DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

(Artificial Intelligence & Machine Learning)

B.Tech. PROGRAMME– 2026 BATCH

SCHEME

(1_{st} to 8_{th} Semester)



Academic Year 2026-27

Dayananda Sagar University

School of Engineering

Devarakaggalahalli, Harohalli Kanakapura Road, Bengaluru South District, Karnataka 562112.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

SCHEME FOR B.TECH CSE(AI&ML) (FIRST TO FOURTH YEAR) PROGRAMME

Definitions / Descriptions

Definition of Credit:	
1 Hour Lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	01 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition:	
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

I - SEMESTER (PHYSICS CYCLE)

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		Linear algebra & data foundations	3	0	0	0	60	40	100	3
2	BSC		Engineering Physics	3	0	2	0	60	40	100	4
3	IPCC		Computational Thinking & Programming Using Python	2	0	2	0	60	40	100	3
4	IPCC		Foundations of AI & Authentic Intelligence	3	0	0	0	60	40	100	3
5	ESC		Engineering Science course–I	3	0	0	0	60	40	100	3
6	PCC		Engineering Communication & Technical Writing	2	0	0	0	100	--	100	2
7	MCC		Biology for Engineers	2	0	0	0	100	--	100	2
8	MCC		Kannada Kali / Manasu	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-I	-	-	-	-	-	-	-	P/F
			Total	**19**	**00**	**04**	**00**	**550**	**200**	**750**	**21**

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

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II - SEMESTER (PHYSICS CYCLE)

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		Calculus & Mathematical Modelling	3	0	0	0	60	40	100	3
2	BSC		Engineering Physics	3	0	2	0	60	40	100	4
3	IPCC		Computational Thinking Programming Using Python	2	0	2	0	60	40	100	3
4	IPCC		Foundations of AI & Authentic Intelligence	3	0	0	0	60	40	100	3
5	ESC		Engineering Science course–I	3	0	0	0	60	40	100	3
6	PCC		Engineering Communication & Technical Writing	2	0	0	0	100	--	100	2
7	MCC		Biology for Engineers	2	0	0	0	100	--	100	2
8	MCC		Kannada Kali / Manasu	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-II	-	-	-	-	100	-	100	P/F
			Total	**19**	**00**	**04**	**00**	**550**	**200**	**750**	**21**

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SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total	Credit
				L	T	P	J				
1	PCC		Linear Algebra and Data Foundations	3	0	0	0	60	40	100	3
2	BSC		Engineering Chemistry	2	0	2	0	60	40	100	3
3	ESC		Engineering Science course – II	2	1	0	0	60	40	100	3
4	HSMC		Human-Centered Design, Ethics &Values	1	1	0	0	100	-	100	2
5	IPCC		Engineering Graphics & Generative Design	2	0	2	0	60	40	100	3
6	PCC		Design Studio I: Engineering Problem Solving	0	1	0	2	100	--	100	2
7	ESC		Environmental Science	2	0	0	0	100	--	100	2
8	MCC		Indian Constitution & Law	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-I	-	-	-	-	-	-	-	P/F
			Total	**13**	**03**	**04**	**02**	**590**	**160**	**750**	**19**

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II - SEMESTER (CHEMISTRY CYCLE)

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	PCC		Calculus & mathematical modeling	3	0	0	0	60	40	100	3
2	BSC		Engineering Chemistry	2	0	2	0	60	40	100	3
3	ESC		Engineering Science course – II	2	1	0	0	60	40	100	3
4	HSMC		Human-Centered Design, Ethics &Values	1	1	0	0	100	-	100	2
5	IPCC		Engineering Graphics & Generative Design	2	0	2	0	60	40	100	3
6	PCC		Design Studio I: Engineering Problem Solving	0	1	0	2	100	--	100	2
7	ESC		Environmental Science	2	0	0	0	100	--	100	2
8	MCC		Indian Constitution & Law	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-II	-	-	-	-	-	-	-	P/F
			Total	**13**	**3**	**4**	**2**	**590**	**160**	**750**	**19**

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Engineering Science Course I & II	
Course Code	**Course Name**
26XXXX	Introduction to Electrical & Electronics Engineering
26XXXX	Introduction to Electronics Engineering
26XXXX	Engineering Mechanics
26XXXX	Introduction to C Programming

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III SEM –CSE (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	PCC	26AM2301	Applied Statistics & Stochastic Processes	3	0	0	0	60	40	100	3
2	IPCC	26AM2302	Data Structures and Algorithms	3	0	2	0	60	40	100	4
3	IPCC	26AM2303	Principles of Database Management	3	0	2	0	60	40	100	4
4	PCC	26AM2304	Theory of Computation & System Software	3	1	0	0	60	40	100	4
5	PCC	26AM2305	Computer Organization and Architecture	3	0	0	0	60	40	100	3
6	IPCC	26AM2306	Design Studio II AI For Embedded Systems	2	0	2	0	60	40	100	3
7	SEC	26AM23XX	Skill Enhancement Course I	1	0	2	0	100	-	100	2
8	AEC	26AM2307	Cognitive and Technical Skills -III	-	-	-	-	-	-	-	P/F
			Total	**18**	**01**	**08**	**0**	**460**	**240**	**700**	**23**

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Skill Enhancement Courses (SEC-I)											
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	SEC	26AM2308	Java Web Stack	1	0	2	0	100	--	100	02
2	PEC	26AM2309	GPU Computing using CUDA	1	0	2	0	100	--	100	02

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IV SEM – CSE (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	PCC	26AM2401	Differential Equations & Optimization	3	0	0	0	60	40	100	3
2	IPCC	26AM2402	Machine Learning	3	0	2	0	60	40	100	4
3	PCC	26AM2403	System Software and Operating Systems	2	1	0	0	60	40	100	3
4	PCC	26AM2404	Sustainability Engineering & ESC	2	0	0	0	60	40	100	2
5	PCC	26AM2405	Introduction to Data Science	2	0	0	0	60	40	100	2
6	IPCC	26AM2406	Sensors, Systems & IoT Fundamentals	2	0	2	0	60	40	100	3
7	HSC	26LSXXXX	Liberal studies	2	0	0	0	100	--	100	2
8	SEC	26AM2407	Skill Enhancement Course II AI in cloud computing	1	0	2	0	100	--	100	2
9	AEC	26AM2408	Cognitive and Technical Skills-IV	-	-	-	-	-	-	-	P/F
			Total	**17**	**01**	**06**	**0**	**560**	**240**	**800**	**21**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Liberal Studies

List of Subjects

Sl. No.	Course Code	Course Title	Offering Dept
1	26LSXXXX	Introduction to Japanese language	Any Dept
2	26LSXXXX	Introduction to German language	
3	26LSXXXX	Law for Engineers	
4	26LSXXXX	Introduction to Painting	
5	26LSXXXX	Vedic Mathematics	
6	26LSXXXX	Fundamentals of Critical Thinking	
7	26LSXXXX	Cyber Crimes, Policies & Laws	
8	26LSXXXX	Introduction to Film Studies	
9	26LSXXXX	Practicing Yoga & Meditation	
10	26LSXXXX	Universal Human values	
11	26LSXXXX	Data Governance	
12	26LSXXXX	Introducing to Film Studies	
13	26LSXXXX	Practicing Yoga and Meditation	
14	26LSXXXX	NPTEL/ MOOC Courses	

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V SEM –CSE (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	PCC	26AM3501	Responsible AI, Ethics & Policy	2	0	0	0	60	40	100	2
2	PCC	26AM3502	Natural Language Models	2	0	0	0	60	40	100	2
3	IPCC	26AM3503	Deep Learning	3	0	2	0	60	40	100	4
4	IPCC	26AM3504	Generative AI	3	0	2	0	60	40	100	4
5	PCC	26AM3505	Sustainable Green AI Computing	2	0	0	0	60	40	100	2
6	PCC	26AM3506	Design Studio IV: Innovation, Design Thinking & IP	1	0	0	2	100	--	100	2
7	PEC	26AM35XX	Professional Elective I / MOOC/DLI	2	0	0	2	100	--	100	3
8	AEC	26AM3507	Cognitive and Technical Skills-V	-	-	-	-	-	-	-	P/F
			Total	**15**	**0**	**4**	**4**	**500**	**200**	**700**	**19**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Professional Elective Courses (PEC-I)												
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM3508	Accelerated Data Science	2	0	0	2	100	--	100	03
2	PEC	26AM3509	LLM-Based Agent Frameworks & Orchestration	2	0	0	2	100	--	100	03
3	PEC	26AM3510	Intelligent Speech Processing Systems	2	0	0	2	100	--	100	03
4	PEC	26AM3511	Foundations of Robotics and Intelligent Systems	2	0	0	2	100	--	100	03
5	PEC	26AM3512	Explainable AI	2	0	0	2	100	--	100	03
6	PEC	26AM3513	Cognitive Linguistics	2	0	0	2	100	--	100	03

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VI SEM – CSE (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	26AM3601	Image Processing and Computer Vision	3	0	2	0	60	40	100	4
2	PCC	26AM3602	Reinforcement Learning	3	0	0	0	60	40	100	3
3	IPCC	26AM3603	Agentic AI	3	0	2	0	60	40	100	4
4	PCC	26AM3604	Computer Networks	3	0	0	0	60	40	100	3
5	PEC	26AM36XX	Professional Elective II / MOOC/DLI	2	0	0	2	100	--	100	3
6	PROJ	26AM3605	Mini Project (CoE-based / Startup / Research Track)	0	0	0	4	100	--	100	2
7	OEC	26OEXXXX	Open Elective I	3	0	0	0	60	40	100	3
8	AEC	26AM3606	Cognitive and Technical Skills-VI	-	-	-	-	-	-	-	P/F
			Total	**17**	**0**	**4**	**6**	**540**	**160**	**700**	**22**

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Professional Elective Courses (PEC-II)											
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM3607	Accelerated Computing	2	0	0	2	100	--	100	03
2	PEC	26AM3608	Multi-Agent AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM3609	Visual Computing and Graphics	2	0	0	2	100	--	100	03
4	PEC	26AM3610	Robot Operating Systems (ROS)	2	0	0	2	100	--	100	03
5	PEC	26AM3611	AI for Autonomous Vehicles & Smart Mobility	2	0	0	2	100	--	100	03
6	PEC	26AM3612	Conversational AI and Spoken Language Understanding	2	0	0	2	100	--	100	03

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Open Elective Course (OEC-I)											
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	OEC	26OEXXXX	Multimodal and Multilingual Language Perception	3	0	0	0	60	40	100	03
2	OEC	26OEXXXX	AI for Autonomous Vehicles and smart mobility	3	0	0	0	60	40	100	03
3	OEC	26OEXXXX	AI For Content Creation	3	0	0	0	60	40	100	03
4	OEC	26OEXXXX	Accelerated Computing (DLI)	3	0	0	0	60	40	100	03

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VII SEM – CSE (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	PCC	26AM4701	Entrepreneurial Finance & AI-driven Deep-Tech Startups	2	0	0	0	100	-	100	2
2	IPCC	26AM4702	Designing MLOps for Enterprises	3	0	0	0	60	40	100	3
3	PEC	26AM47XX	Professional Elective III/MOOC/DLI	2	0	0	2	100	--	100	3
4	PEC	26AM47XX	Professional Elective IV/MOOC/DLI	2	0	0	2	100	--	100	3
5	OEC	26OEXXXX	Open Elective II	3	0	0	0	60	40	100	3
6	CPR	26AM4703	Capstone Project I	0	0	0	8	60	40	100	4
			Total	**12**	**0**	**0**	**12**	**480**	**120**	**600**	**18**

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Professional Elective Courses (PEC-III)											
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4704	Edge AI and Robotics	2	0	0	2	100	--	100	03
2	PEC	26AM4705	Autonomous Agentic AI systems	2	0	0	2	100	--	100	03
3	PEC	26AM4706	Intelligent Computational Imaging and Reconstruction	2	0	0	2	100	--	100	03
4	PEC	26AM4707	Autonomous Robotic Systems	2	0	0	2	100	--	100	03
5	PEC	26AM4708	AI for Healthcare	2	0	0	2	100	--	100	03
6	PEC	26AM4709	Building AI Applications with Large Language Models	2	0	0	2	100	--	100	03

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Professional Elective Courses (PEC-IV)											
SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4710	Deep Learning for Science and Engineering	2	0	0	2	100	--	100	03
2	PEC	26AM4711	Ethics, Safety & Governance of Agentic AI	2	0	0	2	100	--	100	03
3	PEC	26AM4712	Intelligent Video Surveillance Systems	2	0	0	2	100	--	100	03
4	PEC	26AM4713	Foundation Models for Robotics	2	0	0	2	100	--	100	03
5	PEC	26AM4714	AI For Agriculture	2	0	0	2	100	--	100	03
6	PEC	26AM4715	Multi modal and Multi lingual Language Perception	2	0	0	2	100	--	100	03

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Open Elective Course (OEC-II)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	OEC	26OEXXXX	Human Centric Automation and Industry 5.0	3	0	0	0	60	40	100	03
2	OEC	26OEXXXX	Conversational AI and Spoken Language Understanding	3	0	0	0	60	40	100	03
3	OEC	26OEXXXX	AI for Psychology	3	0	0	0	60	40	100	03
4	OEC	26OEXXXX	GenAI and LLM (DLI)	3	0	0	0	60	40	100	03

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VIII SEM –CSE (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	PEC	26AM48XX	Professional Elective V / MOOC	2	0	0	2	100	--	100	3
2	PCC	26AM4801	Leadership, Policy & Authentic Intelligence	2	0	0	0	100	--	100	2
3	INT	26AM4802	Internship (Industry / Research / CoE based)	0	0	0	4	60	40	100	2
4	CPR	26AM4803	Capstone Project II	0	0	0	20	60	40	100	10
			Total	**4**	**0**	**0**	**26**	**280**	**120**	**400**	**17**

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

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(Artificial Intelligence & Machine Learning)

Professional Elective Courses (PEC-V)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4804	NPTEL/MOOC	2	0	0	2	100	--	100	03
2	PEC	26AM4805	Operationalizing Agentic AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM4806	Multi-modal interaction and speech interfaces	2	0	0	2	100	--	100	03
4	PEC	26AM4807	Human-Centric Automation and Industry 5.0	2	0	0	2	100	--	100	03
5	PEC	26AM4808	Blockchain for Data Security	2	0	0	2	100	--	100	03
6	PEC	26AM4809	Building Transformer-Based Natural Language Processing Applications	2	0	0	2	100	--	100	03

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DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

(Artificial Intelligence & Machine Learning)

B.Tech. PROGRAMME– 2026 BATCH

SCHEME

(1st to 8th Semester)

Academic Year 2026-27

Dayananda Sagar University

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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SCHEME FOR B.TECH CSE(AI&ML) (FIRST TO FOURTH YEAR) PROGRAMME

Definitions / Descriptions

Definition of Credit:	
1 Hour Lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	01 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition:	
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course

PROJ	Project Work
INT	Internship

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I - SEMESTER (PHYSICS CYCLE)

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		Linear algebra & data foundations	3	0	0	0	60	40	100	3
2	BSC		Engineering Physics	3	0	2	0	60	40	100	4
3	IPCC		Computational Thinking & Programming Using Python	2	0	2	0	60	40	100	3
4	IPCC		Foundations of AI & Authentic Intelligence	3	0	0	0	60	40	100	3
5	ESC		Engineering Science course–I	3	0	0	0	60	40	100	3
6	PCC		Engineering Communication & Technical Writing	2	0	0	0	100	--	100	2
7	MCC		Biology for Engineers	2	0	0	0	100	--	100	2
8	MCC		Kannada Kali / Manasu	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-I	-	-	-	-	-	-	-	P/F
			Total	**19**	**00**	**04**	**00**	**550**	**200**	**750**	**21**

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II - SEMESTER (PHYSICS CYCLE)

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		Calculus & Mathematical Modelling	3	0	0	0	60	40	100	3
2	BSC		Engineering Physics	3	0	2	0	60	40	100	4
3	IPCC		Computational Thinking Programming Using Python	2	0	2	0	60	40	100	3
4	IPCC		Foundations of AI & Authentic Intelligence	3	0	0	0	60	40	100	3
5	ESC		Engineering Science course–I	3	0	0	0	60	40	100	3
6	PCC		Engineering Communication & Technical Writing	2	0	0	0	100	--	100	2
7	MCC		Biology for Engineers	2	0	0	0	100	--	100	2
8	MCC		Kannada Kali / Manasu	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-II	-	-	-	-	100	-	100	P/F
			Total	**19**	**00**	**04**	**00**	**550**	**200**	**750**	**21**

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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	PCC		Linear Algebra and Data Foundations	3	0	0	0	60	40	100	3
2	BSC		Engineering Chemistry	2	0	2	0	60	40	100	3
3	ESC		Engineering Science course – II	2	1	0	0	60	40	100	3
4	HSMC		Human-Centered Design, Ethics &Values	1	1	0	0	100	-	100	2
5	IPCC		Engineering Graphics & Generative Design	2	0	2	0	60	40	100	3
6	PCC		Design Studio I: Engineering Problem Solving	0	1	0	2	100	--	100	2
7	ESC		Environmental Science	2	0	0	0	100	--	100	2
8	MCC		Indian Constitution & Law	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-I	-	-	-	-	-	-	-	P/F
			Total	**13**	**03**	**04**	**02**	**590**	**160**	**750**	**19**

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I - SEMESTER (CHEMISTRY CYCLE)

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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	PCC		Calculus & mathematical modeling	3	0	0	0	60	40	100	3
2	BSC		Engineering Chemistry	2	0	2	0	60	40	100	3
3	ESC		Engineering Science course – II	2	1	0	0	60	40	100	3
4	HSMC		Human-Centered Design, Ethics &Values	1	1	0	0	100	-	100	2
5	IPCC		Engineering Graphics & Generative Design	2	0	2	0	60	40	100	3
6	PCC		Design Studio I: Engineering Problem Solving	0	1	0	2	100	--	100	2
7	ESC		Environmental Science	2	0	0	0	100	--	100	2
8	MCC		Indian Constitution & Law	1	0	0	0	50	--	50	1
9	AEC		Cognitive and Technical Skills-II	-	-	-	-	-	-	-	P/F
			Total	**13**	**3**	**4**	**2**	**590**	**160**	**750**	**19**

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Engineering Science Course I & II	
Course Code	**Course Name**
26XXXX	Introduction to Electrical & Electronics Engineering
26XXXX	Introduction to Electronics Engineering
26XXXX	Engineering Mechanics
26XXXX	Introduction to C Programming

II - SEMESTER (CHEMISTRY CYCLE)

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

III SEM –CSE (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	PCC	26AM2301	Applied Statistics & Stochastic Processes	3	0	0	0	60	40	100	3
2	IPCC	26AM2302	Data Structures and Algorithms	3	0	2	0	60	40	100	4
3	IPCC	26AM2303	Principles of Database Management	3	0	2	0	60	40	100	4
4	PCC	26AM2304	Theory of Computation & System Software	3	1	0	0	60	40	100	4
5	PCC	26AM2305	Computer Organization and Architecture	3	0	0	0	60	40	100	3
6	IPCC	26AM2306	Design Studio II AI For Embedded Systems	2	0	2	0	60	40	100	3
7	SEC	26AM23XX	Skill Enhancement Course I	1	0	2	0	100	-	100	2
8	AEC	26AM2307	Cognitive and Technical Skills - III	-	-	-	-	-	-	-	P/F
			Total	**18**	**01**	**08**	**0**	**460**	**240**	**700**	**23**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Skill Enhancement Courses (SEC-I)												
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	SEC	26AM2308	Java Web Stack	1	0	2	0	100	--	100	**02**
2	PEC	26AM2309	GPU Computing using CUDA	1	0	2	0	100	--	100	**02**

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IV SEM – CSE (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	PCC	26AM2401	Differential Equations & Optimization	3	0	0	0	60	40	100	3
2	IPCC	26AM2402	Machine Learning	3	0	2	0	60	40	100	4
3	PCC	26AM2403	System Software and Operating Systems	2	1	0	0	60	40	100	3
4	PCC	26AM2404	Sustainability Engineering & ESG	2	0	0	0	60	40	100	2
5	PCC	26AM2405	Introduction to Data Science	2	0	0	0	60	40	100	2
6	IPCC	26AM2406	Sensors, Systems & IoT Fundamentals	2	0	2	0	60	40	100	3
7	HSC	26LSXXXX	Liberal studies	2	0	0	0	100	--	100	2
8	SEC	26AM2407	Skill Enhancement Course II AI in cloud computing	1	0	2	0	100	--	100	2
9	AEC	26AM2408	Cognitive and Technical Skills-IV	-	-	-	-	-	-	-	P/F
			Total	**17**	**01**	**06**	**0**	**560**	**240**	**800**	**21**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Liberal Studies

List of Subjects

Sl. No.	Course Code	Course Title	Offering Dept
1	26LSXXXX	Introduction to Japanese language	Any Dept
2	26LSXXXX	Introduction to German language	
3	26LSXXXX	Law for Engineers	
4	26LSXXXX	Introduction to Painting	
5	26LSXXXX	Vedic Mathematics	
6	26LSXXXX	Fundamentals of Critical Thinking	
7	26LSXXXX	Cyber Crimes, Policies & Laws	
8	26LSXXXX	Introduction to Film Studies	
9	26LSXXXX	Practicing Yoga & Meditation	
10	26LSXXXX	Universal Human values	
11	26LSXXXX	Data Governance	
12	26LSXXXX	Introducing to Film Studies	
13	26LSXXXX	Practicing Yoga and Meditation	
14	26LSXXXX	NPTEL/ MOOC Courses	

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V SEM –CSE (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	PCC	26AM3501	Responsible AI, Ethics & Policy	2	0	0	0	60	40	100	2
2	PCC	26AM3502	Natural Language Models	2	0	0	0	60	40	100	2
3	IPCC	26AM3503	Deep Learning	3	0	2	0	60	40	100	4
4	IPCC	26AM3504	Generative AI	3	0	2	0	60	40	100	4
5	PCC	26AM3505	Sustainable Green AI Computing	2	0	0	0	60	40	100	2
6	PCC	26AM3506	Design Studio IV: Innovation, Design Thinking & IP	1	0	0	2	100	--	100	2
7	PEC	26AM35XX	Professional Elective I / MOOC/DLI	2	0	0	2	100	--	100	3
8	AEC	26AM3507	Cognitive and Technical Skills-V	-	-	-	-	-	-	-	P/F
			Total	**15**	**0**	**4**	**4**	**500**	**200**	**700**	**19**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Professional Elective Courses (PEC-I)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	PEC	26AM3508	Accelerated Data Science	2	0	0	2	100	--	100	**03**
2	PEC	26AM3509	LLM-Based Agent Frameworks & Orchestration	2	0	0	2	100	--	100	**03**
3	PEC	26AM3510	Intelligent Speech Processing Systems	2	0	0	2	100	--	100	**03**
4	PEC	26AM3511	Foundations of Robotics and Intelligent Systems	2	0	0	2	100	--	100	**03**
5	PEC	26AM3512	Explainable AI	2	0	0	2	100	--	100	**03**
6	PEC	26AM3513	Cognitive Linguistics	2	0	0	2	100	--	100	**03**

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VI SEM – CSE (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	26AM3601	Image Processing and Computer Vision	3	0	2	0	60	40	100	4
2	PCC	26AM3602	Reinforcement Learning	3	0	0	0	60	40	100	3
3	IPCC	26AM3603	Agentic AI	3	0	2	0	60	40	100	4
4	PCC	26AM3604	Computer Networks	3	0	0	0	60	40	100	3
5	PEC	26AM36XX	Professional Elective II / MOOC/DLI	2	0	0	2	100	--	100	3
6	PROJ	26AM3605	Mini Project (CoE-based / Startup / Research Track)	0	0	0	4	100	--	100	2
7	OEC	26OEXXXX	Open Elective I	3	0	0	0	60	40	100	3
8	AEC	26AM3606	Cognitive and Technical Skills-VI	-	-	-	-	-	-	-	P/F
			Total	**17**	**0**	**4**	**6**	**540**	**160**	**700**	**22**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Professional Elective Courses (PEC-II)											
SL	**Course Type**	**Course Code**	**Course Name**	Teaching Hours / Week				Examination			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	PEC	26AM3607	Accelerated Computing	2	0	0	2	100	--	100	03
2	PEC	26AM3608	Multi-Agent AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM3609	Visual Computing and Graphics	2	0	0	2	100	--	100	03
4	PEC	26AM3610	Robot Operating Systems (ROS)	2	0	0	2	100	--	100	03
5	PEC	26AM3611	AI for Autonomous Vehicles & Smart Mobility	2	0	0	2	100	--	100	03
6	PEC	26AM3612	Conversational AI and Spoken Language Understanding	2	0	0	2	100	--	100	03

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Open Elective Course (OEC-I)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	OEC	26OEXXXX	Multimodal and Multilingual Language Perception	3	0	0	0	60	40	100	**03**
2	OEC	26OEXXXX	AI for Autonomous Vehicles and smart mobility	3	0	0	0	60	40	100	**03**
3	OEC	26OEXXXX	AI For Content Creation	3	0	0	0	60	40	100	**03**
4	OEC	26OEXXXX	Accelerated Computing (DLI)	3	0	0	0	60	40	100	**03**

HSMC- Humanities and Social Sciences including Management Courses, IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, AEC-Ability Enhancement Course, SEC-Skill Enhancement Courses, PEC-Professional Elective Courses, OEC-Open Elective Courses, PROJ-Project Work, INT-Internship, CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. Of Credits

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

VII SEM – CSE (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	PCC	26AM4701	Entrepreneurial Finance & AI-driven Deep-Tech Startups	2	0	0	0	100	-	100	2
2	IPCC	26AM4702	Designing MLOps for Enterprises	3	0	0	0	60	40	100	3
3	PEC	26AM47XX	Professional Elective III/MOOC/DLI	2	0	0	2	100	--	100	3
4	PEC	26AM47XX	Professional Elective IV/MOOC/DLI	2	0	0	2	100	--	100	3
5	OEC	26OEXXXX	Open Elective II	3	0	0	0	60	40	100	3
6	CPR	26AM4703	Capstone Project I	0	0	0	8	60	40	100	4
			Total	**12**	**0**	**0**	**12**	**480**	**120**	**600**	**18**

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Professional Elective Courses (PEC-III)											
SL	**Course Type**	**Course Code**	**Course Name**	Teaching Hours / Week				Examination			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	PEC	26AM4704	Edge AI and Robotics	2	0	0	2	100	--	100	03
2	PEC	26AM4705	Autonomous Agentic AI systems	2	0	0	2	100	--	100	03
3	PEC	26AM4706	Intelligent Computational Imaging and Reconstruction	2	0	0	2	100	--	100	03
4	PEC	26AM4707	Autonomous Robotic Systems	2	0	0	2	100	--	100	03
5	PEC	26AM4708	AI for Healthcare	2	0	0	2	100	--	100	03
6	PEC	26AM4709	Building AI Applications with Large Language Models	2	0	0	2	100	--	100	03

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Professional Elective Courses (PEC-IV)											
SL	**Course Type**	**Course Code**	**Course Name**	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4710	Deep Learning for Science and Engineering	2	0	0	2	100	--	100	03
2	PEC	26AM4711	Ethics, Safety & Governance of Agentic AI	2	0	0	2	100	--	100	03
3	PEC	26AM4712	Intelligent Video Surveillance Systems	2	0	0	2	100	--	100	03
4	PEC	26AM4713	Foundation Models for Robotics	2	0	0	2	100	--	100	03
5	PEC	26AM4714	AI For Agriculture	2	0	0	2	100	--	100	03
6	PEC	26AM4715	Multi modal and Multi lingual Language Perception	2	0	0	2	100	--	100	03

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Open Elective Course (OEC-II)												
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	
				L	**T**	**P**	**J**				
1	OEC	26OEXXXX	Human Centric Automation and Industry 5.0	3	0	0	0	60	40	100	**03**
2	OEC	26OEXXXX	Conversational AI and Spoken Language Understanding	3	0	0	0	60	40	100	**03**
3	OEC	26OEXXXX	AI for Psychology	3	0	0	0	60	40	100	**03**
4	OEC	26OEXXXX	GenAI and LLM (DLI)	3	0	0	0	60	40	100	**03**

HSMC- Humanities and Social Sciences including Management Courses, IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, AEC-Ability Enhancement Course, SEC-Skill Enhancement Courses, PEC-Professional Elective Courses, OEC-Open Elective Courses, PROJ-Project Work, INT-Internship, CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. Of Credits

Dayananda Sagar University

School of Engineering

Devarakaggalahalli, Harohalli Kanakapura Road, Bengaluru South District, Karnataka 562112.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

VIII SEM –CSE (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	PEC	26AM48XX	Professional Elective V / MOOC	2	0	0	2	100	--	100	3
2	PCC	26AM4801	Leadership, Policy & Authentic Intelligence	2	0	0	0	100	--	100	2
3	INT	26AM4802	Internship (Industry / Research / CoE based)	0	0	0	4	60	40	100	2
4	CPR	26AM4803	Capstone Project II	0	0	0	20	60	40	100	10
			Total	**4**	**0**	**0**	**26**	**280**	**120**	**400**	**17**

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Professional Elective Courses (PEC-V)											
SL	**Course Type**	**Course Code**	**Course Name**	Teaching Hours / Week				Examination			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	PEC	26AM4804	NPTEL/MOOC	2	0	0	2	100	--	100	03
2	PEC	26AM4805	Operationalizing Agentic AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM4806	Multi-modal interaction and speech interfaces	2	0	0	2	100	--	100	03
4	PEC	26AM4807	Human-Centric Automation and Industry 5.0	2	0	0	2	100	--	100	03
5	PEC	26AM4808	Blockchain for Data Security	2	0	0	2	100	--	100	03
6	PEC	26AM4809	Building Transformer-Based Natural Language Processing Applications	2	0	0	2	100	--	100	03

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Professional Elective Courses

S.no	Domain	Domain Clusters	PEC-I	PEC-II	PEC-III	PEC-IV	PEC-V
			SEM – V	SEM- VI	SEM-VII	SEM-VII	SEM- VIII
			Course Name	Course Name	Course Name	Course Name	Course Name
1	Domain-1	DLI/MOOC	Accelerated Data Science	Accelerated Computing	Edge AI and Robotics	Deep Learning for Science and Engineering	NPTEL/MOOC
2	Domain-2	Agentic AI	LLM based Agent Frameworks	Multi-Agent AI Systems	Autonomous Agentic AI Systems	Ethics, Safety & Governance of Agentic AI	Operationalizing Agentic AI Systems
3	Domain-3	Vision, Speech and Multimodal Intelligenc e	Intelligent Speech Processing Systems	Visual Computing and Graphics	Intelligent Computational Imaging and Reconstruction	Intelligent Video Surveillance Systems	Multi-modal interaction and speech interfaces
4	Domain-4	Robotics and Automation	Foundations of Robotics and Intelligent Systems	Robot Operating Systems (ROS)	Au tonomous Robotic Systems	Foundation Models for Robotics	Human-Centric Automation and Industry 5.0
5	Domain-5	Data Analytics and Applications	Explainable AI	AI for Autonomous Vehicles & Smart Mobility	AI for Healthcare	AI for Agriculture	Blockchain for Data Security
6	Domain-6	AI Language Intelligence	Cognitive Linguistics	Conversational AI and spoken Language Understanding	Building AI Applications with Large Language Models	Multi modal and Multilingual Language Perception	Building Transformer-Based Natural Language Processing Applications

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Artificial Intelligence & Machine Learning)

Open Elective Courses

S.NO	6th Semester	7th Semester
	OEC-I	**OEC-II**
1	Multimodal and Multilingual Language Perception	Human Centric Automation and Industry 5.0
2	AI for Autonomous Vehicles and smart mobility	Conversational AI and Spoken Language Understanding
3	AI For Content Generation	AI for Psychology
4	Accelerated Computing (DLI)	GenAI and LLM (DLI)

Syllabus 2026-2030

DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(AI&ML) 2026-2027 DETAILED CURRICULUM

(2026-2030) Batch

Sl.No	Semester	Total No. of Credits
YEAR 1 — FOUNDATION OF ENGINEER & HUMAN (40 CREDITS)		
1	Semester - I	21
2	Semester – II	19
YEAR 2 — CORE ENGINEERING & SYSTEMS (44 CREDITS)		
3	Semester – III	23
4	Semester – IV	21
YEAR 3 — AI + INTERDISCIPLINARY + INDUSTRY (41 CREDITS)		
5	Semester – V	20
6	Semester – VI	21
YEAR 4 — LEADERSHIP, ENTREPRENEURSHIP & IMPACT (35 CREDITS)		
7	Semester – VII	18
8	Semester - VIII	17
Total		160

DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

SCHEME & SYLLABUS FOR

BACHELOR OF TECHNOLOGY

(B.Tech)

COMPUTER SCIENCE & ENGINEERING

(Artificial Intelligence & Machine Learning)

(3rd to 8th Semester)

Graduation Year: 2026-2030

(With effect from 2026-27)

III SEM – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

III SEMESTER

Sl.no	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE Marks	Total Marks	Credits
					L	T	P	J					
1	PCC	26AM2301	Applied Statistics & Stochastic Processes	MATHS	3	0	0	0	0 3	60	40	100	3
2	IPCC	26AM2302	Data Structures and Algorithms	AI& ML	3	0	2	0	05	60	40	100	4
3	IPCC	26AM2303	Principles of Database Management	AI& ML	3	0	2	0	05	60	40	100	4
4	PCC	26AM2304	Theory of Computation & System Software	AI& ML	3	1	0	0	0 3	60	40	100	4
5	PCC	26AM2305	Computer Organization and Architecture	AI& ML	3	0	0	0	0 3	60	40	100	3
6	IPCC	26AM2306	Design Studio – II AI For Embedded Systems	AI& ML	2	0	2	0	0 3	60	40	100	3
7	SEC	26AM23XX	Skill Enhancement Course – 1	AI& ML	1	0	2	0	0 3	100	-	100	2
8	AEC	26AM2307	Cognitive and Technical Skills - III	Placement	-	-	-	-	2	-	-	-	P/F
Total					**18**	**01**	**08**	**0**	**27**	**460**	**240**	**700**	**23**

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

Skill Enhancement Courses (SEC-I)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	**T**	**P**	**J**				
1	SEC	26AM2308	Java Web Stack	1	0	2	0	100	--	100	**02**
2	PEC	26AM2309	GPU Computing using CUDA	1	0	2	0	100	--	100	**02**

Applied Statistics & Stochastic Processes

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

SEMESTER - III

Course Code	:	26AM2301	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45
L–T–P–J	:	3–0–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To develop strong foundations in probability, statistical inference, and stochastic process, enabling students to analyze uncertainty, make data-driven decisions, and explore advanced computational models including AI systems.

Course Description:

This course introduces probability theory, random variables, stochastic models, and statistical processes used in AI and data science. Students learn mathematical methods for uncertainty analysis and predictive modelling. The course provides a strong analytical foundation for machine learning and intelligent systems.

Course Objectives:

This course will enable students to:

1. Understand the concepts of random variables and probability distributions for modelling uncertainty.
2. Analyze relationships between variables using correlation and regression techniques.
3. Apply statistical inference methods for decision-making under uncertainty.
4. Use parametric and non-parametric tests for hypothesis testing and data analysis.
5. Understand the fundamentals of stochastic processes and their applications in modeling random systems, decision-making, and AI-driven applications.

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**:** Concepts, algorithms, and models are explained through structured lectures supported by R Programming demonstrations.
2. Interactive Teaching**:** Active learning is promoted through discussions, brainstorming, and group problem-solving activities.
3. Demonstration using R Programming and Python**:** AI techniques like classification and optimization are demonstrated to visualize results and understand implementation.
4. Multimedia Learning: Videos and simulations are used to explain complex concepts and real-world applications.
5. Collaborative Learning: Students work in groups to implement projects and analyze datasets using computational tools.
6. Higher Order Thinking Questions: Analytical questions are used to develop model design, evaluation, and decision-making skills.
7. Problem-Based Learning: Real-world problems are given to apply techniques using Python for practical solutions.

MODULE – I	**09 Hours**
Random Variables and Probability Distributions **Topics:** Introduction to random variables, probability mass function (PMF), probability density function (PDF), distribution functions, joint probability distribution and joint density functions, marginal and conditional distributions, mathematical expectation and its properties, covariance, moment generating function, characteristic function. **Applications:** Risk analysis and financial modelling, Reliability engineering, Data analysis and forecasting, Signal processing	
MODULE – II	**09 Hours**

Bi-variate Data, Correlation and Regression Analysis

Topics: Bi-variate random variables, correlation, types of correlation, measures of correlation, graphical methods (scatter diagram), Karl Pearson's correlation, rank correlation (for repeated and non-repeated ranks), linear regression model, regression lines, least squares method, fitted model.

Applications: Market trend analysis, Economic forecasting, Quality control and process analysis, Data relationship analysis

MODULE – III	**09 Hours**

Inference for Decision Making – I

Topics: Introduction to hypothesis, hypothesis testing procedure, p-values and decision making, test of hypothesis for proportion (single and difference of proportions), testing hypothesis about mean (Z-test and t-test), two-sample tests, test for equality of variance (F-test), ANOVA (one-way analysis of variance).

Applications: Quality assurance and control, Clinical trials and testing, Business decision-making, Industrial process evaluation

MODULE – IV	**09 Hours**

Inference for Decision Making – II

Topics Introduction to non-parametric tests, Chi-Square test for goodness of fit, Chi- Square test using probability distributions, Chi-Square test for independence of attributes.

Applications: Survey data analysis, Market research, Pattern recognition, Categorical data analysis

MODULE – V	**09 Hours**

Stochastic Processes

Topics: Introduction to Stochastic Processes (SPs), Markov chains, Poisson process, Discrete-time Markov Chains (DTMCs), Continuous-time Markov Chains (CTMCs), Monte Carlo Simulation.

Applications Queueing systems and waiting line models, Reliability and maintenance systems, Population growth and epidemic modelling, Financial market analysis

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration:

1. Feature distribution modelling in data science
2. Regression models in machine learning
3. Statistical decision-making in AI systems
4. Model validation using statistical tests
5. Markov models in reinforcement learning and decision processes

Authentic Intelligence:

1. Understanding uncertainty in AI predictions
2. Avoiding misleading interpretations of correlations
3. Interpreting statistical results responsibly
4. Ethical handling of categorical data
5. Ethical use of simulation-based decision models

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply probability concepts and random variables to analyze uncertainty	L3
2	Analyze data using correlation and regression techniques	L4
3	Perform hypothesis testing and statistical inference for decision making	L4
4	Apply non-parametric tests for categorical data analysis	L3
5	Model and analyze stochastic processes such as Markov chains	L5

Mapping Levels of COs to POs / PSOs

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

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

TEXT BOOKS:

1. Mendenhall, William, Robert J. Beaver, and Barbara M. Beaver. *Introduction to probability and statistics*. Cengage Learning, 2020.
2. Ross, Sheldon, M. (1995). *Stochastic Processes* (2nd edition), John Wiley.

REFERENCE BOOKS:

1. R.E. Walpole, R.H. Mayers, S.L. Mayers and K.Ye, Probability and Statistics for engineers and scientists, 9th Edition, Pearson Education, 2018.
2. Douglas A. Wolfe, Grant Schneider, Intuitive Introductory Statistics, Springer, 2017.
3. Miller & Freund's, Probability and statistics for engineers, 8th edition, Pearson publication, 2018.
4. Richard I. Levin, David S. Rubin, Masood H. Siddiqui, Sanjay Rastogi, Statistics for Management, 8th Edition, Pearson Publications, 2018.
5. S. C. Gupta and V. K. Kapoor, Fundamentals of Applied Statistics, S. Chand, 2006.
6. Mark L. Berenson, David M. Levine, Kathryn A. Szabat, Basic Business Statistics Concept and Application, Thirteenth Edition, Pearson Education Limited, 2015.
7. Bruce L. Bowerman, Richard T. O'Connell, Emily S. Murphree, Business Statistics in Practice, Seventh Edition, McGraw-Hill, 2014.
8. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, Sixth Edition, John Wiley and Sons, 2014.
9. Norean R. Sharpe, Richard D. De Veaux, Paul F. Velleman, Business Statistics, Fourth Edition, Pearson Education. 2019Trivedi, K. S. (2016), Probability & Statistics with Reliability, Queuing & Computer Science Applications (2nd edition), New Jersey, John Wiley & Sons, Inc.

Criteria	Weightage of Marks
CAT 1	10
CAT 2	10
CAT 3	10
Mid-Semester Examination (MSE)	30
Total	**60 Marks**

RECOMMENDED TOOLS

1. Python
2. R Programming
3. NumPy
4. Pandas
5. Matplotlib
6. Scikit-learn

LAB EXERCISES

S.No	Exercise Title	Aim / Objective	Tools	Hrs	CO
	MODULE I: Exercises 1–3: Random Variables and Probability Distributions (03 Hours)				
1	Random Variable Visualization	Generate and visualize discrete and continuous random variables	R Programming	1 h	CO1
2	PMF, PDF & CDF	Compute PMF, PDF, and CDF for standard distributions	R Programming	1 h	CO1
3	Joint Distributions	Simulate joint probability distributions	R Programming	1 h	CO1
	MODULE II: Exercises 4–6: Bi-variate Data, Correlation and Regression Analysis (03 Hours)				
4	Bivariate Data Visualization	Visualize bivariate data using scatter plots	R Programming	1 h	CO2
5	Correlation Analysis	Compute Karl Pearson's and Spearman's rank correlation	R Programming	1 h	CO2
6	Linear Regression	Fit and evaluate regression model	R Programming	1 h	CO2
	MODULE III: Exercises 7–9: Inference for Decision Making – I (03 Hours)				
7	Z-Test & t-Test	Perform Z-test and t-test (single & two-sample)	R Programming	1 h	CO3
8	Proportion Testing	Test for proportion and difference of proportions	R Programming	1 h	CO3
9	F-Test & ANOVA	Perform F-test and one-way ANOVA	R Programming	1 h	CO3

	MODULE IV: Exercises 10–12: Inference for Decision Making – II (03 Hours)				
10	Chi-Square Tests	Perform goodness of fit and independence tests	R Programming	1 h	CO4
11	Bayesian Inference	Implement basic Bayesian inference techniques	R Programming	1 h	CO4
12	Data Visualization	Visualize probability distributions and statistical results	R Programming	1 h	CO4
	MODULE V: Exercises 13–15: Stochastic Processes (03 Hours)				
13	Monte Carlo Simulation	Perform Monte Carlo simulations for probabilistic models	R Programming	1 h	CO5
14	Markov Chains	Construct transition matrices and simulate state transitions	R Programming	1 h	CO5
15	Exponential Distribution	Study exponential distribution and waiting time analysis	R Programming	1 h	CO5

****

DATA STRUCTURES AND ALGORITHMS

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

SEMESTER – III

Course Code	**:**	26AM2302	**Credits**	**:**	04
Hours / Week	**:**	05	**Total Hours**		45+30
L–T–P–J	**:**	3–0–2–0	**CIE+SEE**	**:**	60+40 Marks

Course Vision:

To develop problem-solving skills by learning how to organize and manage data efficiently using appropriate structures and to write optimized programs by understanding performance (time & space) and applying the right data structure for each problem.

Course Description:

Data Structures and Algorithms (DSA) is a foundational course that develops the ability to design efficient computational solutions for complex problems. The course introduces fundamental data structures—such as arrays, linked lists, stacks, queues, trees, graphs, and hash tables—and explores algorithm design techniques including recursion, divide-and-conquer, and greedy methods. Emphasis is placed on analyzing algorithm efficiency using time and space complexity, enabling students to evaluate scalability for large-scale computing systems.

Course Objectives:

This Course will enable students to:

1. Understand the basic approaches for analyzing and designing data structures.
2. Introduce dynamic memory allocation and C language concepts required for building data structures.
3. Develop essential skills to construct data structures to store and retrieve data quickly and efficiently.
4. Utilize different data structures that support different sets of operations which are suitable for various applications.
5. Explore & implement how to insert, delete, search, and modify data in any data structure-Stack, Queues, Lists, Trees.
6. Develop applications using the available data structure

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

STACKS AND QUEUES

Topics: Introduction to Data Structure, Stack: Definition, Array Representation of Stack, Operations on Stacks. Queue: Definition, Representation of Queues, Operations of Queues, Circular Queue.

Applications: Applications of Stack: Expression evaluation, Conversion of Infix to Postfix, Infix to Prefix Recursion, Tower of Hanoi Applications of Queue: Job Scheduling, A Maze Problem.

MODULE – II	**09 Hours**

LINKED LIST

Topics: Linked List: Types, Representation of Linked Lists in Memory. Traversing, Searching, Insertion & Deletion from Linked List. Circular List, Doubly Linked List, Operations on Doubly Linked List (Insertion, Deletion, Traversal).

Applications: Graph adjacency lists

MODULE – III	**09 Hours**

TREES AND GRAPHS

Topics: Basic Terminology, Binary Trees and their representation, Complete Binary Trees, Binary Search Trees, Operations on Binary Trees (Insertion, Deletion, Search & Traversal), Graphs Terminologies, Types of Graphs, Graph Representation

Applications: Breadth-First Search (BFS), Google Maps, Depth First Search(DFS).

MODULE – IV	**09 Hours**

Divide and Conquer, Decrease and Conquer

Topics: Introduction: Analysis Framework, Asymptotic Notations and Standard notations and common functions , The substitution method, The recursion-tree method, The master method. Divide and Conquer: Merge sort, Quick sort, Binary Search, Multiplication of large integers, Decrease and Conquer : Insertion Sort, Graph algorithm: Topological Sorting.

Applications: Computational geometry- Image compression- GPS and mapping systems

MODULE – V	**09 Hour**

Dynamic Programming & Greedy Techniques

Topics: Dynamic Programming : The Floyd-Warshall Algorithm, Johnson's algorithm for sparse graphs. Greedy Techniques: Single-Source Shortest Paths: General method, The Bellman-Ford algorithm, Single-Source Shortest Paths in DAGs, Dijkstra's Algorithm , Minimum Spanning Trees: Prim's Algorithm, Optimal Tree problem: Huffman Trees

- Nsight Systems- CUDA C++

Applications: The Knapsack problem- Fibonacci Sequence- Network routing

AI Integration

- Graphs for relationships, arrays for datasets
- AI parsing systems, task scheduling in AI systems and recursive AI models
- AI caching systems, path finding and knowledge representation
- Fast searching and sorting in AI systems, AI scheduling & optimization problems
- Database indexing and file systems

Authentic Intelligence

- Build the core intelligence behind computing systems, enabling machines to store, access, and process data efficiently in real-world scenarios.
- Stacks and queues represent real-world decision-making processes and they form the base of intelligent systems like AI, OS, and automation.
- Linked Lists represent real-world connections and sequences, Like a chain of nodes (people, tasks, or steps). They allow flexible and adaptive data handling, just like intelligent systems
- Binary Trees represent hierarchical thinking, like how humans make decisions
- Advanced trees bring adaptive, self-balancing intelligence to systems, enabling efficient, fast, and optimized data handling in AI and real-world applications.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the concepts of pointers, arrays, structures, and unions to address real-world problems and implement the concept in C programming language.	L3
2	Utilize stacks and queue data structures to solve problems such as infix to postfix, infix to prefix conversions, the Towers of Hanoi puzzle, job scheduling and maze navigation.	L4
3	Implement and manipulate singly linked lists, doubly linked lists, and circular linked lists, executing operations such as insertion, deletion, and traversal.	L4
4	Understand the concepts of binary trees, binary search trees, and threaded binary trees, and their associated operations.	L3
5	Understand advanced binary tree structures includes optimal binary search trees, AVL trees, Red-Black trees, and Splay trees.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	1	1	-	-	-	1	1	1	2	1
CO-2	3	3	2	1	3	-	-	-	1	1	1	3	2
CO-3	3	3	3	3	3	1	-	-	2	2	2	3	3
CO-4	3	3	3	3	3	1	-	-	3	3	3	3	3
CO-5	3	3	3	3	3	1	-	-	3	3	3	3	3

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

TEXT BOOKS:

1. Ellis Horowitz, Susan Anderson-Freed, and Sartaj Sahni, *Fundamentals of Data Structures in C*, 2nd Edition (Reprint 2023), University Press (India) Pvt. Ltd., 2023.
2. Anany Levitin, *Introduction to the Design and Analysis of Algorithms*, 3rd Edition, Pearson Education, 2022.

REFERENCE BOOKS:

1. Gilbert & Forouzan, "Data Structures: A Pseudo-code approach with C", 2nd Edition, Cengage Learning,2014.
2. Jean-Paul Tremblay & Paul G. Sorenson, "An Introduction to Data Structures with Applications", 2nd Edition, McGraw Hill, 2013.
3. Ellis Horowitz, Sartaj Sahni, and Sanguthevar Rajasekaran, *Computer Algorithms*, 2nd Edition (Reprint 2008), Universities Press (India) Pvt. Ltd., 2008.
4. Thomas H. Cormen, Charles E.Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", 3rd Edition, PHI, 2014.

E-RESOURCES:

1. https://nptel.ac.in/courses/106102064
2. https://www.coursera.org/learn/data-structures?specialization=data-structures-algorithms
3. https://www.udemy.com/topic/data-structures/free/
4. https://www.mygreatlearning.com/academy/learn-for-free/courses/data-structures
5. https://nptel.ac.in/courses/106/101/106101060/
6. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms
7. 4. https://www.coursera.org/specializations/algorithms
8. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-AC-04+V2

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 05 assessments)	10
Mid-Semester Examination (MSE)	30
AI-Powered Assignment (APA)	5
Lab Record	5
Lab Examination	10
Total	**60 Marks**

LAB EXERCISES

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
MODULE I · Exercises 1–2 : Algorithms (06 Hours)					
1	**Stacks**	To implement stack using Arrays.	C	2 h	CO1
2	**Queues**	To implement queue using Arrays.	C	2 h	CO1
MODULE II · Exercises 3–4 : Stacks and Queues (04 Hours)					
3	**Singly Linked List**	To implement a singly linked list and its operations.	C	2 h	CO2
4	**Doubly Linked List**	To implement a doubly linked list and its operations.	C	2 h	CO2
MODULE III · Exercises 5–6 : Linked List (04 Hours)					
5	**Circular Queues**	To create a circular queue using a circular linked list data structure	C	2 h	CO3
6	**Trees**	To implement binary tree traversal techniques.	C	2 h	CO3
MODULE IV · Exercises 7–8 : Circular Queues and Trees (0 6 Hours)					
7	**Sorting**	Sort a given set of n integer elements using Merge Sort and Quick Sort method and	C	2 h	CO4

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
		compute its time complexity. Demonstrate this algorithm using Divide-and-Conquer method.			
8	**Traversal**	Incorporate the array data structure and demonstrate whether a given unweighted graph is connected or not using DFS method. Implement the graph traversal technique using BFS method to print all the nodes reachable from a given starting node in an unweighted graph.	C	2 h	CO4
MODULE V · Exercises 9–11 : Adversarial Robustness & Capstone (10 Hours)					
9	**Shortest path and MST**	Find Minimum Cost Spanning Tree for a given weighted graph using Prim's and Kruskal's algorithm. From a given vertex in a weighted connected graph, determine the Single Source Shortest Paths using Dijkstra's algorithm.	C	2 h	CO5
10	**Case Study**	Design a web browser history tracker in C. Implement a stack data structure to keep track of visited URLs. Create functions to push new URLs onto the stack as users visit websites and pop URLs when users navigate backward in their browsing history.	C	6h	CO5

11	**Case Study**	Imagine you are responsible for designing a queue-based system to manage the queue of regular customers waiting to purchase cinema tickets at a popular movie theatre. Your system should ensure fair and efficient ticket sales for all customers. When a customer's arrive at the cinema, they join the queue. Each customer is represented by his name, age (for record-keeping), and number of tickets needed. When a customer reaches the front of the queue, they are served by the ticketing agent. Implement a ticket sale process where the agent provides the customer with the requested ticket(s). Initialize the total number of tickets and if the tickets are sold, then the ticketing agent should display a houseful message.	C	6 h	**CO5**

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PRINCIPLES OF DATABASE MANAGEMENT

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

SEMESTER - III

Course Code	**:** 26AM2303	**Credits :** 04	
Hours / Week	**:** 05	**Total Hours**	**:**45+30
L–T–P–J	**:** 3–0–2–0	**CIE+SEE**	**: 60+40** Marks

Course Vision:

To develop the ability to design, implement, and manage modern database systems using relational and NoSQL models, while integrating AI-assisted tools for optimization and ensuring data integrity, security, and ethical data management in real-world applications.

