015.

E-Resources:

- Jones, Graeme A., et al. – Video-Based Surveillance Systems: Computer Vision and Distributed Processing, Springer
- Dey, Nilanjan, et al. – Applied Video Processing in Surveillance and Monitoring Systems, IGI Global
- Shan, Caifeng, et al. – Intelligent Video Surveillance Systems, Wiley
- Programming: Python (OpenCV, basic video processing), MATLAB (optional)
- Visualization: Python libraries (Matplotlib, Seaborn), video visualization tools
- AI Tools: ChatGPT / AI assistants, computer vision libraries (OpenCV, TensorFlow, PyTorch) Platforms: Video analytics frameworks, annotation tools (CVAT, Labeling)

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Role play E.g., Stack, Queue, etc.,
3. Demonstration of solution to a problem through programming.
4. Flip class activity E.g., arrays, pointers, dynamic memory allocation, etc.,

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

FOUNDATION MODELS FOR ROBOTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6311	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

Basic knowledge of Linear Algebra, Probability and Statistics, Signals and Systems, Digital Image Processing

Course Objectives:

This course will enable students to:

1. Understand the principles and capabilities of foundation models in AI systems
2. Analyze limitations of traditional robotics pipelines and the need for integrated intelligence
3. Apply language and vision models for robotic perception and interaction
4. Examine how foundation models enable reasoning and decision-making
5. Design robotic applications integrating multimodal AI models
6. Evaluate reliability, safety, and ethical implications of AI-driven robotic systems.

Teaching-Learning Process (General Instructions)

1. **Conceptual Lectures:** Emphasis on imaging models, inverse problems, and mathematical foundations.
2. **Case Studies:** Study of real-world systems such as MRI, CT, HDR cameras, and lensless imaging.
3. **Problem-Solving Sessions:** Analytical derivations and numerical problem discussions.
4. **Tool-Based Learning:** Use of MATLAB/Python for simulation of imaging pipelines.
5. **Research-Oriented Learning:** Reading and discussion of recent research papers.

UNIT – I	**09 Hours**

Foundations of Robotics Paradigm Shift:

Evolution of robotics systems, modular vs integrated architectures, introduction to foundation models (LLMs, VLMs, VLAs), representation learning, limitations of classical robotics	
UNIT – II	**09 Hours**
LANGUAGE AND VISION MODELS FOR ROBOTICS: Vision-Language Models (VLMs), multimodal embeddings, grounding language in perception, semantic scene understanding, perception-language alignment, linking perception outputs to actionable representations for robotic tasks	
UNIT – III	**09 Hours**
REASONING AND DECISION-MAKING WITH GROUNDED ROBOTICS ACTIONS: Task decomposition, Instruction following, Prompt-based planning, reasoning strategies, grounding reasoning into executable robotic actions, decision-making under uncertainty, action abstraction and task-level planning	
UNIT – IV	**09 Hours**
ROBOTICS APPLICATIONS USING FOUNDATION MODELS: Overview of applications including manipulation using vision-language-action models, semantic navigation, human-robot interaction, learning from demonstration, action execution constraints, embodied decision-making, case studies (RT-2, SayCan, PaLM-E)	
UNIT – V	**09 Hours**
SYSTEM INTEGRATION, EVALUATION, AND FUTURE ROBOTICS INTELLIGENCE: System architectures for AI-driven robotics, ROS integration with foundation models, deployment challenges (latency, compute), evaluation of foundation model performance in robotics, failure case analysis (hallucination, grounding errors, safety risks), future trends	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze and describe the principles and role of foundation models in robotics	L4
2	Apply language and vision models for perception and interaction tasks	L3
3	Analyze and utilize foundation models for reasoning and decision-making in robotics	L4
4	Develop and integrate foundation models into robotic subsystems	L5
5	Design and implement a complete multimodal robotic system	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)											PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	-	-	1	-	-	-	-	-	-	2	1
CO2	3	3	2	2	2	-	-	-	-	-	-	3	2
CO3	2	3	3	2	3	-	-	-	1	-	-	3	3
CO4	2	2	2	3	2	1	1	1	-	-	-	2	3
CO5	2	3	3	3	3	-	-	1	1	1	-	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Russell, S., Norvig, P., Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2020
2. Goodfellow, I., Bengio, Y., Courville, A., Deep Learning, MIT Press, 2016.

REFERENCE BOOKS:

1. Thrun, S., Burgard, W., Fox, D., Probabilistic Robotics, MIT Press, 2005.

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Paper Reading, Mini-Project, Simulation Assignments, Seminar, Quiz

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

BLOCKCHAIN FOR CYBERSECURITY AND DATA PRIVACY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6312	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Course Objectives:

This course will enable students to:

1. Understand the fundamentals of blockchain technology and distributed ledger systems.
2. Analyze cryptographic mechanisms used in blockchain for secure data management
3. Explore blockchain-based solutions for cybersecurity challenges
4. Apply blockchain techniques to ensure data privacy, integrity, and access control
5. Evaluate real-world blockchain applications in secure systems and privacy-preserving architectures.