Course Description:

This course introduces the fundamentals of Database Management Systems, including database design, ER modeling, SQL programming, normalization, NoSQL databases, MongoDB, and transaction management. Students will learn to design, implement, and manage relational and NoSQL databases while ensuring data integrity, consistency, security, and efficient data handling for real-world applications.

Course Learning Objectives:

This course will enable students to:

1. Understand DBMS concepts, data models, schemas, and ER-based database design.
2. Learn SQL, queries, joins, constraints, PL-SQL, and triggers.
3. Apply normalization techniques to reduce redundancy and improve database design.
4. Explore NoSQL databases, MongoDB, CRUD operations, and modern data storage models.
5. Understand transactions, ACID properties, concurrency control, deadlocks, and recovery mechanisms.

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. Deliver lectures and interactive sessions on DBMS concepts, data models, schemas, and ER diagrams, supported with case studies such as university and banking databases.
2. Conduct hands-on practice sessions for SQL, joins, constraints, PL-SQL, triggers, and query writing through lab exercises and real-time examples.
3. Use problem-solving activities and group discussions to teach normalization techniques, functional dependencies, and schema refinement using practical database examples.
4. Demonstrate NoSQL concepts, MongoDB document models, and CRUD operations through mini projects such as e-commerce product catalogue development.
5. 5. Explain transaction management concepts using simulations, videos, and case studies on ACID properties, concurrency control, deadlocks, and recovery mechanisms.

MODULE – I	**09 Hours**

Introduction to Database Systems

Topics: DBMS concepts, characteristics of DBMS, advantages of DBMS, data models, schemas and instances, ER diagram basics and extensions.

Applications: Student management systems, banking and ATM systems, hospital record systems, library management systems, employee information systems, online reservation systems.

MODULE – II	**09 Hours**

SQL and Database Programming

Topics: DDL, DML, SQL queries, joins, constraints, views, advanced SQL, PL-SQL, triggers.

Applications: Data retrieval systems, report generation tools, payroll systems, inventory management, CRM systems, banking transaction processing.

MODULE – III	**09 Hours**

Normalization

Topics: Normalization, need for normalization, NF1, NF2, NF3, NF4, NF5, case study on applying conversion rules and normalizing the database.

Applications: Reducing data redundancy, improving data consistency, efficient storage management, better database maintenance, high-quality enterprise database systems.

MODULE – IV	**09 Hours**

NoSQL and Database Design **Topics:** Introduction to databases: structured vs unstructured data, SQL vs NoSQL, JSON fundamentals, JSON objects, arrays, nested documents, JSON schema validation, MongoDB, document models, CRUD operations, case study on E-Commerce product catalog using MongoDB. **Applications:** E-commerce platforms, social media applications, real-time analytics systems, IoT data storage, content management systems, big data applications.	
MODULE – V	**09 Hours**
Transaction Management **Topics:** ACID properties, transactions, schedules, concurrency control, deadlocks, recovery mechanisms. **Applications:** Online banking systems, ticket booking systems, e-commerce payments, multi-user ERP systems, ATM systems, hospital billing systems.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand DBMS concepts, data models, schemas, and ER diagrams for database design.	L2
2	Apply SQL queries, joins, constraints, PL-SQL, and triggers for database programming.	L3
3	Analyse and normalize database schemas using normal forms to reduce redundancy.	L4
4	Explore and implement NoSQL databases, MongoDB document models, and CRUD operations.	L3
5	Evaluate transaction management techniques including ACID properties, concurrency control, deadlocks, and recovery mechanisms.	L5

AI Integration & Authentic Intelligence Reflection (AI^2

Pedagogy) AI Integration:

- AI tools for visualizing DBMS architecture, ER models, schemas, and real-world database applications.
- AI-assisted SQL query generation, joins, trigger creation, PL/SQL coding, query optimization, and debugging.
- AI-based functional dependency analysis, normalization checking, schema refinement, and redundancy detection.

- AI-assisted MongoDB schema design, document modelling, CRUD query generation, and structured vs unstructured data analysis.
- AI simulation tools for ACID properties, concurrency control, deadlock detection, recovery mechanisms, and transaction scheduling.

Authentic Intelligence Reflection:

- Students will evaluate the correctness of AI-generated ER diagrams, schemas, and database models.
- Students will validate AI-generated SQL queries, identify errors, and improve efficiency of database programs.
- Students will analyse inefficiencies in AI-suggested normalized schemas and justify proper normal forms.
- Students will assess the reliability of AI in NoSQL database design, scalability decisions, and data modelling choices.
- Students will examine ethical issues in transaction systems such as privacy, fairness, security, and responsible data recovery practices.

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

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

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

ASSESSMENT SCHEME

Internal Assessment (IA) refers to Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

- **Mid-Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
- **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
- **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
- **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.

2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

Integrated Professional Core Course (Theory + Practical)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 05 assessments)	10
Mid-Semester Examination (MSE)	30
AI-Powered Assignment (APA)	5
Lab Record	5
Lab Examination	10
Total	**60 Marks**

TEXT BOOKS:

1. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2017.
2. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, Database System Concepts, 7th Edition, McGraw-Hill, 2019.
3. Carlos Coronel, Steven Morris, Database Systems: Design, Implementation, & Management, 14th Edition, Cengage, 2022.

REFERENCE BOOKS:

1. Shannon Bradshaw, Kristina Chodorow, Eoin Brazil, MongoDB: The Definitive Guide, 3rd Edition, O'Reilly, 2019.
2. C.J. Date, A. Kannan, S. Swamynathan, An Introduction to Database Systems, 8th Edition, Pearson, 2024.

E-RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc22_cs91/preview
2. https://learn.mongodb.com/
3. https://www.w3schools.com/sql/

RECOMMENDED TOOLS

- Programming: Python (database connectivity)
- Database Systems: MySQL, Oracle

- Visualization & SQL Clients: MySQL Workbench, pgAdmin

LAB EXERCISES

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO
1	ER Diagram – University Management System	Design an ER diagram with entities, attributes, relationships, and constraints for Student, Course, Faculty, Department, and Enrollment.	MySQL Workbench	2h	CO1
2	ER Diagram – Library Management System	Develop an ER diagram for Book, Member, Issue, Return, and Fine management and convert it into schema design.	MySQL Workbench	2h	CO1
3	ER Diagram – Banking System	Construct an ER diagram for Customer, Account, Branch, Loan, and Transaction management.	MySQL Workbench	2h	CO1
4	DDL & DML Commands	Create database objects using DDL and perform insert, update, and delete operations using DML commands.	MySQL Workbench	2h	CO2
5	Joins and Views	Implement inner join, outer join, self join, and create views for data retrieval.	MySQL Workbench	2h	CO2
6	Triggers	Create and execute triggers for automatic database actions during insert, update, and delete events.	MySQL Workbench	2h	CO2
7	Basic Normalization and 1NF	Convert unnormalized data into First Normal Form by removing repeating groups and ensuring atomic values.	MySQL Workbench	2h	CO3
8	2NF and 3NF	Apply Second and Third Normal Forms to remove partial and transitive dependencies.	MySQL Workbench	2h	CO3
9	Higher Normalization (4NF / 5NF)	Apply higher normalization concepts to eliminate multivalued and join dependencies in a given relation.	MySQL Workbench	2h	CO3

10	MongoDB Installation and Setup	Install MongoDB and configure the environment for NoSQL database operations.	MongoDB	2h	CO4
11	Database Creation, CRUD and JSON Queries	Create MongoDB databases and collections, insert JSON documents, perform CRUD operations, and execute JSON-based queries on documents and nested fields.	MongoDB	2h	CO4
12	Case Study – E-Commerce Product Catalog	Design a MongoDB document model with Product Name, Category, Price, Stock, and Brand, and perform CRUD operations.	MongoDB	2h	CO4
13	Transaction Control Commands	Perform transactions using START TRANSACTION, COMMIT, and ROLLBACK to demonstrate Atomicity.	MySQL Workbench	2h	CO5
14	Concurrent Transactions	Execute two simultaneous transactions to observe locking and Isolation behavior.	MySQL Workbench	2h	CO5
15	Savepoint and Recovery	Use SAVEPOINT, ROLLBACK TO SAVEPOINT, and COMMIT for partial recovery of transactions.	MySQL Workbench	2h	CO5

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THEORY OF COMPUTATION AND SYSTEM SOFTWARE

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

SEMESTER – III

Subject Code	:	26AM2304	**Credits**	:	04
Hours / Week	:	03 Hours	**Total Hours**	:	45+15 Hours
L–T–P–S	:	3–1–0–0	**CIA+SEE**	:	60+40 Marks

Course Vision:

To develop a strong foundation in the theoretical principles of computation and the practical aspects of system software design. The course enables students to model and analyze computational problems using formal methods such as automata and Turing machines, while also building skills in assemblers, loaders, and compiler design. It prepares learners to bridge theory and practice, fostering analytical thinking and the ability to develop efficient and reliable computing systems for real-world applications.

Course Description:

Theory of Computation and System Software is a core course that bridges mathematical foundations of computation with practical software system design. The course introduces automata theory including finite automata, regular expressions, context-free grammars, pushdown automata, and Turing machines to understand the limits of computation. It also covers system software components such as assemblers, loaders, and compilers, focusing on lexical analysis, parsing techniques, intermediate code generation, and optimization strategies.

Students gain the ability to model computational problems formally, design language processors, and understand how high-level programs are translated into machine-executable code. The course prepares learners for advanced areas such as compiler design, programming languages, and AI systems.

Course Learning Objectives:

This course will enable students to:

1. Understand the concept of finite automata.
2. Explore Regular Grammar, Context-Free Language & Grammars and Pushdown Automata
3. Explain the working principles of Turing Machines as computational models and undecidability.
4. Explain the functions of assemblers, loaders, and the compilation process including compiler structure and phases.
5. Generate intermediate code using lexical and syntax analysis techniques, construct parsing methods, and apply basic code optimization strategies.

Teaching–Learning Process (Pedagogical Methods for TOC & SS):

1. **Blended Instruction**: The course will be delivered using a combination of traditional lectures and modern teaching strategies to effectively achieve course outcomes.
2. **Active Learning**: Classroom sessions will include concept discussions, brainstorming, group problem-solving, and guided questioning to enhance student engagement.
3. **Visual Learning**: Use of **animations, simulations, and video demonstrations** to explain abstract concepts such as automata, parsing, and compiler processes.
4. **Collaborative Learning**: Encourage team-based activities like automata design, grammar construction, parsing exercises, and system software mini-projects.
5. **Critical Thinking**: Promote higher-order thinking through quizzes, analytical questions, and complex problem-solving tasks with multiple solution approaches.
6. **Creative Problem Solving**: Motivate students to explore alternative methods and develop **innovative solutions** for computational and system-level problems.

MODULE I: Introduction to Finite Automata	**10 Hours**
The Central Concepts of Automata Theory, Deterministic Finite Automata, Non deterministic Finite Automata, An application, Finite Automata with Epsilon Transitions. Regular Expressions Concept, Applications of Regular Expressions, Properties of Regular Languages. ***Applications:*** Properties such as closure and equivalence are used to simplify and analyze languages in compiler optimization, automata minimization, formal verification, and system design.	
MODULE – II : Regular Language Context Free Grammars and Languages	**08 Hours**
Context Free Grammars, Parse Tree, Applications of Context Free Grammar, Ambiguity in Grammars and Languages, The Pumping Lemma for Context Free Languages, Closure Properties of Context Free Languages. ***Application*s**: Closure properties help in combining and manipulating languages, useful in compiler optimization, language processing systems, and formal verification of software systems.	
MODULE – III : Pushdown Automata and Turing Machines	**09 Hours**
Definition of Pushdown Automata, Deterministic Pushdown Automata, The Languages of a PDA, Introduction to Turing Machines: The Turing Machines, Undecidability A language that is not Recursively Enumerable, An Undecidable Problem That is RE, Post Correspondence Problem, HPI , Uwart, CAM. ***Applications***: Turing Machines are used as a theoretical model for modern computers, simulators, and solving complex computational problems step-by-step.	
MODULE – IV : Introduction to System Software, Assemblers	**08 Hours**
Introduction to System Software, ASSEMBLERS: Basic assembler functions: A simple assembler, Machine dependent assembler features, Machine independent assembler features: Literals, Symbol-defining statements, Expressions, Program blocks, Basic loader functions: Design of an Absolute Loader, A Simple Bootstrap Loader. ***Applications***: Loaders place programs into memory for execution and are used in operating systems to manage program loading, relocation, and linking.	
MODULE – V : Compiler	**10 Hours**

Part I: LEXICAL AND SYNTAX ANALYSIS: Role of lexical Analyzer, Specification of Tokens, Lexical Analyzer generator Lex. writing a grammar: Eliminating ambiguity, Left recursion, Left factoring.
Part II: Top-down parsing: Recursive Descent Parsing, First and follow, Bottom up parsing: Shift Reduce Parsing, Three address code: Quadruples, Triples, indirect triples, Basic Blocks, Optimization of Basic Blocks, The Code Generation Algorithm, Peephole optimization.
Applications: Grammar defines the structure of a programming language and is used in compiler design, syntax checking, and language development.

Course Outcomes

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Analyze and formulate finite Automata, Regular Expressions for Text Processing	L4
2	Understanding of Context-Free Grammars and Pushdown Automata	L2
3	Apply Turing Machines to explore Undecidability and Computational Limits	L3
4	Analyze the functioning of assemblers and loaders, and apply concepts such as literals, expressions, and program blocks in system software design.	L4
5	Implement lexical and syntax analysis, perform parsing, generate intermediate code, and apply fundamental code optimization techniques.	L3

Mapping Levels of COs to POs / PSOs

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

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

(Low) RESEARCH INTEGRATION TEACHING

Students review at least one recent topic:

- Compiler optimization using AI
- Formal verification methods
- Automata in machine learning
- Language models and formal grammars
- Students present a short research review.

ASSESSMENT SCHEME :

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    b. **Continuous Internal Assessment (CIA – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.
    c. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
2. Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: Automata Design Evaluation
Generate DFA using AI
Verify correctness and minimize states
Assignment 2: Grammar Validation
AI-generated CFG → check ambiguity and correctness
Assignment 3: Parsing Debugging
Debug AI-generated parser code
Assignment 4: Compiler Output Analysis
Compare AI-generated intermediate code
Assignment 5: Optimization Study
Compare optimized vs non-optimized code

Text Books

1. Esparza, Javier, and Michael Blondin. Automata theory: An algorithmic approach. MIT Press, 2023.
2. Pettorossi, Alberto. Automata Theory and Formal Languages: Fundamental Notions, Theorems, and Techniques. Springer Nature, 2022.
3. "System Software: An Introduction to Systems Programming" by Leland L. Beck and D.Manjula was the 3rd edition, published in 2020.
4. "Compilers: Principles, Techniques, and Tools" by Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey
   D. Ullman (commonly known as the "Dragon Book") 2nd Edition 2020.

Reference Books:

1. K.L.P. Misra and N. Chandrashekaran. Theory of Computer Science- Automata, Languages and Computation, 3rd Edn. PHI, New Delhi, 2007
   .Elaine Rich, Automata, Computability and Complexity, 1st Edition, Pearson education,2013
2. J.E. Hopcroft, R. Motwani, and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 3rd Edn. Pearson Education ,2013
3. Computation, 3rd Edn. PHI, New Delhi, 2007
4. Elaine Rich, Automata, Computability and Complexity, 1st Edition, Pearson education,2013.

E-Resources: (Recommended Tools)

- https://archive.nptel.ac.in/courses/111/103/111103016/
- ChatGPT / Gemini for ideation
- https://www.youtube.com/watch?v=58N2N7zJGrQ&list=PLBlnK6fEyqRgp46KU v4ZY69yXmpwKOIev
- https://www.geeksforgeeks.org/theory-of-computation-automata-tutorials/
- Compiler Design - Course (nptel.ac.in)

Activity Based Learning (Suggested Activities in Class)

- Hands on activity, Quiz, Seminar, Expert Talk, Case Study, Problem Solving Session.

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COMPUTER ORGANIZATION AND ARCHITECTURE

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

SEMESTER - III

Course Code	:	26AM2305	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45
L–T–P–J	:	3–0–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To develop the ability to understand, analyze, and design efficient computing systems by learning processor architecture, instruction execution, memory hierarchy, and low-level programming concepts.

Course Description:

This course explains the internal structure and functioning of computer systems, including processors, memory, instruction sets, and input-output mechanisms. Students learn how hardware components interact to execute programs efficiently. The course develops understanding of system performance and computer architecture design principles

Course Objectives:

This course will enable students to:

1. **Understand** the Architecture and programming of ARM microprocessor.
2. **Develop** program using Arm instruction set and appreciate the advanced features.
3. **Understand** the exception handling techniques.
4. **Study in** detail the concept of instruction level parallelism and concepts of pipelining.
5. **Understand** various cache memory mapping techniques and memory Organization.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	09 Hours

Overview of Computing Systems and ARM Architecture

History of computers, evolution of computing systems, basic components of a computing device, introduction to ARM7TDMI programmer's model, data types, processor modes, registers, program status registers, vector table, GPU Fundamentals & Architecture, Structure of assembly language modules, assembler rules, directives and macros, load and store instructions, operand addressing methods, and endianness.
Applications: Embedded system development, microcontroller-based systems, low-level system programming, and hardware–software interaction in real-time computing devices.

MODULE - II	09 Hours

Data Processing and Control Flow

Constants and literal pools, ARM rotation scheme, loading constants and addresses into registers, logic and arithmetic operations, flags and their usage, compare instructions, data processing instructions, branching and looping mechanisms, conditional execution, straight-line coding, stack operations, subroutines, parameter passing to subroutines, and the ARM Architecture Procedure Call Standard (APCS).
Applications: Development of efficient assembly programs for embedded systems, implementation of control structures in low-level programming, stack-based memory management, and function call handling in microprocessor-based systems.

MODULE – III	09 Hours

Interfacing and Exception Handling

Mixing C programming language with assembly language, inline assembler, embedded assembler, calling functions between C and assembly, interrupts, error conditions, processor exception sequence, vector table, exception handlers, exception priorities, and procedures for handling exceptions in ARM architecture.
Applications: Embedded system programming, development of real-time systems, low-level hardware control, and efficient implementation of interrupt-driven applications in microprocessor-based systems.

MODULE – IV Pipelining and Performance Optimization	08 Hours

Pipelining and Performance Optimization

Introduction to pipelining, basic and intermediate pipelining concepts, challenges in pipelining implementation, major hurdles of pipelining, pipeline stages and implementation, factors that make pipelining difficult, extending the pipeline to support multicycle operations, pipeline structure of the MIPS R4000, and crosscutting issues in pipelined processor design.
Applications: High-performance processor design, optimization of instruction execution in modern CPUs, performance improvement in embedded and general-purpose processors, and efficient instruction-level parallelism in computing systems.

MODULE – V	10 Hours

Memory Hierarchy and Virtual Memory

Introduction to memory hierarchy, cache memory concepts, cache performance evaluation, six basic cache optimizations, virtual memory concepts, memory protection mechanisms, examples of virtual memory systems, and common fallacies and pitfalls in memory system design.
Applications: Design and optimization of memory systems in modern processors, improving system performance using cache memory, efficient memory management in operating systems, and reliable data protection in computing systems.

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration:

1. AI-Assisted ARM Assembly Programming

Students use AI tools (e.g., ChatGPT, GitHub Copilot) to generate ARM assembly programs for arithmetic operations, loops, stack manipulation, and subroutines. They must analyze, debug, optimize the generated code, and explain each instruction to demonstrate conceptual understanding.

2. AI-Based Processor Architecture Exploration

Students interact with AI to compare ARM, RISC-V, MIPS, GPU, and x86 architectures. They validate AI-generated comparisons using textbooks and research papers, identify inaccuracies, and prepare a reflection on the strengths and limitations of AI-generated technical content.

3. AI-Supported Pipeline and Cache Analysis

Students use AI to explain pipeline hazards, cache mapping techniques, branch prediction, and virtual memory concepts. They independently solve numerical problems or design examples, compare their solutions with AI outputs, and justify any differences.

4. AI-Driven Embedded System Design Assistance

Students leverage AI to suggest ARM-based embedded system architectures for applications such as IoT, robotics, or smart healthcare. They critically evaluate the feasibility of AI recommendations, identify hardware–software trade-offs, and propose improvements based on engineering principles.

Authentic Intelligence:

- Students will verify the correctness of AI-generated ARM assembly programs Check whether AI-generated ARM code executes correctly, follows ARM syntax and APCS standards, produces the expected output, and identify logical or instruction-level errors.
- Students will critically evaluate AI-generated processor architecture explanations Analyze AI-generated descriptions of ARM architecture, pipelining, GPU architecture, and exception handling to identify misconceptions, incomplete explanations, or incorrect architectural interpretations.
- Students will validate AI-generated pipeline and performance analysis Verify AI-generated solutions for pipeline hazards, instruction execution, CPI calculations, branch prediction, and performance optimization by manually analyzing execution flow and timing.
- Students will debug and refine AI-generated memory hierarchy solutions

Identify errors in AI-generated cache mapping, cache hit/miss calculations, virtual memory translation, and memory protection mechanisms, and optimize the solutions based on architectural principles.

- Students will assess AI recommendations for computer architecture design Evaluate whether AI-suggested processor, cache, memory, or embedded system designs are efficient, scalable, and suitable for the given application, justifying improvements using Computer Organization and Architecture concepts.

Course Outcomes:

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	**Apply** knowledge of the internal architecture and organization of ARM microprocessors to utilize their components and functionalities.	L3
2	**Apply** the instruction set of ARM Microprocessor by writing Assembly language programs.	L3
3	**Analyze and compare** the various exception handling techniques.	L4
4	**Examine** the concept of instruction-level parallelism and **analyze** the principles of Pipelining techniques.	L4
5	**Compare** and **Contrast** memory hierarchy and its impact on computer cost/performance.	L4

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs													
	Program Outcomes (POs)											PSOs	
COs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1	3		2									2	
CO-2	3		3		1							2	
CO-3	3	3	1									2	
CO-4	3	3	1									2	
CO-5	3	3	1									2	

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

RESEARCH INTEGRATION TEACHING

Students review at least one recent topic:

- AI-Assisted Processor Architecture and Design
- RISC-V vs ARM: Recent Advances in Processor Architectures
- Machine Learning-Based Branch Prediction and Performance Optimization
- Emerging Cache and Memory Technologies (MRAM, ReRAM, CXL, HBM)
- AI Accelerators, GPUs, and Heterogeneous Computing Architectures
- Secure Processor Design: ARM TrustZone, Spectre, and Meltdown Mitigation Techniques
- Energy-Efficient Embedded Systems and Edge AI Processor

ASSESSMENT SCHEME:

1. "Internal Assessment (IA)" refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

   a. Mid Semester Examination (MSE): One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.

   b. Continuous Internal Assessment (CIA – Six Components): Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.

   c. AI-Powered Assignment (APA): Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.

2. Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

Criteria	**Weightage of Marks**
Mid-Semester Examination (MSE)	30
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Program & Quiz	10
Total	60 marks

AI-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1:

Identify ARM-based embedded devices around us.

Assignment 2:

Understand the ARM7TDMI architecture using AI tools.

Text Books

1. William Hohl, "ARM Assembly Language", 2nd Edition, CRC Press, 2009.
2. John L Hennessy, David A Patterson, "Computer Architecture, A Quantitative Approach", 5th Edition, Morgan Kaufmann publishers, 2012.

Reference Books:

1. David A Patterson, John L Hennessy, "Computer Organization and Design", 4th Edition, Morgan Kaufmann publishers, 2010.
2. Steve Furber, "ARM System-on-chip Architecture", 2nd Edition, Pearson Publications, 2000.
3. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, "Computer Organization", 5th Edition, Tata McGraw Hill, 2002.

E-Resources: (Recommended Tools)

1. https://www.udemy.com/topic/arm-cortex-m/
2. https://www.edx.org/school/armeducation
3. https://onlinecourses.nptel.ac.in/noc22_cs93/preview

Activity Based Learning (Suggested Activities in Class)

Hands on activity, Quiz, Seminar, Expert Talk, Case Study, Problem Solving Session.

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DESIGN STUDIO II: AI FOR EMBEDDED SYSTEMS

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

SEMESTER – III

Subject Code	: 26AM2306	**Credits**	: 03
Hours / Week	: 03 Hours	**Total**	: 30 +15 Hours
L–T–P–J	: 2–0–2–0	**CIA + SEE**	: 60+40 Marks

Course Vision

To develop advanced knowledge in embedded system architecture, real-time software development, and intelligent edge systems enabling students to design optimized hardware–software integrated systems for modern AI-enabled applications.

Course Description The course "Design Studio II: AI for Embedded Systems" provides students with a comprehensive understanding of advanced embedded system design integrated with modern Artificial Intelligence concepts for intelligent edge devices. The course covers embedded architectures, ARM Cortex-M processors, memory systems, peripheral interfacing, and real-time embedded software development using C and RTOS concepts. Students gain practical exposure to communication protocols such as I2C, SPI, UART, CAN, Ethernet, and wireless embedded interfaces for building connected embedded applications. The course also emphasizes hardware debugging, interrupt-driven programming, and software optimization techniques for performance and power efficiency. Advanced topics including IoT-enabled embedded systems, TinyML, Edge AI, and embedded cybersecurity are introduced to enable intelligent and secure real-time systems. Through application-oriented learning, students develop the ability to design, optimize, and deploy reliable embedded solutions for industrial automation, smart devices, healthcare, automotive, and IoT applications.

Course Objectives:

This course will enable students to:

1. Understand advanced embedded system architecture and processor design.
2. Develop embedded firmware using advanced C and real-time techniques.
3. Apply communication protocols and hardware interfaces in embedded systems.
4. Design real-time embedded systems using RTOS concepts.
5. Integrate embedded systems with IoT and edge AI applications.

Teaching-Learning Process (General Instructions)

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

a. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.

b. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

c. Showing **Video/animation** films to explain functioning of various concepts.

d. Encourage **Collaborative** (Group Learning) Learning in the class.

e. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

f. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**06 Hours**

Advanced Embedded System Architecture

Topics: Fundamentals review: embedded systems vs general computing systems, Advanced embedded architectures, ARM Cortex-M architecture deep dive, Processor pipeline and instruction execution.

Applications: Design and optimization of embedded architectures for high-performance systems, development of efficient ARM Cortex-M based applications, improving execution speed using pipelining techniques, real-time data processing in control systems, and architecture-level optimization for power and performance in embedded devices.

MODULE – II	**06 Hours**

Embedded Hardware Design & Interfaces

Topics: Memory hierarchy in embedded systems, Interrupt handling and exception management, Low-power embedded design techniques, Embedded processors and microcontrollers, Memory subsystems (Flash, EEPROM, SRAM), Peripheral interfaces, Sensor and actuator interfacing.

Applications: Design and integration of memory subsystems in embedded devices, efficient interrupt handling for responsive systems, development of low-power hardware solutions,
interfacing sensors and actuators for real-time applications, and building reliable embedded systems with optimized peripheral communication.

MODULE – III	**06 Hours**

Embedded Software Design

Topics: Communication Interfaces: I2C, SPI, UART, CAN, USB.

Advanced communication systems: Ethernet for embedded systems, Wireless embedded interfaces, Industrial communication protocols

Embedded hardware debugging tools: Logic analyzers, Oscilloscopes.

Applications: Development of communication-driven embedded applications using I2C, SPI, UART, and CAN protocols, implementation of network-enabled embedded systems using Ethernet and wireless technologies, design of industrial communication solutions, and effective debugging and validation using hardware diagnostic tools.

MODULE – IV	06 Hours
Real-Time Operating Systems (RTOS) **Topics:** Embedded programming using C, Compiler architecture and build stages, Memory management in embedded systems, Bitwise operations and register programming, Interrupt driven programming. Embedded software optimization techniques: Code size optimization, Power-aware programming, Real-time scheduling, Software design patterns in embedded systems. **Applications:** Development of real-time embedded applications using C, efficient memory and resource management in constrained systems, implementation of interrupt-driven and time-critical applications, optimization of embedded software for performance and power efficiency, and design of reliable systems using real-time scheduling and software design patterns.	
MODULE – V	**06 Hours**
Embedded IoT & Edge Intelligence **Topics:** Embedded systems in IoT architecture, Edge AI concepts: TinyML, Embedded cybersecurity: Secure boot, Device authentication, Firmware security. **Applications:** Design and deployment of IoT-enabled embedded systems, implementation of edge intelligence using TinyML techniques, development of secure embedded systems with device authentication and secure boot, enabling real-time data processing at the edge, and building scalable smart applications for connected environments.	

Course Outcome

Course Outcomes	Description	Bloom' s Taxonomy Level
At the end of the course, the student will be able to:		
1	**Understand** the key features of advanced embedded system architectures and processor designs.	L2
2	**Understand** how hardware interfaces and communication modules function within embedded systems.	L2
3	**Analyze** embedded firmware to identify optimization opportunities using advanced programming techniques.	L3
4	**Evaluate** real-time operating system concepts for suitability in different embedded applications.	L5
5	**Examine** intelligent embedded systems integrating IoT and edge AI solutions.	L4

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

CO's	PO'S											PSO'S	
COs / PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1	3	2	1	1	2	-	-	2	1	-	-	1	1

CO-2	3	3	1	1	2	-	-	2	1	-	-	2	2
CO-3	3	3	2	1	3	-	-	2	1	-	-	1	2
CO-4	3	2	3	1	3	-	-	1	2	1	1	2	2
CO-5	3	3	3	2	3	1	1	2	2	2	1	2	2

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

Text Books:

1. Joseph Yiu," The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", 3rd Edition, Newnes, 2013
2. K.V. Shibu," Introduction to Embedded Systems", 2nd Edition, McGraw Hill Education, 2017.

REFERENCE BOOKS:

1. James K. Peckol, "Embedded Systems: A Contemporary Design Tool", Wiley, 2009.
2. Raj Kamal, "Embedded Systems- Architecture, Programming and Design", 4th Edition, McGraw Hill Education, 2020.
3. Jonathan Valvano," Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers", 2nd Edition, CreateSpace Independent Pub, 2012.

E-Resources : (Recommended Tools)

1. **IDE / Firmware development:** VS Code + PlatformIO, Arduino IDE, STM32CubeIDE, Keil uVision, MPLAB X, ESP-IDF.
2. **Simulation / prototyping:** Proteus, Tinkercad Circuits, Arm Mbed simulator.
3. **Debugging / analysis:** Logic analyzer, oscilloscope, JTAG/SWD debugger, Wireshark.
4. **AI-assisted development:** ChatGPT, GitHub Copilot, local LLM tools such as Ollama for privacy-sensitive work.
5. **Learning resources:** Arm learning resources, Coursera embedded systems courses, embedded systems reference libraries and tutorials.

Recommended Tools

1. Keil uVision
2. STM32CubeIDE
3. PlatformIO
4. VS Code
5. MATLAB / Simulink (Embedded Coder)
6. Proteus
7. TensorFlow Lite
8. FreeRTOS

RESEARCH INTEGRATION TEACHING

1. **Paper Review:** Students study recent research on embedded architectures, RTOS, IoT, TinyML, and edge AI.
2. **Case Studies:** Analyze real-world embedded systems such as smart devices, industrial controllers, and AI-enabled edge applications to connect theory with practice.
3. **Mini Presentation:** Present short reviews on emerging topics like low-power design, sensor interfacing, secure boot, and embedded AI deployment.
4. **AI-Assisted Research:** Use AI tools to summarize and compare recent papers on

embedded firmware optimization, communication protocols, and intelligent embedded systems.

5. **Critical Reflection:** Identify research gaps, design limitations, reliability issues, and ethical concerns in autonomous and connected embedded systems.

Assignment 1: Embedded Architecture Analysis using AI Student prompt to AI tool:

"Explain the architecture of an embedded system using a microcontroller-based real-world example."

Students must:

1. Analyze the processor architecture and system components.
2. Identify the role of memory, interrupts, and peripherals.
3. Compare the embedded architecture with general-purpose computing systems.
4. Suggest suitable applications for the given architecture.

Assignment 2: Embedded Hardware Interface Design Student prompt to AI tool: "Design a hardware interface for sensors and actuators in an embedded system." Students must:

1. Analyze the interface requirements for sensors and actuators.
2. Evaluate memory and peripheral selection for the design.
3. Identify possible hardware constraints and low-power concerns.
4. Suggest improvements for reliability and efficiency.

Assignment 3: Embedded Communication and Debugging Student prompt to AI tool:

"Explain how I2C, SPI, UART, or CAN can be used in an embedded application."

Students must:

1. Compare the communication protocols and their use cases.
2. Evaluate the suitability of each protocol for a given embedded scenario.
3. Analyze debugging methods using logic analyzers and oscilloscopes.
4. Suggest the most appropriate communication method for the system.

Assignment 4: RTOS-Based Embedded Software Design Student prompt to AI tool:

"Develop an RTOS-based scheduling plan for a real-time embedded application."

Students must:

1. Analyze task priorities and timing constraints.
2. Evaluate the suitability of RTOS concepts for the application.
3. Identify scheduling and memory management issues.
4. Suggest code optimization techniques for real-time performance.

Assignment 5: IoT and Edge AI Embedded System Design Student prompt to AI tool:

"Design an intelligent embedded system integrating IoT and edge AI for a smart application." Students must:

1. Analyze the role of embedded systems in IoT architecture.
2. Evaluate the edge AI/TinyML approach for the application.
3. Identify cybersecurity, privacy, and reliability concerns.
4. Propose a human-centered and secure embedded solution.

LAB EXERCISES:

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO
1	Design and Implementation of Smart Sensor Monitoring System using Embedded AI	To design an embedded system architecture integrating sensors with AI-based decision-making	Arduino / Raspberry Pi, Embedded C, Python (TinyML), Sensors	2h	CO1
2	Development of AI-Based Predictive Maintenance System using Sensor Data	To interface multiple sensors and analyze data for predictive maintenance	Arduino, Sensors (Vibration/Temp), Python	2h	CO2
3	Implementation of Temperature and Humidity Monitoring System with Anomaly Detection	To design a sensor-based monitoring system with anomaly detection logic	DHT11/DHT22 Sensor, Arduino, Python	2h	CO2
4	Design of Smart Parking System using Embedded Sensors and AI Logic	To implement sensor interfacing and real-time decision-making for parking management	Ultrasonic Sensors, Arduino, Embedded C	2h	CO2
5	Design of Smart Energy Monitoring and Optimization System	To develop communication-enabled embedded system for energy monitoring	Arduino, Energy Meter Sensors, IoT Platform	2h	CO3
6	Development of Voice-Controlled Embedded System using Edge AI	To implement communication interfaces and voice processing in embedded systems	Raspberry Pi, Microphone, Python, Speech Libraries	2h	CO3
7	Implementation of Autonomous Obstacle Avoidance Robot using Edge AI	To design a real-time embedded system with task scheduling and control logic	Arduino/Raspberry Pi, Ultrasonic Sensors, Motor Driver	2h	CO4
8	Development of Edge AI-Based Health Monitoring Device using TinyML	To implement TinyML models for real-time health monitoring on embedded devices	Arduino Nano 33 BLE Sense, TensorFlow Lite	2h	CO5
9	Implementation of Basic Image Classification on Embedded Device (TinyML)	To deploy and run image classification models on resource-constrained embedded systems	Raspberry Pi / Arduino, TensorFlow Lite	2h	CO5

Outcome of Assignments & Projects

Students will:

1. Develop **AI-assisted embedded system design skills**
2. Gain **hands-on experience with real hardware constraints**
3. Learn **debugging, optimization, and validation of AI models on edge devices**
4. Build **industry-relevant intelligent embedded**

applications ASSESSMENT SCHEME

Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Internal Assessment	30
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	30
Total	**60 marks**

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SKILL ENHANCEMENT COURSE – I

(JAVA WEB STACK)

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

SEMESTER - III

Course Code	:	26AM2308	**Credits**	:	02
Hours/ Week	:	03	**Total Hours**	:	15+30 Hours
L–T–P– J	:	1–0–2–0	**CIE**	:	100 Marks

Course Vision:

To equip students with the foundational knowledge and practical skills required to design,develop, and deploy modern full-stack web applications using frontend and backend technologies.

Course Description:

This course enhances technical skills in modern software development and high-performance computing. Students learn web application development using Java technologies or parallel computing using CUDA-enabled GPUs. The course focuses on industry-relevant tools and practical implementation skills.

Course Objectives:

This course will enable students to:

1. Understand the fundamentals of web development and client-server architecture
2. Develop responsive user interfaces using HTML, CSS, and JavaScript
3. Implement backend services using Java and Spring Boot
4. Integrate frontend and backend to build full-stack applications
5. Evaluate performance, usability, and deployment of web applications

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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing Video/animation films to explain functioning of various concepts.

MODULE – I	**03 Hours**

Topics: Introduction to Web Development (Client-Server Architecture), Structure of Web Pages, HTML Elements, Forms, Tables, Semantic HTML, CSS Basics, Selectors, Box Model, Flexbox and Grid, Responsive Design using Media Queries

Applications: Static and responsive webpage development, Portfolio and landing page design

MODULE – II	**03 Hours**

Topics: JavaScript Basics (Variables, Data Types, Operators), Control Structures, Functions and Scope, ES6 Features (let/const, arrow functions) ***Applications:*** Interactive webpage behavior, basic logic building	
MODULE – III	**03 Hours**
Topics: DOM Manipulation, Event Handling, Form Validation, Arrays and Objects, Introduction to asynchronous JavaScript (callbacks, promises – basic) ***Applications:*** Dynamic content updates, form-based applications, interactive UI systems.	
MODULE – IV	**03 Hours**
Topics: Introduction to Spring Boot, Project setup, REST API development, Controllers and Services, Dependency Injection (basic), Handling HTTP Requests & Responses, JSON ***Applications***: Backend services, API development, login and data handling systems	
MODULE – V	**03 Hours**
Topics: Connecting frontend with Spring Boot backend, CRUD operations, Introduction to database (MySQL – basic), Debugging, Deployment basics ***Applications:*** Full-stack applications, student management system, to-do applications	

Course Outcomes:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain core concepts of web development and frontend technologies	L2
2	Develop responsive and interactive user interfaces	L3
3	Implement backend services using Java and Spring Boot	L3
4	Build and integrate full-stack web applications	L6
5	Evaluate performance, usability, and deployment of web applications	L5

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

	Program Outcomes (POs)											PSOs	
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO-1	3	2	3	3	2	-	-	-	-	1	1	2	1
CO-2	3	3	3	2	3	-	-	-	1	2	1	3	3
CO-3	3	3	2	2	3	1	-	-	-	1	1	2	2
CO-4	3	3	3	2	3	1	-	2	2	3	2	3	3
CO-5	3	2	2	2	3	1	1	2	1	2	3	2	2

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **Authentic Intelligence Reflection:**
  a. Students validate AI-generated code
  b. Identify bugs and inefficiencies
  c. Evaluate correctness and performance
  d. Understand limitations of AI-generated solutions

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
   a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
   b. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
   c. **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
   d. **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.
2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively

A. Integrated Professional Core Course (Theory + Practical)

Criteria	Weightage of Marks
Mid Semester Examination (MSE)	30
Hackathon	30
CAT Assessment	20
Assignment / Quizzes	20
Total	**100 Marks**

TEXT BOOKS:

[1] P. Deitel and H. Deitel, Java: How to Program, 11th ed. Hoboken, NJ, USA: Pearson Education, 2018.

[2] K. Sierra and B. Bates, Head First Java, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2005.

[3] E. Freeman and E. Robson, Head First HTML and CSS. Sebastopol, CA, USA: O'Reilly Media, 2012.

REFERENCE BOOKS:

1. C. Walls, Spring in Action, 6th ed. Shelter Island, NY, USA: Manning Publications, 2022.
2. Matt Frisbie, Professional JavaScript for Web Developers, 4th ed. Indianapolis, IN, USA: Wiley, 2019.

E-RESOURCES:

1. D. Flanagan, "JavaScript Documentation and Resources," Mozilla Developer Network (MDN).
2. Mozilla Developer Network (MDN), "HTML & CSS Documentation," MDN Web Docs. [Online].
3. Spring, "Spring Boot Reference Documentation," Spring Official Documentation. [Online].
4. Oracle Corporation, "Java SE Documentation," Oracle Docs. [Online].Sharma, "Full Stack Development with Spring Boot and React – Resources," Packt Publishing. [Online].

RECOMMENDED TOOLS

- Visual Studio Code
- GitHub
- MySQL Workbench

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SKILL ENHANCEMENT COURSE – I

GPU COMPUTING USING CUDA

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

SEMESTER - III

Course Code	:	26AM2309	**Credits**	:	02
Hours / Week	:	03	**Total Hours**	:	15+30 Hours
L–T–P– J	:	1–0–2–0	**CIE**	:	100Marks

Course Vision:

To equip students with foundational knowledge and practical skills in GPU computing and parallel programming using CUDA, enabling them to develop high-performance applications for real-world computational problems.

Course Description :

This course enhances technical skills in modern software development and high-performance computing. Students learn web application development using Java technologies or parallel computing using CUDA-enabled GPUs. The course focuses on industry-relevant tools and practical implementation skills.

Course Objectives:

This course will enable students to:

1. Understand the fundamentals of parallel computing and GPU architecture
2. Develop CUDA-based programs for parallel execution
3. Optimize memory usage and improve performance of GPU applications
4. Implement parallel algorithms using CUDA
5. Analyze and deploy GPU-accelerated solutions for real-world applications

Teaching-Learning Process (General Instructions)

- Lecture method along with modern teaching approaches for better understanding.
- Interactive learning through discussions, group activities, and problem-solving.
- Use of visual demonstrations and GPU execution simulations.
- Encourage collaborative programming and hands-on exercises.
- Conduct quizzes and coding challenges to develop critical thinking.
- Promote multiple approaches for solving parallel computing problems.

MODULE – I	**03 Hours**

Topics: Difference between CPU and GPU Architecture, Basics of Parallel Computing, Introduction to CUDA Programming Model, GPU Execution Model (Threads, Blocks, Grids)

Applications: Basic parallel computation tasks,vector operations, scientific calculations, simple data-parallel programs.

MODULE – II	**03 Hours**

Topics: Writing Kernel Functions, Thread Indexing, Launch Configuration, Memory Allocation and Data Transfer between Host and Device

Applications: Matrix operations, numerical computing, scientific simulations, engineering computations, high-performance computing tasks.

MODULE – III	03 Hours
Topics: Global Memory, Shared Memory, Local Memory, Memory Optimization Techniques, Synchronization (_syncthreads()), Memory Coalescing **Applications:** Performance optimization in parallel programs, real-time data processing, large-scale computations, efficient memory utilization in GPU-based systems.	
MODULE – IV	**03 Hours**
Topics: Reduction Algorithms, Prefix Sum (Scan), Streams and Concurrency, Overlapping Computation and Communication **Applications:** Asynchronous processing, concurrent execution, GPU-accelerated image and signal processing, real-time analytics, performance tuning and profiling.	
MODULE – V	**03 Hours**
Topics: NVIDIA Nsight Tools, Introduction to CUDA Libraries (cuBLAS, cuDNN), Multi-GPU Basics, Deployment of GPU Applications **Applications:** Parallel sorting and searching, simulation systems (particle systems, physics simulations), AI/ML acceleration, big data processing, high-performance application development.	

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain GPU computing concepts and CUDA architecture	L2
2	Develop CUDA programs using kernels and parallel execution	L3
3	Optimize memory usage and improve performance	L4
4	Implement parallel algorithms using CUDA	L5
5	Evaluate and deploy GPU-based solutions	L6

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs													
	Program Outcomes (POs)											PSOs	
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1	3	2	1	1	2	-	-	-	-	1	-	2	1
CO-2	3	3	3	2	3	-	-	-	1	2	-	3	3
CO-3	3	3	2	2	3	1	-	-	-	1	-	2	2
CO-4	3	3	3	2	3	1	-	2	2	3	2	3	3
CO-5	3	2	2	2	3	1	-	2	1	2	3	2	2

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

Authentic Intelligence Reflection:

1. Students validate GPU-based implementations
2. Analyze performance improvements over CPU
3. Identify bottlenecks in parallel execution
4. Evaluate efficiency and scalability of solutions

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

   a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.

   b. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.

   c. **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.

   d. **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.

2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

A. Integrated Professional Core Course (Theory + Practical)

Criteria	Weightage of Marks
Mid Semester Examination (MSE)	30
Hackathon	30
CAT Assessment	20
Assignment / Quizzes	20
Total	**100 Marks**

TEXT BOOKS:

1. Jason Sanders and Edward Kandrot, CUDA by Example, Addison-Wesley
2. David B. Kirkand Wen-mei Hwu, ProgrammingMassivelyParallelProcessors, Morgan Kaufmann

REFERENCE BOOKS:

1. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs
2. John Cheng, Max Grossman, Ty McKercher, Professional CUDA C Programming

E-RESOURCES:

1. NVIDIA Developer Website – CUDA Documentation
2. NVIDIA Deep Learning Institute (DLI) Courses
3. CUDA Toolkit Documentation
4. Nsight Tools Documentation

RECOMMENDED TOOLS

1. NVIDIA CUDA Toolkit
2. Nsight Systems / Nsight Compute
3. Jupyter Notebook / Google Colab (GPU enabled)
4. Visual Studio Code

LAB EXERCISES:

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO
1	Introduction to CUDA Environment	Install CUDA Toolkit and configure environment; verify GPU availability and run a sample CUDA program.	NVIDIA CUDA Toolkit, VS Code	1h	CO1
2	CUDA Program – Vector Addition	Write and execute a CUDA program for vector addition using kernel functions and thread indexing.	CUDA Toolkit, C/C++	1h	CO1
3	Thread and Block Organization	Implement a CUDA program to understand grid, block, and thread hierarchy using simple computations.	CUDA Toolkit	1h	CO1
4	Matrix Addition using CUDA	Develop a CUDA program to perform matrix addition using parallel threads.	CUDA Toolkit	1h	CO2
5	Matrix Multiplication using CUDA	Implement matrix multiplication on GPU and compare execution with CPU implementation.	CUDA Toolkit	1h	CO2
6	Memory Management in CUDA	Demonstrate usage of global, shared, and local memory in CUDA programs.	CUDA Toolkit	1h	CO2
7	Shared Memory Optimization	Optimize a CUDA program (e.g., matrix multiplication) using shared memory for improved performance.	CUDA Toolkit	1h	CO3
8	Synchronization and Atomic Operations	Implement synchronization using syncthreads() and demonstrate atomic operations.	CUDA Toolkit	1h	CO3
9	Parallel Reduction	Implement reduction operations (sum, max) using CUDA parallel reduction techniques.	CUDA Toolkit	1h	CO3
10	CUDA Streams and Concurrency	Demonstrate asynchronous execution using CUDA streams and overlapping computation with data transfer.	CUDA Toolkit	1h	CO4
11	Performance Analysis using CUDA Profiling	Analyze kernel performance using profiling tools and optimize execution time.	NVIDIA Nsight / nvprof	1h	CO4

12	Image Processing using CUDA	Implement a basic image processing operation (e.g., grayscale conversion or blur) using CUDA.	CUDA Toolkit, OpenCV	1h	CO4
13	Mini Project – Parallel Sorting	Implement a parallel sorting algorithm (e.g., bitonic sort) using CUDA.	CUDA Toolkit	1h	CO5
14	Mini Project – GPU-based Simulation	Develop a simple simulation (e.g., particle simulation) using CUDA parallel processing.	CUDA Toolkit	1h	CO5
15	Performance Comparison – CPU vs GPU	Compare execution time of CPU vs GPU implementations for a selected problem and analyze speedup.	CUDA Toolkit, C/C++	1h	CO5

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IV SEMESTER

Sl.no	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE M arks	Total Marks	Credits
					L	T	P	J					
1	PCC	26AM2401	Differential Equations & Optimization	MATHS	3	0	0	0	0 3	60	40	100	3
2	IPCC	26AM2402	Machine Learning	AI& ML	3	0	2	0	05	60	40	100	4
3	PCC	26AM2403	System Software and Operating Systems	AI& ML	2	1	0	0	0 3	60	40	100	3
4	PCC	26AM2404	Sustainability Engineering & ESG	AI& ML	2	0	0	0	0 2	60	40	100	2
5	PCC	26AM2405	Introduction to Data Science	AI& ML	2	0	0	0	0 2	60	40	100	2
6	IPCC	26AM2406	Sensors, Systems & IoT Fundamentals	AI& ML	2	0	2	0	0 4	60	40	100	3
7	HSC	26LSXXXX	Liberal studies	AI& ML	2	0	0	0	0 2	100	-	100	2
8	SEC	26AM2407	Skill Enhancement Course II AI in cloud computing	AI&ML	1	0	2	0	0 3	100	-	100	2
9	AEC	26AM2408	Cognitive and Technical Skills-IV	Placement	-	-	-	-	02	-	-	-	P/F
			Total		17	1	6	0	26	560	240	800	21

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

DIFFERENTIAL EQUATIONS & OPTIMIZATION

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

SEMESTER - III

Course Code	:	26AM2401	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45
L–T–P-J	:	3–0–0–0	**CIE+SEE**	:	60 +40 Marks

Course Vision:

To develop strong mathematical and computational foundations in vector calculus, numerical methods and optimization techniques for solving complex engineering problems and designing intelligent AI-driven optimization systems.

Course Description:

This course introduces mathematical techniques used for modelling and solving engineering and AI-related optimization problems. It covers vector calculus, numerical methods, linear programming, and nonlinear optimization approaches. Students learn to apply optimization algorithms for intelligent systems, machine learning, and computational engineering applications.

Course Learning Objectives:

- This course will enable students to:
- Understand and apply vector calculus concepts for modelling engineering and scientific systems.
- Apply numerical methods for solving ordinary and partial differential equations arising in dynamic systems.
- Analyze and solve classical optimization problems encountered in engineering applications.
- Develop problem-solving skills for AI and computational systems.
- Apply nonlinear optimization algorithms to solve complex real-world optimization problems.

Teaching-Learning Process (General Instructions)

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

- Lecture Method**:** Concepts, algorithms, and models are explained through structured lectures supported by Python/MATLAB demonstrations.
- Interactive Teaching**:** Active learning is promoted through discussions, brainstorming, and group problem-solving activities.
- Demonstration using Python/MATLAB**:** AI techniques like classification and optimization are demonstrated to visualize results and understand implementation.
- Multimedia Learning: Videos and simulations are used to explain complex concepts and real-world applications.
- Collaborative Learning: Students work in groups to implement projects and analyze datasets using computational tools.
- Higher Order Thinking Questions: Analytical questions are used to develop model design, evaluation, and decision-making skills.

  Problem-Based Learning: Real-world problems are given to apply techniques using Python/MATLAB for practical solutions.

MODULE – I	**9 Hours**

Vector Calculus

Topics: Introduction to vector calculus, scalar and vector valued functions, gradient, tangent plane, directional derivative, divergence and curl, scalar and vector potentials. Statement of vector identities and simple problems. Line, surface and volume integrals. Statement of Green's theorem, Stokes' theorem and Gauss divergence theorem.

Applications: Fluid flow analysis, Electromagnetic field modelling, Robotics motion planning, Computer graphics and physical simulations

MODULE – II	**9 Hours**

Numerical Methods for ODE and PDE

Topics: Existence and uniqueness of solutions for ordinary differential equations. Solving initial value problems using Taylor series method, Euler's method and modified Euler method, Runge-Kutta methods, multistep methods. Higher-order equations and systems. Stability analysis. Solving boundary value problems using shooting methods, difference methods and variational methods. Introduction to numerical solutions for partial differential equations.

Applications: Weather prediction models, Mechanical system simulations, Control system modelling, Heat transfer and diffusion problems.

MODULE – III	**09 Hours**

Introduction to Optimization (Classical Optimization)

Topics: Introduction to classical optimization, engineering applications of optimization, classification of optimization problems, single variable optimization, multivariable optimization without constraints, multivariable optimization with equality and inequality constraints, Kuhn-Tucker conditions.

Applications: Resource allocation problems, Engineering design optimization, Production planning, Logistics and supply chain optimization

MODULE – IV	**09 Hours**

Linear Programming

Topics: Linear Programming: Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, graphical method, simplex algorithms, revised simpler methods, duality in linear programming.

Applications: Resource allocation and production planning, Transportation and logistics optimization, Supply chain management, Financial portfolio optimization, Scheduling and assignment problems.

MODULE – V	**09 Hours**

Nonlinear Optimization

Topics: Unconstrained nonlinear optimization, univariate method, gradient of a function, gradient descent method, Fletcher-Reeves method. Constrained nonlinear optimization, characteristics of a constrained optimization problem, cutting plane method, interior and exterior penalty function methods.

Applications: Neural network training, Portfolio optimization, Control system optimization, Engineering system design

AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

AI Integration:

- Gradient calculations in machine learning optimization.
- Simulation of dynamic systems in robotics.
- Decision optimization in intelligent systems.
- Linear programming used in decision-making systems.
- Gradient descent optimization algorithms for training neural networks and deep learning.

Authentic Intelligence:

- Understanding limitations of mathematical approximations in AI systems.
- Evaluating numerical errors in computational models.
- Ethical considerations in automated optimization systems.
- Ethical decision-making in optimization problems.
- Understanding biases introduced by optimization algorithms.

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply vector calculus concepts such as gradient, divergence, curl, and vector integrals to solve engineering and computational problems.	L3
2	Implement numerical methods for solving ordinary and partial differential equations arising in engineering and scientific models.	L3
3	Formulate and solve classical optimization problems including single and multivariable optimization with constraints.	L4
4	Develop and solve linear programming models for real-world problems	L3
5	Apply nonlinear optimization techniques such as gradient descent, Fletcher–Reeves method, and penalty methods to engineering applications.	L3

Mapping Levels of COs to POs / PSOs

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

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

(Low) TEXT BOOKS:

1. Hamdy A. Taha, Operations Research: An Introduction, 2017, 10th Edition, Pearson Education, Inc.
2. Rao, S.S., Engineering optimization: theory and practice, 2019, 5th Edition, John Wiley & Sons, Inc.

REFERENCE BOOKS:

a. Arora, R.K., Optimization: algorithms and applications, 2015, 1st Edition, Chapman and Hall/CRC.
b. Deb, K., Optimization for engineering design: Algorithms and examples, 2012- 2nd Edition, PHI Leaming Pvt. Ltd.
c. Nocedal, Jorge, and Stephen J. Wright. Numerical optimization. New York, NY: Springer New York, 2006.

RECOMMENDED TOOLS

2. Python
3. MATLAB
4. NumPy
5. Pandas
6. Matplotlib
7. Scikit-learn

LAB EXERCISES

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO
1	Gradient Computation	Introduction to computational tools and compute gradient of scalar functions	MATLAB/PYTHON	1h	CO1
2	Tangent Plane & Directional Derivative	Compute divergence and curl of vector fields, Visualize tangent planes and directional derivatives	MATLAB/PYTHON	1h	CO1
3	Line Integrals	Implement numerical computation of line integrals	MATLAB/PYTHON	1h	CO1
4	Taylor Series and Euler Method	Solve ODE using Taylor series method, Euler method and modified Euler method	MATLAB/PYTHON	1h	CO2
5	Runge-Kutta and Multistep Method	Implement fourth-order Runge-Kutta method and multistep method	MATLAB/PYTHON	1h	CO2
6	Shooting and Finite Difference Method	Solve boundary value problems using shooting and finite difference method	MATLAB/PYTHON	1h	CO2
7	Single Variable Optimization	Implement optimization for single variable functions	MATLAB/PYTHON	1h	CO3
8	Multivariable optimization	Perform multivariable optimization and their visualization	MATLAB/PYTHON	1h	CO3
9	Kuhn-Tucker Conditions	Implement KKT conditions for constrained optimization	MATLAB/PYTHON	1h	CO3
10	Formulation of LPP	Formulate and solve linear programming problems (LPP) and implement graphical method	MATLAB/PYTHON	1h	CO4

11	Simplex Method, Revised Simplex Method	Implement simplex algorithm for LPP, Solve LPP using revised simplex method	MATLAB/PYTHON	1h	CO4
12	Duality in LPP	Analyze duality concepts in linear programming	MATLAB/PYTHON	1h	CO4
13	Fletcher-Reeves Method	Implement Fletcher-Reeves optimization method	MATLAB/PYTHON	1h	CO5
14	Cutting Plane Method	Apply cutting plane method for constrained optimization	MATLAB/PYTHON	1h	CO5
15	Interior and Exterior Penalty Method	Implement interior and Exterior penalty function method	MATLAB/PYTHON	1h	CO5

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MACHINE LEARNING

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

SEMESTER - IV

Course Code	:	26AM2402	**Credits**	:	04
Hours / Week	:	05	**Total Hours**	:	45+30
L–T–P–J	:	3–0–2–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To develop the ability to design, analyze, and implement machine learning solutions for engineering problems by integrating data-driven modeling, computational tools, and responsible AI practices.

Course Description:

The course Machine Learning introduces the fundamental concepts, algorithms, and practical applications of data-driven intelligent systems. The course covers supervised and unsupervised learning techniques, feature engineering, probabilistic graphical models, ensemble learning, model validation, optimization, and regularization methods. Students gain hands-on experience in building, training, and evaluating machine learning models using Python-based tools and libraries such as Scikit-learn. Emphasis is placed on solving real-world engineering problems, improving model performance, and understanding responsible and ethical AI practices through practical case studies and laboratory experiments.

Course Objectives:

This course will enable students:

1. To summarize the basic concepts, Feature Engineering and different types of Machine Learning.
2. To make Use of the Supervised Machine Learning techniques for solving appropriate real-world applications.
3. To make Use of the Unsupervised Machine Learning techniques, Dimensionality Reduction techniques for solving appropriate real-world applications.
4. To utilize the Probabilistic Graphical Models and Ensemble Learning Methods for handling complex real time problems.
5. To evaluate the performance and reliability of machine learning models.

Teaching-Learning Process (General Instructions)

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

a) **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.

b) **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

c) Showing **Video/animation** films to explain functioning of various concepts.

d) Encourage **Collaborative** (Group Learning) Learning in the class.

e) To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

f) Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

Foundations of Machine Learning

Topics: Well-posed learning problems, Designing a Learning system, Introduction to Machine learning and types Of Learning: Supervised, Unsupervised, And Reinforcement Learning, Data Pre-processing: Missing Value Imputation, Handling balanced and Imbalanced Data, and Feature Engineering.

Applications: Classification and regression problems in real-world scenarios, predictive analytics in healthcare and finance, feature engineering for improving model performance

MODULE – II	**09 Hours**

Supervised Machine Learning Algorithms

Topics: Introduction to Supervised Learning: Binary and Multi-Class Classification, Regression - Linear Regression and Nonlinear Regression, Logistic Regression, Naive Bayes Classification, Decision Trees (ID3, CART) and Random Forest, K-Nearest Neighborhood, Support Vector Machine (Linear and Non-linear Kernels).

Applications: house price prediction systems, medical diagnosis systems, fault detection in machines, financial risk prediction.

MODULE – III	**09 Hours**

Unsupervised Machine Learning Algorithms

Topics: Introduction to Unsupervised Learning, Clustering (Hard and Soft Clustering), Hierarchal Clustering: K-Means, Fuzzy C-Means (FCM) Algorithm, Gaussian Mixture Models (GMM), Expectation Maximization Algorithm, Dimensionality Reduction - Linear Discriminant Analysis and Principal Component Analysis.

Applications: customer segmentation in business analytics, anomaly detection in network traffic, pattern discovery in industrial data

MODULE – IV	**09 Hours**

Probabilistic Graphical Models and Ensemble Learning

Topics: Probabilistic Graphical Models - Bayesian Networks, Markov Random Fields, and Ensemble Learning - Bagging Algorithms, Understanding Out-Of-Bag Score, Boosting: AdaBoost, Gradient Boosting Machines (GBM), XGBoost, CatBoost.

Applications: uncertainty modeling using Bayesian Networks, image analysis with Markov Random Fields, prediction tasks using ensemble methods, fraud detection and recommendation systems with boosting algorithms.

MODULE – V	**09 Hours**

Machine Learning Model Validation, Optimization, and Regularization

Topics: Hyper parameter Tuning: Grid Search CV, Random Search CV, Machine Learning Model Validation - Confusion Matrix, Accuracy, Precision, Recall, F1 Score, Cost Function, Cross-Validation, Error Metrics (MSE, RMSE, MAE).

Machine Learning Optimization Algorithms: Gradient Descent Techniques, Bayesian Optimization, Overfitting, Underfitting, Optimal Fit, Bias, Variance, Regularization - L1 Regularization, L2 Regularization, Elastic Net Regularization.

Applications: model tuning for improved prediction accuracy, performance evaluation in classification tasks, optimization of machine learning models in healthcare, finance, and engineering applications.

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

Authentic Intelligence:

- Understanding well-posed learning problems and their real-world constraints, challenges in designing efficient learning systems, limitations of deep learning models, risks associated with poor feature selection and sampling bias, ethical considerations and responsible deployment of AI systems.

- Interpretability of machine learning models, risks of incorrect predictions in automated decision-making systems
- Risks of misinterpreting clusters, responsible interpretation of patterns discovered from data.
- Limitations of graphical and ensemble models, overfitting risks in boosting, interpretability challenges, and importance of responsible model selection.
- Understanding overfitting and underfitting, bias-variance tradeoff, limitations of optimization methods, and importance of selecting appropriate validation and regularization techniques.

AI Integration:

- Introduction to Python-based machine learning workflow, data preprocessing and feature engineering techniques, usage of libraries like NumPy, Pandas, and Scikit-learn for building and evaluating models.
- Implementation of supervised learning algorithms using Scikit-learn, training and evaluatingmodels using real-world datasets.
- Implementing clustering and dimensionality reduction techniques using Scikit-learn, visualization of clusters using Python tools.
- Implementation of graphical models and ensemble techniques using Scikit-learn, use of bagging and boosting methods, model evaluation with Out-of-Bag score.
- Use of Grid Search and Random Search for hyperparameter tuning, implementation of validation techniques and performance metrics, application of optimization algorithms and regularization methods using Scikit-learn.

Course Outcome :

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Describe the basic concepts and different types of Machine Learning techniques and to design Well Posed Learning System.	L2
2	Apply the learned concepts of the Supervised learning algorithms for regression and classification problems.	L3
3	Apply Unsupervised Machine Learning Algorithms such as Hard and Soft clustering and Dimensionality Reduction techniques for solving appropriate real-world applications.	L3
4	Make Use of the learned concepts of the Probabilistic Graphical Models and Ensemble Learning Methods for handling complex real time problems.	L3
5	Evaluate the performance of Machine Learning algorithms using appropriate metrics such as accuracy, precision, recall, FI Score and Make Use of the different Optimization and Regularization Techniques for improving the model performance.	L5

Mapping Levels of COs to POs / PSOs

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

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

ASSESSMENT SCHEME :

1. **Internal Assessment (IA):** "Internal Assessment (IA)" refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

   a. **Mid-Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of Machine Learning concepts such as Introduction to Machine learning and types Of Learning: Supervised, Unsupervised, And Reinforcement Learning, Data Pre- processing:.

   b. **Continuous Assessment Tools** (CAT – Six Components): Includes activities such as

   i. uizzes and surprise tests on the ML concept
   ii. Problem-solving.
   iii. Case studies
   iv. Group discussions
   v. Seminars
   vi. Open book assignments and mini case analysis.

2. External Assessment (EA)

"External Assessment (EA)" refers to the Semester End Examination (SEE) with a weightage of 40%.

This examination evaluates:

i. Conceptual understanding of ML principles , Problem-solving ability
ii. Application of Machine Learning techniques.

Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

TEXT BOOKS:

1. Machine Learning – Tom M. Mitchell, McGraw-Hill, 1st Edition, 1997.
2. Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow – Aure´lien Ge´ron, O'Reilly Media, 3rd Edition, 2022.

REFERENCE BOOKS:

1. Pattern Recognition and Machine Learning – Christopher M. Bishop, Springer, 1st Edition, 2006.
2. Introduction to Machine Learning with Python – Andreas C. Müller & Sarah Guido, O'Reilly Media, 1st Edition, 2017.

E-RESOURCES*:*

1. **Accelerating End-to-End Data Science Workflows**https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-01+V2
2. **Best Practices in Feature Engineering for Tabular Data With GPU Acceleration**
3. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-06+V1
4. **Accelerating Clustering Algorithms to Achieve the Highest Performance**
5. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-04+V1
6. **Exploring Adversarial Machine Learning**
7. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-03+V1
8. **Accelerate Data Science Workflows with Zero Code Changes**
9. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-03+V1

RECOMMENDED TOOLS

1. Programming: Python (NumPy, Pandas, Scikit-learn, PyTorch) – Google Colab/ Jupyter Notebook/Visual Studio
2. Visualization: Matplotlib, Seaborn, Plotly, UMAP
3. Experiment Tracking: MLflow, Weights & Biases
4. MLOps & Deployment: Docker, FastAPI, ONNX
5. AI Assistants: GitHub Copilot, ChatGPT, Claude

LAB EXERCISES

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO

	MODULE I · Exercises 1–3 : Introduction to Machine Learning and Data Preprocessing (06 Hours)				
1	Data Preprocessing	Perform data cleaning, handling missing values, encoding categorical variables, and feature scaling using suitable datasets	Google Colab / Jupyter	2 h	CO1
2	Data Visualization	Visualize datasets using plots and statistical summaries for exploratory data analysis	Google Colab / Jupyter	2 h	CO1
3	Cross Validation	Implement cross-validation techniques for machine learning model assessment	Google Colab / Jupyter	2 h	CO1
	MODULE II · Exercises 4–9 : Supervised Machine Learning Algorithms (12 Hours)				
4	Linear Regression	Implement Linear Regression to predict house prices using the Housing Price Dataset	Google Colab / Jupyter	2 h	CO2
5	Logistic Regression	Build a Logistic Regression model to perform classification	Google Colab / Jupyter	2 h	CO2
6	K-Nearest Neighbors (KNN)	Apply the K-Nearest Neighbors (KNN) algorithm to perform classification on suitable dataset (e.g., classify flower species using the Iris Dataset)	Google Colab / Jupyter	2 h	CO2
7	Decision Tree Model	Train and visualize a Decision Tree model to perform classification (e.g., Wine Quality using the Wine Quality Dataset)	Google Colab / Jupyter	2 h	CO2
8	Random Forest Model	Develop a Random Forest model to perform prediction (e.g., Heart Disease using the Heart Disease Dataset)	Google Colab / Jupyter	2 h	CO2

9	Linear and Non-linear Support Vector Machine	Implement Linear and Non-linear Support Vector Machine for classification	Google Colab / Jupyter	2 h	CO2
	MODULE III · Exercises 10–11 : Unsupervised Machine Learning Algorithms (04 Hours)				
10	K-Means Clustering	Apply K-Means Clustering to perform customer segmentation (e.g., using the Mall Customer Segmentation Dataset)	Google Colab / Jupyter	2 h	CO3
11	Principal Component Analysis	Apply Principal Component Analysis (PCA) to reduce feature dimensions (e.g., using the Wine Dataset)	Google Colab / Jupyter	2 h	CO3
	MODULE IV · Exercises 12 : Probabilistic Graphical Models and Ensemble Learning (02 Hours)				
12	Bagging and Boosting	Implement and compare ensemble techniques: Bagging (Random Forest) and Boosting (AdaBoost / Gradient Boosting)	Google Colab / Jupyter	2 h	CO4
	MODULE V · Exercises 13–15 : Machine Learning Model Validation, Optimization, and Regularization (06 Hours)				
13	Model Evaluation	Evaluate classification models by computing Accuracy, Precision, Recall, F1-Score, and Confusion Matrix using suitable dataset (e.g., Breast Cancer Dataset)	Google Colab / Jupyter	2 h	CO5

14	Hyperparameter Tuning	Perform Hyperparameter Tuning using Grid Search with Cross-Validation on suitable dataset (e.g., Digits Dataset)	Google Colab / Jupyter	2 h	CO5
15	Machine Learning Model to Solve a Real-World Engineering Problem	Design and implement a Machine Learning model to solve a real-world engineering problem using an open engineering dataset (e.g., Energy Consumption, Traffic Flow, or Predictive Maintenance Dataset)	Google Colab / Jupyter	2 h	CO5

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SYSTEM SOFTWARE AND OPERATING SYSTEMS

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

SEMESTER - IV

Course Code	:	26AM2403	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	30+15
L–T–P–J	:	2–1–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To equip students with a strong foundation in operating system principles for designing and managing efficient, reliable, and scalable computing systems. The course aims to develop the ability to analyze and optimize system performance through effective resource management, process coordination, and memory handling, while integrating modern trends such as AI-assisted system optimization, ethical decision-making, and responsible use of computing technologies in real-world applications.

Course Description:

The course Operating Systems provides a detailed study of the principles, structure, and functionalities of modern operating systems used in computing environments. It introduces fundamental concepts such as process management, CPU scheduling, multithreading, synchronization, deadlocks, memory management, virtual memory, file systems, and disk scheduling techniques required for efficient resource utilization and system performance. The course emphasizes both theoretical understanding and practical implementation through laboratory exercises, simulations, case studies, and AI-assisted learning activities. It also explores real-world applications in cloud computing, distributed systems, virtualization, embedded systems, and mobile operating systems while encouraging students to critically evaluate AI-based system optimization techniques for ethical, reliable, and sustainable computing solutions.

Course Objectives:

This course will enable students to:

1. **Understand** the fundamental concepts, structure, and functions of operating systems.
2. **Analyse** process management, threads, and CPU scheduling techniques.
3. **Apply** synchronisation mechanisms and deadlock handling techniques.
4. **Evaluate** memory management and virtual memory techniques.
5. **Analyse** file systems and disk scheduling methods for efficient storage management.

Teaching-Learning Process (General Instructions)

These are sample pedagogical methods, that the teacher can use to accelerate the attainment of the various course outcomes:

A. **Lecture method:** Along with traditional lecture method, different teaching methods may be adopted to explain OS concepts such as process management, memory management, and file systems.

B. **Interactive Teaching:** Incorporating brainstorming, discussions, group work, and focused problem-solving on topics like CPU scheduling, synchronization, and deadlocks.

C. **Use of Multimedia:** Showing videos/animation to explain working of OS concepts such as process execution, paging, and disk scheduling.

D. **Collaborative Learning:** Encourage group learning activities such as implementing scheduling algorithms and memory allocation techniques.

E. **Critical Thinking:** Ask higher-order thinking questions through quizzes and programming exercises on OS problems like deadlock handling and resource allocation.

F. **Multiple Problem-Solving Approaches:** Demonstrate different algorithms (FCFS, SJF, LRU, etc.) and encourage students to develop efficient and creative solutions.

MODULE – I	**06 Hours**

OS Fundamentals and System Structure

Topics: Introduction to Operating Systems, Computer System Organization & Architecture, Operating System Structure, Types of Operating Systems (Batch, Time-sharing, Real-time, Distributed), OS Services, System Calls, Virtual Machines.

Applications: Mobile operating systems, cloud platforms, embedded systems.

MODULE – II	**07 Hours**

Process Management

Topics: Process concept, Process states, Process Control Block (PCB), Threads and Multithreading, User vs Kernel Threads, Scheduling Criteria. Scheduling Algorithms: FCFS, SJF, SRTF, Round Robin, Priority Scheduling.

Applications: CPU scheduling in multitasking systems, cloud resource allocation.

MODULE – III	**07 Hours**

Process Synchronization and Deadlocks

Topics: Critical Section Problem, Peterson's Solution, Semaphores, Monitors, Classical Synchronization Problems. Deadlocks: Concept, Characterization, Prevention, Avoidance (Banker's Algorithm), Detection and Recovery.

Applications: Multi-threaded applications, database transaction systems.

MODULE – IV	**06 Hours**

Memory Management

Topics: Contiguous Memory Allocation, Paging, Segmentation, Page Table Structure. Virtual Memory: Demand Paging, Page Replacement Algorithms (FIFO, LRU, Optimal), Frame Allocation, Thrashing.

Applications: Virtual machines, cloud memory management.

MODULE – V	04 Hours
File Systems and Disk Management **Topics:** File Concepts, Access Methods, Disk Scheduling Algorithms (FCFS, SSTF, SCAN, C-SCAN). ***Applications:*** *"Analyze system performance using different scheduling and memory techniques"* Students must: 1. Compare CPU utilisation 2. Analyse efficiency Suggest optimisation strategies	

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION*:*

AI Integration:

a. Apply AI-based system monitoring and analysis tools to observe system performance, detect anomalies, and optimize resource utilization.

b. Use AI techniques to enhance CPU scheduling by predicting process behavior and improving scheduling efficiency in multitasking environments.

c. Implement AI-based approaches for deadlock detection and prevention, and analyze synchronization issues in concurrent systems.

d. Apply AI models to predict memory usage patterns and optimize memory allocation strategies in virtual memory systems.

e. Use AI-driven techniques to optimize disk scheduling and file system performance for efficient data access and storage management.

Authentic Intelligence Reflection:

f. Critically evaluate the reliability and limitations of AI-based system monitoring tools and emphasize the need for human oversight in system decisions.

g. Assess fairness and efficiency in AI-assisted CPU scheduling, including risks such as starvation and bias in process allocation.

h. Analyze ethical issues in synchronization and deadlock handling, focusing on fairness in resource sharing and prevention of indefinite waiting.

i. Reflect on ethical and efficiency concerns in memory management, including resource wastage, equitable allocation, and trust in AI predictions.

j. Evaluate trade-offs between performance and fairness in disk scheduling and file systems, ensuring responsible and sustainable system design.

ASSESSMENT SCHEME *:*

1. **Internal Assessment (IA):** "Internal Assessment (IA)" refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

    a. **Mid-Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of OS concepts such as process management, memory management, synchronization, and file systems.

    b. **Continuous Assessment Tools** (CAT – Six Components): Includes activities such as:

        i. Quizzes and surprise tests on the OS concept

ii. Problem-solving (CPU scheduling, deadlocks, memory allocation.

iii. Case studies (real-world OS issues)

iv. Group discussions (Linux vs Windows OS)

v. Seminars on modern OS trends (cloud OS, distributed systems)

vi. Open book assignments and mini case analysis

2. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
id-Semester Examination (MSE)	30
-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS :

AI^2 Pedagogy: A structured approach where students use AI tools for OS problem-solving while developing Authentic Intelligence through evaluation and decision-making.

Assignment 1: AI-Based CPU Scheduling Analysis

Students prompt an AI tool:

"Generate a CPU scheduling algorithm (SJF / Round Robin)"

Students must:

1. Analyze correctness of scheduling
2. Evaluate waiting time and turnaround time
3. Suggest improvements

Assignment 2: Memory Management Evaluation

Students prompt an AI tool:*"Compare paging and segmentation techniques"*

Students must:

1. Verify performance differences
2. Identify fragmentation issues
3. Evaluate real-world applicability

Assignment 3: Synchronization Debugging

Students use AI-generated faulty code for

synchronization Students must:

1. Identify the bug
2. Fix synchronization issues
3. Explain correctness

Assignment 4: OS Visualization Study

Students use AI tools to:

1. Visualize CPU scheduling (Gantt charts)
2. Analyze memory allocation
3. Compare algorithm performance

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain operating system concepts, structure, and services	L2
2	Analyze and apply process scheduling and threading models	L4
3	Examine synchronization and deadlock handling techniques	L4
4	Evaluate memory management and virtual memory techniques	L5
5	Analyze file systems and disk scheduling algorithms	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	2	1	3	2	-	-	-	-	2	1	2	2	1
CO-2	2	1	1	1	1	-	-	-	1	3	3	2	3
CO-3	1	3	3	3	1	-	-	-	1	2	1	2	1
CO-4	1	2	2	3	-	-	-	-	2	3	3	3	1
CO-5	1	2	3	2	3	-	-	-	3	1	3	1	3

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

TEXT BOOKS*:*

1. Abraham Silberschatz, Peter B. Galvin, Greg Gagne *Operating System Concepts*, 10th Edition, Wiley, 2018.
2. Andrew S. Tanenbaum, Herbert Bos. *Modern Operating Systems*, 4th Edition, Pearson, 2015.
3. William Stallings, *Operating Systems: Internals and Design Principles*, 9th Edition, Pearson, 2018.

REFERENCE BOOKS:

1. Remzi H. Arpaci-Dusseau, Andrea C. Arpaci-Dusseau , *Operating Systems: Three Easy Pieces*, 2018.
2. Christopher Negus, David Clinton, *Linux Bible*, 11th Edition, Wiley, 2025.

E-RESOURCES:

- AI Assistants for OS problem solving
- Jupyter Notebook / Google Colab for simulations
- OS Simulation Tools (CPU scheduling, memory visualization)
- GitHub Copilot for coding support
- Linux environment / Virtual machines

RECOMMENDED TOOLS

- C (GCC Compiler), Python 3.10+
- GitHub for version control and project development
- NumPy, Matplotlib (for analysis and visualization)
- Linux (Ubuntu) and Shell Scripting
- VirtualBox / VMware for OS experimentation

TUTORIAL EXERCISES

S. No	Exercise Title	Aim / Objective	Tools G Dataset	Hrs	CO
	MODULE I · Exercises 1–2 : OS Fundamentals and System Structure (02 Hours)				
1	OS Environment + Process Creation	Study Linux commands, system calls, and implement process creation using fork()	Linux / C	1 h	CO1
2	AI-Based System Monitoring	Monitor CPU and memory usage and detect anomalies using AI tools	Python, AI Tools	1 h	CO1
	MODULE II · Exercises 3–4 : Process Management (03 Hours)				
3	CPU Scheduling	Implement FCFS, SJF, Round Robin, and Priority Scheduling algorithms and calculate waiting & turnaround time	C / Python	2 h	CO2

4	AI vs Manual Scheduling	Compare traditional scheduling with AI-based prediction approach	Python, AI Tools	1 h	CO2
	MODULE III · Exercises 5–6 : Process Synchronization and Deadlocks (03 Hours)				
5	Synchronization Problems	Implement Producer–Consumer and Readers–Writers problems using semaphores	C / Python	1.5 h	CO3
6	Deadlock + Debugging	Implement Banker's Algorithm and analyze/debug synchronization issues	C / Python, AI Tools	1.5 h	CO3
	MODULE IV · Exercises 7–8 : Memory Management (04 Hours)				
7	Page Replacement Algorithms	Implement FIFO, LRU, and Optimal page replacement techniques	C / Python	2 h	CO4
8	Memory Allocation + Analysis	Implement First Fit, Best Fit, and Worst Fit strategies and analyze fragmentation	C / Python	2 h	CO4
	MODULE V · Exercises G–10 : File Systems and Disk Management (03 Hours)				
9	Disk Scheduling Algorithms	Implement FCFS, SSTF, SCAN, and C-SCAN algorithms and analyze performance	C / Python	1.5 h	CO5
10	OS Performance Analysis (Mini Case Study)	Combine scheduling, memory, and disk concepts with AI-based analysis	Python, AI Tools	1.5 h	CO5

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Sustainability Engineering & ESG

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

SEMESTER - IV

Course Code	:	26AM2404	**Credits:**	02	
Hours / Week	:	02	**Total: Hours**	30	
L–T–P-J	:	2–0–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To cultivate engineers who can critically assess and embed sustainability, ESG principles, and ethical governance into technological solutions, driving resilient, inclusive, and environmentally responsible innovation in alignment with global sustainability imperatives.

Course Description:

This course focuses on sustainable engineering practices and Environmental, Social, and Governance (ESG) principles. Students learn to analyze technological solutions from environmental and ethical perspectives. The course promotes responsible innovation and sustainable development awareness.

Course Objectives:

This course will enable students to:

1. Understand sustainability principles and ESG frameworks
2. Analyze environmental impacts of digital and engineering systems
3. Apply lifecycle and carbon footprint analysis using data tools
4. Evaluate social and governance aspects in technology systems
5. Use AI tools for sustainability analytics and decision-making

Teaching-Learning Process (AI Enhanced Pedagogy)

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

a. **Lecture Method:** Conceptual teaching supported by AI-generated visualizations

b. **Interactive Learning:** AI-assisted problem solving and discussion

c. **Video/Simulation:** Use of dashboards, sustainability simulators

d. **Collaborative Learning:** Group ESG case studies using datasets

e. **Higher Order Thinking:** AI output validation and critical evaluation

f. **Problem-Based Learning:** Real-world sustainability problems in IT systems

g. **Multiple Solution Approaches:** Analytical + AI-based evaluation

h. **Real-World Applications:** Cloud sustainability, green computing, ESG analytics

i. **Flipped Learning:** ESG problems will be given and Students are asked to solve using AI tools

MODULE – I	**06 Hours**

Sustainability Fundamentals & ESG

Topics: Sustainable development, Triple Bottom Line, ESG framework, SDGs, ESG vs CSR, sustainability challenges in digital economy.

Applications: Green computing, sustainable IT infrastructure, energy-efficient data centers.

MODULE – II	**06 Hours**

Environmental Sustainability in Digital Systems

Topics: Carbon footprint of IT systems, energy consumption in data centers, lifecycle assessment (LCA), e-waste management, green cloud computing.

Applications: Energy-efficient servers, cloud optimization, sustainable software engineering.

MODULE – III	**06 Hours**

Social Sustainability & Ethical Computing

Topics: Stakeholder analysis, digital inclusivity, data privacy, ethical AI, cybersecurity and society, social impact of automation.

Applications*:* AI ethics in recommendation systems, fairness in algorithms, inclusive software design.

MODULE – IV	**06 Hours**

Governance, ESG Reporting, Sustainable Design & Future Technologies

Topics: Corporate governance, ESG reporting frameworks (GRI, TCFD), ESG metrics, sustainability KPIs, data visualization, Circular economy, sustainable software design, green AI, smart cities, Industry 4.0 sustainability, digital twins for sustainability

Applications: Corporate ESG dashboards, compliance analytics, risk management systems, Smart grids, intelligent transportation, sustainable IoT systems.

MODULE – V	**06 Hours**

Energy Efficiency, Audit & Smart Energy Systems

Topics: Energy efficiency: Definition, importance, and metrics (energy intensity, efficiency ratio), Energy losses in computing and electronic systems (processors, data centers, networks), Energy-efficient computing: Green computing principles, low- power design, virtualization, Energy Audit: Definition, types (preliminary and detailed audit), steps involved, Energy audit of IT infrastructure: servers, cooling systems, networks, Energy-saving techniques in data centers and embedded systems , Introduction to smart energy management systems.

Applications: Energy-efficient data centers and cloud computing systems, Power optimization in embedded systems and IoT devices, Energy audit of IT infrastructure in industries and campuses, Smart energy monitoring in communication networks.

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration:

1. AI-based sustainability trend analysis, ESG scoring tools.
2. AI models for energy prediction and carbon footprint estimation.
3. Sentiment analysis, bias detection in AI systems.

4. AI-based ESG report analysis, dashboards using Power BI/Python, AI-based optimization of sustainable systems.
5. AI-based energy consumption prediction using machine learning models, Optimization of energy usage in data centers using AI algorithms, Smart energy monitoring using IoT and AI analytics, Data-driven identification of energy loss points.

Authentic Intelligence:

1. Students critically analyze AI-generated sustainability insights and validate them using real-world data.
2. Students compare AI predictions with real energy consumption data.
3. Students analyze bias and fairness in AI-generated outputs.
4. Students evaluate transparency and reliability of ESG reports. Students assess trade-offs between performance and sustainability.
5. Students will critically evaluate AI-based energy optimization models by comparing predicted energy savings with actual system performance. They will analyse the trade-offs between computational
performance and energy efficiency, and assess the reliability and scalability of AI- driven energy management systems.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand sustainability principles and ESG frameworks	L2
2	Apply lifecycle and carbon footprint analysis	L3
3	Analyze environmental and social impacts in digital systems	L4
4	Evaluate ESG performance using metrics and reports	L5
5	Interpret ethical and governance issues in technology systems	L5

Mapping Levels of COs to POs / PSOs

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	3	2	-	-	1	2	1
CO-2	2	3	2	3	2	2	3	2	-	-	1	2	2
CO-3	2	3	2	3	2	3	3	2	-	-	1	2	2
CO-4	2	3	2	3	3	2	2	2	-	1	1	2	2

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

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

TEXT BOOKS:

1. Allen & Shonnard – Sustainable Engineering,Prentice Hall, 2011, First Edition

Criteria	**Weightage of Marks**
Mid-Semester Examination (MSE)	30
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Program & Quiz	10
Total	60 marks

E-RESOURCES:

1. UN SDG Reports
2. World Bank ESG Reports
3. Sustainability journals (Elsevier, IEEE)
4. NPTEL Sustainability Courses.
5. Climate Action & Sustainability - t.co/BPEpxEXzI4

RECOMMENDED TOOLS

1. Python (Collab notebooks)
2. ESG datasets (World Bank, UN)
3. MIT Open Courseware

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INTRODUCTION TO DATA SCIENCE

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

SEMESTER – IV

Subject Code	: 22AM2405	**Credits**	: 02
Hours / Week	: 02 Hours	**Total Hours**	: 30 Hours
L–T–P–S	: 2–0–0–0	**CIA +SEE**	: 60 +40 Marks

Course Learning Objectives:

This course will enable students to:

1. Understand fundamental data science concepts and workflows
2. Apply statistical techniques and visualization for data analysis
3. Perform data cleaning and preprocessing
4. Use feature selection and dimensionality reduction methods
5. Gain exposure to scalable data analytics techniques

Course Vision :

The Foundation of Data Science course aims to build a strong understanding of core concepts such as data collection, preprocessing, analysis, and visualization, enabling students to extract meaningful insights from data. It emphasizes the development of analytical thinking and problem-solving skills using statistical methods and computational tools. The course prepares learners to apply data-driven decision-making techniques across diverse real-world domains.

Course Description :

This course introduces the fundamentals of data collection, preprocessing, visualization, and statistical analysis. Students learn data-driven decision-making techniques using analytical tools and methodologies. The course builds the foundation for advanced analytics and AI applications

Teaching-Learning Process (General Instructions)

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

a. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.

b. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

c. Showing **Video/animation** films to explain functioning of various concepts.

d. Encourage **Collaborative** (Group Learning) Learning in the class.

e. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

f. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE– I : Basic Concepts and Python Packages	**6 Hours**

Predictive Modelling, Introduction: Data Preparation, Importance of Data Preparation, Data Cleaning, Feature Selection, Data Transformation, Python Packages: NumPy, Matplotlib, Pandas, SciPy, Scikit-learn, DataFrames, Loading Machine Learning Data.

Applications: Data preprocessing in real-world problems**,** Basic analytics workflows

MODULE – II : Descriptive Statistics and Data Visualization	6 Hours
Sampling, Data Analysis Process, Mean, Median, Standard Deviation, Skewness, Kurtosis, Data Visualization Techniques: Box Plot, Scatter Plot, Histogram, Bar Chart, Pie Chart, Heat Map, Correlation Analysis, Pivot Tables, ANOVA, Data Preprocessing, Rescaling, Standardization, Normalization, Binarization, Univariate and Bivariate Analysis, Recursive Feature Elimination, Principal Component Analysis. ***Applications:*** Data analysis and reporting, Visualization-driven decision making	
MODULE – III : Data Cleaning and Feature Selection	**6 Hours**
Handling Missing Data, Outlier Detection and Removal, Statistical Imputation, KNN Imputation, Iterative Imputation, Feature Selection Techniques, Methods for Categorical and Numerical Data, Feature Selection for Outputs, Recursive Feature Elimination, Importance of Feature Selection. ***Applications:*** Data cleaning in industry datasets**,** Feature engineering workflows	
MODULE– IV : Data Transformation and Dimensionality Reduction	**6 Hours**
Scaling Techniques, Min-Max Scaling, Standard Scaling, Handling Outliers, Encoding Categorical Data, Transforming Data Distributions, Feature Engineering, PCA, LDA, SVD Techniques. ***Applications***: Data transformation pipelines, High-dimensional data analysis	
MODULE – V: Accelerated Data Analytics (NVIDIA DLI)	**6 Hours**
CPU vs GPU in Data Processing, Need for Fast Data Analytics, Introduction to RAPIDS, GPU-Accelerated Data Workflows, Handling Large Datasets Efficiently, Basic Concept of Accelerated DataFrame Operations, Entropy Overview of Machine Learning Acceleration, Identifying Processing Bottlenecks, Real-World Applications of Accelerated Data Analytics. ***Applications:*** Large-scale data analysis, Real-time decision-making systems	

Course Outcome:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
1	Explain basic data science concepts and data preprocessing techniques	L2
2	Apply statistical methods and visualization techniques for data analysis	L3
3	Dissect data cleaning and feature selection for efficient data preparation	L4
4	Apply data transformation and dimensionality reduction techniques	L3
5	Understand scalable data analytics concepts using modern tools	L2

Mapping Levels of COs to POs / PSOs

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

CO-1	3	2	1	1	2	-	-	-	-	-	2	2	2
CO-2	3	3	1	2	2	-	-	-	-	-	2	2	2
CO-3	3	3	2	2	3	-	-	1	-	-	2	2	2
CO-4	3	3	2	2	3	-	-	1	-	-	2	2	2
CO-5	3	2	3	2	3	-	-	1	-	-	2	2	2

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

1. **AI Integration:**
    a. Data preparation for AI systems
    b. Statistical modeling and visualization in AI
    c. Feature optimization for machine learning
    d. GPU-accelerated ML pipelines
    e. High-performance AI systems
2. **Authentic Intelligence Reflection:**
    a. Understanding data quality and reliability
    b. Interpreting statistical and visual insights correctly
    c. Ensuring reliable and unbiased data
    d. Reducing complexity while preserving information
    e. Efficient handling of large datasets
    f. Scalable and reliable data-driven solutions

RESEARCH INTEGRATION TEACHING

1. **Research Paper Review**: Students review recent research articles in data science, machine learning, and data analytics to understand current trends, methodologies, and real-world applications.
2. **Case Study Analysis**: Real-world datasets (e.g., healthcare, finance, smart systems) are analyzed to connect theoretical concepts such as data preprocessing, feature selection, and visualization with practical scenarios.
3. **Mini Project Presentation**: Students present short analyses on emerging topics such as scalable data analytics, GPU-based data processing, and advanced feature engineering techniques.
4. **AI-Assisted Data Analysis**: Students utilize AI tools to explore datasets, generate insights, and critically evaluate the correctness, bias, and reliability of AI-generated outputs.
5. **Exploratory Data Analysis (EDA) Projects**: Students perform EDA on real datasets, applying statistical techniques, visualization methods, and preprocessing strategies similar to research workflows.

ASSESSMENT SCHEME *:*

a. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    i. **Mid Semester Examination (MSE):** One descriptive examination to

evaluate conceptual understanding of AI fundamentals and problem-solving approaches.

ii. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.

iii. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.

b. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS

Assignment 1: AI-Assisted Data Preprocessing and Cleaning

Students prompt an AI tool:
"Clean and preprocess this dataset by handling missing values, outliers, and inconsistencies."

Students must:

1. Analyze the preprocessing steps suggested by the AI
2. Verify correctness of missing value handling and outlier treatment
3. Suggest improvements or alternative preprocessing techniques

Assignment 2: AI-Based Exploratory Data Analysis (EDA)

Students prompt an AI tool:
"Perform exploratory data analysis on this dataset and generate insights with visualizations."

Students must:

1. Evaluate the correctness of statistical summaries and visualizations
2. Interpret patterns, correlations, and anomalies identified by AI
3. Identify missing insights or misleading interpretations

Assignment 3: AI-Assisted Feature Selection and Engineering

Students prompt an AI tool:
"Select important features and suggest feature engineering techniques for this dataset."

Students must:

1. Analyze feature selection methods used (e.g., correlation, RFE, importance)
2. Evaluate the relevance of selected features for model performance
3. Propose improved or domain-specific feature engineering strategies

Assignment 4: AI-Based Data Transformation and Dimensionality Reduction

Students prompt an AI tool:

"Apply scaling and dimensionality reduction techniques such as PCA on this dataset."

Students must:

1. Verify correctness of transformation and scaling methods
2. Analyze impact of dimensionality reduction on data representation
3. Evaluate trade-off between dimensionality reduction and information loss

Assignment 5: AI-Assisted Scalable Data Analytics and Interpretation

Students prompt an AI tool:

"Analyze this large dataset and suggest efficient processing techniques using modern tools."

Students must:

1. Evaluate suggested approaches for handling large-scale data (CPU vs GPU, RAPIDS, etc.)
2. Analyze efficiency and scalability of proposed solutions
3. Suggest improvements for real-time and high-performance data analytics

Supporting Experiments

1. Develop a Python program to read different types of datasets (.txt, .csv, Excel, XML, JSON) from web and local disk using Pandas, merge them based on a common attribute (e.g., employee), and store the merged dataset into a new CSV file in a specified location.
2. Write a Python program to perform Exploratory Data Analysis (EDA) on a given dataset and generate visualizations including box plot, scatter plot, histogram, bar chart, pie chart, and heatmap to analyze data distribution and relationships.
3. Write a Python program to handle missing values in a dataset using Statistical Imputation, KNN Imputation, and Iterative Imputation methods and compare their effectiveness.
4. Write a Python program to detect and remove outliers from a dataset using Standard Deviation method, Interquartile Range (IQR) method, and automatic outlier detection techniques, and compare the results using appropriate plots.

Case Study: Accelerated Data Processing using Pandas and RAPIDS

Problem Statement:

In real-world data science applications, large datasets often lead to increased processing time and reduced efficiency. This case study explores how accelerated data processing techniques can improve performance by comparing traditional Pandas operations with GPU-accelerated alternatives such as RAPIDS cuDF.

Dataset:

A moderately large CSV dataset (e.g., sales data, customer transactions, or sensor data) containing multiple columns and thousands/millions of records.

E-Resources : (Recommended Tools)

1. DLI Link: https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+T-DS-03+V1#:~:text=The%20course%20prerequisites%20include:%20*%20Basic%20understan ding,the%20 NVIDIA%20Deep%20Learning%20Institute%20at%20www.nvidia.com/dli
2. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+C-DS-04+V1#:~:text=Build%20and%20compare%20classification%20models,learning%20and% 20clustering %20on%20embeddings.

Activity Based Learning (Suggested Activities in Class)

1. Load the dataset using Pandas.
2. Perform basic data operations such as:
3. Filtering rows based on conditions
4. Aggregation (groupby, sum, mean)
5. Sorting data based on a column
6. Measure execution time for each operation using Python's time module.
7. (Optional) Perform the same operations using RAPIDS cuDF
8. Compare the execution time between Pandas (CPU) and cuDF (GPU).

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SENSORS, SYSTEMS & IoT FUNDAMENTALS

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

SEMESTER – IV

Subject code	: 26AM2406	**Credits**	: 03
Hours / Week	: 04 Hours	**Total Hours**	: 30 + 30
L–T–P–S	**:** 2–0–2-0	**CIE+SEE**	: 60 + 40 Marks

Course Vision:

To develop skilled engineers with strong foundations in sensors, embedded systems, and IoT technologies for smart applications, while nurturing ethical and innovative professionals capable of designing AI-enabled connected solutions for societal needs.

Course Description:

This course introduces the fundamentals of sensors, embedded systems, and Internet of Things (IoT) technologies for building intelligent and connected systems. It covers sensing principles, data acquisition, and embedded platforms such as Arduino and ESP32 for real-time data processing. Explore IoT architectures, communication protocols including MQTT, CoAP, and HTTP, and cloud-based data integration using modern IoT platforms.The course further integrates Artificial Intelligence with IoT (AIoT), enabling students to design smart applications through data-driven decision-making. Hands-on learning is emphasized through the use of Jetson Nano/Raspberry Pi for image data collection, model training, and real-time inference. Applications span across smart homes, healthcare, agriculture, industrial automation, and intelligent transportation systems. The course adopts an AI^2 pedagogy, encouraging students to critically evaluate AI-generated solutions, address ethical considerations, and develop reliable, real-world intelligent system.

Course Learning Objectives:

This course will enable students to:

1. To introduce the fundamental concepts of sensors and their role in modern intelligent systems.
2. To provide basic understanding of analog and digital sensing technologies and data acquisition.
3. To explain the architecture and components of embedded and sensing systems.
4. To develop knowledge of Internet of Things (IoT) architectures, communication protocols, and connectivity.
5. To develop AI-enabled IoT applications using Jetson Nano/ Raspberry Pi for real-time data processing and inference.

Teaching-Learning Process (General Instructions)

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

a) **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.

b) **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

c) Showing **Video/animation** films to explain functioning of various concepts.

d) Encourage **Collaborative** (Group Learning) Learning in the class.

e) To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

f) Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I:	**06 Hours**
Introduction to Sensors & Physical Systems **Topics:** Analog vs digital signals, Introduction to sensors and its characteristics (Analog and digital sensors, environmental sensors, motion sensors), data acquisition fundamentals, role of sensors in intelligent systems. ***Applications:*** Environmental monitoring, smart homes, healthcare monitoring devices, robotics sensing systems, wearable technologies.	
MODULE – II:	**06 Hours**
Embedded Systems & Edge Devices **Topics:** Fundamentals of embedded systems, microcontrollers Arduino and ESP32 Architecture, sensor interfacing, edge computing basics. ***Applications:*** Industrial monitoring systems, smart agriculture, health monitoring systems, robotics, and automation.	
MODULE– III:	**05 Hours**
IoT Architecture & Networking **Topics:** Internet of Things fundamentals, IoT layered architecture, wireless sensor networks, IoT communication protocols: MQTT (Publish–subscribe model), CoAP (REST-based communication, designed for constrained devices), HTTP (Request–response model used in web-based IoT applications), connectivity technologies (WiFi, Bluetooth, Zigbee). ***Applications:*** Smart homes, smart agriculture, industrial IoT monitoring systems, connected healthcare devices.	
MODULE – IV:	**05 Hours**
IoT Platforms, Data Analytics & Cloud Integration **Topics:** IoT cloud platforms, device management, cloud connectivity, IoT analytics platforms, introduction to AWS IoT, Azure IoT, and Google IoT services. ***Applications***: Smart logistics, predictive maintenance systems, connected supply chains, smart infrastructure monitoring.	
MODULE – V:	**08 Hours**

AI-Enabled IoT Systems & Real-Time Video Analytics

Topics: Introduction to Jetson Nano/Raspberry Pi, Setup and configuration of Jetson Nano/ Raspberry Pi with camera interface, Image data collection for classification models, annotation of image data for regression tasks, Training of neural networks using collected datasets to build custom models, Deployment and real-time inference on Jetson Nano using trained models.

Applications: Smart surveillance systems, intelligent transportation and traffic monitoring, industrial automation and defect detection, smart retail analytics, and healthcare monitoring systems.