Teaching-Learning Process (General Instructions)

1. **Interactive Lectures:** Concept introduction with visual demonstrations and live coding examples
2. **Hands-On Practical Sessions:** Programming exercises with immediate feedback and peer review
3. **Problem-Based Learning:** Theory applied to solve real-world graphics challenges
4. **Project-Based Learning:** Incremental projects building toward comprehensive final application
5. **Contemporary Research Integration:** Discuss recent papers from SIGGRAPH, High-Performance Graphics, and NVIDIA technical blogs

UNIT – I	**09 Hours**

INTRODUCTION TO BLOCKCHAIN:

Blockchain fundamentals, history and evolution, centralized vs decentralized systems, peer-to-peer networks, distributed ledger technology, block structure, blockchain types: public, private, consortium blockchains.

UNIT – II	09 Hours
CRYPTOGRAPHY FOUNDATIONS FOR BLOCKCHAIN SECURITY: Cryptographic hash functions, digital signatures, public key infrastructure (PKI), symmetric and asymmetric encryption, key management, cryptographic security assumptions in blockchain systems.	
UNIT – III	**09 Hours**
BLOCKCHAIN FOR CYBERSECURITY: Cybersecurity threats and attack models, blockchain-based identity management, secure authentication and authorization, distributed trust models, blockchain for intrusion detection systems, DDoS mitigation using blockchain	
UNIT – IV	**09 Hours**
DATA PRIVACY AND PRIVACY-PRESERVING BLOCKCHAIN TECHNIQUES: Data privacy challenges in distributed systems, GDPR and regulatory compliance, privacy issues in public blockchains, anonymization and pseudonymization.	
UNIT –V	**09 Hours**
APPLICATIONS, SMART CONTRACTS, AND EMERGING TRENDS: Smart contracts and security issues, secure smart contract design, vulnerabilities and attacks, blockchain in healthcare data privacy, financial data security, supply chain security, IoT security using blockchain, scalability challenges, future trends and research directions in blockchain security.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand blockchain architecture and distributed ledger principles	L2
2	Analyze cryptographic techniques used in blockchain security	L3

3	Apply blockchain concepts to address cybersecurity threats	L4
4	Evaluate privacy-preserving mechanisms in blockchain systems	L5
5	Design secure and privacy-aware blockchain-based applications	L4

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	3	2	1	-	1	2	-	-	-	1	3	2
CO2	3	3	3	2	-	-	-	2	-	1	-	3	3
CO3	3	3	-	-	2	-	2	2	-	-	2	3	3
CO4	3	3	-	3	3	2	3	-	3	2	2	3	3
CO5	3	3	3	3	3	3	3	3	3	3	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS (TB):

1. Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. Bitcoin and Cryptocurrency Technologies. Princeton University Press, 2023.
2. Antonopoulos, A. M., & Wood, G. Mastering Ethereum. O'Reilly Media, 2022.
3. Drescher, D. Blockchain Basics. Apress, 2021.

REFERENCE BOOKS:

1. Crosby, M., et al. "Blockchain Technology: Beyond Bitcoin." *Applied Innovation Review*, 2020.
2. Bashir, I. *Mastering Blockchain*. Packt Publishing, 2023.
3. Christidis, K., & Devetsikiotis, M. "Blockchains and Smart Contracts for the Internet of Things." *IEEE Access*, 2019.

E-Resources:

1. https://nptel.ac.in/courses/106105235
2. https://ieeexplore.ieee.org/document/10953521/

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	50
Total	**100 marks**

MULTIMODAL AND MULTILINGUAL LANGUAGE PERCEPTION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Course Code	:	26AM6313	**Credits**	:	4
Hours/Week	:	05 Hours	**Total Hours**	:	45 Hrs (30 Hrs Project)
L–T–P-J	:	3–0–0-2	**CIA**	:	100

Prerequisites:

- Natural Language Modelling
- Machine Learning

Course Objectives:

This course will enable students to:

1. Understand the fundamentals of multimodal and multilingual language perception.
2. Analyze how language is processed across text, speech, vision, and audio modalities
3. Explore computational models for multilingual and cross-lingual understanding
4. Apply deep learning techniques for multimodal language perception tasks
5. Evaluate real-world applications involving multilingual and multimodal AI systems.