Course Outcomes :

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand sensor principles, characteristics, and data acquisition techniques for intelligent systems.	L2
2	Apply embedded system concepts and edge devices for sensor interfacing and real-world applications	L3
3	Analyze IoT architectures, networking models, and communication protocols for connected systems.	L4
4	Apply IoT platforms and cloud technologies for data analytics and system integration.	L3
5	Develop AI-enabled IoT applications using Jetson Nano/ Raspberry Pi for data collection, model training, and real-time inference.	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	-	2	-	-	1	-	-	1	1	3
CO-2	3	3	3	1	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	2	3	-	-	1	1	1	2	2	3
CO-4	3	3	3	2	3	1	-	1	1	1	2	3	3
CO-5	3	3	3	2	3	2	1	2	2	2	2	3	3

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

ASSESSMENT SCHEME :

Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

Recommended Tools

1. **Programming & Development**: Python, Arduino IDE, PlatformIO, VS Code
2. **IOT Simulation & Development Platforms**: Cisco Packet Tracer (IoT Mode), Proteus /EWB, Tinkercad Circuits
3. **IoT Communication & Integration Tools**: MQTT Explorer, Node-RED, Postman
4. **Cloud & IoT Platforms**: ThingSpeak, AWS IoT, Azure IoT, Google Cloud IoT
5. **AI& ML Integration Tools**: TensorFlow / TensorFlow Lite, Scikit-learn

LAB EXERCISES:

S. No	Exercise Title	Aim / Objective	Tools	Hrs	CO
	MODULE I · Exercises 1–2 : Introduction to Sensors & Physical Systems (06 Hours)				
1	Sensor Data Acquisition using Arduino	Interface temperature/humidity sensors and acquire real-time data for monitoring applications	Arduino IDE, Arduino Uno, DHT11 / DHT22	2 h	CO1
2	Analog vs Digital Sensor Analysis	Compare outputs from analog and digital sensors and analyze signal behavior, accuracy, and noise characteristics	Arduino IDE, Potentiometer, Digital Sensor Modules	2 h	CO1
	MODULE II · Exercises 3–4 : Embedded Systems & Edge Devices (06 Hours)				
3	Embedded System Interfacing with ESP32	Interface multiple sensors with ESP32 and display acquired sensor data through serial monitor	ESP32, Arduino IDE	2 h	CO2
4	Edge Computing Basics	Perform thresholding, filtering, and local decision-making on embedded devices before cloud transmission	ESP32, Arduino IDE	2 h	CO2

	MODULE III · Exercises 5–6 : IoT Architecture & Networking (06 Hours)				
5	IoT Communication using MQTT Protocol	Publish and subscribe sensor data using MQTT broker for real-time IoT communication	ESP32, MQTT Broker, Node-RED	2 h	CO3
6	Wi-Fi Based Remote Monitoring	Transmit sensor data wirelessly using ESP32 Wi-Fi and visualize through web dashboard	ESP32, Wi-Fi Router, Web Dashboard	2 h	CO3
	MODULE IV · Exercises 7–8 : IoT Platforms, Data Analytics & Cloud Integration (06 Hours)				
7	IoT Cloud Integration	Send sensor data to cloud platforms such as ThingSpeak / AWS IoT and visualize trends	ESP32, ThingSpeak / AWS IoT	2 h	CO4
8	Smart Analytics Dashboard	Create dashboard for live sensor monitoring, alerts, and analytics visualization	Node-RED, ThingSpeak, Cloud Tools	2 h	CO4
	MODULE V · Exercises 9–13 : AI-Enabled IoT Systems & Real-Time Video Analytics (12 Hours)				
9	Jetson Nano / Raspberry Pi Setup and Camera Interface	Configure Jetson Nano / Raspberry Pi and interface camera module for AI applications	Jetson Nano / Raspberry Pi, Camera, Ubuntu	2 h	CO5
10	Image Data Collection using Jetson Nano / Raspberry Pi	Capture and store image datasets using camera interface for AI models	Jetson Nano / Raspberry Pi, Python, Camera	2 h	CO5
11	AI Model Training on Jetson Nano / Raspberry Pi	Train a simple image classification model using collected datasets	Jetson Nano / Raspberry Pi, TensorFlow / PyTorch	2 h	CO5
12	Real-Time Inference on Jetson Nano / Raspberry Pi	Deploy trained AI model and perform live object/image classification	Jetson Nano / Raspberry Pi, Camera, Python	2 h	CO5
13	Mini Project	Design and develop an integrated IoT system with sensors, cloud connectivity, and AI-based analytics for real-time monitoring and decision-making	ESP32 / Arduino, Sensors, Jetson Nano / Raspberry Pi, MQTT, Cloud Platform, Python	6 h	CO5

TEXT BOOKS:

1. Xiao, P., Designing Embedded Systems and the Internet of Things (IoT) with ARM Mbed, 1st Edition, John Wiley & Sons, 2018

2. Bahga, A., & Madisetti, V., Internet of Things: A Hands-On Approach, 1st Edition, Universities Press, 2015

REFERENCE BOOKS:

3. Cirani, S., Ferrari, G., Picone, M., & Veltri, L., Internet of Things: Architectures, Protocols and Standards, 1st Edition, John Wiley & Sons, 2019
4. Song, H., Internet of Everything: Key Technologies, Practical Applications and Security of IoT, World Scientific Publishing, 2023.

E-Resources : (Recommended Tools)

1. MIT OpenCourseWare
2. IEEE research articles
3. NVIDIA DLI Courses
4. Dimitrios Serpanos, Marilyn Wolf, Internet of Things (IoT) Systems: Architecture, Algorithms, Methodologies, Springer, 2018. https://link.springer.com/book/10.1007/978-3-319-69715-4

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SKILL ENHANCEMENT COURSE II
(AI IN CLOUD COMPUTING)

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

SEMESTER - IV

Course Code	:	26AM2407	**Credits**	:	02
Hours / Week	:	03	**Total Hours**	:	15 + 30
L–T–P-J	:	1–0–2–0	**CIE+SEE**	:	100 Marks

Course vision: To equip learners with the knowledge and skills to design, deploy, and manage scalable and secure applications using modern cloud computing technologies and platforms.This course introduces cloud computing platforms and AI deployment techniques in cloud environments. Students learn scalable computing, virtualization, cloud services, and AI model integration. The course prepares students for cloud-enabled intelligent application development.

Course Description: This course introduces cloud computing platforms and AI deployment techniques in cloud environments. Students learn scalable computing, virtualization, cloud services, and AI model integration. The course prepares students for cloud-enabled intelligent application development.

Course Objectives:

This Course will enable students to:

1. Understand the basic concepts, history, architecture, and key characteristics of cloud computing.
2. Explain and compare different cloud deployment models such as public, private, hybrid, and community clouds.
3. Understand various cloud service models and platforms used for building and deploying cloud applications.
4. Learn to develop, deploy, and manage cloud applications using Amazon Web Services tools such as Elastic Beanstalk and related services.
5. Analyse major cloud platforms used in industry

Teaching-Learning Process (General Instructions)

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

A. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.

B. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

C. Showing **Video/animation** films to explain functioning of various concepts.

D. Encourage **Collaborative** (Group Learning) Learning in the class.

E. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

F. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**03 Hours**

Cloud Computing Fundamentals

Topics: Introduction to Cloud Computing, Evolution of Cloud Computing, Distributed Systems and Grid Computing, Virtualization Concepts and Virtual Machines, Cloud Computing Architecture, Characteristics and Benefits of Cloud Computing, Challenges and Issues in Cloud Computing

Application: On-demand startup infrastructure, Virtual labs for education and research, Disaster recovery and backup systems, Big data processing using distributed systems

MODULE – II	**03 Hours**

Cloud Models and Architecture

Topics: Cloud Deployment Models (Public, Private, Hybrid, Community), Cloud Service Models (IaaS, PaaS, SaaS), Cloud Reference Architecture, Multi-Cloud and Hybrid Cloud Architecture, Resource Management and Scalability, Fault Tolerance and Load Balancing

Application: Hybrid cloud for sensitive and scalable workloads, SaaS-based enterprise applications, Auto-scaling e-commerce platforms, Fault-tolerant financial systems

MODULE – III	**03 Hours**

Cloud Platforms and Services

Topics: Overview of major cloud providers, Cloud platforms such as Amazon Web Services, and Google Cloud Platform, Compute, Storage, and Networking services, Cloud databases and data management, Application deployment in cloud environments

Application: Web and mobile app hosting on Amazon Web Services and Google Cloud Platform, Cloud storage and content delivery systems, Managed cloud database applications, Data analytics and processing pipelines

MODULE – IV	**03 Hours**

Cloud Development and DevOps

Topics: Cloud application development, Microservices architecture, Containers and Docker, Kubernetes basics, CI/CD pipelines and DevOps practices, Infrastructure as Code (IaC) and automation

Application: Microservices-based application development, Containerized deployment using Docker and Kubernetes, Automated CI/CD pipelines, Infrastructure as Code (IaC) automation

MODULE – V	**03 Hour**

Cloud Security and Emerging Trends

Topics: Cloud security principles, Identity and Access Management (IAM), Data privacy and compliance, Monitoring and cost optimization (FinOps), Serverless computing, Edge computing, AI/ML in cloud, and future trends

Application: Identity and access management systems, Serverless application development, Edge computing for IoT applications, AI/ML model deployment in cloud.

INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration:

- Cloud computing supports the development, training, and deployment of artificial intelligence applications using scalable computing resources.

- Different cloud deployment models enable scalable infrastructure for running AI and machine learning workloads efficiently.
- Cloud platforms provide powerful computing services for building, training, and deploying AI- based applications.
- Cloud application platforms support deployment and scaling of AI-driven applications using automated cloud services.
- Industry cloud platforms provide large-scale computing resources for advanced AI, analytics, and parallel computing tasks.

Authentic Intelligence:

- Secure and interoperable cloud environments support reliable data sharing and trustworthy intelligent systems.
- Cloud platforms enable reliable data processing and intelligent systems that support reliable data sharing and trustworthy intelligent systems.
- Integrated cloud services enable intelligent data processing and decision-making across distributed systems.
- Monitoring, scaling, and secure management tools ensure reliable and intelligent cloud application performance.
- Enterprise cloud systems enable secure, efficient, and intelligent business solutions

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the fundamental concepts, architecture, characteristics, and evolution of cloud computing.	L3
2	Compare different cloud deployment models such as public, private, hybrid, and community clouds.	L4
3	Analyze various cloud service models (IaaS, PaaS, SaaS) and cloud computing platforms.	L4
4	Develop and deploy basic cloud applications using cloud platforms and services.	L3
5	Evaluate cloud computing solutions for scalability, security, cost efficiency, and real-world industry applications.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	1	2	3	-	3	-	-	-	-	-	-	2	2
CO-2	1	2	3	-	3	-	-	-	-	-	-	2	2
CO-3	1	2	3	-	3	-	-	-	-	-	-	2	2
CO-4	-	1	2	-	3	-	-	-	-	-	-	2	2
CO-5	-	1	2	-	-	-	-	-	-	-	-	2	2

TEXT BOOKS:

1. Mastering Cloud Computing: Foundations and Applications Programming (2nd ed.), Buyya, R., Vecchiola, C., Selvi, S. T., et al. (2026), Morgan Kaufmann
2. Cloud Computing: Concepts, Technology & Architecture, Thomas Erl, Ricardo Puttini, and Zaigham Mahmood. (2013), Prentice Hall

REFERENCE BOOKS:

1. Cloud Computing Bible, Barrie Sosinsky. (2011), Wiley Publishing
2. Buyya, R., et al. (2017). A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade. arXiv.
3. Chaudhary, S., Somani, G., & Buyya, R. (2018). Research Advances in Cloud Computing. Springer

E-RESOURCES:

1. https://www.coursera.org/resources/cloud-computing-learning-roadmap?msockid=184202ec9ab1682a134a169b9b1c6958
2. Cloud Computing Tutorial - GeeksforGeeks
3. Cloud Computing Resources and Their Management

LAB EXERCISES

S. No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
	MODULE I · Exercises 1–3 (06 Hours)				
1	Introduction to Cloud and Virtualization	Install VirtualBox, create and manage a virtual machine (e.g., Ubuntu)	VirtualBox, Ubuntu	2 h	CO1
2	Setting Up a Private Cloud using Eucalyptus / OpenStack	Install Eucalyptus / DevStack, launch a VM instance inside the private cloud, and access the dashboard	Eucalyptus / OpenStack / DevStack	2 h	CO1
3	Creating a Virtual Machine in AWS	Launch an EC2 instance, connect via SSH, and install a web server (e.g., Apache or Nginx)	AWS EC2, Apache / Nginx	2 h	CO1
	MODULE II · Exercises 4–5 (04 Hours)				
4	Deploying a Web Application on AWS Elastic Beanstalk	Initialize Elastic Beanstalk environment, deploy app using CLI or Console, and monitor deployment logs	AWS Elastic Beanstalk, Python / Node.js Application	2 h	CO2
5	Using AWS S3 for Object Storage	Create an S3 bucket, upload/download files, set permissions, and enable static website hosting	AWS S3	2 h	CO2
	MODULE III · Exercises 6–7 (04 Hours)				
6	Load Balancing and Auto Scaling	Create multiple EC2 instances, attach them to Load Balancer, and configure auto-scaling rules	AWS Elastic Load Balancer, Auto Scaling Groups	2 h	CO3
7	Monitoring and Logging with CloudWatch	Set up alarms (CPU usage, memory), view application logs, and create monitoring dashboards	AWS CloudWatch	2 h	CO3
	MODULE IV · Exercises 8–9 (06 Hours)				

8	Working with Cloud Databases (RDS / Firebase)	Launch an RDS instance (MySQL/PostgreSQL), connect from a web app, and perform CRUD operations	AWS RDS / Firebase	3 h	CO4
9	Identity and Access Management (IAM)	Create users and groups, assign policies (S3 access, EC2 control), and test access restrictions	AWS IAM	3 h	CO4
	MODULE V · Exercise 10 (10 Hours)				
10	Host a Full-Stack Application on Cloud	Develop and deploy a backend (Node.js/Python) and frontend (HTML/CSS/JS) application on EC2 or Beanstalk, use S3 for static content and RDS for database integration	CloudSim, Cisco Packet Tracer, Google Cloud Shell, AWS EC2 / Beanstalk, S3, RDS	10 h	CO5

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V SEMESTER – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

V SEMESTER													
Sl.no	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE Marks	Total Marks	Credits
					L	T	P	J					
1	PCC	26AM3501	Responsible AI, Ethics & Policy	AI& ML	2	0	0	0	0 2	60	40	100	2
2	PCC	26AM3502	Natural Language Models	AI& ML	2	0	0	0	0 2	60	40	100	2
3	IPCC	26AM3503	Deep Learning	AI& ML	3	0	2	0	0 5	60	40	100	4
4	IPCC	26AM3504	Generative AI	AI& ML	3	0	2	0	0 5	60	40	100	4
5	PCC	26AM3505	Sustainable Green AI Computing	AI& ML	2	0	0	0	0 2	60	40	100	2
6	PCC	26AM3506	Design Studio IV: Innovation, Design Thinking & IP	AI& ML	1	0	0	2	0 2	100	--	100	2
7	PEC	26AM35XX	Professional Elective I / MOOC/DLI	AI& ML	2	0	0	2	0 3	100	--	100	3
8	AEC	26AM3507	Cognitive and Technical Skills-V	Placement	-	-	-	-	02	-	-	-	P/F
			Total		15	0	4	4	23	500	200	700	19

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

Professional Elective Courses Offering (PEC-I)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	T	P	J				
1	PEC	26AM3508	Accelerated Data Science	2	0	0	2	100	--	100	03
2	PEC	26AM3509	LLM-Based Agent Frameworks & Orchestration	2	0	0	2	100	--	100	03
3	PEC	26AM3510	Intelligent Speech Processing Systems	2	0	0	2	100	--	100	03
4	PEC	26AM3511	Foundations of Robotics and Intelligent Systems	2	0	0	2	100	--	100	03
5	PEC	26AM3512	Explainable AI	2	0	0	2	100	--	100	03
6	PEC	26AM3513	Cognitive Linguistics	2	0	0	2	100	--	100	03

RESPONSIBLE AI, ETHICS & POLICY

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

SEMESTER - VI

Course Code	**:** 26AM3501	**Credits**	**:** 02
Hours / Week	**:** 02	**Total Hours**	**:** 30
L–T–P–J	**:** 2–0–0–0	**CIE+SEE**	**:** 60+40 Marks

Course Vision:

To equip Undergraduate students with the knowledge and ethical perspective required to design, develop, and deploy trustworthy, fair, and accountable AI systems, while understanding the societal, legal, and policy implications of artificial intelligence.

Course Description:

Responsible AI focuses on the development and deployment of AI systems that are fair, transparent, accountable, and aligned with societal values. The course introduces ethical frameworks, bias detection, explainable AI, privacy-preserving techniques, and governance models. Students explore real-world case studies and learn how AI systems impact individuals and society. Emphasis is placed on integrating ethical reasoning with technical AI development to ensure trustworthy and human-centric AI solutions.

Course Objectives:

This course will enable students to:

1. Understand ethical frameworks and principles relevant to the design and deployment of artificial intelligence technologies.
2. Analyze the societal, legal, and policy implications of AI adoption across different sectors.
3. Apply the principles of Responsible AI in the development and evaluation of AI systems.
4. Evaluate and design AI solutions that are ethical, transparent, and socially responsible.
5. Design responsible AI strategies and governance mechanisms aligned with global standards and regulatory frameworks.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Encourage **Collaborative** (Group Learning) Learning in the class.
4. To make **Critical thinking**, asking higher order thinking questions in the class in the form of Quiz and writing programs with complex solutions.
5. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I	**06 Hours**

Foundation of Responsible and Authentic Intelligence

Topics: Concept of Responsible AI and Authentic Intelligence, Principles of Authentic Intelligence Human-centred AI, trust, transparency, fairness, accountability, and inclusivity and its societal impact, Ethical frameworks for AI, Human values and cultural contexts in AI systems.

Applications: Ethical decision-making in AI-powered recommendation systems, Responsible deployment of AI assistants and chatbots.

MODULE – II	**06 Hours**

Bias, Fairness, Transparency and Human-Aligned AI **Topics:** Sources of bias in AI, data bias, algorithmic bias, societal bias, Fairness metrics and bias mitigation techniques, Algorithmic transparency and explainability, Explainable AI (XAI) models and interpretability methods. **Applications:** Transparent AI decision systems in government services, Bias detection in hiring and recruitment AI systems.	
MODULE – III	**06 Hours**
Privacy, Safety and Trustworthy AI Systems **Topics:** Privacy challenges in AI-driven systems, Privacy-preserving machine learning, differential	

privacy, federated learning, AI security risks and adversarial attacks, Robustness, safety, and reliability of AI models, Trustworthy AI lifecycle frameworks. **Applications:** Privacy-preserving healthcare analytics, Secure AI-based financial fraud detection systems, autonomous vehicles.	
MODULE – IV	**06 Hours**
AI Governance, Regulation and Responsible Innovation **Topics:** AI governance and regulatory frameworks, Algorithmic accountability and auditing mechanisms, AI risk assessment and impact evaluation models, Global AI policy initiatives and standards, Responsible innovation in AI development. **Applications:** AI compliance frameworks in organizations, Ethical review boards for AI systems.	
MODULE – V	**06 Hours**
Designing Authentic and Responsible AI Systems **Topics:** Human-centered AI design methodologies, Responsible AI development lifecycle, Social and economic implications of emerging AI technologies, Sustainable and inclusive AI development. **Applications:** Responsible design of generative AI systems, AI solutions for social good, AI deployment in smart cities and governance.	

AI Integration*:*

1. AI development lifecycle and ethical checkpoints, Ethical considerations in data collection and model design.
2. Fairness evaluation in machine learning pipelines, explainable AI tools for model interpretation, datasets that ensure diversity and representation.
3. Privacy-preserving techniques in ML models, security testing and robustness checks in AI systems, reliability and safe AI systems.
4. Governance mechanisms in AI development processes, Compliance with regulatory standards in AI products, AI auditing tools.
5. Responsible AI frameworks into AI system design, AI models with transparency and accountability mechanisms, monitoring and evaluation of deployed AI systems.

Authentic Intelligence*:*

1. Human-centered AI design principles, Aligning AI behavior with human values.
2. Value-aligned AI systems, Ethical dataset design and inclusive AI development.
3. Ethical protection of user privacy and digital rights, trust between humans and AI systems.
4. Ethical leadership in AI development, Accountability and transparency in AI-driven decision systems, AI innovation with societal values and public interest.
5. AI systems that respect human dignity and autonomy, fairness, inclusivity, and sustainability in AI innovation, AI systems remain aligned with human values and societal needs.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain key concepts and principles of Responsible AI, including fairness, transparency, accountability, and privacy	L2
2	Analyze ethical challenges and societal impacts associated with AI technologies	L4
3	Evaluate AI systems for bias, reliability, and ethical risks using appropriate frameworks	L5
4	Interpret AI governance models, regulatory guidelines, and policy frameworks related to responsible AI for ethical governance	L3
5	Apply responsible AI principles in the design and development of trustworthy AI solutions	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	1	1	3	1	3	-	-	-	2	1
CO-2	2	3	2	2	1	3	2	3	-	-	-	2	1
CO-3	3	3	2	2	3	3	1	3	1	-	-	2	1
CO-4	2	3	2	2	2	3	2	3	1	-	-	2	2
CO-5	3	2	3	3	3	3	2	3	2	-	2	2	2

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

ASSESSMENT SCHEME :

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of NLM fundamentals and problem-solving approaches.

b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, project-based learning, seminars, reflection notes, model buildings.

c. **AI-Powered Assignment (APA):** Use of AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and

solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

Text Books :

- M. Coeckelbergh - AI ethics, 2020, MIT press, ISBN: 978-0262538190.
- S. Agarwal & S. Mishra - Responsible AI Implementing Ethical and Unbiased Algorithms, 2021, Springer, https://doi.org/10.1007/978-3-030-76860-7.

REFERENCE BOOKS:

1. S. Voeneky, P. Kellmeyer, O. Mueller, and W. Burgard - The Cambridge handbook of responsible artificial intelligence: interdisciplinary perspectives, eds., 2022, Cambridge University Press, ISBN: 9781009207867 / 9781009207898, DOI: 10.1017/9781009207898.

E-RESOURCES:

1. Virginia Dignum – *Responsible AI.*
   https://people.cs.umu.se/virginia/docs/responsibleAI2018.pdf
2. Luciano Floridi – *The Ethics of AI*.
   https://www.researchgate.net/publication/385157886_The_Ethics_of_Artificial_Int elligence

RECOMMENDED TOOLS

- Programming: Python (basic ML models)
- AI Libraries: Scikit-learn, TensorFlow (conceptual exposure)
- Explainability Tools: SHAP, LIME
- AI Tools: ChatGPT / AI assistants

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NATURAL LANGUAGE MODELS

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

SEMESTER – V

Subject Code	: 26AM3502	**Credits**	: 02
Hours / Week	: 02 Hours	**Total Hours**	: 30 Hours
L–T–P–S	: 2–0–0–0	**CIA+SEE**	**:** 60+40 Marks

Course Vision:

This course provides a comprehensive introduction to Natural Language Processing (NLP), covering fundamental concepts, linguistic techniques, and advanced deep learning approaches for processing and understanding human language.

Course Description:

This course provides a comprehensive introduction to Natural Language Processing (NLP), covering fundamental concepts, linguistic techniques, and advanced deep learning approaches for processing and understanding human language. It begins with essential text preprocessing methods such as tokenization, normalization, and syntactic analysis, followed by statistical and probabilistic models including part-of-speech tagging, named entity recognition, and sequence modeling techniques.

The course further explores modern Neural NLM techniques, including word embeddings, recurrent neural networks (RNN), and long short-term memory (LSTM) models for handling sequential data. Building on these foundations, it introduces transformer-based architectures and large language models (LLMs) such as BERT and GPT, emphasizing encoder–decoder frameworks and attention mechanisms for tasks like machine translation and text summarization.

In addition, the course covers performance evaluation metrics such as BLEU, ROUGE, and BERTScore, along with real-world applications including recommendation systems, social media analytics, and automated text summarization. Students will also learn to design end-to-end NLP systems, integrating models with modern AI frameworks and APIs.

Course Learning Objectives:

This course will enable students to:

1. To understand the fundamental concepts of natural language processing, and linguistic structures.
2. To apply statistical and probabilistic models such as POS tagging, HMM, and CRF for language analysis and information extraction.
3. To analyze word embedding techniques and deep learning models including RNN, and LSTM for NLM tasks.
4. To utilize encoder-decoder architectures, attention mechanisms, and transformer-based models for advanced NLM applications.
5. To Evaluate NLM systems using standard performance metrics and to design, build, and deploy an end-to-end conversational AI pipeline.

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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing Video/animation films to explain functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the different ways to solve the same problem and encouraging the students to come up with their own creative ways to solve them

MODULE – I	04 Hours
NLP Foundations & Text Processing Systems **Topics:** Fundamentals for NLP; Text Processing pipelines: Tokenization (Byte Pair Encoding, WordPiece tokenization, Sentence Piece tokenisation), Normalization, Stop word removal, Stemming, Lemmatization, Regular expressions in information extraction; N-grams, Edit distance algorithms (spell correction). ***Applications:*** Document processing systems, legal document analysis, medical text processing, automated content moderation, enterprise document intelligence systems.	
MODULE – II	**05 Hours**
Language Models & Semantic Understanding **Topics:** Linguistic Processing Techniques: Part-of-speech Tagging, Named Entity Recognition, Relation extraction; Sequence Modeling Techniques: Hidden Markov Models; Conditional Random Fields; Semantic Analysis: Semantic Similarity, WordNet; Latent Semantic Analysis. ***Applications:*** Search engines, recommendation systems, enterprise knowledge discovery, document classification systems, automated email routing systems.	
MODULE – III	**05 Hours**
Word Embeddings & Sequence Models **Topics:** Word embeddings (Bag of Words, TF-IDF, Word2Vec: Continuous Bag of Words, Skip- Gram; GloVe, FastText) Sequence models, RNN and LSTM models; ***Applications:*** Machine translation systems, intelligent chatbots, AI writing assistants, conversational agents, multilingual information systems.	
MODULE – IV	**08 Hours**
Encoder-Decoder Models **Topics:** Generative AI overview; Evolution of Generative models; GPT architecture overview; BERT, RoBERTa, Seq2Seq Frameworks: Encoder-Decoder modelling for translation and summarization, Attention Mechanisms. Building **Transformer-Based Natural Language Processing Applications:** Introduction to Transformers; self- supervised transformer-based models to concrete NLP tasks using NVIDIA NeMo, BERT, and Beyond, Inference and Deployment for NLP - NVIDIA Triton. ***Applications***: AI copilots, enterprise knowledge assistants, automated report generation, coding assistants, conversational AI systems.	
MODULE – V :	**08 Hours**
Model Evaluation and Applications **Topics :** Performance Metrics: Evaluation using BLEU, ROUGE, and BERT Score; **Building Conversational AI Applications:** Introduction to Conversational AI - Explore the conversational AI landscape and gain a deeper understanding of the key components of Automatic Speech Recognition (ASR); Customized Conversational AI Pipelines - Explore the key components of the Text-to-Speech (TTS) pipeline and full pipeline customizations; Inference and Deployment Challenges (Explore challenges related to performance, optimization, and scaling in production deployment of conversational AI applications) ***Applications:*** Smart customer support systems, intelligent document processing platforms, social media sentiment monitoring systems, AI-powered education assistants, automated news summarization systems.	

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**
  - AI-assisted code generation for the text preprocessing pipelines and comparison.
  - AI-based POS tagging and NER systems, semantic similarity computation using pretrained models, automated information extraction tools.
  - AI-driven word embedding visualization (Word2Vec, GloVe), deep learning model

implementation using frameworks, comparison of embedding techniques using AI tools.

- AI-powered transformer models (BERT, GPT), LLM API integration, attention visualization tools for sequence models.
- AI-based evaluation tools for NLP metrics (BLEU, ROUGE, BERT Score), automated summarization systems, AI-driven recommendation and tagging systems.

- **Authentic Intelligence Reflection:**
  - Students analyze bias in text preprocessing, limitations of automated tokenization, and the need for human validation in language data preparation
  - Students evaluate errors in linguistic and semantic models, reliability of automated entity recognition, and risks of incorrect semantic interpretation.
  - Students discuss bias in word embeddings, interpretability of deep learning models, and ethical concerns in NLP-based predictions.
  - Students analyze hallucination in transformer models, reliability of generative AI outputs, and ethical implications of large language models.
  - Students evaluate limitations of evaluation metrics, fairness in NLP applications, and accountability in real-world AI deployment.

Course Outcomes:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain NLP fundamentals, text preprocessing methods, and linguistic concepts such as tokenization, normalization, and n-grams.	L2
2	Apply linguistic and probabilistic models including POS tagging, NER, HMM, and CRF for sequence labeling and information extraction tasks.	L3
3	Analyze word embeddings and deep learning models such as Word2Vec, GloVe, FastText, RNN, and LSTM for NLM applications.	L4
4	Implement Encoder-Decoder models, attention mechanisms, and transformer-based architectures (BERT, GPT) for real-world NLM problems.	L3
5	Evaluate NLM systems using standard performance metrics and to design, build, and deploy an end-to-end conversational AI pipeline.	L5

Mapping Levels of COs to POs / PSOs

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

CO-3	3	2	1	-	2	-	-	2	2	1	-	1	1
CO-4	3	2	1	-	2	-	-	2	2	1	-	1	1
CO-5	3	2	1	-	2	-	-	3	3	1	-	1	1

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

ASSESSMENT SCHEME :

3. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of NLM fundamentals and problem-solving approaches.

b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, project-based learning, seminars, reflection notes, model buildings.

c. **AI-Powered Assignment (APA):** Use of AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

4. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS :

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: AI-Generated Code Evaluation Students prompt an AI tool:

"Perform sentiment analysis on this dataset and provide predictions." Students must:

1. Analyze correctness of predictions
2. Identify biases or miscommunications
3. Improve results (data cleaning / prompt refinement / model selection)

Assignment 2: AI-Based Logical Reasoning Analysis Students ask AI:

" Compare BLEU, ROUGE, and BERT Score for evaluating NLM models."

Students must:

1. Verify correctness of metric definitions
2. Appropriate use cases (translation vs summarization)
3. Limitations of each metric

Assignment 3: AI Debugging

Challenge Students prompt an AI tool:

" AI generates faulty code for Tokenization / Text preprocessing / NER:"

1. Analyse agent structure and environment
2. Evaluate decision-making capability
3. Identify ethical and real-world limitations

Assignment 4: NLM Visualization and Analysis

Students use AI visualization tools:

"Summarize or translate a given text using NLP techniques." Students must:

1. Visualize word embeddings (Word2Vec/GloVe)
2. Analyze semantic similarity between words/sentences

Assignment 5: NLM Model Performance Study

Students prompt an AI tool:

" • Students implement three." Students must:

1. Language understanding and generation quality (Perplexity, BLEU, ROUGE, BERTScore)
2. Computational efficiency (Inference time, memory usage, scalability)
3. Model behavior on real-world text data (robustness, generalization, handling ambiguity)

TEXT BOOKS:

1. Deep Learning for Natural Language Processing Jason Brownlee, 2023, Machine Learning Mastery.

2. Speech and Language Processing, Daniel Jurafsky and James H. Martin, 3rd Edition (Draft), 2023, Pearson.

REFERENCE BOOKS:

1. Practical Natural Language Processing, Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, and Harshit Sura 2020, O'Reilly Media.
2. Transformers for Natural Language Processing, Denis Rothman, 2023, Packt Publishing.

E-Resources : (Recommended Tools)

- ChatGPT / Gemini for ideation
- Python
- Jupyter Notebook / Google Colab
- NLTK
- spaCy
- Hugging Face Transformers
- PyTorch
- LangChain

Activity Based Learning (Suggested Activities in Class)

1. Explore the recent research article related to NLM Techniques and Build a Simple NLM Application.
2. Collaborative Activity of Practical Learning on Different Embedding and NLM Technique.

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DEEP LEARNING

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

SEMESTER – V

Subject Code	:	26AM3503	**Credits**	:	04
Hours / Week	:	05 Hours	**Total Hours**	:	45+30 Hours
L–T–P–S	:	3–0–2–0	**CIA+SEE**	:	60+40 Marks

Course Vision:

To develop a strong foundation in deep learning by understanding neural networks, hierarchical representation learning, and core optimization techniques, enabling learners to design and apply advanced architectures such as CNNs, RNNs, and LSTMs for complex tasks in computer vision and sequence modelling, and to build efficient, scalable, and innovative deep learning solutions for real-world applications.

Course Description :

Deep Learning is a subset of Artificial Intelligence that focuses on multi-layer neural networks capable of learning hierarchical representations from data. It extends traditional machine learning by enabling models to automatically extract features and perform complex tasks such as image recognition, natural language processing, and speech understanding. This course introduces the fundamentals of neural networks, including activation functions, loss functions, and training challenges such as vanishing gradients. It explores computational techniques like forward and backward propagation, optimization algorithms, regularization, and batch normalization.

The course covers Convolutional Neural Networks (CNNs) for computer vision, including architectures such as AlexNet, VGG, and ResNet, along with transfer learning techniques. Sequence modeling is addressed using Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM) networks. The course also applications of Deep Learning techniques to solve real world problems.

Course Learning Objectives:

This course will enable students to:

1. To Understand the fundamentals of deep learning and neural network architectures.
2. To apply optimization techniques for training deep neural networks effectively.
3. To design and implement CNN-based architectures for image-based applications.
4. To apply sequence models such as RNN, LSTM, and Transformers for sequential data problems.
5. To apply Artificial Intelligence techniques, including Machine Learning and Deep Learning (e.g., LSTM Autoencoders), for anomaly detection in network data and predictive maintenance in real-world systems.

Course Description :

Deep Learning is a subset of Artificial Intelligence that focuses on multi-layer neural networks capable of learning hierarchical representations from data. It extends traditional machine learning by enabling models to automatically extract features and perform complex tasks such as image recognition, natural language processing, and speech understanding. This course introduces the fundamentals of neural networks, including activation functions, loss functions, and training challenges such as vanishing gradients. It explores computational techniques like forward and backward propagation, optimization algorithms, regularization, and batch normalization.

The course covers Convolutional Neural Networks (CNNs) for computer vision, including architectures such as AlexNet, VGG, and ResNet, along with transfer learning techniques. Sequence modeling is addressed using Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM) networks. The course also applications of Deep Learning techniques to solve real world problems.

UNIT – I : Foundations of Deep Learning	**09 Hours**

Introduction to Deep Learning, Artificial Neural Networks : Single layer and multilayer perceptron, Shallow Neural Network. Activation Functions (Linear, ReLU, Leaky ReLU Sigmoid, Tanh, Softmax, Swish, Elu, Gelu). Loss Functions (MSE, Binray Cross-Entropy Loss, Categorical Cross-Entropy Loss, Focal Loss), Training Challenges: Vanishing and Exploding Gradients. Model Evaluation: Bias-Variance tradeoff, Overfitting and Underfitting.

Applications: Image recognition, speech processing, anomaly detection, predictive systems.

UNIT – II : Computation and Optimization in Deep Learning	**09 Hours**

Forward and Backpropagation, Computational Graphs. Gradient Descent Variants (Optimizers: Gradient Descent (GD), Stochastic GD, Mini-Batch Gradient Descent, Momentum Based GD, AdaGrad, RMSProp, Adam). Weight Initialization (Xavier, He). Regularization: Dropout, L1/L2, Early Stopping. Batch Normalization. Learning Rate Scheduling and Hyperparameter Tuning (Grid Search, Random Search, Bayesian Optimization). Automatic Differentiation. ***Applications:*** Efficient training of large-scale neural networks, model tuning in real-world AI systems.	
UNIT – III : Convolutional Neural Networks (CNNs) & Transfer Learning Models	**09 Hours**
PyTorch, Shallow Neural Network, CNN architecture and biological inspiration. Convolution, Padding, Stride. Pooling Layers. Fully Connected Layers. **Data Augmentation and Transfer Learning,** Transfer Learning Architectures: AlexNet, VGG16, VGG19, ResNet (skip connections),	
Lightweight models - MobileNet, **Graph Neural Network** Build and efficiently train GNN based models. ***Applications:*** Image classification, object recognition, medical imaging, autonomous driving.	
UNIT – IV : Sequence Models and Transformers	**09 Hours**
Sequential Data and Sequence Modeling. RNN Architecture, Variants of RNN and limitations, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Bidirectional RNNs, RNN Language Model, GRU, LSTM, Bi-LSTM. Transformer Architecture (Encoder-Decoder, Self-attention, Multi-head Attention). ***Applications***: Language translation, speech recognition, chatbots, time-series forecasting.	
UNIT – V : Deep learning Applications	**09 Hours**
Applications of AI for Anomaly Detection - **Anomaly Detection in Network Data using Machine Learning,** Applications of AI for Predictive Maintenance - LSTM autoencoder. ***Applications:*** Image generation, anomaly detection, medical diagnostics, recommendation systems.	

Course Outcome:

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Make use of the fundamentals of deep learning, neural networks, activation functions to handle challenges associated on the given data.	L3
2	Apply optimization techniques, regularization methods, and computational strategies for training deep models.	L3
3	Implement CNN-based architectures for image-based applications.	L4
4	Apply sequence models such as RNN, LSTM, and Transformers for sequential data problems.	L3
5	Implement and evaluate AI-based models for anomaly detection and predictive maintenance, and compare their effectiveness across different approaches.	L5

RESEARCH INTEGRATION TEACHING

1. Students review on at least one recent research topics
   such as: Generative AI
   Transformer Models
   Explainable AI for Interpretabilty
2. Students present a short research review.

Mapping CO/PO – PSO:

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

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**
  - Students develop and implement basic neural network models using Python frameworks such as TensorFlow/Keras, and analyze their performance on simple datasets.
  - Students apply optimization techniques, examine loss functions, and visualize convergence behavior to understand model training dynamics.
  - Students design and evaluate Convolutional Neural Network (CNN) models using pre-trained architectures, and assess the effectiveness of transfer learning.
  - Students implement LSTM and Transformer-based models for sequence prediction tasks, and analyze their performance on temporal and textual data.
  - Students generate images using Generative Adversarial Networks (GANs), evaluate model outputs for deep learning models.

- **Authentic Intelligence Reflection:**
  - Integrate theoretical concepts with practical implementation to build and evaluate deep learning models on real-world datasets.
  - Critically analyze model performance using optimization techniques, loss functions, and visualization of training behavior.
  - Reflect on the effectiveness of architectures such as CNNs, LSTMs, Transformers, and GANs in solving diverse problems.
  - Identify limitations, challenges, and potential improvements in deep learning models through experimentation.
  - Demonstrate awareness of ethical considerations and responsible use of AI while developing scalable and efficient solutions.

ASSESSMENT SCHEME :

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of NLM fundamentals and problem-solving approaches.

b. Continuous Assessment Tools (CAT – Six Components): Includes activities such as quizzes, project-based learning, seminars, reflection notes, model buildings.

c. **Lab Assessment:** Programming for solving real-world problems while simultaneously developing Authentic Intelligence through critical evaluation, model validation, ethical reasoning, and responsible decision-making

2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of Deep Learning concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	15
Mid-Semester Examination (MSE)	30
Lab Record	05
Lab Examination	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students leverage AI tools to design, analyze, and optimize deep learning models while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: AI-Generated Code Evaluation

Students prompt an AI tool:

"Generate a Convolutional Neural Network (CNN) model for image classification."

Students must:

1. Analyze the correctness of the generated architecture (layers, activation functions, parameters)
2. Identify design flaws or inefficiencies in the model

Improve the architecture (hyperparameter tuning, layer modification, regularization techniques)

Assignment 2: AI-Based Optimization Analysis

Students ask AI:

"Compare SGD and Adam optimizers with training results."

Students must:

1. Verify correctness of optimizer implementation and results
2. Compare convergence behavior and performance metrics
3. Analyze limitations and suitability for different deep learning tasks

Assignment 3: AI Debugging Challenge

Students prompt an AI tool:

" AI generates faulty code for LSTM/GAN code"

1. Identify and fix coding errors in model implementation
2. Analyze model structure and training issues
3. Evaluate limitations, instability (e.g., vanishing gradients, GAN mode collapse), and ethical concerns

Assignment 4: Model Interpretability

Students use AI visualization tools:

"Explain CNN predictions using Grad-CAM or similar techniques."

Students must:

1. Visualize feature maps and important regions influencing predictions
2. Interpret model decisions and identify biases or misclassifications
3. Evaluate transparency and reliability of deep learning models

Assignment 5: Performance Evaluation Study

Students prompt an AI tool:

"Train and evaluate deep learning models for a given dataset."

Students must:

1. Evaluate model performance (accuracy, precision, recall, F1-score)
2. Analyse computational efficiency (training time, inference time, resource usage)
3. Assess robustness, generalization, and behaviour on real-world data scenarios

Suggested Reading :

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
2. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, 2016, MIT Press.
3. Understanding Deep Learning, Simon J. D. Prince, 2023, MIT Press.
4. Deep Learning: Foundations and Concepts, Christopher M. Bishop and Hugh Bishop, 2023, Springer.
5. Deep Learning with Python (2nd Edition), François Chollet, 2021, Manning Publications.

E-Resources : (Recommended Tools)

- ChatGPT / Gemini for ideation
- Programming: Python (TensorFlow, Keras, PyTorch)
- Visualization: Matplotlib, Seaborn
- AI Tools: ChatGPT, GitHub Copilot, AutoML tools
- https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+C-TC-01+V1
- https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+C-MF-02+V1
- https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-05+V1
- https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-01+V1

Activity Based Learning (Suggested Activities in Class)

1. Explore the recent research article related to Deep Learning Techniques and Build a DL Framework.
2. Collaborative Activity of carrying out Experimentation using Different Models.

LAB EXERCISES

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
MODULE I · Exercises 1–2 : Perceptron (04 Hours)					
1	single unit perceptron	Design a single unit perceptron for classification of a linearly separable binary dataset	Python	2 h	CO1

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
2	Multi layer perceptron	Design a Multilayer perceptron to demonstrate the classification of non-linear data.	Python	2 h	CO1
MODULE II · Exercises 3–4 : Feed Forward with Back Propagation (04 Hours)					
3	Feed Forward	Design and implement an Image classification model to classify a dataset of images using Deep Feed Forward NN. Record the accuracy corresponding to the number of epochs.	Python	2 h	CO2
4	Back Propagation	Design and implement an Image classification model to classify a dataset of images using back Propagation. Record the accuracy corresponding to the number of epochs.	Python	2 h	CO2
MODULE III · Exercises 5–7 : Convolutional Neural Network (06 Hours)					
5	CNN	Design a Convolutional Neural Network (CNN) and analyse the performance of CNN on the image dataset. a. Load the dataset as input. b. Change the hyper-parameter (Varying with different convolutional8 and pooling layer) of classification model and analyze its performance. c. valuate and compare the model performance by using metrics – classification accuracy and Binary Cross Entropy Loss.	**Python**	**2 h**	**CO3**

6	CNN	Design and implement a CNN model (with 2+ layers of convolutions) to classify multi category image datasets. Use the concept of padding and Batch Normalization while designing the CNN model. Record the accuracy corresponding to the number of epochs.	**Python**	**2 h**	**CO3**
7	CNN	Design and implement a CNN model (with 4+ layers of convolutions) to classify multi category image datasets. Use the concept of regularization and dropout while designing the CNN model. Use the Fashion MNIST/MNIST/CIFAR10 datasets. Record the Training accuracy and Test accuracy corresponding to the following architectures. a) Base Model b) Model with L1 Regularization c) Model with L2 Regularization d) Model with Dropout	**Python**	**2 h**	**CO3**
MODULE III · Exercises 8–9 : CNN Variants (06 Hours)					
8	VGG 16 and VGG 19	Implement the standard VGG-16 and VGG -19 architecture model to classify multi category image dataset and check the accuracy.	Python	4 h	CO3
9	Resnet	Implement the standard Resnet architecture model to classify multi category image dataset and check the accuracy.	Python	2 h	CO3
MODULE IV · Exercises 10–11 : RNN & LSTM (06 Hours)					
10	RNN, LSTM	Develop an RNN-LSTM model for stock price prediction using TensorFlow.	Python	4 h	CO4
11	Bi-LSTM	Implement Bidirectional LSTM for sentiment analysis on movie reviews/other dataset and tabulate the results.	Python	2h	CO4
MODULE V · Exercises 12 : Case Study (04 Hours)					

S.No	**Exercise Title**	**Aim / Objective**	**Tools & Dataset**	**Hrs**	**CO**
12	Case Study	Anomaly Detection Predictive Maintainance	Python	4 h	CO5

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GENERATIVE AI

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

SEMESTER - V

Course Code	**:** 24AM3504	**Credits**	**:** 04
Hours / Week	**:** 05	**Total Hours**	**:** 45+30
L–T–P–J	**:** 3–0–2–0	**CIE+SEE**	**:** 60+40 Marks

Course Vision:

To develop students' ability to understand, design, and apply generative AI models across text, image, and multimodal domains, while integrating AI-assisted tools, critical evaluation of generated outputs, NVIDIA DLI certified learning pathways, and responsible engineering judgment.

Course Description:

This course introduces generative models and AI systems capable of creating text, images, audio, and multimedia content. Students learn transformers, diffusion models, LLMs, and prompt engineering techniques. The course focuses on innovation, ethical AI usage, and creative AI applications.

Course Objectives:

This course will enable students to:

1. To understand the fundamental concepts, architectures, and applications of Generative AI across modalities.
2. To apply prompt engineering techniques for effective interaction with generative models and large language models.
3. To analyze generative model architectures including VAEs, GANs, transformers, GPT, RoBERTa, diffusion models, and orchestration frameworks (LangChain, AutoGen).
4. To evaluate and compare different large language models for real-world text processing applications.
5. To design AI agent workflows and autonomous systems with planning, memory, and tool use capabilities.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

Introduction to Generative AI

Topics: Landscape and hierarchy of Generative AI (conceptual framing pre-studied via DLI); domain-specific applications in healthcare, finance, creative industries, engineering; hands-on categorization of GenAI tools by architecture and modality (ChatGPT, Claude, DALL-E, Stable Diffusion); ethical considerations — bias amplification, deepfakes, intellectual property, environmental cost of training.

Applications: Content generation in media, drug discovery, synthetic data for engineering simulations, automated design and prototyping.

MODULE – II	**09 Hours**

Prompt Engineering

Topics: 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 not covered in the DLI course. – Overview of SLM.

Applications: Automated report generation, code generation assistants, customer service automation, educational content creation.

MODULE – III	**09 Hours**

Generative AI Architectures — Transformers, GPT, Diffusion

Topics: 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, RoBERTa), decoder-only (GPT), encoder-decoder (T5) comparison, - Basics of GAN's.

Applications: Machine translation, text summarization, code completion, image captioning, question answering, text-to-image generation.

MODULE – IV	**09 Hours**

Language Models & LLM Architectures

Topics: 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 (covered in depth via DLI); alignment techniques including RLHF (Reinforcement Learning from Human Feedback) and DPO.

Applications: Sentiment analysis, document classification, chatbots, knowledge extraction, legal document analysis, scientific literature review, TCR/OCR (text and optical character recognition) classification.

MODULE – V	**09 Hours**

AI Agents & Agentic Workflows

Topics: 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 framework — primary focus for agentic AI workflows — alongside 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.

Applications: Autonomous research assistants, multi-agent software development, enterprise workflow automation, supply chain optimization.

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

Authentic Intelligence :

1. Introduction to GenAI: Students critically assess hallucination, bias amplification, and the environmental cost of training; they evaluate ethical considerations around deepfakes and intellectual property and reflect on when AI-generated content requires mandatory human verification.

2. Prompt Engineering: Students evaluate when prompt engineering is the right tool versus when fine-tuning or RAG architectural changes are needed, developing engineering judgment about scope, cost, and security implications; they explore defensive prompting and prompt injection risks.

3. GenAI Architectures: Students discuss the interpretability of transformer models and the reliability of attention as an explanation mechanism, reflecting on what 'understanding' means for a model that generates statistically plausible but potentially factually incorrect text.

4. Language Models & LLMs: Students analyze LLM limitations — training data biases, knowledge cutoffs, and the critical importance of grounding outputs in verified sources rather than accepting plausible-sounding content uncritically.

5. AI Agents: Students discuss when autonomous agents should defer to human judgment, the alignment problem in agent design, and the risks of uncoordinated multi-agent systems; they propose human-in-the-loop safeguards and define trust boundaries for autonomous deployment.

AI Integration :

1. Introduction to GenAI: Students explore popular generative AI tools (ChatGPT, Claude, DALL-E, Stable Diffusion), categorize them by architecture and modality, and compare outputs across generative model types.

2. Prompt Engineering: Students complete DLI hands-on labs on HuggingFace Transformers, encoder/decoder models, LangChain state management, fine-tuning techniques, and RAG fundamentals; classroom session debriefs results and compares strategies across zero-shot, few-shot, and chain-of-thought techniques.

3. GenAI Architectures: Students visualize attention weights and latent spaces using BertViz; compare BERT, RoBERTa, GPT-2, and T5 outputs on the same task; run Stable Diffusion with varying CFG scales and ControlNet conditioning to understand diffusion model behavior.

4. Language Models & LLMs: Students compare multiple LLMs (GPT-4, Claude, LLaMA, Gemini) on standardized tasks using perplexity, BLEU, and ROUGE; DLI course on Evaluating RAG and Semantic Search provides quantitative retrieval and deployment evaluation skills.

5. AI Agents: Students build an AI agent using LangChain or CrewAI demonstrating planning, memory-augmented reasoning, and tool use; DLI course on Techniques for Improving RAG provides advanced retrieval patterns for robust agent grounding.

Course Outcomes:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the fundamental concepts, hierarchy, and applications of Generative AI across modalities.	L2
2	Apply prompt engineering strategies (zero-shot, few-shot, chain-of-thought) for effective interaction with generative models.	L4
3	Analyze generative model architectures including transformers, GPT, BERT, T5, and diffusion models.	L4
4	Evaluate different large language models on standardized tasks using perplexity, BLEU, ROUGE, human evaluation, and alignment techniques (RLHF).	L3
5	Design AI agent workflows with planning, memory, and tool use for autonomous task execution using LangChain/CrewAI.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	1	2	–	–	2	1	–	–	3	2
CO-2	3	3	1	1	3	–	–	1	1	–	–	2	3
CO-3	3	3	1	2	2	–	–	1	1	–	–	3	3
CO-4	2	2	2	3	2	–	–	2	1	–	–	2	3
CO-5	3	2	3	3	3	1	–	1	2	1	2	3	3

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

ASSESSMENT SCHEME :

3. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of NLM fundamentals and problem-solving approaches.

b. Continuous Assessment Tools (CAT – Six Components): Includes activities such as quizzes, project-based learning, seminars, reflection notes, model buildings.

c. Lab Assessment: Programming for solving real-world problems while simultaneously developing Authentic Intelligence through critical evaluation, model validation, ethical reasoning, and responsible decision-making

4. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of Deep Learning concepts, application skills, and their ability to analyze and solve problems effectively.

B. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	15
Mid-Semester Examination (MSE)	30
Lab Record	05
Lab Examination	10
Total	**60 marks**

TEXT BOOKS:

1. David Foster, *Generative Deep Learning*, 2nd Edition, O'Reilly Media, 2023.
2. Numa Dhamani and Maggie Engler, *Introduction to Generative AI*, Manning Publications, 2024.

REFERENCE BOOKS:

1. Chip Huyen, *AI Engineering: Building Applications with Foundation Models*, O'Reilly Media, 2025.
2. Valentina Alto, *Modern Generative AI with ChatGPT and OpenAI Models*, Packt Publishing, 2023.
3. Ashish Vaswani et al., *Attention Is All You Need*, NeurIPS 2017.

E-RESOURCES:

1. https://huggingface.co/learn/nlp-course (Hugging Face NLP Course)
2. https://www.deeplearning.ai/short-courses/ (DeepLearning.AI LLM & RAG Courses)
3. https://www.promptingguide.ai/ (Prompt Engineering Guide)
4. https://python.langchain.com/ (LangChain Documentation)
5. https://web.stanford.edu/class/cs224n/ (Stanford CS224N: NLP with Deep Learning)

NVIDIA DLI: Generative AI Explained (2 hrs, FREE) — Foundational overview of GenAI concepts, hierarchy (AI→ML→DL→GenAI), model types (VAE, GAN, diffusion, transformer), domain applications, and ethical challenges. Ideal as pre-reading before Unit 1. URL: https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-07+V1

NVIDIA DLI: Rapid Application Development With Large Language Models (8 hrs, $90) — Covers HuggingFace Transformers API, encoder and decoder models, LangChain state management, multimodal formulations, and RAG fundamentals with hands-on GPU labs. Reinforces Unit 2. URL: https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+C-FX-09+V1

NVIDIA DLI: Introduction to Multimodal Data Curation (1 hr, FREE) — NeMo Curator for processing text, image, and video data at scale; synthetic data pipelines for training and customizing generative models. Supports Unit 3. URL: [Verify at learn.nvidia.com]

NVIDIA DLI: Evaluating RAG and Semantic Search Systems (3 hrs, $30) — RAG evaluation metrics (recall, MRR, NDCG, faithfulness), semantic search scoring, enterprise retrieval challenges, and deployment considerations for production systems. Supports Unit 4. URL: [Verify at learn.nvidia.com]

NVIDIA DLI: Techniques for Improving the Effectiveness of RAG Systems (4 hrs, $30) — Advanced RAG patterns: query transformation, re-ranking, chunk size optimization, metadata filtering, and evaluation-driven iteration for more reliable agent grounding. Supports Unit 5. URL: [Verify at learn.nvidia.com]

RECOMMENDED TOOLS

Python 3.10+, PyTorch, TensorFlow, Hugging Face
Transformers Agent Frameworks: LangChain, LangGraph,
CrewAI, AutoGen LLM APIs: OpenAI, Anthropic Claude,
Google Gemini, NVIDIA NIM Visualization: Matplotlib, BertViz
(attention), t-SNE / UMAP
Vector Stores: ChromaDB, FAISS, Pinecone — chromadb.com

LAB EXERCISES

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
UNIT I · Exercises 1–3 : Foundations of Generative AI (06 Hours)					
1	**GenAI Environment Setup & Model Exploration**	Configure Python GenAI stack (Transformers, Diffusers, OpenAI SDK); load pretrained models; explore GPT-2, Stable Diffusion outputs; document differences across architectures.	Python, Transformers, Diffusers, Gradio **Dataset:** *Hugging Face Hub (pretrained checkpoints)*	2 h	**CO1**
2	**Iterative Prompt Engineering Lab**	Design zero-shot, few-shot, and chain-of-thought prompts for the same task; systematically evaluate output quality and hallucination rates; document iteration improvements.	Python, LangChain, OpenAI/Anthropic API **Dataset:** *Diverse task suite (summarization, reasoning, code gen)*	2 h	**CO1**
3	**Simple RAG Pipeline**	Build a simple RAG pipeline with ChromaDB for document retrieval; compare LLM output accuracy before and after grounding with retrieved context.	LangChain, ChromaDB, Python **Dataset:** *University FAQ corpus or Wikipedia subset*	2 h	**CO1**
UNIT II · Exercises 4–5 : Transformer Architecture Deep-Dive (04 Hours)					
4	**Attention Mechanism Implementation**	Implement multi-head self-attention from scratch in PyTorch; verify correctness against a reference transformer block.	PyTorch, NumPy **Dataset:** *UCI Adult Income Dataset*	2 h	**CO1**
5	**BERT vs GPT Comparison**	Load pretrained BERT (encoder) and GPT-2 (decoder); compare on classification vs. generation tasks; visualize attention patterns with BertViz.	Hugging Face Transformers, BertViz **Dataset:** *UCI Adult Income Dataset*	2 h	**CO1**
UNIT III · Exercises 6–7 : Diffusion & Multimodal Generation (04 Hours)					
6	**Diffusion Model Inference & Control**	Run Stable Diffusion inference with varying CFG scales and step counts; generate images with ControlNet conditioning; evaluate prompt fidelity.	Diffusers, PyTorch **Dataset:** *Custom prompts + ControlNet reference poses*	2 h	**CO2**

7	**CLIP / BLIP Multimodal Experimentation on Images and Text**	Use CLIP/BLIP for image captioning and visual Q&A; evaluate behavior on ambiguous images and adversarial captions to identify failure modes across modalities.	Transformers, CLIP, BLIP **Dataset:** *COCO Captions subset*	2 h	**CO2**
UNIT IV · Exercises 8–10 : LLM Fine-Tuning & Evaluation (06 Hours)					
8	**LoRA Fine-Tuning of Pretrained LLM**	Fine-tune a 7B-parameter LLM using LoRA on a domain-specific dataset; measure perplexity, task accuracy, and training cost.	PEFT, Transformers, bitsandbytes **Dataset:** *Custom domain corpus (legal / medical / technical)*	2 h	**CO2**
9	**LLM Evaluation Pipeline**	Build an automated pipeline comparing 3 LLMs on a task suite; compute BLEU, ROUGE, perplexity; conduct structured human evaluation.	Hugging Face evaluate, nltk **Dataset:** *Custom task suite (summarization, Q&A, generation)*	2 h	**CO3**
10	**LLM Inference Sizing & Cost Analysis**	Benchmark LLM inference with varying batch sizes, precision (FP16/INT8), and KV-cache strategies; compute cost per 1M tokens.	vLLM, NVIDIA NIM, TensorRT-LLM **Dataset:** *Standard benchmark prompts*	2 h	**CO4**
UNIT V · Exercises 11–12 : AI Agent Design & Capstone (10 Hours)					

S.No	Exercise Title	Aim / Objective	Tools & Dataset	Hrs	CO
11	**AI Agent with Tool Use & Memory**	Build a ReAct agent with LangChain/CrewAI using web search, calculator, and retrieval tools; evaluate reliability; document failure modes.	LangChain, CrewAI, Python **Dataset:** *Multi-hop research questions*	4 h	**CO4**
12	**End-to-End Generative AI Application (Capstone)**	Design a complete GenAI application: problem framing → model selection → prompt engineering → RAG integration → agent orchestration → evaluation → NIM deployment.	Full stack: PyTorch, Transformers, LangChain, ChromaDB, NVIDIA NIM **Dataset:** *Student-chosen domain problem*	6 h	**CO5**

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SUSTAINABLE GREEN AI COMPUTING

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

SEMESTER - V

Subject Code	:	26AM3505	**Credits**	:	02
Hours / Week	:	02 Hours	**Total Hours**	:	30 Hours
L–T–P–S	:	2–0–0–0	**CIA +SEE**	:	60 + 40

Course Vision:

The course envisions developing environmentally responsible engineers who can design and deploy energy-efficient computing systems and AI solutions. It aims to integrate sustainability principles with modern computing technologies to reduce carbon footprints and optimize resource utilization. The course promotes awareness of green computing practices across hardware, software, and data centers. It emphasizes innovation in Green AI techniques that balance performance with energy efficiency. Ultimately, the vision is to prepare learners to contribute toward sustainable digital transformation and environmentally conscious AI development.

Course Description:

This course explores energy-efficient AI systems, sustainable computing practices, and environmentally responsible AI deployment strategies. Students learn optimization techniques for reducing computational costs and carbon footprint. The course emphasizes sustainable and ethical AI innovation.

Course Learning Objectives:

This course will enable students to:

1. Understand the environmental impact of computing systems and AI technologies.
2. Explore sustainable software and hardware design principles.
3. Learn techniques for developing energy-efficient AI models.
4. Analyze green data center strategies and renewable energy integration.
5. Evaluate ethical, policy, and lifecycle aspects of sustainable computing.

Teaching-Learning Process (General Instructions)

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

a. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
b. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
c. Showing **Video/animation** films to explain functioning of various concepts.
d. Encourage **Collaborative** (Group Learning) Learning in the class.
e. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
f. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**06 Hours**

Introduction to Green Computing & Sustainability

Topics: Introduction, Definition, Environmental impact of IT: Energy consumption, carbon footprint, e-waste - Green IT frameworks (Green IT 1.0 vs 2.0) - Sustainability metrics and KPIs

- Sustainable software engineering principles ***Applications:*** Carbon footprint analysis tools, sustainable IT practices in enterprises

MODULE – II	**06 Hours**
Green AI and Sustainable Algorithms **Topics :** Green AI vs Red AI (efficiency vs performance trade-offs) - Model optimization: pruning, quantization, knowledge distillation - Efficient training strategies - Carbon-aware computing and workload schedulingAI Problems. ***Applications:*** Efficient NLP and vision models, low-power AI systems.	
MODULE – III	**06 Hours**
Green Data Centers and Hardware **Topics :** Energy-efficient processors and hardware design - Cooling technologies and thermal management - Data Center Infrastructure Management (DCIM)- Renewable energy integration in data centers ***Applications:*** Cloud sustainability, energy-efficient server management.	
MODULE – IV	**06 Hours**
AI for Environmental Sustainability **Topics :** AI for climate modeling and prediction - Environmental monitoring using AI - Smart agriculture and resource optimization - AI in energy systems and smart grids. ***Applications***: Precision agriculture, disaster prediction systems.	
MODULE – V	**06 Hours**
Authentic Intelligence in Emerging Intelligent Systems **Topics :** Green computing policies and global standards - Ethical AI and sustainability governance - Circular economy and hardware lifecycle management - Future trends: Neuromorphic computing, quantum-efficient AI. ***Applications:*** Sustainable AI governance, eco-friendly system design	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze environmental impact of computing systems	L4
2	Apply Green AI techniques for efficient models	L3
3	Evaluate sustainable computing strategies	L3
4	Design energy-efficient AI and IT systems	L5
5	Examine ethical and policy implications in Green AI	L3

Mapping Levels of COs to POs/PSOs

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

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

RESEARCH INTEGRATION TEACHING

1. Paper Review: Students study recent AI research on agents, search, and reasoning.
2. Case Studies: Analyze real-world AI systems to link theory with practice.
3. Mini Presentation: Present short reviews on emerging AI topics.
4. AI-Assisted Research: Use AI tools for summarization and comparison of studies.
5. Critical Reflection: Identify research gaps, limitations, and ethical issues.

ASSESSMENT SCHEME :

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.
    c. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT) every 2 weeks (Minimum 06 assessments)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**60 marks**

Text Books:

1. Green Computing and Green IT: Energy-Efficient Computing, J. Harris, 2023, CRC Press.
2. Sustainable Computing: Principles and Practice, A. Hurson, 2022, Wiley Publications.
3. Energy-Efficient Machine Learning and AI, Y. H. Lu, 2023, Springer Publications.
4. Architecting the Cloud: Design Decisions for Cloud Computing Service Models, M. J. Kavis, 2021, Wiley Publications.

Reference Books:

1. Bratko, — Prolog: Programming for Artificial Intelligence||, Fourth edition, Addison-Wesley Educational Publishers Inc., 2011.
2. M. Tim Jones, — Artificial Intelligence: A Systems Approach (Computer Science) ||, Jones and Bartlett Publishers, Inc.; First Edition, 2008.
3. William F. Clocksin and Christopher S. Mellish, Programming in Prolog: Using the ISO Standard||, Fifth Edition, Springer, 2003.

E-Resources : (Recommended Tools)

- NPTEL – Green Computing
- IEEE Xplore Digital Library (Green AI research papers)
- Google AI – Green AI and sustainability research
- Microsoft Research – Sustainable AI initiatives
- United Nations Environment Programme – Digital sustainability resources

Activity Based Learning (Suggested Activities in Class)

1. Students work in small groups to analyze the energy consumption and carbon footprint of a real-world AI application (e.g., chatbot, recommendation system). They will estimate energy usage, identify inefficiencies, and propose Green AI techniques such as model optimization or efficient deployment strategies.
2. Students collaboratively design a simple AI model (e.g., classification or prediction task) and apply techniques like pruning, quantization, or lightweight model selection to reduce energy consumption. They will compare performance vs efficiency and present findings with sustainability metrics.

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Design studio- IV

Innovation, Design Thinking & Intellectual Property

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

SEMESTER – V

Subject Code	: **26AM3506**	**Credits**	: 02
Hours / Week	: 02 Hours	**Total Hours**	: 30 Hrs (15Hrs T+15 Hrs J)
L–T–P-J	: 1–0–0-2	**CIA**	: 100

Course Vision This course introduces students to the principles and practices of innovation and design thinking, emphasizing a user-centric approach to solving real-world problems. It enables learners to understand the complete innovation lifecycle—from problem identification and ideation to prototyping and solution development—using structured design methodologies.

Course Description : This course develops innovation and entrepreneurial thinking through design thinking methodologies and intellectual property concepts. Students work on product ideation, prototyping, and patent-oriented innovation activities. The course encourages creativity, problem-solving, and startup-oriented thinking

Prerequisites: - Basic Problem Solving, Creativity, Communication Skills

Course Learning Objectives:

This Course will enable students to:

1. Understand principles of design thinking and innovation processes.
2. Apply user-centric approaches to identify and solve real-world problems.
3. Develop creative prototypes using design tools and methodologies.
4. Gain knowledge of intellectual property rights (IPR) and innovation protection.
5. Build collaborative and interdisciplinary problem-solving skills.

Teaching-Learning Process (General Instructions)

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

a. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
b. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
c. Showing **Video/animation** films to explain functioning of various concepts.
d. Encourage **Collaborative** (Group Learning) Learning in the class.
e. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
f. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**03 Hours**

Introduction to Design Thinking & Innovation: Design thinking process (Empathise, Define, Ideate, Prototype, Test), Innovation types, Case studies (product/service innovation). **Applications:** Solving campus and community problems. **AI Integration:** Use of AI tools for idea generation and user insight analysis. **Authentic Intelligence:** Understanding real user needs vs assumed needs.

MODULE – II	**03 Hours**

Empathy & Problem Definition: User research methods (interviews, observation), Persona creation, Journey mapping, Problem framing, Design challenges. **Applications:** Identifying real-world problems in healthcare, education, smart cities. **AI Integration:** AI-based sentiment analysis and user feedback interpretation. **Authentic Intelligence:** Ethical data collection and unbiased problem identification.

MODULE – III	**03 Hours**

Ideation & Concept Development: Brainstorming techniques, SCAMPER, Mind mapping, Concept selection, Feasibility analysis. **AI Applications:** Innovative product/service design. **AI Integration:**

Generative AI for idea expansion and concept visualisation. **Authentic Intelligence:** Originality vs AI-generated ideas—critical evaluation.

MODULE – IV	03 Hours
Prototyping & Testing: Low-fidelity and high-fidelity prototypes, Wireframing, MVP development, User testing, Feedback loops. **Applications:** App prototypes, IoT concepts, service models. **AI Integration:** AI-assisted prototyping tools and UI/UX generators. **Authentic Intelligence:** Importance of human validation in AI-generated designs.	
MODULE – V	**03 Hours**
Intellectual Property & Innovation Protection: Types of IP (Patents, Copyrights, Trademarks, Trade secrets), Patent filing process, Prior art search, Technology transfer. **Applications:** Protecting student innovations and startup ideas. **AI Integration:** AI tools for patent search and novelty detection. **Authentic Intelligence:** Ethical innovation and avoiding plagiarism.	

Recommended Tools

- Design Tools: Figma, Canva, Adobe XD
- Prototyping: Balsamiq, Tinkercad
- AI Tools: ChatGPT, Ideation tools, UI generators
- IP Tools: Google Patents, WIPO databases

Laboratory / Studio Component

1. Identify a real-world problem through field observation.
2. Conduct user interviews and create personas.
3. Develop problem statements and design challenges.
4. Perform ideation sessions (brainstorming, SCAMPER).
5. Create low-fidelity prototypes (paper/wireframes).
6. Develop digital prototypes using design tools.
7. Conduct user testing and collect feedback.
8. Perform basic patent search for the idea.
9. Prepare IP strategy for the solution.
10. Final design showcase + innovation pitch.

Integrated Tools for Studio

- Software: Figma, Canva, Tinkercad
- Platforms: Google Forms (user feedback), Miro (brainstorming)
- AI Tools: Generative AI tools for ideation and prototyping
- IP Platforms: Google Patents, WIPO

Course Outcomes:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply design thinking methodologies to identify user needs and problem statements	L3
2	Innovative solutions through ideation and prototyping	L3
3	Use modern tools for rapid prototyping and design validation	L3
4	Analyze user requirements and evaluate alternative design solutions	L4
5	Work collaboratively to design and present innovative solutions	L3

Mapping Levels of COs to POs/PSOs

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**
CO-1	1	1	3	2	2	2	2	-	2	2	2	3	3
CO-2	2	1	2	3	2	3	2	-	2	3	2	3	3
CO-3	1	1	2	3	2	3	1	-	1	2	2	3	2
CO-4	1	1	1	2	1	2	2	1	3	1	2	3	-
CO-5	1	1	2	3	1	2	2	-	2	3	3	3	-

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

TEXT BOOKS

1. Change by Design – Tim Brown Covers fundamentals of design thinking, innovation strategies, and human-centered design (CO1, CO2, CO3).
2. Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days – Jake KnappFocuses on rapid prototyping, ideation, and solution validation
3. WIPO Intellectual Property Handbook – World Intellectual Property Organization Provides comprehensive understanding of IPR concepts, laws, and protection mechanisms (CO1, CO5).

REFERENCE BOOKS

1. IDEO Design Thinking Resources Practical toolkits, case studies, and real-world applications of design thinking (CO2, CO3, CO4).
2. Stanford school Materials Structured methodologies, design frameworks, and collaborative innovation practices
3. The Design of Everyday Things – Don Norman Enhances understanding of user experience and usability principles (CO2, CO3).
4. Creative Confidence – Tom Kelley, David Kelley

E-RESOURCES

1. World Intellectual Property Organization – Official Learning Resources https://www.wipo.int (IPR tutorials, case studies, global standards
2. IDEO U – Design Thinking Courses https://www.ideou.com (Hands-on innovation and design thinking modules
3. Stanford University – d.school Open Resources https://dschool.stanford.edu/resources (Design thinking toolkits and guides
4. Coursera / edX (Courses on innovation, design thinking, and IPR
5. Google Patents https://patents.google.com (Patent search and analysis for practical IPR Understanding

Evaluation Scheme (2-Credit Studio)

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

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Accelerated Data Science

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

SEMESTER-V

Course Code	**:** 26AM3508	**Credits**	**:** 03
Hours/Week	**:** 03	**Total Hours**	**: 45(15Hrs Project)**
L–T–P–J	**: 2**–0–0–2	**CIE**	**: 100** Marks

Course Vision:

To empower the ability to harness modern data science techniques and GPU-accelerated computing frameworks for solving real-world problems, while promoting ethical, scalable, and efficient data-driven decision-making aligned with industry standards. The course envisions developing skilled professionals who can integrate advanced analytics, machine learning, and high-performance computing to build impactful, responsible, and future-ready AI solutions across diverse domains.

Course Description:

This course focuses on high-performance data analytics techniques and accelerated computing approaches for large-scale data processing. Students learn optimized workflows, data pipelines, and AI-driven analytics methods. The course prepares students for advanced data science applications.

Course Objectives:

This course will enable students to:

1. To introduce students to the fundamentals of data science and the role of GPU-accelerated computing using NVIDIA RAPIDS for efficient data processing.
2. To develop the ability to perform data collection, preprocessing, and ETL operations for handling real-world datasets.
3. To enable students to understand ethical considerations, bias, and responsible practices in data science and AI systems.
4. To equip learners with skills in data analysis, visualization, and interpretation using modern tools and techniques.
5. To provide foundational knowledge of scalable computing and machine learning methods for building high-performance data-driven applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that a teacher can use to accelerate the attainment of the various course outcomes:

1. **Lecture method:** Along with the traditional lecture method, different types of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and role-playing.
3. Showing **video/animation** films to explain the functioning of various concepts.
4. Encourage **collaborative** (group learning) learning in the class.
5. To foster critical thinking by asking higher-order thinking questions in the class in the form of quizzes and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE– I	10 Hours
Introduction to data science and rapids **Topics:** Accelerating End-to-End Data Science Workflows, Fundamentals of Data Science, Data Science lifecycle and workflow, Introduction to NVIDIA RAPIDS framework, GPU vs CPU computing in data science, Overview of accelerated analytics. **Applications**: Analyzing and Visualizing Large Data using Accelerated Computing - Interactive data visualization, GPU-accelerated visualization (cuDF, RAPIDS), Scalable visualization tools (hvPlot, Datashader), Dashboard development (Plotly Dash, cuXfilter), Large dataset visualization techniques, Real-time and exploratory data analysis, Applications (customer, geospatial, embeddings).	
MODULE – II	**8 Hours**
Data Collection and Preprocessing (ETL) **Topics:** Data acquisition techniques Collecting Data, Data cleaning and preprocessing Scraping Data, ETL (Extract, Transform, Load) pipeline, handling missing and noisy data SQLite as Simple, Effective Storage, Feature engineering basics SQL Refresher - Beware of Missing Indexes **Applications:** Feature scaling and normalization techniques, Dimensionality reduction (PCA, UMAP concepts), Hyper parameter tuning (grid search, optimization basics), Model performance evaluation metrics, Handling imbalanced datasets, End-to-end ML pipeline optimization.	
MODULE – III	**9 Hours**
Data Ethics and Bias in Data Sets **Topics:** Ethical issues in data science, Bias in datasets and algorithms, Fairness and accountability, Responsible AI practices, Case studies on bias mitigation, Introduction to Data Pre-processing, Data Cleaning and Statistical Preprocessing, Data Cleaners: OpenRefine and Wrangler, Feature Selection: Introduction to Filter Methods, Feature Selection: Introduction to Model-based Methods, Feature Reduction: PCA **Applications:** AI-Based Recruitment System, Healthcare Prediction System, Loan Approval and Credit Scoring, Customer Recommendation Engine, Smart Crime Analysis System.	
MODULE – IV	**10 Hours**
Data Ethics and Reducing Bias in Data Sets **Topics:** Sources of Bias and Fairness Measures, Tools for Discovering and Interpreting Bias in Models, Challenges Faced by Underrepresented Groups, Data integration techniques, Exploratory Data Analysis (EDA), Statistical analysis methods, Data visualization techniques, Tools for analytics (RAPIDS, Python libraries). **Applications:** Fair Hiring and Resume Screening Systems, Inclusive Healthcare Risk Prediction, Fair Loan and Insurance Decision Systems, Customer Behavior Analytics and Personalization, Social Media Sentiment and Bias Detection.	
MODULE – V	**08 Hours**
Scalable Computing and Machine Learning **Topics:** Scalable and distributed computing concepts, GPU-accelerated computing frameworks, Introduction to Machine Learning, Neural Networks basics, Graph analytics fundamentals **Applications:** Large-Scale Fraud Detection Systems, Real-Time Image and Video Recognition, Smart Traffic and Route Optimization, Social Network Graph Analysis, Predictive Maintenance in Industry.	

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain GPU-accelerated data processing, visualization, and machine learning concepts.	L2
2	Apply machine learning algorithms and data processing techniques for real-world problems.	L3
3	Analyze large-scale datasets, clustering methods, and forecasting models.	L4
4	Evaluate graph-based AI systems, RAG pipelines, and distributed AI applications.	L5
5	Evaluate AI system performance, security threats, and deploy scalable AI solutions.	L5

Mapping Levels of Cos to POs/PSOs

Table:MappingLevelsofCOstoPOs/PSOs													
COS	ProgramOutcomes(POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO-1	3	2	1	1	2	2	–	3	–	–	2	3	3
CO-2	2	2	1	1	2	2	–	2	–	–	–	2	2
CO-3	3	2	2	1	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3
CO-5	3	2	2	1	3	3	–	3	2	2	2	3	3

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration:

1. AI is integrated through GPU-accelerated data science workflows using tools like RAPIDS and NVIDIA Triton Inference Server. Students apply AI models such as XGBoost and cuML for large-scale data processing, visualization, and real-time analytics. Integration focuses on handling big data efficiently and deploying AI models in production environments.
2. AI is integrated through advanced feature engineering and optimization techniques using GPU-accelerated libraries like cuDF and cuML. Students implement clustering algorithms (K-Means, DBSCAN) and dimensionality reduction methods (PCA, UMAP) to improve model performance. AI integration emphasizes building efficient ML pipelines and improving predictive accuracy for real-world datasets.
3. This module integrates AI into domain-specific applications such as time series forecasting and financial modeling. Using GPU-based tools and optimization frameworks like cuOpt, students develop AI models for forecasting trends and optimizing portfolios. AI is applied to solve real-world problems in finance and analytics with high computational efficiency.
4. AI is integrated through advanced techniques like Graph AI and Retrieval-Augmented Generation (RAG). Students work with knowledge graphs using cuGraph and build

intelligent systems combining LLMs and vector databases. Frameworks like LangChain enable development of AI-powered applications such as semantic search, recommendation systems, and question-answering pipelines.

5. This module integrates AI security and robustness through adversarial machine learning. Students analyze vulnerabilities in ML and LLM systems, including attacks like data poisoning and prompt injection. AI integration focuses on developing secure, reliable, and ethical AI systems through testing, evaluation, and red-teaming methodologies.

TEXT BOOKS:

1. Aure´lien Ge´ron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2023.
2. Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter, 3rd Edition, O'Reilly Media, 2022.

REFERENCE BOOKS:

1. Cathy O'Neil & Rachel Schutt, Doing Data Science: Straight Talk from the Frontline, O'Reilly Media, 2023..
2. Chip Huyen, Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications, O'Reilly Media, 2022.

E-RESOURCES:

1. https://www.nvidia.com/en-us/training/self-paced-courses/Data-Science
2. https://www.coursera.org/browse/data-science
3. https://www.udemy.com/topic/data-science/ https://developer.nvidia.com/data-science-teaching-kit-syllabus

RECOMMENDED TOOLS

Python, Jupyter Notebook, RAPIDS, cuDF, cuML, cuGraph, cuPy, Dask, Pandas, NumPy, XGBoost, Scikit-learn, Triton Inference Server, Bokeh, hvPlot, Datashader, Plotly Dash, cuXfilter, NetworkX, UMAP, ARIMA/SARIMA (statsmodels), cuOpt, cuVS, Milvus, OpenAI APIs, NVIDIA NIM, BioNeMo, LangChain.

Evaluation Scheme :

Internal (100 Marks – No End Semester Exam Recommended) Component Marks

Continuous Assessment (Activities) 30

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

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LLM based Agent Frameworks

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

SEMESTER-V

Course Code	**:** 26AM3509		**Credits**	**:**	03
Hours/Week	**:** 03		**Total Hours**	**:**	45(15 Hrs Project)
L–T–P–J	**:** **2**–0–0–2		**CIE**	**:**	100 Marks

Course Vision:

To empower learners with strong foundations and practical expertise in Large Language Models and agent-based AI systems, enabling them to design, analyze, and deploy intelligent, scalable, and efficient AI solutions for real-world applications.

Course Description:

This course introduces frameworks for building autonomous AI agents using large language models. Students learn orchestration techniques, workflow automation, tool integration, and multi-agent collaboration. The course focuses on next-generation intelligent AI system.

Course Objectives:

This course will enable students to:

1. To understand the architecture and working principles of Large Language Models and transformers
2. To master practical techniques for building AI applications including prompt engineering and RAG
3. To implement agentic workflows and fine-tune models using parameter-efficient techniques
4. To design evaluation methodologies and optimize models for production deployment
5. To develop end-to-end AI engineering skills for real-world LLM applications.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE–I	**09 Hours**

INTRODUCTION TO AI ENGINEERING AND FOUNDATION MODELS:

Topics: The Rise of AI Engineering: From language models to large language models, from LLMs to foundation models, AI engineering vs ML engineering, the AI engineering stack. **Understanding Foundation Models**: Training data (Speech processing and domain-specific models), model size considerations, post-training (supervised fine-tuning, preference fine- tuning), sampling fundamentals and strategies, test-time compute, structured outputs, the probabilistic/deterministic AI. **Planning AI Applications**: Foundation model use cases (coding, writing, education, conversational bots, information aggregation, workflow automation), use case evaluation, setting expectations, milestone planning, cost and latency considerations, model build vs buy decisions, model econometrics.

MODULE – II	**09 Hours**

TRANSFORMER ARCHITECTURE AND LLM FUNDAMENTALS

Topics: Working with Text Data: Understanding word embeddings, tokenizing text (byte pair encoding), converting tokens to token IDs, adding special context tokens, data sampling with sliding window, creating token embeddings, encoding word positions. **Attention Mechanisms**: Exploring LCS (Long Common Sequences), capturing data dependencies with attention, self-attention mechanism (with and without trainable weights), computing attention weights, causal attention and masking future words, dropout in attention, multi-head attention. **Transformer Architecture:** Introduction to transformer architecture, encoder-decoder models, GPT architecture deep-dive. Implementing GPT Components: Layer normalization, feed-forward networks with GELU activations, shortcut connections, connecting attention and linear layers in transformer blocks, coding the GPT model, text generation mechanisms.

Applications : Smart autocomplete / text generation systems, document similarity and plagiarism detection, chatbots for customer support and FAQs, machine translation systems, text summarization tools, named entity recognition (NER) systems, sentiment analysis applications, code generation and explanation tools

MODULE – III	**09 Hours**

RETRIEVAL-AUGMENTED GENERATION & MODEL ORCHESTRATION:

Topics: Prompt Engineering: Introduction to prompting, in-context learning (zero-shot and few-shot), system prompts vs user prompts, context length and efficiency. **Best Practices**: Writing clear instructions, providing sufficient context, breaking complex tasks into subtasks, chain-of-thought prompting, iterative prompt development, evaluating prompt engineering tools, organizing and versioning prompts. **Defensive Prompting**: Proprietary prompts and reverse engineering, jail breaking and prompt injection attacks, information extraction risks, defenses against attacks. **RAG Fundamentals**: RAG architecture and workflow, when to use RAG vs fine-tuning, RAG limitations and challenges. Retrieval Systems: Dense retrieval (semantic search with embeddings), sparse retrieval (BM25, TF-IDF), hybrid retrieval strategies, vector databases and indexing (Pinecone, Weaviate, Chroma). **Retrieval Optimization**: Query transformation and expansion, re-ranking strategies, chunk size optimization, metadata filtering, evaluation metrics for retrieval (recall, MRR, NDCG), RAG beyond text (multimodal RAG).

Applications : Prompt engineering for chatbots and AI assistants, automated content generation systems, safe and secure AI interaction systems (defensive prompting), AI-powered search engines with semantic retrieval, retrieval-augmented generation (RAG) applications for knowledge bases, enterprise document question-answering systems, recommendation systems using hybrid retrieval, multimodal AI applications (text + image retrieval), AI tools for summarization and report generation

MODULE – IV	**09 Hours**

AGENT SYSTEMS AND FINE-TUNING TECHNIQUES:

Topics: Agent Systems: Agent overview and architecture, agentic workflows vs traditional pipelines, when to use agents. Agent Components: Tools and tool use (web search, calculators, databases), planning strategies (ReAct, tree-of-thoughts, chain-of-thought), agent memory (short-term and long-term), agent orchestration frameworks (LangChain, AutoGPT, AutoGEN). **Agent Challenges**: Failure modes and debugging, agent evaluation strategies, cost and latency optimization. **Fine-tuning Fundamentals**: When to fine-tune (vs RAG vs prompt engineering). **Parameter-Efficient Fine-Tuning (PEFT)**: LoRA (Low-Rank Adaptation) theory and implementation, QLoRA for memory efficiency.

Applications : AI agents for task automation and workflow management, intelligent virtual assistants with tool usage (search, calculators, databases), autonomous research agents for information gathering, multi-step reasoning systems using ReAct and chain-of-thought, enterprise AI copilots integrating tools and memory, debugging and evaluation systems for agent performance, domain-specific model fine-tuning applications, cost-efficient LLM customization.

MODULE – V	**09 Hours**

MODEL EVALUATION, INFERING AND DEPLOYMENT:

Topics: Evaluation Methodology: Challenges of evaluating foundation models, language modeling metrics (entropy, cross-entropy, perplexity, bits-per-character), exact evaluation methods, functional correctness, similarity measurements (lexical and semantic), introduction to embeddings. **AI as a Judge**: Why and how to use AI as judge, limitations, comparative evaluation and ranking models. **Evaluation Criteria**: Domain-specific capability, generation capability, instruction-following capability, cost and latency evaluation. **Designing Evaluation Pipelines**: Model selection workflow, navigating public benchmarks, evaluating all components in a system,creating evaluation guidelines, defining evaluation methods and data. **Inference Optimization**: Understanding inference optimization, inference overview, performance metrics (latency, throughput, TTFT, cost), AI accelerators (GPUs, TPUs). **Model Optimization**: Quantization (post-training and quantization-aware), pruning, knowledge distillation. **Inference Service Optimization**: Batching strategies, caching mechanisms, and model serving frameworks. **Applications** : model evaluation and benchmarking systems for LLMs, automated AI evaluation pipelines and scoring frameworks, AI-as-a-judge systems for response ranking and comparison, domain-specific model performance analysis tools, embedding-based similarity and semantic search systems, optimized inference systems for low-latency applications, scalable model deployment and serving frameworks

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the architecture of transformers and GPT models including attention mechanisms.	L2
2	Implement prompt engineering techniques and build RAG systems with retrieval optimization	L3
3	Design and implement agentic workflows and apply parameter-efficient fine-tuning (LoRA, PEFT).	L5
4	Develop comprehensive evaluation methodologies and pipelines for AI systems.	L5
5	Optimize LLM inference and deploy production-ready AI applications with monitoring.	L5

Mapping Levels of COs to POs/PSOs

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
CO-1	3	2	–	1	2	–	–	–	–	–	–	2	1
CO-2	2	3	2	2	3	–	–	–	1	–	–	3	2
CO-3	2	3	3	2	3	–	–	–	2	1	–	3	3
CO-4	2	3	2	3	2	–	–	–	1	1	–	2	3
CO-5	2	3	3	3	3	1	–	–	2	2	1	3	3

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

AI Integration

- AI is integrated in this unit through exploratory and application-based learning using tools such as ChatGPT and Google Gemini. Students interact with large language models to understand real-world AI applications, probabilistic outputs, and foundational concepts. Case studies on foundation models are discussed, and learners identify domain-specific AI use cases in areas like education, automation, and conversational systems, enabling conceptual clarity and practical exposure.

- This unit incorporates AI integration through hands-on implementation and experimentation with transformer models using libraries such as Hugging Face Transformers. Students perform tokenization, embedding generation, and attention visualization through coding exercises. They also experiment with pre-trained models to understand text generation and internal working of GPT architectures, thereby strengthening their foundational and analytical skills.

- This unit integrates AI through the development of intelligent agent systems using frameworks such as LangChain and AutoGPT. Students build agentic workflows capable of tool usage, planning, and memory handling. Additionally, they explore parameter-efficient fine-tuning concepts like LoRA through guided experiments, along with analysing real-world challenges in agent performance and debugging.

- AI integration in this unit emphasizes evaluation and deployment of AI systems in practical environments. Students apply evaluation metrics, use AI-as-a-judge techniques, and analyze model performance in terms of latency and cost. They also gain exposure to deploying AI models using APIs and cloud platforms, and perform optimization techniques such as quantization and caching. A mini-project involving end-to-end AI application deployment ensures industry readiness and hands-on expertise.

TEXT BOOKS:

1. Chip Huyen, AI Engineering: Building Applications with Foundation Models, O'Reilly ,Media, 2025.

REFERENCE BOOKS:

1. Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications, 2025.
2. Jay Alammar and Maarten Grootendorst, Hands-On Large Language Models, O'Reilly Media, 2024.

3. Lewis Tunstall, Leandro von Werra, and Thomas Wolf, Natural Language Processing with Transformers, O'Reilly Media, 2022.
4. Chip Huyen, Designing Machine Learning Systems, O'Reilly Media, 2022.
5. Ashish Vaswani et al., Attention Is All You Need, NeurIPS, 2017.

E-RESOURCES:

- Hugging Face NLP Course: https://huggingface.co/learn/nlp-course
- DeepLearning.AI Courses on LLMs, RAG, and Agents: https://www.deeplearning.ai/short-courses/ Stanford CS224N: Natural Language Processing with Deep Learning: https://web.stanford.edu/class/cs224n/
- LangChain Documentation: https://python.langchain.com/ OpenAI API Documentation: https://platform.openai.com/docs
- Papers with Code – Transformers: https://paperswithcode.com/methods/category/transformers AI Engineering Resources by Chip Huyen: https://github.com/chiphuyen/aie-book

RECOMMENDED TOOLS

Python, Jupyter Notebook, Google Colab, Hugging Face Transformers, LangChain, OpenAI API, Chroma, Pinecone, PyTorch, Weights & Biases.

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**

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Intelligent Speech Processing Systems

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

SEMESTER - V

Course Code	**:** 26AM3510	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	: 45(15Hrs Project)
L–T–P–J	**: 2**–0–0–2	**CIE**	**:** 100 Marks

Course Vision:

This course develops the ability to design, analyse, and evaluate intelligent speech processing and recognition systems by integrating speech signal processing, probabilistic modelling, deep learning, and responsible AI for real-world spoken language applications.

Course Description:

This course introduces speech recognition, speech synthesis, audio signal processing, and intelligent voice-enabled systems. Students learn AI techniques for spoken language understanding and conversational interfaces. The course focuses on modern speech AI applications.

Course Objectives:

Students will:

1. Understand the fundamentals of speech production, perception, and automatic speech recognition pipelines.
2. Apply speech signal processing and feature extraction techniques for speech analysis.
3. Analyze acoustic and language modelling approaches used in conventional ASR systems.
4. Evaluate deep learning and end-to-end methods for modern speech processing applications.
5. Design intelligent speech-enabled solutions with appropriate ethical and engineering judgment.

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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussion, group work, focused listening, problem formulation, note-taking, and classroom demonstrations.
3. Showing video/animation clips and speech demos to explain speech generation, signal analysis, and recognition workflows.
4. Encourage collaborative learning through mini case studies, waveform analysis, and toolkit-based exercises.
5. To make critical thinking, asking higher order thinking questions in the class in the form of quiz, interpretation of speech outputs, and model comparison.
6. Showing different ways to solve the same speech processing problem and encourage the students to come up with creative and responsible solutions.

MODULE – I	**08 Hours**

Foundations of Intelligent Speech Processing

Topics: Introduction to speech processing and speech-based AI systems, speech production mechanism, speech perception, characteristics of speech signals, speech representation, stages of intelligent speech processing systems, and challenges in speech understanding.

Applications: Voice assistants, spoken dialogue systems, dictation systems, and assistive communication tools.

MODULE – II	**09 Hours**

Speech Signal Processing and Feature Extraction

Topics: Sampling and quantization, pre-emphasis, framing, windowing, short-time analysis, time-frequency representation, spectrogram analysis, feature extraction methods such as MFCC, LPC, PLP, and filter-bank energies.

Applications: Keyword spotting, speaker interfaces, embedded speech systems, and robust front-end design.

MODULE – III	**08 Hours**

Acoustic and Language Modelling **Topics:** Acoustic modelling concepts, Hidden Markov Models, Gaussian Mixture Models, Baum-Welch training, Viterbi decoding, pronunciation lexicons, N-gram language models, and decoding strategies in conventional ASR systems. **Applications:** IVR systems, command-and-control interfaces, transcription engines, and speech analytics pipelines.	
MODULE – IV	**10 Hours**
Deep Learning for Speech Processing **Topics:** Limitations of traditional ASR, deep neural networks for speech, Transformer concepts in speech processing, self-supervised learning, end-to-end ASR, CTC, and attention-based speech models. **Applications:** Real-time transcription, multilingual speech interfaces, mobile ASR, and cloud speech services.	
MODULE – V	**10 Hours**
Evaluation, Multilingual Speech Applications, and Emerging Trends **Topics:** Speaker-dependent and speaker-independent systems, noise-robust speech recognition, multilingual and low-resource speech processing, evaluation metrics such as WER, SER, and CER, speech APIs and toolkits, ethics, privacy, fairness, and recent research trends. **Applications:** Healthcare transcription, customer support automation, educational technology, accessibility systems, and domain-specific spoken language solutions.	

AI Integration:

- AI tools for waveform, spectrogram, and speech feature understanding; AI-assisted explanation of speech pipelines.
- Classical ASR modelling support using AI for comparing HMM, GMM, lexicon, and language model workflows.
- Deep learning based speech models, speech embeddings, and transformer-based ASR prototyping tools.
- Pretrained speech APIs, toolkit benchmarking environments, and multilingual speech processing platforms.
- Evaluation of intelligent speech systems using standard datasets, recognition metrics, and responsible AI validation.

Authentic Intelligence:

- Limitations of machine speech perception compared with human auditory perception and context understanding.
- Bias due to accents, languages, dialects, and data imbalance in speech datasets.
- Challenges in noisy speech, multilingual speech processing, and over-reliance on AI-generated modelling suggestions.
- Ethical concerns in speech technologies including privacy, inclusion, fairness, transparency, and deployment risks.
- Students evaluate societal impact, data sensitivity, and practical trustworthiness of intelligent speech systems.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		

1	Understand the fundamentals of speech production, perception, and speech signal characteristics.	L2
2	Apply speech signal processing and feature extraction techniques for speech analysis.	L3
3	Analyze acoustic and language modelling approaches used in conventional ASR systems.	L4
4	Evaluate deep learning and end-to-end speech processing models for recognition tasks.	L5
5	Design intelligent speech-enabled applications for multilingual and real-world environments.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	–	1	–	–	–	–	–	1	1	2
CO-2	3	3	2	2	2	–	2	2	–	1	1	2	3
CO-3	3	3	3	2	2	–	1	1	–	1	1	2	3
CO-4	3	2	3	3	3	–	2	2	–	2	2	3	3
CO-5	3	3	3	3	3	1	1	–	–	2	2	3	3

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

TEXT BOOKS:

1. Jurafsky, D., & Martin, J. H., Speech and Language Processing, 3rd Edition, Pearson,
2. Rabiner, L. R., & Juang, B.-H., Fundamentals of Speech Recognition, Pearson, year..
3. Quatieri, T. F., Discrete-Time Speech Signal Processing, 3rd Edition, Pearson.

REFERENCE BOOKS:

1. Yu, D., & Deng, L., Automatic Speech Recognition: A Deep Learning Approach, Springer.
2. Deng, L., & Yu, D., Deep Learning for Speech Recognition and Language Processing, Springer.
3. O'Shaughnessy, D., Speech Communications: Human and Machine, 2nd Edition, Wiley-IEEE Press.

E-RESOURCES:

1. Research papers from IEEE, Springer, Elsevier, and ACL Anthology related to speech processing and ASR.
2. NPTEL / SWAYAM courses on Speech Processing, Pattern Recognition, and Machine Learning.
3. Official documentation of Librosa, Kaldi, SpeechBrain, torchaudio, and Hugging Face speech models.

RECOMMENDED TOOLS

- Programming: Python, Jupyter Notebook
- Libraries: Librosa, torchaudio, SpeechBrain, Kaldi, Hugging Face Transformers
- Data Processing: NumPy, SciPy, pandas
- Visualization: Matplotlib, waveform and spectrogram analysis tools
- AI Tools: ChatGPT, code assistants, speech API sandboxes, and model benchmarking 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**

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FOUNDATIONS OF ROBOTICS AND INTELLIGENT SYSTEMS

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

SEMESTER - V

Subject Code	:	26AM3511	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45 Hrs(15Hrs Project)
L–T–P–S	:	**2**–0–0–2	**CIA**	:	100 Marks

Course Vision:

To establish a strong foundational understanding of robotic systems by integrating modeling, kinematics, motion representation, and sensing principles, enabling students to systematically analyze and interpret robotic behavior. The course aims to build the essential theoretical and conceptual base required for advanced topics such as autonomous systems, robot intelligence, and human–robot interaction, forming a critical bridge between fundamental engineering concepts and modern robotics applications.

Course Description:

To develop a foundational understanding of robotic system modeling, motion representation, and sensing principles that enable students to analyze and build the basis for autonomous and intelligent robotic systems.

Course Learning Objectives:

Students will:

1. Understand the fundamental components and architecture of robotic systems.
2. Model robotic motion using coordinate transformations and kinematic representations.
3. Analyze basic trajectory generation and motion characteristics in robotic systems.
4. Understand sensing principles and their role in robotic perception.
5. Interpret the role of actuation and control in enabling robotic motion.

MODULE – I	**09 Hours**

Introduction to Robotic Systems

Robot definition, automation vs robotics, robot classification, robot anatomy, degrees of freedom, workspace, introduction to coordinate frames and reference systems.

Applications: Industrial robots, service robots, mobile robots

Module – II	**12 Hours**

Robot Kinematics and Motion Representation

Coordinate transformations, rotation matrices, homogeneous transformations, coordinate frames, Denavit-Hartenberg (D-H) parameters (conceptual), forward and inverse kinematics (conceptual), representation of motion in joint space and task space, introduction to Jacobian (conceptual), velocity mapping between joint space and task space, basic understanding of singularities.

Applications: Robotic manipulators, medical robotics

Module – III : Motion and Actuation in Robotic Systems	**09 Hours**

Basic trajectory planning concepts, types of robotic motion (point-to-point and continuous), joint space vs task space trajectories, overview of actuators (electric, pneumatic, hydraulic), DC motors, servo motors, stepper motors (functional understanding). ***Applications:*** Pick-and-place systems, robotic assembly	
Module – IV : Sensing and Introduction to Robotic Perception	**09 Hours**
Position and velocity sensing, encoders, tactile sensors, proximity sensors, introduction to perception in robotics, basic sensor data interpretation, role of sensors in enabling environment interaction. ***Applications:*** Smart manufacturing, autonomous systems, inspection robots	
Module – V : Application, Case Studies, and System-Level Modeling	**6 Hours**
Integration of robotic system components including kinematics, motion, actuation, and sensing; system-level understanding of robotic workflows; case studies of robotic systems (industrial manipulators, mobile robots, service robots); modeling and simulation of simple robotic systems; interpretation of robot behavior through system representation; introduction to basic simulation tools for robotic systems. ***Applications:*** Pick-and-place robots, mobile robot navigation (conceptual), service robotics systems	

Course Outcomes:

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Analyze and describe robotic system components and classifications	L4
CO2	Apply coordinate transformations and kinematic models for robotic manipulators	L3
CO3	Analyze motion representation and basic trajectory planning in robotic systems.	L4
CO4	Evaluate sensing mechanisms and their role in robotic perception.	L5
CO5	Model and simulate basic robotic systems for simple applications.	L6

Mapping Levels of COs to POs / PSOs

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

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

(Low) AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

AI Integration:

- Role of sensing and data in intelligent robotics
- Learning-based approaches for motion approximation (overview)
- Adaptive motion and trajectory optimization (conceptual)
- Sensor data processing and basic sensor fusion concepts

Authentic Intelligence Reflection:

- Human supervision and limitations of automated systems
- Reliability and limitations in robotic motion modeling
- Safety considerations in robot motion and human interaction
- Ethical considerations and reliability of sensing systems

Mini Project (Mandatory)

Students will design and simulate a basic robotic system using modeling and representation concepts.

Example Problem Statements:

- Simulation of a robotic manipulator using forward kinematics
- Basic trajectory generation for a robotic arm
- Modeling and visualization of robot motion using coordinate transformations
- Sensor-based simple robotic system simulation

Students must demonstrate:

- System modeling and representation
- Motion analysis and visualization
- Basic simulation and validation

Evaluation Focus:

- Correctness of modeling
- Clarity of system representation
- Simulation quality
- Understanding of robotic motion principles

Recommended Tools

- MATLAB Robotics Toolbox
- Python (NumPy, basic simulation libraries)
- Arduino (optional for simple demonstrations)
- Basic ROS visualization (optional)

Evaluation Scheme: CIE:

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 Tool Usage for Teaching and Learning

AI tools will be used in this course as structured pedagogical support to enhance understanding, system design, and problem-solving.

Instructor Use (AI as Co-Teacher)

- Generate alternative explanations, examples, and case studies
- Demonstrate system workflows, debugging strategies, and design variations

Student Use (AI as Teaching Assistant)

- Concept clarification and understanding
- Code assistance and debugging (with explanation)
- System design exploration and documentation support

Guidelines for Use

- All AI-assisted work must be understood and explainable by the student
- Blind use of AI-generated content is not acceptable
- Students must critically evaluate AI outputs and identify errors or limitations

Evaluation Integration

- Viva and project discussions will assess individual understanding
- Students may be asked to explain or modify AI-assisted solutions

Suggested

Reading Text

Books

1. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, 3rd Edition, John Wiley & Sons, 2020.
2. Groover, Mikell P., Industrial Robotics: Technology, Programming and Applications, 1st Edition, McGraw-Hill Education, 2013.

Reference Books

3. Yan, Lili & Gene M. Grossman, Robots and AI: A New Economic Era, 1st Edition, Taylor & Francis, 2023.

4. Klafter, Richard D., Thomas A. Chmielewski & Michael Negin, Robotic Engineering: An Integrated Approach, 1st Edition, Prentice Hall, 2013.
5. Fu, K. S., R. C. Gonzalez & C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence, 1st Edition, McGraw-Hill, 2013.

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Explainable AI

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

SEMESTER - V

Course Code	**:** 26AM3512	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	**:** 45(15 Hrs Project)
L–T–P–J	**: 2-0-0-2**	**CIE**	**:** 100 Marks

Course Vision:

To enable learners to develop transparent, interpretable, and trustworthy AI systems by understanding and applying Explainable AI techniques in real-world engineering applications.

Course Description:

This course focuses on techniques for interpreting, explaining, and evaluating AI model decisions. Students learn transparency methods, fairness analysis, bias detection, and trustworthy AI principles. The course promotes responsible and interpretable AI development.

Course Objectives:

This course will enable students to:

1. To understand the fundamental concepts, need, and challenges of Explainable AI.
2. To explore various taxonomy of XAI methods, including model-agnostic and model-specific approaches.
3. To study and apply interpretable machine learning models for transparent decision-making.
4. To analyze explainability techniques in deep learning models using visualization and attribution methods.
5. To implement and evaluate XAI techniques using tools and real-world case studies.

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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing Video/animation films to explain functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, asking Higher order Thinking questions in the class in the class in the form of Quiz and writing programs with complex solutions.
6. Showing different ways to solve the same problem and encouraging the students to come up with their own creative ways to solve them

MODULE – I :	**09 Hours**

Black Box Problem in AI, History of AI & Explainability, Need for Explainability: Trust, Transparency Accountability, Definitions, Goals, and Scope of XAI, Science of Interpretable Machine Learning Motivation, Challenges, and Trade-offs of Explainable AI, Human Factors in Explainability, Interpreting Interpretability.