Teaching-Learning Process (General Instructions)

1. **Interactive Lectures:** Concept introduction with visual demonstrations and live coding examples
2. **Hands-On Practical Sessions:** Programming exercises with immediate feedback and peer review
3. **Problem-Based Learning:** Theory applied to solve real-world graphics challenges
4. **Project-Based Learning:** Incremental projects building toward comprehensive final application
5. **Contemporary Research Integration:** Discuss recent papers from SIGGRAPH, High-Performance Graphics, and NVIDIA technical blogs

UNIT – I	**09 Hours**

FOUNDATIONS OF MULTIMODAL AND MULTILINGUAL LANGUAGE PERCEPTION:

Introduction to human and machine language perception, multimodal communication, modalities in language perception (text, speech, vision, gesture), multilingualism and language diversity, challenges in multilingual AI, overview of multimodal AI systems, applications in real-world scenarios.

UNIT – II	**09 Hours**
MULTILINGUAL LANGUAGE PROCESSING: Multilingual NLP fundamentals, language typology and scripts, tokenization and representation challenges, cross-lingual word embeddings, multilingual language models, transfer learning across languages, low-resource languages, language identification and code-mixing	
UNIT – III	**09 Hours**
MULTIMODAL REPRESENTATION LEARNING: Multimodal data representations, feature extraction from text, speech, and images, joint embedding spaces, alignment of multimodal data, fusion techniques (early, late, hybrid fusion), attention mechanisms, transformers for multimodal perception	
UNIT – IV	**09 Hours**
MULTIMODAL AND MULTILINGUAL MODELS: Vision-language models, speech-text multimodal systems, multilingual speech recognition, multimodal machine translation, pretrained multimodal models, zero-shot and few-shot learning, bias and fairness in multimodal and multilingual models	
UNIT –V	**09 Hours**
APPLICATIONS, EVALUATION, AND EMERGING TRENDS: Multimodal sentiment analysis, emotion recognition, visual question answering, multilingual chatbots and assistants, accessibility technologies, evaluation metrics for multimodal and multilingual systems, ethical issues, privacy concerns, future research directions	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		

1	Understand fundamentals of multimodal and multilingual language perception	L2
2	Analyze multilingual language processing techniques	L3
3	Apply multimodal representation learning methods	L4
4	Evaluate multimodal and multilingual AI models	L5
5	Design applications using multimodal and multilingual perception systems	L4

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**											**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	1	-	-	-	1	-	1	2	1	1	1
CO2	3	3	2	-	2	-	-	1	-	-	1	1	1
CO3	3	3	3	2	-	2	2	2	-	-	3	2	2
CO4	2	3	3	3	2	-	-	-	2	-	2	3	3
CO5	2	2	2	3	3	2	-	-	2	3	3	2	3

TEXT BOOKS:

1. Jurafsky, D., & Martin, J. H. *Speech and Language Processing*. Pearson, 3rd Edition, 2023.
2. Baltrusaitis, T., Ahuja, C., & Morency, L. "Multimodal Machine Learning." *IEEE Signal Processing Magazine*, 2019.
3. Eisenstein, J. *Natural Language Processing*. MIT Press, 2022.

REFERENCE BOOKS:

1. Goldberg, Y. *Neural Network Methods for Natural Language Processing*. Morgan & Claypool, 2017.
2. Poria, S., et al. Multimodal AI: From Theory to Practice. Springer, 2022.
3. Lewis, M., et al. "Multilingual Language Models." *ACL Proceedings*, 2020.

Evaluation Scheme:

Criteria	**Weightage of Marks**

Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment “Or” Mini Project*	50
Total	**100 marks**

IV SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credit
				L	T	P	J				
1	PrSI	26AM6401	Capstone Project-II	-	-	-	28	60	40	100	14
2	PrSI	26AM6402	Industry/Research Internship	-	-	-	8	100	-	100	04
			Total	-	-	-	36				**18**

PrSI-Project Seminar and Internship, L – Lecture, T – Tutorial, P – Practical, J – Project, C – No. Of Credits

CAPSTONE PROJECT - II

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 26AM6401	**Credits**:	14
Hours/Week	: 28 Hours	**Total Hours**:	420 Hours
L–T–P–J	: 0–0–0–28	**CIA+SEE:**	60+40

Course Learning Objectives:

This course will enable students to:

1. To identify key research questions within a field to carry out research in a team.
2. To identify and summarize the literature review of the relevant field.
3. To demonstrate relevant referencing and inculcate new skills in various aspects of academic writing.
4. To demonstrate the knowledge and understanding of writing the publication/report.
5. To showcase the strong evidence on the clarity of the argument, understanding of the selected domain area and presentation of its technical information.
6. To detail description of the process of carrying out the independent research in written document along with results and conclusions with reference to the existing literature.
7. To analyze and synthesize the new research findings.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Lecture method means it includes not only the traditional lecture method but a different type of teaching method that may be adopted to develop the course outcomes.
2. Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Show Video/animation films to explain the functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, ask at least three Higher-order Thinking questions in the class.
6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.