Engineering Applications: Healthcare diagnosis systems, transparent credit scoring in financial systems, AI-based recommendation systems with user trust

MODULE – II	**09 Hours**
Model-Agnostic Approaches: LIME, SHAP, Integrated Gradients. Model-Specific Approaches: Rule-based Explanation, Tree Feature Importance. What-if Analysis: Counterfactual Explanations Reasoning-based: Causal Inference and User-facing: Interactive Explanations and Visualizations. ***Applications:*** Explainable Credit Scoring System (Finance), Healthcare Diagnosis Support System, Counterfactual Explanation in Insurance Systems	
MODULE – III	**09 Hours**
Interpretable vs. Explainable Algorithms, Ensemble-Based-Boosted Rulesets, Explainable, Boosting Machines (EBM), RuleFit, Skope-Rules, Iterative Random Forests (iRF), Decision Tree. ***Applications:*** High-stakes decision systems like healthcare, finance, and risk assessment	
MODULE – IV	**09 Hours**
Applications, Tools and Libraries, Intrinsic, Perturbation- LIME, Occlusion, RISE, Prediction, Difference Analysis, Meaningful Perturbation, Gradient/Backpropagation Activation, Maximization, Class Mode Visualization, Saliency Maps, DeepLIFT, DeepSHAP, Deconvolution, Guided Backpropagation Integrated Gradients, Layer-Wise Relevance Propagation, Excitation, Backpropagation, CAM. ***Applications:*** Computer vision, medical imaging, and autonomous systems	
MODULE – V	**09 Hours**
Hands-on implementation of XAI libraries (e.g., LIME, SHAP). Explainability metrics and evaluation methods. Trade-offs between model performance and explainability. Case studies of XAI applications in real-world scenarios. ***Applications:*** Applied in real-world AI deployment and model validation systems	

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**

1. Understanding transparency and interpretability in AI-driven decision systems.
2. Application of model-agnostic and model-specific XAI techniques for explaining machine learning models.
3. Use of interpretable machine learning models for transparent prediction and decision-making.
4. Explainability techniques for deep learning models using visualization and attribution methods.
5. Evaluation, deployment, and ethical integration of explainable AI in real-world systems.

- **Authentic Intelligence Reflection:**

1. Reflect on the importance of transparency and trust in AI systems and their impact on human decision-making.
2. Analyze how different explanation techniques influence understanding, fairness, and accountability of AI models.
3. Evaluate the balance between model accuracy and interpretability in real-world problem-solving scenarios.
4. Interpret deep learning model behaviors using visualization techniques and reflect on their reliability
5. Assess ethical implications, biases, and societal impact of deploying explainable AI systems.

Course Outcome

Course Outcomes (COs)	Description	Bloom's xonomy Level
the end of the course the student will be able to:		
1	Explain the importance of interpretability and transparency in systems.	L2
2	Differentiate between various XAI methods such as model-agnostic, model-specific, and causal approaches.	L4
3	Apply interpretable machine learning models for solving real-world problems	L3
4	Analyze and interpret deep learning models using advanced XAI techniques	L4
5	Evaluate and implement explainable AI solutions considering performance and interpretability trade-offs.	L5

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

	Program Outcomes (POs)											PSOs	
COS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO-1	2	2	–	–	1	–	–	2	–	–	–	1	2
CO-2	2	3	–	2	1	–	–	2	–	–	–	2	2
CO-3	3	3	2	2	2	–	–	1	–	–	–	3	3
CO-4	3	3	2	3	2	–	–	1	–	–	–	3	3
CO-5	3	3	3	3	2	1	1	3	1	1	1	3	3

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

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 BOOKS:

1. Samek, W., Montavon, G., Vedaldi, A., Hansen, L. K., & Müller, K.-R. (2019). Explainable AI: Interpreting, Explaining and Visualizing Deep Learning. Springer.
2. Molnar, C. (2020). Interpretable Machine Learning: A Guide for Making Black Box Models Explainable. Independently published.

REFERENCE BOOKS:

1. Raschka, S., & Mirjalili, V. (2019). Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2 (3rd ed.). Packt Publishing.
2. Mayuri Mehta, Vasile Palade, Indranath Chatterjee, "Explainable AI: Foundations, Methodologies and Applications", Springer, 2023.

E-RESOURCES:

1. https://nvdam.widen.net/s/wlbgbqr7cj/nvidia-learning-training-course-catalog
2. https://www.coursera.org/learn/explainable-ai-xai

RECOMMENDED TOOLS

- Python, OpenCV
- TensorFlow / PyTorchScikit-learn
- Jupyter Notebook

COGNITIVE LINGUISTICS

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

SEMESTER – V

Course Code : 26AM3513		**Credits :**	03
Hours / Week : 03		**Total Hours :**	45(15Hrs Project)
L–T–P–J : 2-0-0-2		**CIE:**	100 Marks

Course Vision: To provide learners with a comprehensive understanding of how language reflects human cognition, perception, and conceptualization. To explore the relationship between language, thought, meaning, and communication through interdisciplinary approaches. To develop analytical and research skills for applying cognitive linguistic principles in artificial intelligence, language processing, and real-world communication contexts.

Course Description: This course explores the relationship between language, cognition, and intelligent systems. Students study meaning representation, language understanding, and human communication processes. The course connects linguistic theories with AI and natural language processing applications.

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.

Module - 1	**09 Hours**

INTRODUCTION AND ORIGINS OF COGNITIVE LINGUISTICS: Cognitive linguistics and other cognitive sciences. Formal, functional and cognitive linguistics; historical development and core assumptions.

Module - 2	**09 Hours**

Grammar, Cognition and Usage-Based Model: Grammar and cognition; Talmy's cognitive representations.Language as human behaviour, language acquisition, language as a complex adaptive system (usage-based model).

Module -3	09 Hours
Frame Semantics and Construction Grammar: Frame semantics: frames and Fillmore's case grammar. Construction grammar: constructions as elements of grammar; Fillmore, Langacker; construction grammar vs cognitive grammar.	
Module - 4	**09 Hours**
Conceptual Metaphor and Conceptual Blending: Lakoff & Johnson: metaphor as a cognitive mechanism. Faucon Nier: conceptual blending and its applications in meaning construction.	
Module - 5	**09 Hours**
Prototype Theory, Typology and Applications: Prototype theory: Rosch, Berlin & Kay;	

Course Outcomes:

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

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	0	0	0	1	0	1	0	1	0	2	1	1
CO2	2	0	2	1	1	1	1	0	1	0	1	0	2	1
CO3	2	0	3	1	2	1	1	0	1	1	2	1	2	2
CO4	1	0	2	1	2	1	2	1	2	1	3	1	2	2
CO5	2	0	3	2	3	2	2	1	2	2	3	2	3	2

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

TEXT BOOKS (TB):

1. Evans, Vyvyan, & Green, Melanie. Cognitive Linguistics.
    - A comprehensive, up-to-date general introduction to cognitive linguistics covering cognitive semantics, construction grammar, metaphor, blending, and comparisons with formal approaches.
    - Intended as a primary textbook for undergraduate and postgraduate courses, with clear structure aligning well with units on frames, constructions, metaphor, and typology.
2. Dąbrowska, Ewa, & Divjak, Dagmar (eds.). Handbook of Cognitive Linguistics. De Gruyter, 2015.
    - State-of-the-art handbook with chapters on usage-based grammar, frame semantics, construction grammar, metaphor, prototypes, and typology by leading scholars.researchportal.northumbria+1
    - Suitable as an advanced text to support student projects and term papers, giving research-level depth beyond the core textbook.
3. Dąbrowska, Ewa (ed.). The Cambridge Handbook of Cognitive Linguistics. Cambridge University Press, 2017.
    - Provides a thorough overview of methods, key concepts, and new subfields in cognitive linguistics, including construction grammar, conceptual mappings, acquisition, corpus studies, and diachrony.
    - Well-suited as a reference and complementary reading for units on grammar–cognition, metaphor/blending, and prototype theory.

REFERENCE BOOKS:

1. *Tomasello, Michael. A Natural History of Human Thinking. Harvard University Press, 2014 (often used post-2015).*
    - Explores how uniquely human forms of thinking and shared intentionality underpin language and communication, complementing usage-based and cognitive views of grammar and meaning.
2. *Bybee, Joan. Frequency of Use and the Organization of Language. Oxford University Press, 2006 (still a key reference in 2015–2025 syllabi).*
    - Classic usage-based account of how frequency and experience shape grammar, morphology, and constructions, directly supporting units on usage-based models and construction grammar.

E-Resources:

NPTEL courses

- **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.

audit-mode MOOCs

- **Coursera – Linguistics & Cognitive Science courses** – Several linguistics and cognitive science courses can be audited free (access to videos and readings; certificate is paid).
- **FutureLearn – Free Linguistics Courses** – Short, fully online linguistics courses (often free for the duration of the course) that cover language, communication and sometimes language & mind topics.
- **Alison – Cognitive Processing and Language Acquisition** – Free course on cognitive processing and language acquisition, useful as a supplementary psycholinguistics resource.

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**

VI SEMESTER – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

VI SEMESTER													
Sl.no	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE Marks	Total Marks	Credits
					L	T	P	J					
1	IPCC	26AM3601	Image Processing and Computer Vision	MATHS	3	0	2	0	05	60	40	100	4
2	PCC	26AM3602	Reinforcement Learning	AI& ML	3	0	0	0	0 3	60	40	100	3
3	IPCC	26AM3603	Agentic AI	AI& ML	3	0	2	0	05	60	40	100	4
4	PCC	26AM3604	Computer Networks	AI& ML	3	0	0	0	03	60	40	100	3
5	PEC	26AM36XX	Professional Elective II / MOOC	AI& ML	2	0	0	2	03	100	--	100	3
6	PROJ	26AM3605	Mini Project (CoE-based / Startup / Research Track)	AI& ML	0	0	0	4	04	100	-	100	2
7	OEC	26OEXXXX	Open Elective I	AI& ML	3	0	0	0	03	60	40	100	3
8	AEC	26AM3606	Cognitive and Technical Skills-VI	Placement	-	-	-	-	02	-	-	-	P/F
Total					17	0	4	6	28	540	160	700	22

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

Professional Elective Courses Offering (PEC-II)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practical**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	T	P	J				
1	PEC	26AM3607	Accelerated Computing	2	0	0	2	100	--	100	03
2	PEC	26AM3608	Multi-Agent AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM3609	Visual Computing and Graphics	2	0	0	2	100	--	100	03
4	PEC	26AM3610	Robot Operating Systems (ROS)	2	0	0	2	100	--	100	03
5	PEC	26AM3611	AI for Autonomous Vehicles & Smart Mobility	2	0	0	2	100	--	100	03
6	PEC	26AM3612	Conversational AI and Spoken Language Understanding	2	0	0	2	100	--	100	03

Open Elective Course Offering (OEC-I)											
SL	**Course Type**	**Course Code**	**Course Name**	**Teaching Hours / Week**				**Examination**			
				Lecture	**Tutorial**	**Practic**	**Project**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
				L	T	P	J				
1	OEC	26OEXXXX	Multimodal and Multilingual Language Perception	3	0	0	0	60	40	100	**03**
2	OEC	26OEXXXX	AI for Autonomous Vehicles and smart mobility	3	0	0	0	60	40	100	**03**
3	OEC	26OEXXXX	AI For Content Generation	3	0	0	0	60	40	100	**03**
4	OEC	26OEXXXX	Accelerated Computing	3	0	0	0	60	40	100	**03**

HSMC- Humanities and Social Sciences including Management Courses, IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, AEC-Ability Enhancement Course, SEC-Skill Enhancement Courses, PEC-Professional Elective Courses, OEC-Open Elective Courses, PROJ-Project Work, INT-Internship, CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. Of Credits

Image Processing and Computer Vision

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

SEMESTER - VI

Course Code	: 26AM3601	**Credits**	: 04
Hours / Week	: 05	**Total Hours**	: 45+30
L–T–P–J	: 3–0–2–0	**CIE+SEE**	: 60+40 Marks

Course Vision:

To develop the ability to analyze, process, and interpret visual data by applying computational techniques and modern methods in **Image Processing** and **Computer Vision**, enabling the design of efficient and intelligent vision-based systems with responsible engineering practices.

Course Description:

This course introduces image analysis, feature extraction, object detection, and computer vision techniques. Students learn AI-based methods for visual recognition, segmentation, and pattern analysis. The course enables development of intelligent visual systems and automation applications.

Course Objectives:

This course will enable students to:

1. Understand fundamental concepts of image representation and processing.
2. Apply spatial and frequency domain techniques for image enhancement.
3. Analyze segmentation and feature extraction methods.
4. Apply machine learning and deep learning techniques in vision problems.
5. Develop practical skills using tools such as MATLAB and OpenCV.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

Digital Image Fundamentals and Processing Techniques

Digital image fundamentals, elements of visual perception, simple image model, sampling and quantization, image file formats, RGB color model, HSV color model, spatial domain processing - basic gray-level transformations, histogram processing, arithmetic and logical operations, smoothing spatial filters, sharpening spatial filters, and frequency domain processing using Fourier Transform - low-pass, high-pass, and band-pass filters.

Applications: Image enhancement in medical imaging, satellite and remote sensing image analysis, noise reduction in photographs, edge enhancement for object detection, and pre-processing for computer vision systems.

MODULE– II	**09 Hours**

Image Segmentation and Analysis

Introduction to image segmentation, detection of isolated points, line detection (Prewitt operator, Sobel operator), edge detection techniques (Canny edge-detection), local edge linking (Threshold-based), global edge linking (graph-based methods), region-based segmentation - region growing, split-and-merge techniques.

Applications: Object detection in surveillance systems, medical image analysis, industrial inspection, and scene understanding in Computer Vision applications.

MODULE – III	**09 Hours**

Morphological Image Processing and Compression Erosion, dilation, opening, and closing operations, hole filling, connected component analysis, Hit- Miss Transform, thinning, thickening, and skeletonization. Feature extraction techniques - textural features, shape features, and color features for image analysis. Introduction to image compression - coding redundancy, inter-pixel redundancy, image compression models, lossy and lossless compression techniques, and entropy-based methods (Huffman Coding).

Applications: Object recognition, medical image analysis, pattern recognition systems, efficient storage and transmission of images, and multimedia communication systems.

MODULE – IV	**09 Hours**

Computer Vision and Feature Detection

Introduction to Computer Vision, camera calibration- types and methods (Pinhole camera, Fisheye camera), lens distortion effects, camera projection models - orthographic, affine, and perspective projections, projective geometry, Camera internal and external parameters, local feature detection and description techniques - Harris Corner Detector, Hessian Corner Detector, Laplacian of Gaussian (LoG) Detector, and Difference of Gaussian (DoG) Detector.

Applications: Camera calibration for robotics and autonomous systems, feature detection for image matching, object recognition in surveillance systems, and 3D scene understanding in vision-based applications.

MODULE– V	**09 Hours**

Computer Vision for Industrial Inspection

Stereo vision, epipolar geometry, stereo image rectification, challenges in stereo correspondence,feature extraction techniques - Scale-Invariant Feature Transform (SIFT), PCA-SIFT, Speeded Up Robust Features (SURF), Histogram of Oriented Gradients (HOG), and advanced image segmentation methods – Otsu's, clustering and Watershed algorithm.

Applications: Depth estimation in 3D reconstruction, object recognition in autonomous systems, human detection in surveillance systems, and visual scene understanding in robotics and intelligent vision applications.

Course Outcome:

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Illustrate image representations and color models	L2
2	Apply image enhancement and filtering techniques	L3
3	Implement spatial and edge detection operations	L4
4	Apply segmentation and feature extraction methods	L3
5	Analyze real-world computer vision applications	L4

AI Integration:

- Use of AI-based tools for automatic image enhancement, intelligent feature extraction, and integration of image preprocessing techniques with machine learning models.
- Integration of segmentation techniques with machine learning models for automated object detection, intelligent feature extraction, and improved image understanding using AI-based vision systems.
- Use of AI models for automatic feature extraction, intelligent image representation, and advanced compression techniques integrated with machine learning-based vision systems.
- integration of feature detection methods with deep learning models for object detection, image matching (SIFT method), and intelligent visual perception in modern AI-based vision systems.
- Integration of stereo vision and feature descriptors with deep learning models for 3D perception, object detection, and intelligent visual analysis in modern AI-based vision systems.

Authentic Intelligence

- Authentic intelligence enables systems to interpret images meaningfully, not just recognize patterns, by understanding objects and their relationships.
- It uses techniques from Computer Vision and Deep Learning to simulate human-like visual perception.
- It allows machines to analyze context, such as recognizing actions or situations rather than just identifying objects.
- Authentic intelligence improves robustness, enabling systems to work accurately under different lighting, angles, and real-world conditions.
- It supports explainable decision-making, where the system can justify why it identified a particular object or scene.

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	2	2	2	–	3	–	–	2	3	3
CO-2	3	3	2	2	3	3	–	3	–	–	–	3	3
CO-3	3	2	2	2	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3
CO-5	3	3	2	2	3	3	–	3	2	2	2	3	3

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

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

TEXT BOOKS:

1. Gonzalez, R.C., and Woods, R.E., Digital Image Processing. 4th edition. Pearson Education (2017).
2. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2nd Edition, 2022.

REFERENCE BOOKS:

1. Tekalp A.M., Digital Video Processing, Prentice Hall (1995).
2. Simon Prince, Computer Vision: Models, Learning, and Inference, 2012.Manas Kamal Bhuyan, "Computer vision and Image Processing Fundamentals and Applications", © 2020 by Taylor & Francis Group.
3. Jain A.K., Fundamentals of Digital Image Processing, Prentice Hall (2015).
4. David Forsyth, Jean Ponce, Computer Vision: A Modern Approach, 2015.

E-RESOURCES:

1. Image Processing/Open CV| Udemy
2. Introduction to Computer Vision and Image Processing | Coursera
3. MIT Open Course Ware
4. Stanford Algorithms Lectures
5. IEEE research articles
6. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+C-MF-01+V2

RECOMMENDED TOOLS

- Python 3.10+, cv2
  NumPy, Pandas,
  Scikit-
- learn, PyTorch,
- Hugging Face Transformers

LAB EXERCISES

S.No	Exercise Title	Aim / Objective	Tools G Dataset	Hrs	CO
	MODULE I · Exercises 1–3 : Image Fundamentals G Intensity Transformations (06 Hours)				
1	Image Display & Negative Transformation	Read, display, and compute negative of binary and grayscale images to understand intensity inversion	Python, OpenCV, NumPy, Matplotlib Dataset: Standard images (Lena, Cameraman)	2 h	CO1
2	Image Intensity Transformations	Implement image transformations such as log, power-law (gamma), and contrast stretching to enhance image quality	Python, OpenCV, NumPy Dataset: Standard grayscale images	2 h	CO1
3	Histogram & Histogram Equalization	Compute histogram and apply histogram equalization to improve contrast and analyze pixel distribution	Python, OpenCV, Matplotlib Dataset: Low-contrast images	2 h	CO1
	MODULE II · Exercises 4–5 : Filtering Techniques (04 Hours)				
4	Spatial & Frequency Domain Filtering	Implement mean, Gaussian, median filters (spatial) and low/high-pass filters (frequency) for noise removal and enhancement	Python, OpenCV, NumPy, SciPy Dataset: Noisy images (Gaussian, Salt & Pepper)	2 h	CO2
5	Image Segmentation Techniques	Perform segmentation using edge-based (Sobel, Canny), region-based, and threshold-based methods for object extraction	Python, OpenCV, NumPy Dataset: Natural scene images	2 h	CO2
	MODULE III · Exercises 6–7 : Morphology G Feature Detection (04 Hours)				
6	Morphological Image Processing	Apply erosion, dilation, opening, closing, and boundary extraction to analyze shape and structure	Python, OpenCV, NumPy Dataset: Binary images	2 h	CO3

7	Harris Corner Detection (Without Built-in Function)	Implement Harris Corner Detector from scratch to detect interest points and understand corner response computation	Python, NumPy, Matplotlib Dataset: Standard object images	2 h	CO3
	MODULE IV · Exercises 8–G : Feature Extraction G Object Detection (04 Hours)				
8	SIFT Feature Descriptor	Extract keypoints and compute SIFT descriptors for feature matching and image comparison	Python, OpenCV Dataset: Object images with different viewpoints	2 h	CO4
9	Object Detection using HOG	Detect objects using Histogram of Oriented Gradients (HOG) and understand feature-based detection	Python, OpenCV, Scikit-image Dataset: Pedestrian dataset	2 h	CO4
	MODULE V · Exercises 10 : Advanced Applications (02 Hours)				
10	Object Detection using OpenCV	Implement object detection using pre-trained models (e.g., Haar cascades / DNN module) and evaluate detection performance	Python, OpenCV Dataset: COCO / Custom images	2 h	CO5

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REINFORCEMENT LEARNING
SEMESTER – VI

Subject Code	:	26AM3602	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45 Hours
L–T–P–S	:	3–0–0–0	**CIE+SEE**		60+40 Marks

Course Vision:
To enable learners to model, analyze, and design intelligent decision-making systems using reinforcement learning, empowering them to develop agents that learn optimal behavior through interaction with uncertain environments and apply these principles to real-world sequential decision problems.

Course Description :
This course develops the ability to model, analyze, and design intelligent decision-making systems using reinforcement learning, focusing on how agents learn optimal behavior through interaction with uncertain environment

Course Learning Objectives:

Students will:

1. Understand the reinforcement learning paradigm and key components
2. Model sequential decision problems using Markov Decision Processes
3. Apply classical and temporal-difference learning algorithms
4. Explore modern reinforcement learning approaches including deep RL
5. Develop and evaluate RL-based solutions for real-world applications

MODULE – I : Introduction and Bandits	**09 Hours**

Reinforcement Learning paradigm and real-world examples, Elements of RL: Agent, Environment, State, Action, Reward, Policy, Value Function, Reward Hypothesis, Exploration vs Exploitation, Multi-Armed Bandits: ε-Greedy, Softmax, Action-value methods

Applications: Online recommendation systems, Adaptive control systems, A/B testing in intelligent systems

MODULE – II : Markov Decision Processes (MDP)	**09 Hours**

Markov Property and state representation, MDP formulation: States, Actions, Rewards, Transitions, Return, discounting, episodic vs continuing tasks, Decision-making formulation using MDPs, Policy evaluation perspective and value-based reasoning, Goal specification and reward design

Applications: Robot navigation problem formulation, Game environments, Decision-making under uncertainty

MODULE – III : Dynamic Programming and Monte Carlo Methods	**09 Hours**

Policy Evaluation and Bellman Equation, Policy Improvement, Policy Iteration and Value Iteration, Monte Carlo Methods: First-visit and Every-visit MC, MC Prediction and Control, Exploring Starts and ε-greedy policies, Comparison of Dynamic Programming (model-based) and Monte Carlo (model-free) approaches, Limitations of full model knowledge and motivation for learning from interaction

Applications: Grid-world optimization, Planning in known environments, Simulation-based learning

MODULE – IV : Temporal Difference Learning	09 Hours
Motivation for bootstrapping and online learning, TD Learning and Bootstrapping, TD(0) Prediction, SARSA (On-policy control), Q-Learning (Off-policy control), Expected SARSA, n-step TD methods **Applications:** Real-time learning agents, Robotics control under uncertainty, Online decision systems	
MODULE – V : Function Approximation and Deep RL	**09 Hours**
Limitations of tabular methods, Function approximation basics, Value function approximation, Introduction to Deep Reinforcement Learning: Experience replay and target networks (conceptual), Policy gradient intuition (loss formulation overview), Actor-critic interaction mechanism **Applications:** Autonomous robotics, Game AI (Atari, robotics simulators), Continuous control systems	

AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

AI Integration

- Simulation of bandit problems; comparison of exploration strategies AI-assisted MDP modeling and reward design experimentation
- Implementation and comparison of DP and MC methods in simulated environments Visualization and analysis of TD learning (SARSA, Q-learning)
- Exploration of function approximation and basic Deep RL implementations

Authentic Intelligence Reflection

- Limitations of exploration strategies and reward bias
- Assumptions in MDP modeling and impact of poor state/reward design Trade-offs between model-based and model-free methods
- Stability, convergence, and off-policy learning challenges
- Scalability, instability, and real-world deployment limitations of Deep RL

Course Outcomes :

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Understand the reinforcement learning framework, components, and exploration strategies	L2
CO2	Discuss real-world problems as Markov Decision Processes and analyze policies	L5
CO3	Apply dynamic programming and Monte Carlo methods for policy evaluation and control	L3
CO4	Implement temporal-difference learning algorithms for prediction and control	L3
CO5	Evaluate reinforcement learning solutions using function approximation and real-world applications	L5

Mapping Levels of COs to POs / PSOs

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

COS	1	2	3	4	5	6	7	8	9	10	11	1	2
CO-1	3	2	1	1	2	-	-	1	1	-	2	3	2
CO-2	3	3	2	1	2	-	-	1	1	-	2	3	2
CO-3	3	3	3	2	2	-	-	1	1	-	2	3	3
CO-4	3	3	2	2	3	-	-	2	1	1	2	3	3
CO-5	3	2	3	2	3	-	-	2	2	1	3	3	3

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

Evaluation Scheme:

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

Textbook

Sutton, R. S., Barto, A. G., Reinforcement Learning: An Introduction, 2018, MIT Press.

Reference Books

- Davin Silver, Lectures on Reinforcement Learning, 2015, University College London (UCL).
- Szepesva´ri, C., Algorithms for Reinforcement Learning, 2022, Springer Nature.
- Bertsekas, D. P., Reinforcement Learning and Optimal Control, 2019, Athena Scientific.
- Zai, A., Brown, B., Deep Reinforcement Learning in Action, 2020, Manning Publications.
- Vamvoudakis, K. G., Wan, Y., Lewis, F. L., Cansever, D., Handbook of Reinforcement Learning and Control, 2021, Springer.
- Murphy, K. P., Machine Learning: A Probabilistic Perspective, 2012, MIT Press.

Recommended Tools

- Programming: Python
- Libraries: NumPy, Matplotlib
- RL Frameworks: OpenAI Gym / Gymnasium
- Visualization: Jupyter Notebook

Tutorial Exercises:

S.No	Exercise Title	Aim / Objective	Tools G Dataset	Hrs	CO
	MODULE I · Exercises 1–3 (06 Hours)				
1	RL Environment Setup (Gym)	Set up and explore Reinforcement Learning environments using OpenAI Gym	Python, OpenAI Gym, NumPy, Matplotlib	2 h	CO1

2	Multi-Armed Bandit Implementation	Implement Multi-Armed Bandit algorithms for action-value estimation and decision-making	Python, NumPy, Matplotlib	2 h	CO1
3	MDP Simulation	Simulate Markov Decision Process (MDP) environments and analyze state transitions	Python, NumPy, Matplotlib	2 h	CO1
	MODULE II · Exercises 4–5 (04 Hours)				
4	Dynamic Programming (Policy Iteration)	Implement Dynamic Programming techniques such as Policy Iteration for optimal policy evaluation	Python, NumPy, Matplotlib	2 h	CO2
5	Monte Carlo Prediction & Control	Implement Monte Carlo methods for prediction and control in Reinforcement Learning	Python, NumPy, Matplotlib	2 h	CO2
	MODULE III · Exercises 6–7 (04 Hours)				
6	TD Learning (SARSA, Q-Learning)	Implement Temporal Difference (TD) Learning algorithms including SARSA and Q-Learning	Python, NumPy, Matplotlib	2 h	CO3
7	Expected TD Methods	Implement Expected TD methods for policy evaluation and control	PyTorch, Matplotlib	2 h	CO3
	MODULE IV · Exercise 8 (04 Hours)				
8	Mini RL Implementation	Develop a Reinforcement Learning implementation for solving a simple environment-based task	Python, OpenAI Gym, OpenCV	4 h	CO4
	MODULE V · Exercise G (02 Hours)				
9	Mini Project	Design and implement a Reinforcement Learning-based application using suitable RL algorithms and environments	Python, OpenAI Gym, PyTorch / TensorFlow	2 h	CO5

Mini Project (Mandatory)

Problem-Based RL System Design: Projects must demonstrate learning behavior over episodes and include performance evaluation metrics.

Students design a learning agent for a task such as:

- Navigation problem
- Game playing agent
- Resource allocation system

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AGENTIC AI

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

SEMESTER - VI

Course Code	**:** 24AM3603	**Credits**	**:** 04
Hours / Week	**:** 05	**Total Hours**	**:** 45+30
L–T–P–J	**:** 3–0–2–0	**CIE+SEE**	**:** 60+40 Marks

Course Vision:

To cultivate engineers capable of designing, implementing, and responsibly deploying AI agents that reason, plan, use tools, and collaborate — integrating modern agentic frameworks, industry-certified learning pathways, and sound judgment about human oversight in autonomous systems.

Course Description:

This course focuses on autonomous AI agents capable of reasoning, planning, and task execution. Students learn multi-agent collaboration, decision-making frameworks, and AI orchestration techniques. The course explores intelligent autonomous systems for real-world applications.

Course Objectives:

This course will enable students to:

1. To understand the foundations of agentic AI: agent taxonomies, perception-reasoning-action loops, and environments.
2. To apply reasoning patterns (ReAct, Reflexion, Chain-of-Thought) and build self-correcting memory-augmented agents.
3. To implement tool use, retrieval-augmented generation, and agent orchestration with LangChain, LangGraph, CrewAI.
4. To design multi-agent systems with role specialization, delegation, and supervisor-worker architectures.
5. To evaluate agent safety, alignment, and production deployment with human-in-the-loop oversight and benchmarking.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

Foundations of Agentic AI

Topics: Evolution from rule-based systems to LLM-powered agents; defining agency (autonomy, reactivity, proactivity, social ability); perception-reasoning-action loop; environment types (observable, deterministic, static/dynamic); agent taxonomies (reflex, model-based, goal-based, utility-based, learning); structured outputs and JSON mode for reliable tool interfaces; local LLM inference setup (complemented by DLI for NIM-specific deployment).

Applications: Virtual assistants, autonomous coding agents, customer support bots, educational tutoring systems.

MODULE– II	**09 Hours**

Agent Architectures & Reasoning Patterns

Topics: Advanced reasoning frameworks: ReAct (Reasoning + Acting) implementation from scratch; Chain-of-Thought and Tree-of-Thought prompting; Reflexion and self-critique loops — agents evaluating their own outputs; memory systems (short-term working, long-term vector stores, episodic); state and context window management; cognitive architectures (BDI model, ACT-R parallels in LLM agents); code generation and self-debugging agent patterns. (Prompt engineering fundamentals, LangChain LCEL, structured outputs, and basic tool invocation are covered in depth via the 8-hour DLI course.)

Applications: Research assistants, code generation and review agents, document analysis pipelines, automated debugging tools.

MODULE – III	**09 Hours**

Tool Use, RAG & Orchestration

Topics: Production-grade patterns beyond the DLI course: error handling and retry strategies; circuit breakers for unreliable tools; advanced structured output schemas with Pydantic; function and tool calling API patterns across providers (OpenAI, Anthropic, open-source); RAG evaluation discussion — when retrieval helps vs. hurts. (RAG architecture fundamentals, vector databases, LangGraph state machines, dialog management, and base RAG evaluation metrics are covered in depth via the 8-hour DLI RAG Agents course.)

Applications: Enterprise search agents, data analysis pipelines with tool chains, automated report generation, domain-specific Q&A systems.

MODULE – IV	**09 Hours**

Multi-Agent Systems & Collaboration

Topics: Multi-agent communication protocols, message passing, and inter-agent interaction patterns; role-based agent design (planner, researcher, writer, critic, executor); cooperative vs competitive strategies; debate and consensus mechanisms for improved reasoning; agent-to-agent delegation; supervisor/worker patterns; hierarchical orchestration with LangGraph; swarm architectures; multi-agent reinforcement learning with PPO (Proximal Policy Optimization) for collaborative training; game-theoretic foundations; multimodal agents reasoning across text, images, and tool outputs.

Applications: Multi-agent software development teams (planner + coder + tester); collaborative research agents; compliance agents for drug discovery and pharmaceutical research; supply chain optimization; automated content pipelines.

MODULE V	**09 Hours**

Agent Safety, Evaluation & Deployment

Topics: Agent safety and alignment — sandboxing, permission models, guardrails, policy enforcement; evaluation metrics for agents (task completion, efficiency, safety violations); benchmarking frameworks (AgentBench, SWE-bench, WebArena); human-in-the-loop design patterns; interrupt/resume primitives for supervised execution; deployment architecture (containerization, monitoring, observability with LangSmith for agent tracing and evaluation); red-teaming agents; regulatory considerations (EU AI Act Article 14 human oversight, NIST AI RMF); alignment via RLHF (Reinforcement Learning from Human Feedback) and Constitutional AI. (Inference sizing and cost-latency trade-offs covered in depth via DLI.)

Applications: Production AI assistants, autonomous DevOps agents, healthcare decision support, financial advisory agents, compliance agents.

Authentic Intelligence :

1. Foundations: When should an agent defer to a human? Students discuss the limits of autonomous decision-making and the critical distinction between capability and trustworthiness — an agent that CAN perform a task is not one that SHOULD do it unsupervised in all contexts.

2. Reasoning Patterns: Hallucination detection and self-correction — when does the agent know it doesn't know? Students evaluate the reliability of agent self-assessment through

Reflexion experiments, and reflect on new failure modes introduced when self-critique itself becomes unreliable.

3. Tool Use, RAG & Orchestration: Grounding vs. hallucination — students evaluate when retrieval genuinely improves agent outputs versus when it introduces noise, stale information, or misleading sources that sound authoritative but are factually wrong.

4. Multi-Agent Systems: Emergent behavior risks — students analyze when multi-agent approaches amplify individual agent failures through cascading errors versus when they improve reliability through debate, redundancy, and consensus mechanisms; they design safeguards accordingly.

AI Integration :

1. Foundations: Students set up local LLM inference using Ollama and NVIDIA NIM, compare model variants on reasoning tasks, and use the DLI NIM course to understand microservice deployment patterns for production agent backends. Reasoning Patterns: Students complete DLI Prompt Engineering labs on LangChain LCEL, structured outputs, and tool-use patterns; classroom then implements a ReAct agent scratch to expose the mechanics beneath framework abstractions and identify failure modes.

2. Tool Use, RAG & Orchestration: Students complete the DLI Building RAG Agents lab covering RAG architecture, LangGraph state machines, dialog management, and retrieval evaluation; classroom focuses on productionizing results with error handling, circuit breakers, advanced output schemas, and domain-specific fine-tuning of retrieval and generation components.

3. Multi-Agent Systems: Students build CrewAI multi-agent workflows with role specialization (planner, researcher, writer, critic) and implement a hierarchical supervisor- routing system with LangGraph; they quantitatively measure end-to-end task quality against a single-agent baseline.

4. Safety & Deployment: Students implement human-in-the-loop agents with interrupt/resume primitives, red-team a deployed agent with prompt injection and unauthorized tool-use attempts, and instrument observability with LangSmith; DLI Inference Sizing course provides cost-latency trade-off analysis.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain foundations of agentic AI including agent taxonomies, perception-reasoning-action loops, and environment classifications.	L2
2	Apply reasoning patterns (ReAct, Reflexion, CoT) and implement memory-augmented agents from scratch and with frameworks.	L3
3	Analyze and implement tool use, RAG, and agent orchestration with LangChain, LangGraph, and CrewAI.	L4
4	Design multi-agent systems with role specialization, delegation patterns, and supervisor-worker architectures.	L5
5	Evaluate agent safety, alignment, and production deployment with HITL oversight, benchmarking, and regulatory awareness.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	1	–	1	1	–	–	3	2
CO-2	3	3	3	2	3	1	–	–	–	–	2	3	3
CO-3	3	3	3	2	3	1	–	–	2	1	2	3	3
CO-4	3	2	2	3	1	2	1	–	–	–	3	3	3
CO-5	3	3	3	3	3	2	–	3	2	–	3	3	3

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

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

TEXT BOOKS:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: AModern Approach*, 4th Edition, Pearson, 2021.
2. Michael Wooldridge, *An Introduction to MultiAgent Systems*, 2nd Edition, Wiley, 2009.

REFERENCE BOOKS:

1. Chip Huyen, *AI Engineering: Building Applications with Foundation Models*, O'Reilly Media, 2025.
2. Shunyu Yao et al., *ReAct: Synergizing Reasoning and Acting in Language Models*, ICLR 2023.
3. Noah Shinn et al., *Reflexion: Language Agents with Verbal Reinforcement Learning*, NeurIPS 2023.

E-RESOURCES:

1. https://langchain-ai.github.io/langgraph/ (LangGraph Documentation)
2. https://microsoft.github.io/autogen/ (AutoGen Documentation)
3. https://www.deeplearning.ai/short-courses/ (Multi AI Agent Systems with CrewAI)
4. https://lilianweng.github.io/posts/2023-06-23-agent/ (Lilian Weng: LLM Powered Autonomous Agents)
5. https://www.anthropic.com/engineering/building-effective-agents (Anthropic: Building Effective Agents)

RECOMMENDED TOOLS

Python 3.10+, LangChain, LangGraph, CrewAI, AutoGen
LLM Inference: Ollama, OpenAI API, Anthropic API, NVIDIA NIM
Vector Stores: ChromaDB, FAISS, Pinecone LangSmith,
OpenTelemetry, Weights & Biases Vector Stores: ChromaDB,
FAISS, Pinecone — chromadb.com

LAB EXERCISES

S.no	Exercise Title	Aim / Objective	Tools G Dataset	Hrs	CO
	MODULE I · Exercises 1–3 : Agentic AI Foundations (06 Hours)				
1	Agent Development Environment Setup	Configure Python agent stack (LangChain, Ollama); run local LLM inference; test structured JSON output for tool interfaces	Python, LangChain, Ollama Dataset: Local LLMs (Llama 3, Mistral, Qwen)	2 h	CO1
2	Single-Turn Tool-Calling Agent	Build a basic agent that calls calculator and web search tools; test structured output validation and error recovery	Python, LangChain, Tavily API Dataset: Multi-step calculation tasks	2 h	CO1
3	ReAct Agent from Scratch	Implement the ReAct loop without frameworks; observe Thought–Action–Observation traces; identify hallucinated tools and infinite loops	Raw OpenAI / Anthropic API, Python Dataset: Multi-hop factual questions	2 h	CO1
	MODULE II · Exercises 4–5 : Reasoning Patterns G Memory (04 Hours)				
4	Chain-of-Thought vs Tree-of-Thought	Implement CoT and ToT on the same benchmark (GSM8K subset); measure accuracy, cost, and latency trade-offs	LangChain, Python Dataset: GSM8K Subset	2 h	CO1
5	Memory-Augmented Agent	Add ChromaDB vector memory to an agent; evaluate long-conversation consistency; test Reflexion self-critique on reasoning errors	LangChain, ChromaDB Dataset: Conversational memory tasks	2 h	CO1

	MODULE III · Exercises 6–7 : RAG G Orchestration (04 Hours)				
6	Production-Style RAG Pipeline	Build a RAG pipeline with dense + sparse retrieval, query transformation, and re-ranking; measure MRR, NDCG, and faithfulness	LangChain, ChromaDB, Rerankers Dataset: Enterprise document corpus	2 h	CO2
7	LangGraph Stateful Agent with Error Handling	Design a stateful LangGraph workflow with conditional routing; implement retry logic and circuit breakers for tool failures	LangGraph, Pydantic Dataset: Customer service / triage scenarios	2 h	CO2
	MODULE IV · Exercises 8–10 : Multi-Agent Systems (06 Hours)				
8	CrewAI Role-Based Multi-Agent System	Build a CrewAI team with planner, researcher, writer, and critic agents; compare performance with single-agent baseline	CrewAI, Python Dataset: Research report generation tasks	2 h	CO2
9	Multi-Agent Debate for Reasoning	Implement debate between multiple agents with a judge agent synthesizing responses; evaluate reasoning improvements	LangChain, Python Dataset: GSM8K subset, logic puzzles	2 h	CO3
10	Supervisor–Worker Orchestration	Build a supervisor agent that routes tasks to specialized worker agents (coder, researcher, validator); evaluate routing accuracy	LangGraph, Python Dataset: Mixed task stream (code, search, math)	2 h	CO4
	MODULE V · Exercises 11–12 : Safety G Capstone (10 Hours)				
11	Agent Red-Team & Guardrail Design	Perform red-team testing using prompt injection and unauthorized tool-use attempts; design and evaluate guardrails	LangChain, guardrails-ai, Python Dataset: Custom adversarial prompt suite	4 h	CO4

12	Production-Grade Agent with HITL (Capstone)	Design a production-grade agent with LangGraph state machine, interrupt/resume primitives, observability, cost tracking, and regulatory documentation	LangGraph, LangSmith, guardrails-ai, OpenTelemetry, NVIDIA NIM Dataset: Student-chosen enterprise workflow domain	6 h	CO5

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Computer Networks

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

SEMESTER - V

Course Code	: 26AM3604	**Credits**	:	03
Hours / Week	: 03	**Total Hours**	:	45
L–T–P–J	: 3–0–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision:

To equip learners with strong foundational and practical knowledge of computer networks, enabling them to design, analyze, and manage modern communication systems effectively.

Course Description:

This course introduces networking fundamentals, communication protocols, network architectures, and data transmission techniques. Students learn routing, switching, network security, and wireless communication concepts. The course provides the foundation for modern distributed and cloud-based systems.

Course Objectives:

This course will enable students to:

1. Understand fundamental concepts and architectures of computer networks.
2. Analyze networking protocols and their functionality across layers.
3. Design and evaluate network systems for performance and scalability.
4. Apply concepts of routing, congestion control, and data transmission.
5. Explore modern networking technologies and applications.

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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing Video/animation films to explain functioning of various concepts.
4. Encourage Collaborative (Group Learning) Learning in the class.
5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the different ways to solve the same problem and encouraging the students to come up with their own creative ways to solve them

MODULE – I	**09 Hours**

Topics: Network definition, components of networks, types of networks (LAN, MAN, WAN), network topologies, OSI reference model, TCP/IP model, transmission media (guided and unguided), Network performance metrics (bandwidth, delay, throughput), Ethernet Networks ***Applications:*** Internet, enterprise networks, wireless communication

MODULE – II	**09 Hours**

Topics: Framing techniques, error detection (CRC, checksum), error correction, flow control, multiple access protocols (ALOHA, slotted ALOHA, CSMA/CD), switching techniques (circuit switching, packet switching), and MAC addressing. ***Applications:*** LAN design- virtual local area network (VLAN), Spanning Tree Protocol (STP), link aggregation (LAG), and multi-chassis link aggregation (MLAG) , data communication systems.	
MODULE – III	**09 Hours**
Topics: IP addressing (IPv4), basics of IPv6, subnetting, CIDR, routing algorithms (distance vector, link state), routing protocols (RIP, OSPF basics), packet forwarding, congestion control basics. ***Applications:*** Internet routing, large-scale networks.	
MODULE – IV	**09 Hours**
Topics: Transport layer services, UDP, TCP, reliable data transfer, flow control, congestion control, sliding window protocol. ***Applications***: Web services, real-time communication.	
MODULE – V	**09 Hours**
Topics: Application layer architecture, client-server model, peer-to-peer model, http,FTP, SMTP, DNS, Remote execution over SSH / APIs, network security basics (introduction to encryption, authentication) ***Applications:*** Web applications, email systems, distributed services.	

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION (AI^2 Pedagogy)
AI INTEGRATION

- AI enables intelligent analysis of network performance and adaptive optimization of bandwidth, topology, and communication systems.
- AI enhances data transmission efficiency through smart error detection, flow control, and collision management techniques.
- AI improves routing and congestion control using predictive analytics for dynamic and large-scale network environments.
- AI optimizes transport layer performance by adapting TCP/UDP mechanisms for reliable and efficient data transfer.
- AI strengthens application layer services and security through intelligent automation, anomaly detection, and protocol optimization.

AUTHENTIC INTELLIGENCE REFLECTION

- Students develop foundational understanding and critical thinking in analyzing network structures and performance.
- Students enhance logical reasoning and problem-solving skills in data communication and LAN design.
- Students build analytical abilities to design and evaluate efficient routing and scalable network solutions.
- Students apply critical thinking to understand reliable data transfer and transport layer protocols.
- Students develop ethical awareness and practical skills in designing secure and efficient network applications.

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain networking fundamentals and layered architectures	L2
2	Analyze protocols across different network layers	L4
3	Apply routing and addressing techniques in networks	L3
4	Evaluate network performance using standard metrics	L5
5	Evaluate basic network solutions for real-world applications	L5

Mapping Levels of COs to POs / PSOs

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

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

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
   - Mid Semester Examination (MSE): One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
   - AI-Powered Assignment (APA): Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
   - Lab Record: Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
   - Lab Examination: Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.

2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

A. **Integrated Professional Core Course**

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

TEXT BOOKS:

1. Computer Networks, Andrew S. Tanenbaum, David J. Wetherall, 5th Edition, 2010, Pearson.
2. Computer Networking: A Top-Down Approach James F. Kurose, Keith W. Ross, 8th Edition, 2021, Pearson.
3. Data Communications and Networking Behrouz A. Forouzan, 5th Edition, 2013, McGraw-Hill Education.

REFERENCE BOOKS:

1. Co-Intelligence: Living and Working with AI Ethan Mollick, 1st Edition, 2024, Penguin Publishing Group.
2. Computer Networks: A Systems Approach Larry L. Peterson, Bruce S. Davie, 6th Edition, 2021, Morgan Kaufmann.
3. Data and Computer Communications William Stallings, 10th Edition, 2013, Pearson.
4. Internetworking with TCP/IP Volume 1 Douglas E. Comer, 6th Edition, 2014, Pearson.

E-RESOURCES:

- Programming: Java (basic network simulation, socket programming), C/C++ (optional for protocol-level understanding).
- Network Analysis: Wireshark (packet capture and analysis)
- AI Tools: ChatGPT / AI assistants for protocol explanation, network analysis support, simulation guidance.
- Simulation Tools: NS-3, OMNeT++, Cisco Packet Tracer
- Network Administration with NVIDIA Onyx Switch System (3 hrs) | Path: VLAN, STP,LAG https://nvdam.widen.net/s/wlbgbqr7cj/nvidia-learning-training-course- catalog
- Introduction to Networking (1 hr) | Path: https://nvdam.widen.net/s/wlbgbqr7cj/nvidia-learning-training-course-catalog
- Network Ansible Essentials for Network Engineers (3 hrs) | Path:https://nvdam.widen.net/s/wlbgbqr7cj/nvidia-learning-training-course-catalog

RECOMMENDED TOOLS

2. Wireshark For packet analysis, protocol inspection, and network troubleshooting.
3. Cisco Packet Tracer For simulating network topologies, routing, and switching concepts.
4. GNS3 For advanced network emulation and real device simulation.
5. Ansible For network automation and configuration management.
6. NVIDIA Deep Learning Institute For industry-based networking courses (DPU, RDMA, automation).
7. Python (with libraries like Scapy) For network scripting, automation, and packet manipulation.

ACCELERATED COMPUTING

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

SEMESTER - VI

Course Code	**:** 26AM3607	**Credits :**	03
Hours / Week	**:** 03	**Total Hours :**	45(15Hrs Project)
L–T–P–J	**: 2-0-0-2**	**CIE**	**:** 100 Marks

Course Vision:

This course introduces students to accelerated computing using GPUs, focusing on parallel programming concepts with CUDA. It covers memory hierarchy, performance optimization, parallel computation patterns, and multi-GPU systems, enabling students to design high-performance computing applications.

Course Description:

This course introduces high-performance computing techniques using GPUs and parallel architectures. Students learn optimization strategies for computationally intensive AI and data science applications. The course focuses on scalable and efficient computing solutions.

Course Objectives:

This course will enable students to:

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

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I	**09 Hours**

Introduction to CUDA

Topics: 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

Applications: Vector addition, image processing, scientific simulations.

MODULE – II	**09 Hours**

Memory and Data Locality

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

Applications: Matrix operations, numerical computing, real-time data processing.

MODULE – III	**09 Hours**

Thread Execution and Performance Optimization

Topics: Thread Execution Model, Warp Execution and Divergence, Thread Scheduling,

Performance Bottlenecks, Optimization Techniques, Profiling CUDA Programs. **Applications:** AI pipeline optimization, HPC workloads, real-time analytics systems.	
MODULE – IV	**09 Hours**
Parallel Computation Patterns **Topics:** Common Parallel Patterns, Reduction, Scan (Prefix Sum), Stencil Computations, Algorithm Design for Parallelism, Load Balancing, Synchronization Mechanisms. **Applications:** Large-scale data processing, simulation systems, scientific computing workflows.	
MODULE – V	**09 Hours**
Advanced CUDA and Multi-GPU Systems **Topics:** 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 **Applications:** Deep learning training, autonomous systems, big data analytics, real-time inference systems.	

Course Outcome

Course Outcomes (COs)	Description	Bloom's xonomy Level
the end of the course the student will be able to:		
1	plain the fundamentals of parallel computing, GPU architecture, d CUDA programming models.	L2
2	ply CUDA programming and parallel algorithms to develop high-performance computing solutions.	L3
3	alyze performance bottlenecks and optimize applications using profiling and GPU optimization techniques.	L4
4	eate scalable and efficient GPU-accelerated applications using modern C++ and parallel computing frameworks.	L5
5	aluate real-world problems and implement accelerated computing solutions for AI, data science, and HPC applications.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	1	2	2	–	2	–	–	2	2	2
CO-2	3	3	3	1	3	3	–	2	–	–	–	3	3
CO-3	3	2	3	1	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3 -
CO-5	3	2	3	–	3	3	–	3	2	2	2	3	3

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

AI Integration

1. GPU acceleration for faster model training; parallel data preprocessing; efficient handling of large-scale datasets.
2. Accelerating neural network computations; parallel feature extraction; optimizing training pipelines.
3. Optimizing deep learning workflows; identifying slow stages in ML pipelines; improving GPU utilization.
4. Integration of C++ acceleration in AI systems; improving inference speed; scalable deployment of models.
5. Full GPU-based AI workflow optimization; deployment-ready accelerated models; performance-aware AI system design.

Authentic Intelligence

1. Understanding computational efficiency vs energy consumption; responsible use of high-performance resources; scalability considerations in real-world systems.
2. Designing efficient algorithms with minimal resource wastage; balancing speed and accuracy; avoiding redundant computations.
3. Interpreting performance trade-offs; optimizing without compromising correctness; responsible benchmarking practices.
4. Writing portable and maintainable parallel code; ensuring system reliability; efficient resource utilization at scale.
5. Designing efficient and sustainable AI systems; evaluating trade-offs in performance vs cost; end-to-end optimization for real-world 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**

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.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.
2. Nemirovsky, M., & Tullsen, D. (2022). *Multithreadingarchitecture*. Springer Nature.

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/accelerated-computing-teaching-kit-syllabus

1. https://developer.nvidia.com/cuda/toolkit/
2. https://www.nvidia.com/en-in/training/
3. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-07+V1
4. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- DS-01+V1
5. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-05+V1
6. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-05+V1

RECOMMENDED TOOLS

- Use CUDA by Example for lab/practical understanding

Keep others as reference books for depth and evaluation

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MULTI AGENT AI SYSTEMS

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

SEMESTER-VI

Course Code: 26AM3608		**Credits :**	03
Hours/Week	**:** 03	**Total Hours :**	45(15 hrs for project)
L–T–P–J	**:** **2**–0–0–2	**CIE :**	100 Marks

Course Vision:

To develop learners' understanding of intelligent and multi-agent systems, enabling them to analyze, design, and apply autonomous agent-based solutions for complex real-world problems with consideration of coordination, communication, and ethical implications.

Course Description:

This course explores intelligent systems composed of multiple autonomous agents working collaboratively. Students learn coordination, communication, negotiation, and distributed AI techniques. The course focuses on real-world multi-agent problem-solving applications.

Course 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, where teacher can use to accelerate the attainment of the various course outcomes:

1. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE–I	**09 Hours**

Intelligent Agents vs Conventional Expert Systems

Topics: 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.

MODULE – II	**09 Hours**

Intelligent Agent Architectures

Topics: 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.

MODULE – III	09 Hours

Multi-Agent Systems and Interaction Models

Topics: 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.

MODULE – IV	09 Hours

Agent AI, Communication, Coordination and Ethics

Topics: Principles of agent communication, speech acts and communication semantics, agent communication languages, Knowledge Query and Manipulation Language (KQML), Knowledge Interchange Format (KIF), FIPA framework and interaction protocols, ontologies for agent communication, ethical issues in autonomous agent communication, accountability and transparency in agent interactions .

MODULE – V	09 Hours

Cooperative Multi-Agent Systems and Ethical Framework

Topics: 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

Course Outcomes (COs)	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

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**
CO-1	3	2	1	1	1	–	–	–	–	–	–	2	1
CO-2	2	3	2	2	2	–	–	–	1	–	–	2	2
CO-3	2	3	3	2	2	–	–	–	2	1	–	3	2
CO-4	2	2	1	2	1	2	1	2	1	1	–	2	2
CO-5	2	3	3	2	2	2	1	2	2	2	1	3	3

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

AI Integration:

AI integration in this unit is achieved through conceptual exploration and interactive demonstrations using AI-based tools and simulators. Students analyze real-world intelligent agent applications such as chatbots, recommendation systems, and autonomous assistants. They compare traditional expert systems with modern AI agents through case studies and hands-on interactions, enabling them to understand agent characteristics, environments, and practical application domains..

This unit integrates AI through modeling and simulation of various agent architectures such as BDI, reactive, and hybrid systems. Students engage in practical exercises to design simple agents and observe behavior differences across architectures. Tools and frameworks for agent development are introduced to demonstrate subsumption and layered architectures, helping learners visualize decision-making and autonomy in intelligent systems.

AI integration focuses on simulating multi-agent environments where students observe cooperation, competition, and strategic interactions. Practical activities include modeling scenarios like Prisoner's Dilemma and analyzing agent strategies. Simulation tools are used to study coordination and interaction patterns, enabling students to understand real-world applications such as distributed systems, traffic management, and economic systems.

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 BOOKS:

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

REFERENCE BOOKS:

1. François Chollet, *Deep Learningwith Python*, 2nd Edition, Manning Publications, 2021.
2. Aure´lien Ge´ron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, 3rd Edition, O'Reilly Media, 2022.

E-RESOURCES:

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

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

https://online.stanford.edu RECOMMENDED TOOLS

Python, Jupyter Notebook, Google Colab, JADE, SPADE, TensorFlow, PyTorch, NetLogo.

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VISUAL COMPUTING AND GRAPHICS

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

SEMESTER - VI

Course Code	**:** 26AM3609	**Credits**	**:**	03
Hours / Week	**:** 03	**Total Hours**	**:**	45(15 hrs for Project)
L–T–P–J	**:** **2**–0–0–2	**CIE**	**:**	100 Marks

Course Vision:

This course develops an understanding of modern computer graphics by integrating concepts from rendering pipelines, GPU programming, real-time ray tracing, and neural rendering, enabling students to design and analyze advanced visual computing systems.

Course Description:

This course introduces computer graphics, visualization techniques, rendering methods, and visual computing principles. Students learn image generation, animation, and interactive visual system development. The course connects graphics technologies with AI-enabled applications

Course Objectives:

Students will:

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, where teacher can use to accelerate the attainment of the various course outcomes:

1. Lecture method combined with interactive discussions
2. Brainstorming, group activities, and case-based learning
3. Demonstrations using audio-visual tools and datasets
4. Problem-solving sessions and analytical exercises
5. Encouraging critical thinking through real-world scenarios and design challenges

MODULE – I	**08 Hours**

Graphics Pipeline and GPU

Fundamentals Topics:

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).

Applications: Game engines, simulation systems, visualization platforms, real-time rendering systems.

MODULE – II	**09 Hours**

Geometric Transformations and Shader Programming ,**Topics:** 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.

Applications: 3D modeling systems, animation pipelines, AR/VR environments, interactive graphics applications.

MODULE – III	**06 Hours**

Lighting, Shading and Rendering Techniques: Topics: 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.

Applications: Realistic rendering systems, visual effects, gaming graphics, cinematic visualization.	
MODULE – IV	**11 Hours**
Advanced Rendering and Neural Graphics **Topics:** 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. **Applications:** Next-gen game engines, film production, AI-based rendering systems, immersive visualization technologies.	
MODULE – V	**11 Hours**
Advanced Rendering and Neural Graphics **Topics:** 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. **Applications:** Next-generation game engines, film production, AI-based rendering systems, immersive visualization technologies.	

AI Integration:

- AI-assisted visualization and rendering optimization tools
- AI-supported shader generation and transformation modeling
- AI-based lighting and rendering enhancement tools
- Neural rendering models, AI-based denoising, NeRF systems.

Authentic Intelligence:

- Limitations of automated rendering systems
- Errors in shader design and transformation inaccuracies
- Trade-offs between realism and performance
- Ethical use of AI-generated graphics and synthetic content.

Course Outcome

Course Outcomes (COs)	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

Table: Mapping Levels of COs to POs / PSOs													
COS	Program Outcomes (POs)											PSO	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO-1	3	1	–	–	–	–	–	–	–	–	–	3	2
CO-2	3	3	2	2	2	–	–	–	–	–	–	3	3
CO-3	2	3	2	2	2	–	–	–	–	–	–	3	3
CO-4	2	3	2	2	3	–	–	–	1	–	–	3	3
CO-5	1	2	2	3	3	–	–	–	2	1	–	3	3

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

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 BOOKS:

1. Shirley, Peter, Michael Ashikhmin, and Steve Marschner. *Fundamentals of Computer Graphics*. **4th Edition. A K Peters/CRC Press, 2021.**Akenine-Möller, Tomas, Eric Haines, and Naty Hoffman. *Real-Time Rendering*. **4th Edition. CRC Press, 2018.**
2. Shreiner, Dave and Bill Licea-Kane. *OpenGLProgramming Guide: The Official Guideto 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-**

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/ RECOMMENDED TOOLS

- **Programming:** C++ / Python
- **Graphics APIs:** OpenGL / Vulkan
- **Frameworks:** Unity / Unreal Engine (conceptual exposure)
- **Libraries:** OpenGL Shading Language (GLSL)
- **AI Tools:** ChatGPT, AI-based rendering tools

ROBOT OPERATING SYSTEMS (ROS)

Professional Elective

Subject Code	:	22AM3610	**Credits**	:03
Hours / Week	:	03 Hours	**Total Hours**	:45 (15 hrs for project)
L–T–P–S	:	2–0–0–2	CIE	:100 Marks

Course Vision:

To develop the ability to design, implement, and integrate robotic systems using ROS middleware by combining communication, perception, and control components. The course aims to provide a strong system-level understanding of robotic software architecture, enabling students to build scalable and modular robotic applications aligned with modern autonomous and intelligent systems.

Course Description:

To enable students to design and implement robotic systems using ROS middleware by integrating sensing, communication, and control components for real-world robotic applications.

Course Learning Objectives:

Students will:

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.

MODULE – I : Introduction to ROS and Robotic Middleware	**07 Hours**

Evolution of robotic middleware, ROS ecosystem, computation graph, nodes, topics, services, ROS architecture, ROS file system, basic ROS setup.

Applications: Autonomous robots, service robots

MODULE – II : ROS Programming and Communication	**07 Hours**

ROS workspace and package creation, publishing and subscribing, message types, services, ROS client libraries (Python), inter-node communication.

Applications: Sensor data communication, robot control pipelines

MODULE – III : Sensor Integration and Data Handling	**08 Hours**

Integration of sensors (camera, LiDAR – conceptual), data acquisition in ROS, message handling, basic data processing, introduction to sensor-based decision pipelines.

Applications: Perception-enabled robotic systems

MODULE – IV : ROS Tools, Simulation, and System Integration	08 Hours
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. Applications: Autonomous navigation systems, warehouse robots	
MODULE – V :NVIDIA DLI: ROS 2 and Isaac Sim	**15 Hours**
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 Getting Started With Isaac ROS - An Introduction to AI-Based Robot Development With Isaac ROS Accelerating ROS 2 Workloads With NVIDIA GPU-Powered Libraries and AI Models -	

Course Outcome

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Analyze and describe ROS architecture and communication mechanisms.	L4
CO2	Develop ROS-based programs using nodes, topics, and services.	L5
CO3	Implement sensor integration and data processing in ROS-based systems.	L5
CO4	Analyze and debug robotic systems using ROS visualization and diagnostic tools.	L4
CO5	Design and implement a basic robotic system using ROS in simulation or hardware.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	-	2	-	-	-	-	-	1	3	1
CO-2	3	3	2	1	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-4	3	3	2	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	-	1	2	2	1	2	3	3

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

AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

AI Integration:

- ROS as middleware for AI-enabled robotic systems
- Integration of perception modules into ROS
- Handling perception data in ROS pipelines
- Simulation-based development for AI-driven robotics

Authentic Intelligence Reflection:

- Role of human supervision in robotic autonomy
- Reliability and robustness in communication systems
- Handling noisy and uncertain sensor data
- Simulation-to-real challenges and validation

Mini Project (Mandatory)

Students will design and implement a ROS-based robotic system (simulation or hardware-based).

Minimum Requirement (Mandatory for all)

- ROS-based system with:
- Sensor input
- Inter-node communication
- Basic control or decision logic

Example Problem Statements:

- ROS-based obstacle avoidance robot
- Sensor-driven mobile robot simulation

- ROS-based teleoperation with feedback
- Basic perception-integrated robotic system

Advanced Track (Optional / High-grade band)

- Integration with SLAM or navigation stack
- Multi-node system with modular design

Evaluation Focus:

- System design and architecture
- Correct ROS implementation
- Integration quality
- Debugging and validation

Recommended Tools

- ROS2
- Gazebo
- RViz
- Python
- Ubuntu Linux environment

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 Tool Usage for Teaching and Learning

AI tools will be used in this course as structured pedagogical support to enhance understanding, system design, and problem-solving.

Instructor Use (AI as Co-Teacher)

- Generate alternative explanations, examples, and case studies
- Demonstrate system workflows, debugging strategies, and design variations

Student Use (AI as Teaching Assistant)

- Concept clarification and understanding
- Code assistance and debugging (with explanation)
- System design exploration and documentation support

Guidelines for Use

- All AI-assisted work must be understood and explainable by the student
- Blind use of AI-generated content is not acceptable
- Students must critically evaluate AI outputs and identify errors or limitations

Evaluation Integration

- Viva and project discussions will assess individual understanding
- Students may be asked to explain or modify AI-assisted solutions

Suggested Reading

Text Books

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

AI FOR AUTONOMOUS VEHICLES & SMART MOBILITY

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

SEMESTER – VI

Subject Code	:	26AM3611	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for project)
L–T–P–S		**: 2**–0–0–2	**CIE**	:	100 marks

Course Learning Objectives:

This course will enable students to:

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. Analyse localisation, 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.

Course Vision

AI for Autonomous Vehicles & Smart Mobility introduces students to the integration of artificial intelligence with modern transportation systems. The course covers perception using deep learning, decision-making using machine learning models, and intelligent path planning for autonomous navigation.

Course Description:

AI for Autonomous Vehicles & Smart Mobility introduces the integration of artificial intelligence with modern transportation systems. The course covers perception using deep learning, decision-making using machine learning models, and intelligent path planning for autonomous navigation. Explore how AI enables vehicles to sense environments, predict traffic patterns, and make real-time decisions. Topics include computer vision, neural networks, reinforcement learning, and AI-based optimization for mobility systems.

The course emphasizes real-world applications such as self-driving cars, smart traffic systems, and connected mobility platforms, along with ethical and safety considerations in AI-driven transportation.

Module I : AI in Smart Mobility & Autonomous Systems	**09 Hours**
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). ***Applications:*** Self-driving cars, smart cities, ride-sharing platforms.	
Module II : AI-Based Perception Systems	**09 Hours**
Sensors (Camera, LiDAR, RADAR), sensor fusion, Computer Vision basics for autonomous vehicles, image processing, Convolutional Neural Networks (CNNs), object detection (YOLO, SSD), semantic segmentation. ***Applications:*** Lane detection, obstacle detection, and pedestrian recognition under different environmental scenario.	
MODULE – III : AI for Localization & Prediction	**09 Hours**
simultaneous Localization and Mapping (SLAM), neural networks, supervised learning: regression & classification in mobility systems, time-series prediction, traffic forecasting. ***Applications:*** GPS enhancement, traffic prediction, recommendations, and route optimization.	
MODULE – IV : AI-Based Planning, Control & Connectivity	**09 Hours**

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. ***Applications***: Autonomous navigation, smart traffic signals, connected vehicles, V2G, G2V.	
MODULE – V : AI Safety, Ethics & Future Mobility	**09 Hours**
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. ***Applications:*** Autonomous cars, delivery robots, smart city ecosystems, and personalized recommendations.	

Course Outcome

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Analyze and describe AV architecture and communication mechanisms.	L4
CO2	Develop SLAM programs using nodes, topics, and services.	L5
CO3	Implement sensor integration and data processing in Autonomous investigation	L5
CO4	Analyze and debug robotic systems using XAI visualization and diagnostic tools.	L4
CO5	Design and implement a basic safety in simulation or hardware.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	-	2	-	-	-	-	-	1	3	1
CO-2	3	3	2	1	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-4	3	3	2	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	-	1	2	2	1	2	3	3

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- *AI Integration:*
  - Module-1: AI-driven mobility system analysis
  - Module-2: Deep learning for perception (CNN models)
  - Module-3: ML models for prediction and forecasting
  - Module-4: Reinforcement learning for navigationModule-5: Explainable AI and ethical AI systems.
- *Authentic Intelligence Reflection:*

- Module-1: Evaluate reliability of AI perception models
- Module-2: Identify bias in datasets
- Module-3: Analyze safety-critical decisions
- Module-4: Reflect on ethical dilemmas
- Module-5: Assess sustainability in AI mobility.

RESEARCH INTEGRATION TEACHING

1. Paper review on autonomous driving datasets (KITTI, Waymo, TiAND).
2. Case studies on smart mobility systems.
3. Mini presentations on emerging AI mobility technologies.
4. AI-assisted research using tools for analysis.
5. Critical evaluation of safety and ethical issues.

ASSESSMENT SCHEME:

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project- based learning, seminars, industrial visits, reflection notes, model building, e- course certifications, or open book assignments.
    c. **AI-Powered Assignment(APA):** Studentsutilize AI tools for solvingproblems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

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-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: AI Perception Model Evaluation

Students prompt an AI tool:

"" Generate code for lane detection using CNN." Students must:

1. Analyze accuracy
2. dataset limitations
3. improve performance

Assignment 2: Traffic Prediction Model Verification

- Students ask AI:

" Compare ML models (Linear Regression vs Neural Networks)."

- Students must verify:

1. Evaluate accuracy and edge cases

Assignment 3: AI Debugging Challenge

- Debug faulty object detection or prediction model
- Students must:

1. Identify the bug
2. Fix the code
3. Explain the error

Assignment 4: Mobility Data Visualization

- Students use AI visualization tools to:

1. Analyze real-world traffic datasets

Assignment 5: AI-Based Path Planning Study

1. Compare classical algorithms vs AI-based approaches

Suggested Reading:

Primary Textbooks

Transportation Systems: Real-Time Applications & Related Technologies. Springer, 2025.

1. Houbing Song, Sabina Jeschke, et al., Smart Transportation: AI Enabled Mobility and Autonomous Driving. CRC Press, 2021.Dayyala, N. M. Kottayi, and R. B. Mallick,
   Machine Learning in Transportation: Applications with Examples and Codes. De Gruyter, 2024.

Additional Resources

1. IEEE research articles
2. Hussein T. Mouftah, Melike Erol-Kantarci, Sameh Sorour, onnected and Autonomous Vehicles in Smart Cities. CRC Press, 2020.
3. Dominique Paret and Hassina Rebaine, Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet. Wiley, 2022.
4. Y. Wang, Z. Cui, and R. Ke, Machine Learning for Transportation Research and Applications. Elsevier, 2023.

E-Resources : (Recommended Tools)

- Python/OpenCV
- Tensorflow/ PyTorch
- Scikit-learn
- CARLA Simulator, SUMO Traffic Simulator
- Jupyter Notebook

Activity Based Learning (Suggested Activities in Class)

1. Group discussion: Discuss different AI techniques used in autonomous vehicles such as perception, localization, and path planning to understand real-world mobility challenges.
2. Collaborative Activity: Develop a mini project in teams of 4 students, such as a smart traffic system, lane detection model, or traffic prediction system using AI techniques.

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CONVERSATIONAL AI AND SPOKEN LANGUAGE UNDERSTANDING

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

SEMESTER – VI

Subject Code	: 26AM3612	**Credits**	: 03
Hours / Week	: 03 Hours	**Total Hours**	: 45(15 hrs for Project)
L–T–P–S	**: 2**–0–0–2	**CIE**	: 100 Marks

Course Vision: Fundamentals of Artificial Intelligence, Machine Learning concepts, Probability and Statistics, Natural Language Processing. Familiarity with Python programming language is desirable. Prior exposure to optimization or deep learning and Neural Network concepts will be an added advantage.

Course Description:

This course introduces AI systems for natural language conversations and voice-based interaction. Students learn dialogue systems, speech understanding, intent recognition, and chatbot development. The course focuses on intelligent communication interfaces.

Course Learning 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.

MODULE – I : Foundations of Conversational AI	**8 Hours**

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.

MODULE – II : Natural Language Understanding & Representation Learning	**8 Hours**

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

MODULE – III : Dialogue Management, Generation & LLMs	**8 Hours**

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.

MODULE – IV : Advanced Conversational AI Systems	**8 Hours**

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)	
MODULE – V : Deployment, Evaluation, Ethics & Future Trends	**7 Hours**
Evaluation metrics, human evaluation of conversational agents, deployment architectures and APIs, MLOps for conversational AI, security issues, future research directions and open challenges.	

Course Outcomes

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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	-	-	-	-	-	-	2	2
CO-2	2	3	2	3	2	-	-	-	-	-	-	2	3
CO-3	2	3	3	3	2	-	-	-	1	1	_	2	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	3	2

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

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 BOOKS:

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. **"Effective Conversational AI" by Andrew Freed, Cari Jacobs, Eniko Rozsa, Foreword by Jesús Mantas, April 2025.**
2. "Designing Bots: Creating Conversational Experiences" by Amir Shewat, June 2017.
3. **The Definitive Guide to Conversational AI with Dialogflow and Google Cloud by Lee Boonstra, 2021.**

E-Resources:

1. **Conversational AI: LLM Driven Development for Beginners – course by udemy**
2. **Getting started with Conversational AI - https://www.youtube.com/watch?v=OsbY7ju o KgI**
3. **Conversational AI (2024): A Comprehensive Guide - https://www.gupshup.ai/resources/guide/conversational-ai- comprehensive-guide/**

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Multimodal and Multilingual Language Perception

SEMESTER - VI

Course Code	: 26OEXXXX	**Credits**	: 03
Hours / Week	: 03	**Total Hours**	: 45(15 hrs for project)
L–T–P–J	: **3**–0–0–0	**CIE**	: 100 Marks

Course Vision:

This course develops an understanding of multimodal and multilingual language perception by integrating concepts from natural language processing, computer vision, and speech technologies, enabling students to design and evaluate intelligent systems that process diverse linguistic and sensory inputs.

Course Description:

This course explores AI systems capable of understanding multiple languages and multimodal data such as text, speech, and images. Students learn multilingual NLP techniques and multimodal learning approaches. The course focuses on inclusive and intelligent communication technologies.

Course Objectives:

Students will:

1. Understand strengths, limitations, and risks of AI-generated content
2. Develop advanced prompting and content structuring strategies
3. Design AI-assisted content workflows and systems
4. Analyses content performance using platform insights
5. Evaluate ethical and authenticity concerns.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – I	**08 Hours**

Foundations of Multimodal and Multilingual Perception

Topics: Introduction to language perception (human vs machine), multimodal communication, modalities (text, speech, vision, gesture), multilingualism and language diversity, challenges in multilingual AI, overview of multimodal AI systems, data sources and preprocessing basics.

Applications: Speech assistants, multilingual translation systems, human-computer interaction, accessibility technologies.

MODULE – II	**09 Hours**

Multilingual Language Processing

Topics: Multilingual NLP fundamentals, language typology and scripts, tokenization challenges, cross-lingual embeddings, multilingual language models, transfer learning, low-resource languages, language identification, code-mixing and code-switching.

Applications: Machine translation systems, multilingual chatbots, cross-lingual information retrieval, global content processing systems.

MODULE – III	06 Hours

Multimodal Representation Learning **Topics:** Multimodal data representation, feature extraction (text, speech, images), joint embedding spaces, alignment techniques, fusion methods (early, late, hybrid), attention mechanisms, transformer architectures for multimodal learning. **Applications:** Image captioning, visual question answering, emotion recognition, multimodal sentiment analysis.	
MODULE – IV	**11 Hours**
Multimodal and Multilingual Models & Applications **Topics:** Vision-language models, speech-text systems, multimodal machine translation, pretrained multimodal models, zero-shot and few-shot learning, evaluation metrics, bias and fairness, privacy concerns, emerging trends. **Applications:** AI assistants (multilingual), accessibility tools (speech-to-text, captioning), intelligent tutoring systems, cross-modal search engines.	
MODULE – V	**11 Hours**
Applications, Evaluation, and Emerging Trends **Topics:** Multimodal sentiment analysis, emotion recognition, visual question answering, multilingual chat-bots, evaluation metrics, ethical issues, privacy concerns, future trends. **Applications:** Assistive technologies, AI-driven communication systems, real-time translation tools.	

AI Integration:

- AI tools for multimodal data understanding, language detection systems.
- Multilingual NLP models, AI-based translation tools.Transformer-based multimodal models, embedding visualization tools.
- Pretrained multimodal AI systems, evaluation and benchmarking tools.
- Evaluation of AI systems using standard datasets and performance metrics for multimodal and multilingual applications.

Authentic Intelligence:

- Limitations of machine perception vs human perception. Bias in multilingual datasets and fairness issues.
- Challenges in multimodal fusion and misinterpretation risks. Ethical concerns in AI systems, privacy, inclusivity, and reliability.
- Students evaluate ethical implications, privacy concerns, and societal impact of AI-driven systems.

Course Outcome

Course Outcomes (COs)	Description	Bloom's xonomy Level
the end of the course the student will be able to:		
1	Understand fundamentals of multimodal and multilingual language perception.	L1
2	Analyze multilingual language processing techniques	L2
3	Apply multimodal representation learning methods	L2
4	Evaluate multimodal and multilingual AI models	L4
5	Design applications using multimodal and multilingual perception systems.	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	-	-	-	-	-	-	2	2
CO-2	2	3	2	3	2	-	-	-	-	-	-	2	3
CO-3	2	3	3	3	2	-	-	-	1	1	_	2	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	3	2

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

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment	10
Total	**60 marks**

TEXTBOOKS:

1. Jurafsky, D., & Martin, J. H., Speech and Language Processing, 3rd Edition, Pearson.
2. Baltrusaitis, T. et al., Multimodal Machine Learning: A Survey and Taxonomy, IEEE, 2019.
3. Eisenstein, J., Introduction to Natural Language Processing, MIT Press, 2019.

REFERENCE BOOKS:

1. Goldberg, Y., Neural Network Methods for Natural Language Processing, Morgan & Claypool, 2017.
2. Poria, S., Cambria, E., & Bajpai, R., Multimodal AI: From Theory to Practice, CRC Press, 2022.
3. Lewis, M. et al., Multilingual Language Models and Cross-lingual NLP, Cambridge University Press, 2020.

E-RESOURCES:

1. Research papers from IEEE, ACL, and Springer
2. NPTEL courses on NLP and AI
3. Hugging Face documentation (transformers & multimodal

models). RECOMMENDED TOOLS

- Programming: Python (NLP and ML libraries)
- Libraries: TensorFlow / PyTorch, Hugging Face Transformers
- Data Processing: NLTK, SpaCy
- Visualization: Matplotlib, Seaborn
- AI Tools: ChatGPT, multilingual AI platform

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AI FOR AUTONOMOUS VEHICLES & SMART MOBILITY

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

SEMESTER – VI

Subject Code	: 26OEXXXX	**Credits**	: 03
Hours / Week	: 03 Hours	**Total Hours**	: 45(15 hrs for Project)
L–T–P–S	3–0–0–0	**CIE**	: 100Marks

Course Learning Objectives:

This course will enable students to:

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.

Course Vision:

AI for Autonomous Vehicles & Smart Mobility introduces students to the integration of artificial intelligence with modern transportation systems. The course covers perception using deep learning, decision-making using machine learning models, and intelligent path planning for autonomous navigation. Explore how AI enables vehicles to sense environments, predict traffic patterns, and make real-time decisions. Topics include computer vision, neural networks, reinforcement learning, and AI-based optimization for mobility systems.

Course Description: The course emphasizes real-world applications such as self-driving cars, smart traffic systems, and connected mobility platforms, along with ethical and safety considerations in AI-driven transportation.

Course Description:

This course focuses on AI technologies used in autonomous driving, intelligent transportation systems, and smart mobility solutions. Students learn perception, navigation, sensor fusion, and decision-making algorithms. The course addresses future transportation technologies and automation.

Course Modules :

MODULE – I : AI in Smart Mobility & Autonomous Systems	**09 Hours**
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). ***Applications:*** Self-driving cars, smart cities, ride-sharing platforms.	
MODULE – II : AI-Based Perception Systems	**09 Hours**
Sensors (Camera, LiDAR, RADAR), sensor fusion, Computer Vision basics for autonomous vehicles, image processing, Convolutional Neural Networks (CNNs), object detection (YOLO, SSD), semantic segmentation. ***Applications:*** Lane detection, obstacle detection, pedestrian recognition.	
MODULE – III : AI for Localization & Prediction	**09 Hours**
Localization (SLAM) and Mapping, supervised learning: regression & classification in mobility systems, neural networks, time-series prediction, traffic forecasting, ***Applications:*** GPS	
MODULE – IV : AI-Based Planning, Control & Connectivity	**09 Hours**
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. ***Applications***: Autonomous navigation, smart traffic signals, connected vehicles.	
MODULE – V : AI Safety, Ethics & Future Mobility	**09 Hours**

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.
Applications: Autonomous cars, delivery robots, smart city ecosystems.

Course Outcomes :

Course Outcome	Description	Bloo m's Taxo nomy 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

Mapping Levels of COs to POs / PSOs

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

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- *AI Integration:*
  - Module-1: AI-driven mobility system analysis
  - Module-2: Deep learning for perception (CNN models)
  - Module-3: ML models for prediction and forecasting
  - Module-4: Reinforcement learning for navigation
  - Module-5: Explainable AI and ethical AI systems.
- *Authentic Intelligence Reflection:*
  - Module-1: Evaluate reliability of AI perception models
  - Module-2: Identify bias in datasets
  - Module-3: Analyze safety-critical decisions
  - Module-4: Reflect on ethical dilemmas
  - Module-5: Assess sustainability in AI mobility.

RESEARCH INTEGRATION TEACHING

1. Paper review on autonomous driving datasets (KITTI, Waymo, TiAND).
2. Case studies on smart mobility systems.
3. Mini presentations on emerging AI mobility technologies.
4. AI-assisted research using tools for analysis.
5. Critical evaluation of safety and ethical issues.

ASSESSMENT SCHEME:

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.
    c. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment	10
Total	**60 marks**

AI-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem- solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: AI Perception Model Evaluation

Students prompt an AI tool:

"" Generate code for lane detection using CNN."

Students must:

1. Analyze accuracy

2. dataset limitations
3. improve performance

Assignment 2: Traffic Prediction Model Verification

- Students ask AI:

  " Compare ML models (Linear Regression vs Neural Networks)."

- Students must verify:

  1. Evaluate accuracy and edge cases

Assignment 3: AI Debugging Challenge

- Debug faulty object detection or prediction model
- Students must:

  1. Identify the bug
  2. Fix the code
  3. Explain the error

Assignment 4: Mobility Data Visualization

- Students use AI visualization tools to:

  1. Analyze real-world traffic datasets

Assignment 5: AI-Based Path Planning Study

1. Compare classical algorithms vs AI-based

approaches Suggested Reading:

Textbooks :

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.
3. Dayyala, N. M. Kottayi, and R. B. Mallick, Machine Learning in Transportation: Applications with Examples and Codes. De Gruyter, 2024.

Additional Resources

1. IEEE research articles
2. Hussein T. Mouftah, Melike Erol-Kantarci, Sameh Sorour, onnected and Autonomous Vehicles in Smart Cities. CRC Press, 2020.
3. Dominique Paret and Hassina Rebaine, Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet. Wiley, 2022.
4. Y. Wang, Z. Cui, and R. Ke, Machine Learning for Transportation Research and Applications. Elsevier, 2023.

E-Resources : (Recommended Tools)

- Python/OpenCV
- Tensorflow/ PyTorch

- Scikit-learn
- CARLA Simulator, SUMO Traffic Simulator
- Jupyter Notebook

Activity-Based Learning (Suggested Activities in Class)

1. Group discussion: Discuss different AI techniques used in autonomous vehicles such as perception, localization, and path planning to understand real-world mobility challenges.
2. Collaborative Activity: Develop a mini project in teams of 4 students, such as a smart traffic system, lane detection model, or traffic prediction system using AI techniques.

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AI FOR CONTENT CREATION

SEMESTER – VI

Subject Code	:	26OEXXXX	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for Project)
L–T–P–S	:	3–0–0–0	**CIE**	:	100Marks

Course Learning Objectives:

Students will:

1. Understand limitations and challenges of AI-generated content
2. Develop advanced prompting and content strategy skills
3. Design scalable AI-assisted content systems
4. Analyze content performance using platform-level insights
5. Evaluate ethical, societal, and authenticity concerns in AI content

Course Vision:

The course aims to provide students with comprehensive knowledge of Artificial Intelligence technologies and their applications in intelligent content creation across text, image, audio, video, and multimedia domains. The course is designed to develop creative, analytical, and technical skills required to design and implement AI-driven content generation systems for media, communication, education, marketing, and entertainment industries. It emphasizes the ethical and responsible use of generative AI tools while encouraging innovation in digital storytelling and automated media production. The course further prepares students to explore emerging trends in AI-assisted creative systems, enabling them to contribute effectively to modern content development ecosystems and future AI-powered media industries.

Course Description:

AI for Content Creation is an advanced, application-driven course that focuses on building intelligent, differentiated content using AI systems rather than basic tool usage. The course explores why most AI-generated content fails to stand out, and how human creativity, strategic prompting, and system-level thinking can be used to create impactful and high-performing content.Students will learn to design content pipelines that transform a single idea into multiple formats, analyze how digital platforms prioritize and rank content, and understand how to optimize engagement through structure, hooks, and storytelling.

The course also examines the risks of AI-generated content, including hallucination, misinformation, bias, and copyright issues. Through practical exercises and case-based learning, students will develop the ability to critically assess AI outputs and build responsible, high-quality content systems. By the end of the course, students will be able to integrate AI tools with human intelligence to create scalable, ethical, and high-impact digital content.

Course Modules :

MODULE I: Understanding AI Content and Limitations	**10 Hours**
AI content generation: capabilities and limitations, hallucination and misinformation, AI sameness problem, human vs AI creativity, content differentiation strategies.	
MODULE – II : Advanced Prompting and Content Structuring	**08 Hours**
Prompt engineering vs prompt strategy, context stacking, iterative prompting, role-based prompting, structuring content for clarity, engagement, and impact.	
MODULE – III : AI-Assisted Content Systems	**09 Hours**
Content pipelines (idea → script → multi-format), content repurposing, personal brand voice creation, human-AI collaboration workflows.	
MODULE – IV : Platform Algorithms and Content Optimization	**09 Hours**
Content ranking systems (YouTube, social media), engagement metrics (CTR, retention, watch time), hook design, storytelling patterns, content psychology.	
MODULE – V : Ethics, Authenticity and Future of AI Content	**09 Hours**

AI misinformation, deepfakes, copyright and ownership, bias and fairness, AI governance, future of creators (augmentation vs replacement).

Course Outcomes:

Course Outcome	Description	Bloo m's Taxo nomy Level
At the end of the course, the student will be able to:		
1	Explain strengths and limitations of AI-generated content	L2
2	Apply advanced prompting and content structuring techniques	L3
3	Design AI Assisted content workflows and systems	L3
4	Analyze content performance and platform behaviour	L4
5	Critically evaluate ethical and authenticity issues in AI-generated content	L4

Mapping Levels of COs to POs / PSOs

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

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

ASSESSMENT SCHEME :

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    b. **Continuous Assessment Tools (CAT – Six Components):** Includes activities such as quizzes, surprise tests, case studies, group discussions, project-based learning, seminars, industrial visits, reflection notes, model building, e-course certifications, or open book assignments.
    c. **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment	10
Total	**60 marks**

Text Books

1. Taulli, Tom – *Artificial Intelligence Basics: A Non-Technical Introduction*
2. Handley, Ann – *Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content*
3. Miller, Donald – *Building a StoryBrand: Clarify Your Message So Customers Will Listen*

Reference Books:

1. Berger, Jonah – *Contagious: Why Things Catch On*
2. Schaefer, Mark W. – *The Content Code: Six Essential Strategies for Igniting Your Content, Your Marketing, and Your Business*
3. Vaynerchuk, Gary – *Crush It!: Why NOW Is the Time to Cash In on Your Passion*
4. OpenAI Documentation – Generative AI Concepts and Applications
5. Google AI Documentation – Responsible AI and Content Systems
6. IEEE Research Articles – Generative AI, Bias, and Content Authenticity

E-Resources: (Recommended Tools)

1. MDN Web Docs (for content structure and digital publishing basics)
2. OpenAI & Anthropic Documentation
3. Canva AI Learning Resources
4. YouTube Creator Academy
5. HubSpot Content Marketing Resources

Activity-Based Learning (Suggested Activities in Class)

- Mini projects
- Content creation exercises
- Case studies
- Group discussions

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ACCELERATED COMPUTING

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

SEMESTER - VI

Course Code	**:** 26OEXXXX	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	**:** 45(15 hrs for Project)
L–T–P–J	**:** **3**–0–0–0	**CIE**	**:** 100Marks

Course Vision:

This course introduces students to accelerated computing using GPUs, focusing on parallel programming concepts with CUDA. It covers memory hierarchy, performance optimization, parallel computation patterns, and multi-GPU systems, enabling students to design high-performance computing applications.

Course Description:

This course introduces parallel computing and GPU acceleration techniques for AI and scientific applications. Students learn high-performance programming models and optimization strategies. The course enhances computational efficiency for modern AI workloads.

Course Objectives:

This course will enable students to:

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

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I	**09 Hours**

Introduction to CUDA

Topics: 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

Applications: Vector addition, image processing, scientific simulations.

MODULE – II	**09 Hours**

Memory and Data Locality

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

Applications: Matrix operations, numerical computing, real-time data processing

MODULE – III	**09 Hours**

Thread Execution and Performance Optimization **Topics:** Thread Execution Model, Warp Execution and Divergence, Thread Scheduling, Performance Bottlenecks, Optimization Techniques, Profiling CUDA Programs.	
Applications: AI pipeline optimization, HPC workloads, real-time analytics systems.	
MODULE – IV	**09 Hours**
Parallel Computation Patterns **Topics:** Common Parallel Patterns, Reduction, Scan (Prefix Sum), Stencil Computations, Algorithm Design for Parallelism, Load Balancing, Synchronization Mechanisms. **plications:** Large-scale data processing, simulation systems, scientific computing workflows.	
MODULE – V	**09 Hours**
Advanced CUDA and Multi-GPU Systems **Topics:** 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 **Applications:** Deep learning training, autonomous systems, big data analytics, real-time inference systems.	

Course Outcomes:

Course Outcomes (COs)	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	Design 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

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
CO-1	3	2	2	–	2	2	–	2	–	–	2	2	2
CO-2	3	3	3	–	3	3	–	2	–	–	–	3	3
CO-3	3	2	3	–	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3 -
CO-5	3	2	3	–	3	3	–	3	2	2	2	3	3

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

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment	10
Total	**60 marks**

AI Integration

1. GPU acceleration for faster model training; parallel data preprocessing; efficient handling of large-scale datasets.
2. Accelerating neural network computations; parallel feature extraction; optimizing training pipelines.
3. Optimizing deep learning workflows; identifying slow stages in ML pipelines; improving GPU utilization.
4. Integration of C++ acceleration in AI systems; improving inference speed; scalable deployment of models.
5. Full GPU-based AI workflow optimization; deployment-ready accelerated models; performance-aware AI system design.

Authentic Intelligence

1. Understanding computational efficiency vs energy consumption; responsible use of high-performance resources; scalability considerations in real-world systems.
2. Designing efficient algorithms with minimal resource wastage; balancing speed and accuracy; avoiding redundant computations.
3. Interpreting performance trade-offs; optimizing without compromising correctness; responsible benchmarking practices.
4. Writing portable and maintainable parallel code; ensuring system reliability; efficient resource utilization at scale.
5. Designing efficient and sustainable AI systems; evaluating trade-offs in performance vs cost; end-to-end optimization for real-world deployment.

TEXTBOOKS:

1. Yoshida, K., Miwa, S., Yamaki, H., & Honda, H. (2024). Analyzing the impact of CUDA versions on GPU applications. *Parallel Computing*, *120*, 103081.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.
2. Nemirovsky, M., & Tullsen, D. (2022). *Multithreadingarchitecture*. Springer Nature.

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/accelerated-computing-teaching-kit-syllabus

1. https://developer.nvidia.com/cuda/toolkit/
2. https://www.nvidia.com/en-in/training/
3. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-07+V1
4. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- DS-01+V1
5. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-05+V1
6. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S- FX-05+V1

MINOR PROJECT
SEMESTER – VI

Subject Code	: 26AM3605	**Credits**	: 02
Hours / Week	: 04 Hours	**Total Hours**	: 30 Hours
L–T–P–S	: 0–0–0–4	**CIE Marks**	: 100 Marks

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.

Course Vision:

The Minor Project course provides students with an opportunity to apply the concepts of Artificial Intelligence and Machine Learning to solve real-world problems. Students will work individually or in small teams to identify a problem, design an AI/ML-based solution, and implement a working prototype. The course emphasizes problem formulation, data handling, model development, evaluation, and documentation. Students are encouraged to explore interdisciplinary applications such as healthcare, agriculture, smart cities, sustainability, finance, and robotics.

Course Description:

The Minor Project course provides students with an opportunity to apply the concepts of Artificial Intelligence and Machine Learning to solve real-world problems. Students will work individually or in small teams to identify a problem, design an AI/ML-based solution, and implement a working prototype. The course emphasizes problem formulation, data handling, model development, evaluation, and documentation. Students are encouraged to explore interdisciplinary applications such as healthcare, agriculture, smart cities, sustainability, finance, and robotics.

Course Outcome:

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

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. 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.
4. The topics of the project can be chosen from various AI application domains but not limited to Machine Learning, Deep Learning, NLP, Computer Vision, Multi Agent Systems, GenAI, LLMs etc..
5. The student teams need to use the Nvidia AI factory DGX H200 systems for implementation of their projects.
6. 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 Team 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

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)**

ASSESSMENT SCHEME :

- **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) that includes three assessments.
- Phase-1 comprises of Literature Survey, Problem identification, and Objectives.
- Phase-2 comprises of Methodology and Initial Results.
- Phase-3 comprises of Results, conclusion and Project Outcome.
- There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department based on the rubrics.

Additionally, there will be a continuous assessment by the guide to monitor the performance of the students.

Criteria	**Weightage of Marks**
Continuous Assessment Tool (CAT) once in a month (3 assessments)	80
Marks awarded by Guide	20
Total	**100 marks**

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VII SEMESTER – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

VII SEMESTER														
Sl.no	Course Type	Course Code	Course Name	Teaching Department nt	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE Marks	Total Marks	Credits
					L	T	P	J					
1	PCC	26AM4701	Entrepreneurial Finance & AI-driven Deep-Tech Startups	AI&ML	2	0	0	0	02	100	--	100	2
2	IPCC	26AM4702	Designing MLOps for Enterprises	AI& ML	3	0	0	0	03	60	40	100	3
3	PEC	26AM47XX	Professional Elective III / MOOC/DLI	AI& ML	2	0	0	2	03	100	--	100	3
4	PEC	26AM47XX	Professional Elective IV / MOOC/DLI	AI& ML	2	0	0	2	03	100	--	100	3
5	OEC	26OEXXXX	Open Elective II	AI& ML	3	0	0	0	03	60	40	100	3
6	CPR	26AM4703	Capstone Project-I	AI& ML	0	0	0	8	04	60	40	100	4
			Total		12	0	0	12	18	480	120	600	18

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

Professional Elective Courses Offering (PEC-III)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4704	Edge AI and Robotics	2	0	0	2	100	--	100	03
2	PEC	26AM4705	Autonomous Agentic AI systems	2	0	0	2	100	--	100	03
3	PEC	26AM4706	Intelligent Computational Imaging and Reconstruction	2	0	0	2	100	--	100	03
4	PEC	26AM4707	Autonomous Robotic Systems	2	0	0	2	100	--	100	03
5	PEC	26AM4708	AI for Healthcare	2	0	0	2	100	--	100	03
6	PEC	26AM4709	Building AI Applications with Large Language Models	2	0	0	2	100	--	100	03

Professional Elective Courses Offering (PEC-IV)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4710	Deep Learning for Science and Engineering	2	0	0	2	100	--	100	03
2	PEC	26AM4711	Ethics, Safety & Governance of Agentic AI	2	0	0	2	100	--	100	03
3	PEC	26AM4712	Intelligent Video Surveillance Systems	2	0	0	2	100	--	100	03
4	PEC	26AM4713	Foundation Models for Robotics	2	0	0	2	100	--	100	03
5	PEC	26AM4714	Blockchain for Data Security	2	0	0	2	100	--	100	03
6	PEC	26AM4715	Multimodal and Multilingual Language Perception	2	0	0	2	100	--	100	03

Open Elective Course Offering (OEC-II)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practic	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	OEC	26OEXXXX	Human Centric Automation and Industry 5.0	3	0	0	0	60	40	100	**03**
2	OEC	26OEXXXX	Conversational AI and Spoken Language Understanding	3	0	0	0	60	40	100	**03**
3	OEC	26OEXXXX	AI for Psychology	3	0	0	0	60	40	100	**03**
4	OEC	26OEXXXX	GenAI and LLM (DLI)	3	0	0	0	60	40	100	**03**

HSMC- Humanities and Social Sciences including Management Courses, IPCC-Integrated Professional Core Course, PCC-Professional Core Courses, AEC-Ability Enhancement Course, SEC-Skill Enhancement Courses, PEC-Professional Elective Courses, OEC-Open Elective Courses, PROJ-Project Work, INT-Internship, CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. Of Credits

Entrepreneurial Finance & AI-Driven Deep-Tech Start-ups

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

SEMESTER – VII

Subject Code	: **26AM4701**	**Credits**	: 02
Hours / Week	: 02 Hours	**Total Hours**	: 30 Hrs
L–T–P-J	: 2–0–0-0	CIE: 100 marks	

Course vision: To equip students with the skills to finance, launch, and scale AI-driven deep-tech start-ups. The course fosters innovation, strategic decision-making, and sustainable entrepreneurial growth in cutting-edge technologies.

Course Description: This course introduces entrepreneurial finance, startup ecosystems, investment strategies, and AI-driven innovation management. Students learn business modelling, funding approaches, and commercialization of deep-tech solutions. The course encourages entrepreneurial and leadership skills.

Prerequisites: - Basics of Economics, AI/ML Fundamentals, Data Science

Course Objectives:

This Course will enable students to:

1. Understand fundamentals of entrepreneurial finance and start-up ecosystems.
2. Analyse valuation methods and funding strategies for AI-driven start-ups.
3. Apply AI tools for financial modelling, forecasting, and market analysis.
4. Develop skills to design, pitch, and scale deep-tech ventures.
5. Evaluate ethical, regulatory, and societal implications of AI entrepreneurship.

MODULE– I	**06 Hours**

Foundations of Entrepreneurial Finance : Start-up ecosystem overview, types of start-ups (SaaS, AI, Deep-Tech), financial statements (Profit & Loss, Balance Sheet, Cash Flow), unit economics (Customer Acquisition Cost, Lifetime Value), break-even analysis.

MODULE – II	**06 Hours**

Start-up Valuation & Funding Strategies

Start-up valuation methods (DCF, Comparable, Scorecard), capitalization tables, equity vs debt financing, funding stages (Seed, Series A/B/C), venture capital, angel investors, government funding schemes.

MODULE– III	**06 Hours**

AI-Driven Business Models & Deep-Tech Ventures - AI business models (platform, API-based, subscription), deep-tech domains (AI, robotics, IoT, quantum computing), product-market fit, competitive analysis, monetization strategies

MODULE– IV	**06 Hours**

Financial Planning, Forecasting & Scaling

Financial projections, burn rate, runway, scenario planning, scaling strategies, growth metrics,exit strategies (IPO, M&A).

MODULE– V	**06 Hours**

Legal, Ethical & Future of AI Entrepreneurship

Start-up legal frameworks, intellectual property (patents, copyrights), AI regulations, data privacy laws, ESG principles, future trends in AI entrepreneurship

AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

- **AI-Augmented Financial Analysis:** Use AI tools for financial dashboards, forecasting, and automated analysis.
- **AI-Assisted Start-up Ideation:** Leverage generative AI for idea validation, market research, and MVP design.
- **Human vs AI Decision Making:** Compare human intuition vs AI-driven insights in financial and strategic decisions.
- **Data-Driven Entrepreneurship:** Use AI tools for market intelligence and predictive analytics.
- **Ethical AI Entrepreneurship:** Address bias, fairness, and responsible innovation in start- up ecosystems.
- **Experiential Learning:** Build real-world AI start-up projects with AI-assisted tools.

Applications:

1. AI-based start-up financial planning
2. Venture capital investment analysis
3. Deep-tech innovation ecosystems
4. FinTech and AI-driven business models
5. Start-up valuation and fundraising
6. Smart city and healthcare start-up solutions

Mini Project Component

Industry-Driven Projects

Project 1 – AI Startup Financial Model oblem: Build financial projections for an AI-based startup.

- Concepts: Unit economics, forecasting, valuation
- Industry relevance: Startup financial planning

Project 2 – Deep-Tech Startup Pitch

- Problem: Develop and pitch a scalable AI startup idea
-
- Concepts: Business model, funding strategy, AI integration
- Industry relevance: Venture capital ecosystem

COURSE OUTCOME

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	Apply financial concepts such as cash flow and valuation	L3
CO2	Design AI-driven business models for deep-tech ventures	L3
CO3	Analyze startup funding strategies	L4
CO4	Develop financial projections and pitch decks	L6
CO5	Build scalable and ethical AI startups	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	–	2	2	–	2	–	–	2	2	2
CO-2	3	3	3	–	3	3	–	2	–	–	–	3	3
CO-3	3	2	3	–	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3 -
CO-5	3	2	3	–	3	3	–	3	2	2	2	3	3

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

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

Suggested Tools :

- Excel, Power BI, Tableau
- Python, SQL
- AI Tools (ChatGPT, AutoML, forecasting tools)
- Startup tools (Pitch deck, Cap table tools)

TEXT BOOKS

1. Brad Feld & Jason Mendelson – *Venture Deals*
2. Eric Ries – *The Lean Start-up*

REFERENCE BOOKS

1. Ash Maurya – *Running Lean*

2. Scott Kupor – *Secrets of Sand Hill Road*
3. Harvard Business Review – Entrepreneurship Articles
4. NASSCOM & Start-up India

Reports E-Resources

1. Coursera – Entrepreneurship & Finance
2. edX – Start-up & Innovation Courses
3. NPTEL – Entrepreneurship

Activity Based Learning (Suggested Activities in Class)

1. Start-up Pitch Simulation
2. Financial Modelling Workshop
3. Case Study Discussions (AI Start-ups)
4. Ethical AI Entrepreneurship Debate

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DESIGNING MLOPS FOR ENTERPRISES

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

SEMESTER – VII

Course Code	**:** 26AM4702	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	**:** 45 hrs
L–T–P–J	**:** 3–0–0–0	**CIE+SEE**	**:** 60+40 Marks

Course Vision: To develop the ability to design, deploy, monitor, and manage machine learning systems in production using MLOps principles, integrating automation, scalability, governance, and responsible AI practices in real-world environments.

Course Description:

This course introduces the principles and practices of Machine Learning Operations (MLOps) for designing, deploying, and managing production-grade machine learning systems. Students learn the end-to-end ML lifecycle, including data management, model development, automation, deployment, monitoring, and governance. The course covers CI/CD pipelines, version control, containerization, and model lifecycle management using industry-standard MLOps tools and frameworks. Emphasis is placed on scalability, reliability, responsible AI, and monitoring of machine learning systems in real-world environments. Through case studies and practical applications, students gain the skills required to build and maintain enterprise-ready AI solutions.

Course Objectives:

This course will enable students to:

1. Understand MLOps principles and challenges in production ML systems.
2. Learn the end-to-end ML lifecycle including data, model development, and deployment.
3. Apply pipeline automation, CI/CD, and versioning techniques in ML workflows.
4. Explore model deployment, monitoring, and drift management.
5. Understand MLOps maturity models, governance, and responsible AI practices.

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. Deliver lectures on MLOps concepts supported by real-world case studies (Netflix, Uber, Airbnb, etc.)
2. Use demonstrations of tools like MLflow, Docker, and basic CI/CD workflows
3. Conduct problem-solving sessions on ML pipeline design and deployment strategies
4. Encourage group discussions on ethical AI, model failures, and production challenges
5. Use mini case studies and scenario-based learning for drift detection and monitoring

MODULE – I	**07 Hours**

Introduction to DevOps

Topics: Need for MLOps: Challenges in traditional, ML deploymentEvaluation: DevOps ,DataOps → MLOps,ML Lifecycle: Data collection, preprocessing,training, evaluation, deployment Roles inMLOps ecosystem Reproducibility, versioning and collaboration **Applications:**Recommendation systems (Netflix, Amazon),Fraud detection (banking systems),Healthcare diagnosis systems.