COURSE CONTENT:

1. The research topic proposed by both the guide and the student should be approved by the department chairman to proceed further.
2. A degree of industrial or other academic institute input and involvement will be encouraged, and can be facilitated through existing academic-industrial collaborations or by addressing specific topics that are of interest to industrial/academic partners.

3. The problem statement should be big enough to be carried out in two phases over the two semesters i.e., III and IV semesters in the II year.
4. All projects will be closely supervised by the Project Guide with ongoing feedback and guidance at all stages of the project from conception to completion.
5. The following criteria will be checked by the department chairman to approve the research proposal:
   c) Department staff as project guide
      vi. Ability to provide research direction to the student in the chosen field of interest
      vii. Ability to design an appropriate research strategy and methodology to carry out the research by the student
      viii. Ability to provide and evaluate a strong literature review document for the chosen research topic
      ix. Ability to train students on research paper/technical writing skills
      x. Conduct reviews in a regular time period and submit the evaluation to the department chairman
   d) Student Participation
      v. To be dedicated and committed to work on a new research topic by learning new technical skills
      vi. To have fair knowledge on what is product development or research topic
      vii. To have constant interaction with allocated guide by providing weekly updates
      viii. To be committed to complete the project and submitting the technical paper within the stipulated time framed by the university

Evaluation:

i. The problem statement selected in Capstone Project - I (III semester) will be carried in the IV semester.
ii. Phase 2 comprises of the detailed design, implementation, and testing results during the internal and external review.
iii. Each student needs to submit the technical paper or patent or participate in hackathons and project exhibitions as well as apply for various state and national funding agencies within the stipulated time frame by the university
iv. There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department.
v. Additionally, there will be a Semester end evaluation of the work done that would include an internal Faculty and an external academic expert.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		

1	Identify and Select an Appropriate Research Problem	L1
2	Explain and Summarize Relevant Literature	L2
3	Compare and Critically Analyze Relevant Research Papers	L3
4	Construct a Research Model and Perform Evaluation	L4
5	Create and Draft Publications or Demonstrations	L5

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3	2	2	1	1	1	1	1	2	2	3	2	1
CO2	2	2	3	2	2	1	1	1	2	2	3	1	2
CO3	3	3	3	2	3	2	2	1	2	2	2	2	2
CO4	2	3	2	3	2	1	2	2	2	2	2	2	2
CO5	1	1	2	1	2	1	1	1	3	3	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

INDUSTRY/RESEARCH INTERNSHIP

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 26AM6402	**Credits**:	4
Hours/Week	: 08 Hours	**Total Hours**:	120 Hours
L–T–P–J	: 0–0–0–8	**CIA:**	100

Course Learning Objectives:

This course will enable students to:

1. To expose students to the industrial environment
2. To create competent professionals for the industry.
3. To provide possible opportunities to learn, understand and sharpen the real time technical/managerial skills required at the job
4. To work on a problem assigned by a mentor at industry, prepare action plan and complete within time limit
5. To learn, create/prepare report for Project/research as used in industry with productive and efficient way
6. To strengthen industry-institute linkage and increase employability of the students.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

1. Lecture method means it includes not only the traditional lecture method but a different type of teaching method that may be adopted to develop the course outcomes.
2. Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Show Video/animation films to explain the functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, ask at least three Higher-order Thinking questions in the class.
6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.

COURSE CONTENT:

1. The course includes a 15 weeks of on-job training on current industry-relevant problem through supervised self-learning approach.
2. The internship is an individual activity.
3. The student should obtain approval from the chairman/supervisor to pursue.
4. A student shall submit a brief proposal about the work to be carried out in the internship, to coordinator within 3 weeks, after starting the internship.

5. A comprehensive report is required to be prepared and submit to the department at the end of the semester.
6. A certificate shall be attached with the report duly signed by the competent authority of the industry for the successful completion of the internship.
7. An attendance report shall also be attached with this report.
8. The CIA evaluation will be done by faculty mentor or Industry Supervisor.
9. There is no SEE Exam for this course.

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course, the student will be able to:		
1	Comprehend the modern tools used in the field of AIML and engineering for product development.	L2
2	Demonstrate ethical conduct and professional accountability while working in a team for the benefit of society	L3
3	Analyze the resources requirement and planning to facilitate the project success	L4
4	Assess and adapt technical skills on industry environment	L5
5	Apply the modern industry practice for internship	L3

Mapping Levels of COs to POs / PSOs													
COs				**Program Outcomes (POs)**								**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO 1	3	2	2	1	1	1	1	1	2	2	3	2	1
CO 2	2	2	3	2	2	1	1	1	2	2	3	1	2
CO 3	3	3	3	2	3	2	2	1	2	2	2	2	2
CO 4	2	3	2	3	2	1	2	2	2	2	2	2	2

CO 5	1	1	2	1	2	1	1	1	3	3	2	3	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**