MODULE – II	**08 Hours**

Basics Concepts of MLOps

Topics: Data pipelines: ingestion, preprocessing, transformation Data versioning and validation Feature engineering and feature stores (conceptual) Experiment tracking: parameters, metrics, artifacts Introduction to tools: MLflow, DVC (conceptual)

Applications:

Customer churn prediction Predictive maintenance in manufacturing Credit risk modeling.

Module - III	**08 Hours**

Machine Learning Pipelines and Automation

Topics: ML pipelines: components and design,Workflow orchestration (Airflow / Kubeflow – overview),CI/CD for ML systems,Containerization using Docker (concepts), Automated training and validation pipelines.

Applications: Continuous model retraining systems,Automated content recommendation pipelines Smart traffic management systems

Module - IV	**08 Hours**

Model Management in MLOps

- **Topics:** Model deployment strategies: batch vs real-time, Model serving using APIs,Monitoring ML systems: accuracy, latency, throughput,Data Drift and Model Drift:,Types and causes,Detection techniques,Impact on model performance,Feedback loops and retraining pipelines

Applications:

Real-time fraud detection,Stock price prediction systems, E-commerce recommendation engines.

Module - V	**08 Hours**

MLOps Case Studies and Best Practices

- **Topics:** MLOps maturity levels (Level 0, Level 1, Level 2 automation),Model lifecycle management and versioning,Governance in ML systems,Responsible AI: fairness, bias, explainability,Security in ML systems,Industry case studies (Netflix, Uber, Airbnb, NASA),Emerging trends: LLMOps, Edge MLOps.

Applications: Autonomous vehicles,Healthcare AI systems,Financial risk analytics.

AI Integration

1. Use AI tools (ChatGPT/Copilot) to generate ML pipelines and scripts
2. Generate Dockerfiles and CI/CD configurations using AI
3. Use AI for feature engineering and hyperparameter tuning
4. Generate model deployment APIs using AI assistance
5. Use AI for monitoring dashboards and alert systems

Authentic Intelligence

1. Evaluate AI-generated ML pipelines for scalability and correctness
2. Identify bias and data leakage in AI-generated solutions
3. Compare AI-generated vs manual deployment strategies
4. Analyze limitations of AI tools in production ML systems
5. Evaluate AI-generated monitoring and drift detection approaches

Course Outcome :

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
the end of the course the student will be able to:		
1	Understand core concepts, principles, and frameworks of Responsible Artificial Intelligence.	L2
2	Analyze ethical theories and decision-making models in AI system design and deployment.	L4
3	Examine responsibility, accountability, transparency, and trust in AI ecosystems.	L4
4	Apply Responsible AI design principles, including ethics-by-design and human-in-the-loop approaches.	L3

5	Evaluate governance frameworks and lifecycle-based Responsible AI practices using case studies.	L5

Mapping Levels of COs to POs / PSOs :

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
CO-1	3	2	2	–	2	2	–	2	–	–	2	2	2
CO-2	3	3	3	–	3	3	–	2	–	–	–	3	3
CO-3	3	2	3	–	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3 -
CO-5	3	2	3	–	3	3	–	3	2	2	2	3	3

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
   - **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
   - **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
   - **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
   - **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.
2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

A. Integrated Professional Core Course (Theory + Practical)

Criteria	Weightage of Marks
Mid-Semester Examination (MSE)	30
CAT Assessment	20
Lab Record	5
Lab Examination	5
Total	**60 Marks**

TEXTBOOKS:

1 Beginning MLOps with MLFlow, Alla, Sridhar & Adari, Suman Kalyan, Apress, 2021

2 Keras to Kubernetes: The Journey of a Machine Learning Model to Production, Rao, Dattaraj, John Wiley & Sons , 2019

REFERENCE BOOKS:

1 Introducing MLOps , Treveil, Mark et al.O'Reilly Media, 2020 Machine Learning Engineering, Burkov, Andriy, True Positive Inc., 2020

2 Virginia Dignum, Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way, Springer Nature, 2019.

E-RESOURCES:

1 https://mlflow.org/docs/latest/

2 https://www.kubeflow.org/docs/

3 https://www.tensorflow.org/tfx/guide

4 https://dvc.org/doc

5 https://paperswithcode.com/

RECOMMENDED TOOLS

Python 3.10+, NumPy, Pandas, Scikit-learn, PyTorch, Hugging Face Transformers IBM AI Fairness 360 (AIF360) — https://aif360.mybluemix.net
Aequitas Bias Audit Toolkit — http://aequitas.dssg.io
SHAP — https://shap.readthedocs.io | LIME — https://github.com/marcotcr/lime
OpenAI Gymnasium (RL) — https://gymnasium.farama.org

Edge AI and Robotics

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

SEMESTER-VII

Course Code	**:** 26AM4704	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	**:** 45 (15 hrs for Project)
L–T–P–J	**:** **2**–0–0–2	**CIE**	**:** 100 Marks

Course Vision: To equip learners with knowledge and practical skills in Edge Artificial Intelligence and Robotics for designing intelligent, autonomous, and real-time systems that solve industrial and societal challenges.

Course Description:

This elective course enables students to pursue advanced specialization in AI, robotics, vision systems, healthcare AI, and emerging intelligent technologies. Students gain domain-specific expertise through practical and research-oriented learning. The course supports career-focused technical advancement.

Course Objectives:

This course will enable students to:

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 a teacher can use to accelerate the attainment of the various course outcomes:

1. **Lecture method:** Along with the traditional lecture method, different types of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and role-playing.
3. Showing **video/animation** films to explain the functioning of various concepts.
4. Encourage **collaborative** (group learning) learning in the class.
5. To foster critical thinking by asking higher-order thinking questions in the class in the form of quizzes and writing programs with complex solutions.

Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I	**10 Hours**

Introduction to Edge AI

Topics: AI Introduction, AI Hardware, Introduction to Jetson Nano, Edge, AIoT, Big Data, Introduction to Parallel Programming, Machine Learning Fundamentals.

Applications: Smart surveillance systems using real-time video analytics, AI-powered IoT devices for home and industrial automation, Edge-based healthcare monitoring and wearable devices, Predictive maintenance using sensor data analytics, Autonomous drones and robots with onboard intelligence, Real-time traffic monitoring and smart city applications, GPU-accelerated data processing for large-scale analytics

MODULE – II	**08 Hours**

Vision Deep Neural Networks (DNNs) **Topics:** Computer Vision, Image Classification, Object Detection, Semantic Segmentation, Pose Estimation **Applications:** Face recognition and biometric attendance systems, Autonomous vehicle pedestrian and lane detection, medical image diagnosis and anomaly detection, Smart retail product recognition and inventory tracking, Human pose estimation for fitness and healthcare monitoring, Industrial defect detection in manufacturing, Intelligent surveillance and activity monitoring.	
Module - III	**08 Hours**
Diversity, Ethics, and Security **Topics:** 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. **Applications:** Fair AI-based hiring and recruitment systems, Secure facial recognition and access control systems, Privacy-preserving healthcare analytics, Fraud detection with transparent decision models, Robust autonomous systems against adversarial attacks, Secure smart home and IoT edge devices, Ethical decision-making in robotics and surveillance systems.	
Module - IV	**09 Hours**
Autonomous Robotics **Topics:** Agent Architectures, Teaching Machines to Act, Introduction to ROS2, Robot Navigation, Path Planning Algorithms, Obstacle Detection and Avoidance. **Applications:** Self-driving delivery robots in campuses and warehouses, Autonomous drones for inspection and surveillance, Smart warehouse robots for material handling, Robot vacuum cleaners with intelligent navigation, Agricultural robots for crop monitoring and spraying, Search-and-rescue robots in hazardous environments, Hospital service robots for medicine and food delivery.	
Module - V	**09 Hours**
Reinforcement Learning **Topics:** 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. **Applications:** Robot path planning in dynamic environments, Self-learning game-playing agents, Warehouse robots for task optimization, Traffic signal control using adaptive learning, Energy management in smart grids, Autonomous drone navigation and control, Industrial robot arm motion optimization.	

Course Outcome

Course Outcomes (COs)	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

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
CO-1	3	2	-	–	2	2	–	3	–	–	2	2	-
CO-2	2	3	2	–	3	2	–	2	–	–	–	3	2
CO-3	2	3	3	2	3	3	–	3	–	–	–	3	3
CO-4	2	3	3	3	3	3	–	3	2	–	–	3	3
CO-5	2	2	-	2	2	3	–	3	2	2	2	2	2

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

AI Integration :

1. AI is integrated through Edge AI platforms and embedded computing devices such as NVIDIA Jetson Nano and Raspberry Pi. Students learn to deploy lightweight AI models for real-time decision-making directly on robotic hardware. Integration focuses on low-latency processing, offline intelligence, and efficient resource utilization.
2. AI is integrated through robotic sensors, actuators, and IoT communication systems using tools like Arduino IDE and ROS. Students build intelligent sensing systems for environment monitoring and robot control. AI integration emphasizes smart perception, data acquisition, and autonomous response mechanisms.
3. AI is integrated through computer vision and machine learning techniques using OpenCV, TensorFlow Lite, and YOLO models. Students develop systems for object detection, face recognition, and robotic vision. Integration focuses on enabling robots to interpret and react to visual information in real time.
4. This module integrates AI through autonomous navigation and reinforcement learning using Gazebo and ROS. Students implement path planning, obstacle avoidance, and self-learning robotic agents. AI is applied to create adaptive robots capable of operating in dynamic environments.
5. AI is integrated into industrial and service robotics through collaborative robots, predictive maintenance, and smart automation using NVIDIA Isaac platforms and cloud-edge systems. Students explore secure, ethical, and scalable robotic AI solutions.

Integration focuses on Industry 4.0, healthcare robotics, and future intelligent autonomous systems.

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

    - **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
    - **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.
    - **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
    - **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.
2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

A. Integrated Professional Core Course (Theory + Practical)
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 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/

3. https://opencv.org/university/free-opencv-course/?srsltid=AfmBOorQQWQA-Dwg0eibzbCI4LbZ5moQ6Mkrn5016jUvFYBJTKKbQLDD
4. https://www.edx.org/learn/embedded-systems
5. https://www.mathworks.com/solutions/electrical-computer-engineering/robotics.html

RECOMMENDED TOOLS

- Python
- OpenCV
- TensorFlow Lite
- ROS
- Raspberry Pi
- NVIDIA Jetson Nano
- Gazebo
- MATLAB

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AUTONOMOUS AGENTIC AI SYSTEMS

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

SEMESTER VII

Subject Code	: 26AM4705	**Credits**:	03
Hours / Week	: 03 Hours	**Total Hours** :	45(15 hrs for project)
L–T–P–S	: 2–0–0–2	**CIE :**	100 Marks

Course Vision:

enable students to design and develop intelligent autonomous AI agents capable of perceiving, reasoning, and acting independently. The course fosters innovation, ethical understanding, and real-world problem-solving with agentic AI systems.

Course Description:

This elective course offers advanced interdisciplinary learning in emerging AI applications and intelligent systems. Students explore industry-oriented topics aligned with current technological trends. The course encourages innovation, research, and professional specialization.

Co urse Objectives:

is 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. ***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.*

MODULE – 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.	
MODULE – II	**8 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.	
MODULE – III	**8 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.	
MODULE – IV	**7 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.	
MODULE – V	**8 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:

Course Outcome	Description	Bloom's Taxonomy Level
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

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
CO-1	3	2	-	–	2	2	–	3	–	–	2	2	-
CO-2	2	3	2	–	3	2	–	2	–	–	–	3	2
CO-3	2	3	3	2	3	3	–	3	–	–	–	3	3
CO-4	2	3	3	3	3	3	–	3	2	–	–	3	3
CO-5	2	2	-	2	2	3	–	3	2	2	2	2	2

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

ASSESSMENT SCHEME

A. Integrated Professional Core Course (Theory + Practical)

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 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:

Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, 4th Edition, 2017.

Csaba Szepesva´ri, Algorithms for Reinforcement Learning, 2010, Morgan & Claypool.

Mykel J. Kochenderfer, Decision Making Under Uncertainty: Theory and Application, 2015, MIT Press.

E-Resources:

- NPTEL – Reinforcement Learning (IIT Madras)
  https://nptel.ac.in/courses/106106143
- OpenAI Spinning Up in Deep RL
  https://spinningup.openai.com/
- David Silver's RL Course (UCL/DeepMind)

  https://www.youtube.com/playlist?list=PLqYmG7hTraZDMOYHWgPebj2MfCFzFObQ
- UC Berkeley CS188 – Introduction to AI
  https://inst.eecs.berkeley.edu/~cs188/
- Stanford CS221 – AI: Principles and Techniques
  https://stanford-cs221.github.io/
- DeepMind x UCL Deep RL Course
  https://www.deepmind.com/learning-resources/reinforcement-learning-lecture-series
- Gymnasium (OpenAI Gym) Documentation
  https://gymnasium.farama.org/
- Stable-Baselines3 RL Algorithms
  https://stable-baselines3.readthedocs.io/

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Intelligent Computational Imaging and Reconstruction

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

SEMESTER - VII

Course Code	**:** 26AM4706	**Credits**	**:** 03
Hours / Week	**:** 03	**Total Hours**	**:** 45(15 hrs for Project)
L–T–P–J	**:** **2**–0–0–2	**CIE**	**:** 100 Marks

Course Vision: To develop the ability to model, analyze, and design advanced imaging systems by integrating physical models, computational methods, and AI-driven techniques in **Computational Imaging**, enabling efficient and intelligent visual data reconstruction.

Course Description:

This course introduces computational imaging principles and reconstruction techniques by combining physical models, inverse problem solving, and AI-based methods. It focuses on advanced imaging systems, optimization techniques, and learning-based approaches for intelligent image reconstruction. Students explore real-world applications in medical imaging, photography, and scientific visualization.

Course 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, where teacher can use to accelerate the attainment of the various course outcomes:

1. **Lecture method** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

MODULE – 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**.

MODULE – 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)**

Applications: Image reconstruction in medical imaging (CT/MRI), deblurring and denoising in photography, super-resolution imaging, and restoration in scientific and remote sensing applications.

Module - 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.

Applications: Enhancement of photographic quality in mobile cameras, medical image reconstruction, astronomical imaging, surveillance systems, and high-resolution imaging in scientific research.

Module - 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.

Applications: 3D scene reconstruction, biomedical imaging and diagnostics, remote sensing, autonomous systems, and advanced scientific imaging applications.

Module - V	**09 Hours**

Learning-Based Computational Imaging

Topics: 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.

Applications: AI-based image reconstruction in medical imaging, intelligent denoising and super-resolution, automated visual inspection systems, and smart imaging solutions in scientific and industrial domains.

- *AI Integration:*
  - Integration of computational imaging with AI techniques for image reconstruction, denoising, and enhancement using machine learning-based models.
  - Use of AI and deep learning models for solving inverse imaging problems, data-driven regularization techniques, and intelligent optimization for faster and more accurate image reconstruction.
  - Use of deep learning models for super-resolution, AI-based denoising and deblurring, and intelligent reconstruction techniques for compressive

sensing and advanced imaging systems.

- Integration of advanced imaging systems with AI for depth estimation, hyperspectral data analysis, medical image interpretation, and real-time intelligent vision systems.

Course Outcome:

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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	–	2	2	–	3	–	–	2	3	3
CO-2	3	3	2	–	3	3	–	3	–	–	–	3	3
CO-3	3	2	2	–	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3
CO-5	3	–	2	–	3	3	–	3	2	2	2	3	3

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

ASSESSMENT SCHEME

1. **Internal Assessment (IA)** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
   - **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.
   - **AI-Powered Assignment (APA):** Students utilize AI tools for solving problems while demonstrating Authentic Intelligence through critical

evaluation, validation of AI outputs, ethical reasoning, and responsible decision-making.

- **Lab Record:** Evaluation of regular laboratory work, observations, coding exercises, and maintenance of lab records.
- **Lab Examination:** Practical examination conducted to assess students' ability to design, implement, test, and analyze AI-based solutions using appropriate tools and techniques.

2. **External Assessment (EA)** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of DBMS concepts, application skills, and their ability to analyze and solve problems effectively.

A. Integrated Professional Core Course (Theory + Practical)
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 BOOKS:

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

REFERENCE BOOKS:

E-RESOURCES:

1. MIT OpenCourseWare
2. Stanford Algorithms Lectures
3. IEEE research articles

RECOMMENDED TOOLS

Python 3.10+, NumPy, Pandas, Scikit-learn, PyTorch, Hugging Face Transformers IBM AI Fairness 360 (AIF360) — https://aif360.mybluemix.net
Aequitas Bias Audit Toolkit — http://aequitas.dssg.io
SHAP — https://shap.readthedocs.io | LIME — https://github.com/marcotcr/lime
OpenAI Gymnasium (RL) — https://gymnasium.farama.org.

AUTONOMOUS ROBOTIC SYSTEMS

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

SEMESTER - VII

Subject Code	:	22AM4707	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for project)
L–T–P–S	:	2–0–0–2	**CIE**	:	100 Marks

Course Vision:

To develop a system-level understanding of autonomous robotic systems by integrating perception, localization, planning, and execution under real-world uncertainty. The course aims to equip students with the ability to design and analyze complete autonomy pipelines, balancing accuracy, robustness, and computational constraints, and preparing them for advanced work in intelligent and autonomous systems.

Course Description :

To enable students to design, implement, and evaluate autonomous robotic systems under uncertainty by integrating perception, localization, planning, and system-level decision-making frameworks for real-world deployment.

Course Learning Objectives:

Students will:

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.

Course Vision :

To enable students to design, implement, and evaluate autonomous robotic systems under uncertainty by integrating perception, localization, planning, and system-level decision-making frameworks for real-world deployment.

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Analyze and describe the architecture of autonomous robotic systems	L4
CO2	Apply perception techniques for environment understanding under uncertainty	L3
CO3	Analyze and implement localization and mapping methods	L4

CO4	Design planning and decision-making strategies for autonomous navigation	L5
CO5	Develop and evaluate an integrated autonomous robotic system	L6

MODULE -I : Perception for Autonomous Systems	**09 Hours**
Sensors for robotics (LiDAR, camera, IMU), data acquisition, feature extraction, object detection (classical + deep learning overview), basic sensor fusion concepts. NVIDIA DLI Self-Paced Courses Mapping:Getting Started with Deep Learning - Module: Image classification using convolutional neural networks, Building Real-Time Video AI Applications - Modules: Object detection in images and video streams, Deep learning inference workflows for visual data **Applications:** Mobile robots, autonomous vehicles, service robotics	
MODULE – II : Localization and Mapping	**09 Hours**
Coordinate frames, odometry, probabilistic localization (Kalman Filter, Particle Filter concepts), mapping basics, occupancy grid maps, SLAM overview (visual and LiDAR-based). NVIDIA DLI Self-Paced Courses Mapping: Getting Started with Deep Learning - Modules: Feature extraction using convolutional neural networks, Learned visual representations for image-based tasks Applications: Indoor navigation, warehouse robotics, mapping unknown environment	
MODULE – III : Planning and Decision Making	**09 Hours**
Graph-based planning methods (A*, Dijkstra), sampling-based planning (RRT, PRM), and hierarchical decision-making frameworks incorporating cost functions and constraints. **Applications:** Robot navigation, path optimization, exploration tasks	
MODULE – IV : Navigation and Execution	**09 Hours**
Navigation stack architecture (ROS-based), global vs local planning, trajectory generation, execution constraints, obstacle avoidance in dynamic environments, system limitations. NVIDIA DLI Self-Paced Courses Mapping: Building Real-Time Video AI Applications - Modules: Real-time video inference workflows, Processing visual data streams for object detection **Applications:** Autonomous mobile robots, drone navigation	
MODULE – V : System Integration and Evaluation	**09 Hours**
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). NVIDIA DLI Self-Paced Courses Mapping: Building Real-Time Video AI Applications - End-to-end video AI pipelines **Applications:** End-to-end autonomous systems	

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	1	-	1	-	-	-	-	-	1	3	1
CO-2	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	3	2	-	-	1	-	-	2	3	3
CO-4	3	3	3	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	1	1	2	2	1	2	3	3

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

AI Integration & Authentic Intelligence Reflection (AI^2 Pedagogy)

AI Integration:

- Vision-based perception using deep learning models
- earning-based localization (overview only)
- Reinforcement learning for decision-making (conceptual exposure)
- earning-based control (high-level overview)
- odular AI pipelines in robotics

Authentic Intelligence Reflection:

- Limitations of perception systems, uncertainty and noise handling
- Uncertainty modeling, failure modes in localization
- Trade-offs between optimality and computational efficiency
- Safety, robustness, and real-world deployment constraints
- System reliability, ethical deployment, human-in-the-loop systems

Mini Project (Mandatory)

Students will design and implement a basic autonomous robotic system (simulation or hardware-based).

Minimum Requirement (Mandatory for all)

- Autonomous navigation with:
- Perception input
- Basic planning
- Obstacle avoidance

Advanced Track (Optional / High-grade band)

- SLAM-based navigation OR

- Dynamic environment decision-making OR
- Vision-based autonomy

Evaluation Focus

- System design clarity
- Level of autonomy achieved
- Robustness under uncertainty

Recommended Tools

- ROS / ROS2
- Gazebo / Webots
- Python / C++
- OpenCV
- RViz
- SLAM packages (e.g., Gmapping, Cartographer)

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 Tool Usage for Teaching and Learning

AI tools will be used in this course as structured pedagogical support to enhance understanding, system design, and problem-solving.

Instructor Use (AI as Co-Teacher)

- Generate alternative explanations, examples, and case studies
- Demonstrate system workflows, debugging strategies, and design variations

Student Use (AI as Teaching Assistant)

- Concept clarification and understanding
- Code assistance and debugging (with explanation)
- System design exploration and documentation support

Guidelines for Use

- All AI-assisted work must be understood and explainable by the student
- Blind use of AI-generated content is not acceptable
- Students must critically evaluate AI outputs and identify errors or limitations

Evaluation Integration

- Viva and project discussions will assess individual understanding
- Students may be asked to explain or modify AI-assisted solutions

Suggested

Reading Text

Books

1. Thrun, S., Burgard, W., Fox, D., Probabilistic Robotics, 2005, MIT Press.
2. LaValle, S. M., Planning Algorithms, 2006, Cambridge University Press.

Reference Books

1. Siciliano, B., Khatib, O., Springer Handbook of Robotics, 2016, Springer.
2. Corke, P., Robotics, Vision and Control, 2017, Springer.

E-Resources

1. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX-01+V1
2. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-IV-01+V1
3. Selected recent IEEE/ICRA/IROS research papers on autonomous systems

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AI FOR HEALTHCARE

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

SEMESTER – VII

Course Code	:	26AM4708	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45(15 hrs for Project)
L–T–P-J	:	2-0-0-2	**CIE :**		**100 Marks**

Course Vision: It aims to equip students with skills to apply artificial intelligence in improving diagnosis, treatment, and healthcare systems. It promotes innovation, ethical practices, and interdisciplinary knowledge to enhance patient care and healthcare efficiency.

Course Description: This course introduces AI applications in healthcare diagnostics, predictive analytics, medical imaging, and intelligent healthcare systems. Students learn machine learning methods for clinical decision support and personalized medicine. The course emphasizes ethical and reliable healthcare AI solutions.

Course Objectives:

1. To develop advanced understanding of AI techniques for healthcare applications
2. To analyze complex clinical datasets using ML and DL models
3. To design AI-driven decision support systems for medical use cases
4. To evaluate ethical, legal, and regulatory challenges in healthcare AI
5. To assess real-world deployment readiness of medical AI systems

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

MODULE – I	**9 Hours**

INTRODUCTION: Introduction to AI in Healthcare

Overview of AI in medicine, Role of AI in clinical workflows, Intelligent systems in clinical workflows, Smart vs traditional healthcare systems, Basic Case studies

Application: Case study on clinical labs, AI-based radiology tools detect diseases like cancer from medical images quickly and accurately.

MODULE – II	**9 Hours**

Healthcare Data & ML Basics

Types of healthcare data: Electronic Health Record, images, biosignals-Basic ML concepts: Supervised & Unsupervised learning- Simple ML pipeline- Basic evaluation metrics (accuracy, precision)

Application: Using ML to analyze EHR, medical images, and biosignals for disease prediction, diagnosis, and patient monitoring.

MODULE – III	**9 Hours**

Disease prediction & diagnosis-Medical imaging basics-Patient, monitoring systems-Hospital management systems

Application: Applying AI in disease prediction, medical imaging analysis, patient monitoring, sentiment of treatment, and efficient hospital management systems.

MODULE – IV	**9 Hours**

Modern Trends in Healthcare AI

Introduction to Deep Learning-AI chatbots & Virtual Assistants Wearables & remote monitoring-Advanced DL models

Application: Using deep learning, AI chatbots, and wearable devices for advanced diagnosis, virtual assistance, and continuous remote patient monitoring.

MODULE – V	**9 Hours**

Ethics, Governance & Responsible AI Bias, fairness, and trust in medical AI, Privacy, security, and data protection, AI as Software as Medical Device (SaMD), Regulatory frame works (FDA, CDSCO, HIPPA, DPDP, EU AI Act)and governance frameworks, Validation, clinical trials, and deployment challenges.
Application: Applying ethical AI principles, regulatory standards, and validation processes to ensure safe, fair, and secure deployment of medical AI systems.

AI Integration:

- Hospitals integrate AI systems into workflows to assist doctors in diagnosis and patient monitoring.
- Integrating supervised and unsupervised learning models into healthcare systems through a structured ML pipeline for automated decision support.
- Embedding AI models into imaging tools, monitoring devices, and hospital systems for real-time analysis and decision support.
- Integrating advanced deep learning models and AI assistants into healthcare platforms and wearable technologies for real-time insights and support.
- Integrating compliant AI solutions (SaMD) into healthcare with adherence to frameworks like FDA, CDSCO, HIPAA, DPDP Act, and EU AI Act.

Authentic Intelligence:

- AI enhances human intelligence by supporting doctors with accurate insights, not replacing them.
- Ensuring reliable, ethical, and interpretable AI by using accurate data, transparent models, and meaningful evaluation metrics like accuracy and precision.
- Ensuring accurate, trustworthy, and ethical outcomes through validated data, reliable models, and human oversight in healthcare processes.
- Ensuring ethical, transparent, and reliable AI by combining advanced models with human validation and secure, high-quality data handling.
- Ensuring trustworthy AI through bias mitigation, data privacy, rigorous clinical validation, transparent governance, and continuous monitoring after deployment.

Course Outcome :

Course Outcomes (COs)	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
CO1	Analyze AI concepts in clinical healthcare systems	L2
CO2	Apply ML/DL techniques to healthcare datasets	L4
CO3	Design AI-based solutions for medical applications	L3
CO4	Evaluate ethical and regulatory aspects of healthcare AI	L4
CO5	Assess deployment readiness of AI healthcare solutions	L5

Mapping Levels of COs to POs / PSOs

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**
CO-1	3	3	1	-	1	-	-	-	-	-	1	3	1
CO-2	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	3	2	-	-	1	-	-	2	3	3
CO-4	3	3	3	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	1	1	2	2	1	2	3	3

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

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 BOOKS (TB):

1. S. Dash, B. Shickel, M. A. Bray, and S. Saria, Machine Learning for Healthcare, MIT Press, Cambridge, 2021
2. E. Topol, Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again, Basic Books, New York, 2019.
3. A. Holzinger, Explainable AI in Healthcare, Springer Nature, Cham, 2022.
4. K. D. Kulkarni and P. G. Bhat, Artificial Intelligence and Machine Learning in Healthcare, Academic Press (Elsevier), 2020.

REFERENCE BOOKS:

5. Rajkomar, A., Dean, J., & Kohane, I., Machine Learning in Medicine, Cambridge University Press, 2019.
6. J. Jiang, J. Zhi, A. Ni, & D. Shen, Advanced Methods and Tools for ECG Data Analysis, Springer, 2019 — *(for AI in signal processing)*
7. Biomedical Informatics: Computer Applications in Health Care and Biomedicine, Springer, 2018.
8. L. L. Popescu, Deep Learning and Convolutional Neural Networks for Medical Imaging and Clinical Informatics, IGI Global, 2021.
9. K. Friston et al., Statistical Parametric Mapping: The Analysis of Functional Brain Images, Academic Press, 2011 — *(For neuroimaging AI)*
10. D. S. Char, N. Shah, and D. Magnus, Implementing Machine Learning in Healthcare: From Ethical Challenges to Legal Frameworks, Cambridge University Press, 2020.
11. G. Litjens et al., Deep Learning for Medical Image Analysis, Elsevier, 2017.

E-Resources:

- IEEE, springer, mdp, science direct

- https://ocw.mit.edu/courses/hst-921-information-technology-in-the-health-care-system-of-the-future-spring-2009/
- https://www.nlm.nih.gov/
- https://www.who.int/
- https://ocw.mit.edu/search/?q=Health%20care

BUILDING AI APPLICATIONS WITH LARGE LANGUAGE MODELS

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

SEMESTER – VII

Subject Code	:	26AM4709	**Credits**:	03
Hours / Week	:	03 Hours	**Total Hours**:	45(15 hrs for Project)
L–T–P–S	:	2–0–0–2	**CIE :**	**100 marks**

Course Vision :

This course envisions empowering students to design and deploy intelligent applications using Large Language Models (LLMs) by integrating theory with real-world implementation. It aims to develop expertise in modern generative AI systems that can understand, generate, and reason over human language. The course emphasizes practical problem-solving using cutting-edge tools, APIs, and frameworks. It also promotes ethical, responsible, and scalable AI application development. Ultimately, the vision is to create industry-ready engineers capable of building next-generation AI-driven solutions.

Course Description:

This course focuses on designing and deploying AI applications using large language models and generative AI frameworks. Students learn prompt engineering, model integration, and AI workflow development. The course emphasizes real-world intelligent application building.

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)

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 interdisciplinary research examples from social and behavioral sciences*
2. ***Interactive Teaching:****Active learning through problem-solving sessions, debates, and guided discussions on real-world social and behavioral scenarios.*
3. ***Visual Learning:*** *Use of data visualizations, dashboards, case demonstrations, and short videos to explain behavioral patterns and social dynamics.*
4. ***Collaborative Learning:*** *Group-based analysis of social datasets, network structures, and behavioral case studies*
5. ***Critical Thinking:*** *Faculty will pose higher-order thinking questions related to ethics, fairness, bias, and interpretability in AI-driven social systems..*
6. ***Application-Oriented Learning:*** *Continuous emphasis on translating AI concepts into real-world social applications such as governance, education, healthcare, and public policy.*

MODULE – I	**08 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

Case Study: AI-based analysis of public behavior during large-scale social or societal events.

MODULE – II	**08 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. **Case Study:** Predicting student engagement and dropout patterns using educational and interaction data.	
MODULE – III	**08 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	
MODULE – IV	**08 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.	
MODULE – V	**07 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. **Case Study:** Ethical evaluation of AI-based predictive policing and social risk assessment systems.	

AI Integration:

1. Integration of LLM APIs (OpenAI, Hugging Face) into applications.
2. Use of AI frameworks like LangChain for workflow orchestration.
3. Deployment of AI models in cloud environments (AWS, Azure, GCP).
4. Real-time AI systems such as chatbots, virtual assistants, and recommendation engines.
5. Integration with databases using Retrieval-Augmented Generation (RAG)

AI Authentication :

1. Model output verification using human-in-the-loop validation.
2. Bias detection and fairness evaluation in generated outputs.
3. Secure API usage with authentication keys and access control.
4. Detection of hallucinations and misinformation in LLM responses.
5. Ethical compliance and responsible AI governance practices

COURSE OUTCOME

Course Outcome	Description	Bloom's xonomy Level
At the end of the course, the student will be able to:		
1	Explain AI principles and architectures used in social and behavioral science applications.	L2
2	Analyze human behavior, social interactions, and decision-making processes using AI-driven models	L3
3	Apply machine learning, natural language processing, and network analysis techniques for social and behavioral data analysis.	L3
4	Examine social dynamics, group behavior, and collective decision-making using computational and AI-based approaches.	L4

5	Evaluate real-world AI-driven social systems with respect to fairness, privacy, ethical impact, and societal outcomes.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	1	-	1	-	-	-	-	-	1	3	1
CO-2	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	3	2	-	-	1	-	-	2	3	3
CO-4	3	3	3	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	1	1	2	2	1	2	3	3

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

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 BOOKS:

1. Russell, S., & Norvig, P. Artificial Intelligence: A Modern Approach. Pearson, 2021.
2. Salganik, M. J. Bit by Bit: Social Research in the Digital Age. Princeton University Press, 2020.
3. Generative AI with Large Language Models" – DeepLearning.AI (2024 Edition)
4. Natural Language Processing with Transformers" – Lewis Tunstall et al. (O'Reilly, 2023)
5. Hands-On Large Language Models" – Jay Alammar & Maarten Grootendorst (2024)
6. Building LLM Powered Applications" – Chip Huyen (2024)
7. Aggarwal, C. C. Social Network Data Analytics. Springer, 2022.
8. Jurafsky, D., & Martin, J. Speech and Language Processing. Pearson, 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.
4. Barocas, S., Hardt, M., & Narayanan, A. Fairness and Machine Learning. MIT Press, 2023.
5. Salganik, M. J. Bit by Bit: Social Research in the Digital Age. Princeton University Press, 2020.
6. Pentland, A. Social Physics: How Social Networks Can Make Us Smarter. Penguin Books, 2015.
7. Lazer, D. et al. Computational Social Science. Science, 2009.

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. Analysis of social and behavioral datasets using AI techniques through group discussion. Case-study-based evaluation of AI models applied in governance, education, healthcare, or social media platforms.

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Deep Learning for Science and Engineering

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

SEMESTER – VII

Course Code	:	26AM4710	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45(15 hrs for Project)
L–T–P-J	:	2-0-0-2	**CIE :**		**100 Marks**

Course Vision: This course aims to develop a strong foundation in deep learning and its application to scientific and engineering problems. It focuses on integrating data-driven models with physical principles, enabling learners to solve complex real-world problems using scalable, efficient, and
intelligent computational techniques.

Course Description: This course explores deep learning techniques for solving scientific and engineering problems. Students learn AI-based modelling, simulation, prediction, and optimization methods. The course focuses on interdisciplinary applications of deep learning.

Course Objectives:

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)

These are sample new pedagogical methods that a teacher can use to accelerate the attainment of the various course outcomes:

1. **Lecture method:** Along with the traditional lecture method, different types of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** Incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and role-playing.
3. Showing **video/animation** films to explain the functioning of various concepts.
4. Encourage **collaborative** (group learning) learning in the class.
5. To foster critical thinking by asking higher-order thinking questions in the class in the form of quizzes and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encouraging the students to come up with their own creative ways to solve them.

MODULE – I	**09 Hours**

Fundamentals of Deep Learning

Topics: 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

Applications: Image Classification and Object Detection, Chatbots and Text Analysis, Speech Recognition Systems, Deep Learning Model Development, Data Analysis with Python Tools

MODULE – II	**09 Hours**

Neural Differential Equations

Topics: Discovering Differential Equations, Physics-Informed Neural Networks (PINNs)—Part I, Physics-Informed Neural Networks (PINNs)- Part II

Applications: Solving Differential Equations in Engineering Systems, Fluid Dynamics Aerodynamics Simulation, Heat Transfer and Thermal Analysis, Structural Health Monitoring and Material Modelling, Climate Modelling and Environmental Prediction

MODULE– III	**09 Hours**

Neural Operators **Topics:** 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 **Applications:** Solving Partial Differential Equations in scientific computing, Fluid Flow and Turbulence Modelling, Weather and Climate Prediction, Material Science and Structural Simulation, Real-time Engineering Simulations and Digital Twins	
MODULE – IV	**09 Hours**

Data and Uncertainty **Topics:** 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. **Applications:** Engineering Design Optimization with Limited Data, Risk Assessment and Decision Making under Uncertainty, Climate and Weather Forecasting with Confidence Intervals, Medical Diagnosis with Uncertainty Estimation, Surrogate Modelling for Complex Simulations	
MODULE – V	**09 Hours**
Scalable Scientific Machine Learning **Topics:** 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. **Applications:** Large-Scale Scientific Simulations using Multi-GPU Systems, High-Performance Computing for physics-based modeling, Real-Time Fluid Dynamics and Wave Simulations, Parallel Training of Deep Learning Models for big data, and Digital Twin Development for Complex Engineering Systems.	

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
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

Mapping Levels of COs to POs / PSOs

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**
CO-1	3	3	1	-	1	-	-	-	-	-	1	3	1
CO-2	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	3	2	-	-	1	-	-	2	3	3
CO-4	3	3	3	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	1	1	2	2	1	2	3	3

AI Integration

1. Application of deep learning models in scientific problem solving
2. Integration of AI with physics-based simulations
3. Automated model training and optimization
4. AI-driven predictive analytics for engineering systems
5. Deployment of intelligent, scalable AI systems

Authentic Intelligence

1. Real-world case studies from science and engineering domains
2. Hands-on implementation using industry tools
3. Problem-solving using real datasets
4. Ethical considerations in AI applications
5. Project-based experiential learning.

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 BOOKS:

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

E-RESOURCES:

https://developer.nvidia.com/teaching-kits/science-and-engineering-syllabus

1. https://www.tensorflow.org/
2. https://pytorch.org/tutorials/
3. https://ocw.mit.edu/courses/6-036-introduction-to-machine-learning-fall-2020/

4. NVIDIA Deep Learning Institute (DLI)
5. Deep Learning with PyTorch (Coursera)
6. TensorFlow 2 Deep Learning Specialization

RECOMMENDED TOOLS

- Python (NumPy, SciPy, Jupyter Notebook) TensorFlow / PyTorch / JAX

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ETHICS, SAFETY & GOVERNANCE OF AGENTIC AI

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

SEMESTER – VII

Course Code	:	26AM4711	**Credits**	03
Hours / Week	:	3 Hours	**Total Hours**	45 Hours
L–T–P-J	:	2–0–0-2	**CIE :**	**100 Marks**

Course Vision :

The course "Ethics, Safety & Governance of Agentic AI" aims to provide students with a comprehensive understanding of the ethical principles, safety mechanisms, regulatory frameworks, and governance strategies associated with autonomous and agent-based Artificial Intelligence systems. The course focuses on responsible AI development, transparency, accountability, bias mitigation, privacy protection, risk assessment, and human-centered AI decision-making in intelligent autonomous environments. It enables learners to critically analyze the societal, legal, and technological impacts of agentic AI while promoting secure, trustworthy, and ethically aligned AI deployment across industries. The course further prepares students to design and manage AI systems that comply with global ethical standards, safety regulations, and governance policies for sustainable and responsible innovation.

Course Description: This course examines ethical, legal, and safety considerations associated with autonomous and agentic AI systems. Students learn governance frameworks, AI risk management, and responsible deployment strategies. The course promotes trustworthy and human-aligned AI development.

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)

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.

MODULE – I	**09 Hours**
Foundations of Ethics and Agentic AI **Topics:** 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. **Applications**: Autonomous Decision-Making in Healthcare Triage Systems	
MODULE – II	**09 Hours**
Safety, Risk, and Alignment in Agentic Systems **Topics:** 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. **Applications**: Reward Hacking in a Reinforcement Learning Trading Agent	
MODULE – III	**09 Hours**
Governance, Law, and Policy Frameworks **Topics:** 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). **Applications**: Facial Recognition AI and Regulatory Conflict	
MODULE – IV	**09 Hours**
Societal Impact and Responsible Deployment **Topics:** 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. **Applications**: Algorithmic Hiring Agent and Workforce Discrimination	
MODULE – V	**Hours**
Future Directions and Trustworthy Agentic AI **Topics:** 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. **Applications**: Autonomous Weapons and Human Oversight	

Course Outcomes :

Course Outcomes (COs)	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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	1	-	1	-	-	-	-	-	1	3	1
CO-2	3	3	2	2	3	-	-	1	-	-	2	3	3
CO-3	3	3	2	3	2	-	-	1	-	-	2	3	3
CO-4	3	3	3	2	3	-	1	2	1	1	2	3	3
CO-5	3	3	3	2	3	1	1	2	2	1	2	3	3

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

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 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., & Mane´, 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.

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INTELLIGENT VIDEO SURVEILLANCE SYSTEMS

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

SEMESTER – VII

Course Code	:	26AM4712	**Credits**	03
Hours / Week	:	3 Hours	**Total Hours**	45 (15 hrs for Project)
L–T–P-J	:	2–0–0-2	**CIE**	100 Marks

Course Vision:

To equip students with the knowledge and practical skills required to design and develop intelligent video surveillance systems using advanced video analytics, machine learning, and deep learning techniques, enabling them to address real-world challenges in security, smart cities, traffic management, and business intelligence while ensuring ethical and responsible use of surveillance technologies.

Course Description:

Intelligent Video Surveillance Systems focuses on designing systems that analyze and interpret video data for real-world applications. The course covers video analytics pipelines, pre-processing, feature extraction techniques (PCA, SIFT, HOG), segmentation, object tracking, and classification using machine learning and deep learning models such as CNNs, RNNs, and LSTMs. It also explores applications in security, traffic monitoring, crowd analysis, anomaly detection, and business intelligence, while introducing advanced topics like edge computing, AI-powered surveillance, and ethical use of intelligent systems.

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.

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: The course adopts a student-centric and application-oriented teaching methodology to ensure both conceptual understanding and practical skill development in intelligent video surveillance systems.

1. **Lectures & Interactive Sessions:** Core concepts such as video analytics pipelines, feature extraction, segmentation, and classification techniques are delivered through lectures supported by real-world examples and case studies.
2. **Multimedia-Based Learning**: Use of videos, animations, and simulation tools to demonstrate concepts like object tracking, motion detection, and human activity recognition.
3. **Hands-on Practice / Laboratory Sessions:** Students implement algorithms using tools such as Python, OpenCV, and deep learning frameworks to gain practical exposure to video analytics tasks.
4. **Case Studies & Problem-Based Learning:** Analysis of real-world applications in surveillance, traffic monitoring, and business intelligence to enhance analytical and problem-solving skills.
5. **Mini Projects / Assignments:** Students design and develop small-scale intelligent surveillance systems or modules such as object detection, crowd monitoring, or anomaly detection.
6. **Group Discussions & Seminars:** Encourages collaborative learning through presentations on emerging topics like AI-powered surveillance, edge computing, and ethical issues in surveillance.
7. **Industry Interaction / Guest Lectures:** Experts from industry share insights on current trends, tools, and deployment challenges in video analytics and surveillance systems.
8. **Self-Learning & E-Resources:** Students are encouraged to explore online platforms, research papers, and open-source datasets to deepen their understanding.
9. **Continuous Assessment:** Regular quizzes, coding assignments, and project evaluations to monitor progress and provide feedback.

Course Modules:

MODULE – I: Video Analytic Components	**09 Hours**
Topics: 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. ***Applications:*** Surveillance and security systems, Traffic monitoring and accident detection, Facial recognition systems, Industrial quality inspection, Human activity recognition, Video search and retrieval.	
MODULE – II: Foreground Extraction & Segmentation	**09 Hours**
Topics: 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. ***Applications:*** Object detection and tracking in surveillance, Motion detection in video analytics, medical image segmentation, Autonomous vehicle navigation, Industrial defect detection, Crowd and activity monitoring.	
MODULE– III: Classifiers for Video Analysis	**09 Hours**
Topics: 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. ***Applications:*** Action and activity recognition, video-based anomaly detection, Speech and gesture recognition, Emotion recognition from video, autonomous driving perception systems, and smart surveillance and behavior analysis.	

MODULE – IV: Video Analytics for Security Applications	09 Hours
Topics: 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. ***Applications:*** Smart surveillance systems, Intrusion and perimeter security, Crowd monitoring and management, Biometric identification (gait and pose), Suspicious activity detection, Smart city safety applications.	
MODULE– V: Business Intelligence, Traffic Monitoring & Advanced Topics	**09 Hours**
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. ***Applications:*** Retail analytics and customer behavior analysis, Queue management systems, Traffic monitoring and violation detection, ADAS in smart vehicles, 3D surveillance and scene reconstruction, Edge-based real-time video analytics.	

AI INTEGRATION & AUTHENTIC INTELLIGENCE:

- **AI Integration:**
  - Module-1: AI-based video understanding systems, automated feature extraction tools, and AI-driven video classification models.
  - Module-2: AI-based background subtraction models, motion detection algorithms, intelligent object segmentation tools.
  - Module-3: Deep learning models (CNN, RNN, and LSTM) for video classification, AI-based activity recognition systems, and probabilistic sequence modeling tools.
  - Module-4: AI-powered surveillance systems, human behavior analysis models, crowd monitoring and anomaly detection systems.
  - Module-5: AI-driven retail analytics, smart traffic monitoring systems, ADAS and edge-based video analytics solutions.

- **Authentic Intelligence Reflection:**
  - Module-1: Students analyze limitations of video analytics systems, challenges in feature extraction, and the need for human interpretation in complex scenarios.
  - Module-2: Students evaluate accuracy issues in segmentation and tracking, challenges in dynamic environments, and robustness of motion detection techniques.
  - Module-3: Students assess model performance, overfitting issues, and limitations of deep learning models in real-time video applications.
  - Module-4: Students examine ethical concerns in surveillance, privacy issues, and biases in behavior and facial recognition systems.
  - Module-5: Students evaluate reliability of AI in traffic and retail analytics, challenges in edge deployment, and ethical implications of large-scale video monitoring.

Course outcomes:

Course Outcomes (COs)	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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	-	-	-	-	-	-	2	1
CO-2	2	3	2	3	2	-	-	-	-	-	-	3	2
CO-3	2	3	3	3	2	-	-	-	1	1	_	3	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	2	3

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

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**

ASSESSMENT SCHEME:

1. **"Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:

a. **Mid Semester Examination (MSE):** One descriptive examination to evaluate conceptual understanding of AI fundamentals and problem-solving approaches.

b. **Continuous Assessment Tools (CAT – Six Components):** It may include: Surprise test (Computer-based), Quiz, Project based learning, Reflection Note on Guest Lecture, Industrial visit, E-course certification, Building models, Group discussion, Case study, Seminar, or Open Book Assignment.

c. **AI-Powered Assignment (APA):** Use of AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

2. **"External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of AI concepts, application skills, and their ability to analyze and solve problems effectively.

Text Books:

1. Patil, Lalit V., et al. – Video Analytics, Nirali Prakashan, 2023.
2. Tekalp, A. Murat – Digital Video Processing, Pearson, 2015.

Reference Books:

1. Video Analytics – Lalit V. Patil, Anup Ingle, Sunita S. Dhotre, Nitin N. Sakhare – Video Analytics, Nirali Prakashan, 2023.
2. Intelligent Image and Video Analytics – El-Sayed M. El-Alfy, George Bebis, Mengchu Zhou – Intelligent Image and Video Analytics, CRC Press, 2023.
3. Video Data Analytics for Smart City Applications: Methods and Trends – Abhishek Singh Rathore, Surendra Rahamatkar, Syed Imran Ali, Ramgopal Kashyap, Nand Kishore Sharma – Video Data Analytics for Smart City Applications: Methods and Trends, Bentham Science Publishers, 2023.
4. Computational Intelligence in Image and Video Processing – Mukesh D. Patil, Gajanan K. Birajdar, Sangita S. Chaudhari – Computational Intelligence in Image and Video Processing, Chapman & Hall/CRC, 2023.

E-Resources: (Recommended Tools)

- 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. Collaborative Activity is minor project development with a team of 4 students.

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FOUNDATION MODELS FOR ROBOTICS

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

SEMESTER – VII

Subject Code	:	26AM4713	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for Project)
L–T–P–S	:	2–0–0–2	**CIE**	:	100 Marks

Course Vision:

To develop a deep understanding of how foundation models transform robotic systems by integrating perception, reasoning, and action into unified intelligent frameworks. The course aims to equip students with the ability to design and analyze multimodal robotic systems that leverage language and vision models, enabling flexible, context-aware, and generalizable robotic behavior beyond traditional modular architectures.

Course Description:

To enable students to understand and apply foundation models (LLMs, VLMs, and Vision-Language-Action models) in robotic systems for perception, reasoning, and task-level decision-making, representing a paradigm shift from traditional modular pipelines to integrated intelligent systems.

This course emphasizes how foundation models transform robotic autonomy by enabling language understanding, cross-modal reasoning, and generalization across environments, moving beyond rigid perception–planning–control architectures toward flexible, intelligent robotic behavior.

Course Learning Objectives:

Students will:

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

Course Vision:

To enable students to understand and apply foundation models (LLMs, VLMs, and Vision-Language-Action models) in robotic systems for perception, reasoning, and task-level decision-making, representing a paradigm shift from traditional modular pipelines to integrated intelligent systems.

This course emphasizes how foundation models transform robotic autonomy by enabling language understanding, cross-modal reasoning, and generalization across environments, moving beyond rigid perception–planning–control architectures toward flexible, intelligent robotic behavior.

Course Outcome	Description	Bloom's Taxonomy Level

CO1	Analyze and describe the principles and role of foundation models in robotics	L4
CO2	Apply language and vision models for perception and interaction tasks	L3
CO3	Analyze and utilize foundation models for reasoning and decision-making in robotics	L4
CO4	Develop and integrate foundation models into robotic subsystems	L5
CO5	Design and implement a complete multimodal robotic system	L6

UNIT – I : Foundations of Robotics Paradigm Shift	**09 Hours**
Evolution of robotics systems, modular vs integrated architectures, introduction to foundation models (LLMs, VLMs, VLAs), representation learning, limitations of classical robotics Applications: Natural language-based robot control, generalization across environments	
UNIT – II : Language and Vision Models for Robotics	**09 Hours**
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. Applications: Language-guided object detection, scene interpretation, robot perception enhancement.	
UNIT – III : Reasoning and Decision-Making with Grounded Robotics Actions	**09 Hours**
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. Applications: High-level task planning with executable robot actions, instruction-driven embodied agents.	
UNIT – IV : Robotics Applications using Foundation Models	**09 Hours**
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) Applications: Language-driven manipulation, context-aware navigation, assistive and service robotics	
UNIT – V : System Integration, Evaluation, and Future Robotics Intelligence	**09 Hours**
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 ***Applications:*** End-to-end robotic systems, cloud vs edge AI in robotics	

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs													
COS	Program Outcomes (POs)											PSOs	
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CO-1	3	2	1	2	1	-	-	-	-	-	-	2	1
CO-2	2	3	2	3	2	-	-	-	-	-	-	3	2
CO-3	2	3	3	3	2	-	-	-	1	1	_	3	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	2	3

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

AI Integration & Authentic Intelligence Reflection (AI² Pedagogy)

AI Integration:

- Use of pretrained AI models in robotics workflows, API-based model access
- Integration of VLMs with robotic perception pipelines, transforming sensor data into actionable representations.
- LLM-based planners, prompt engineering for robotics tasks, integration of reasoning outputs with robotic execution pipelines.
- Combining perception, reasoning, and action in embodied systems
- Model orchestration, system-level integration strategies

Authentic Intelligence Reflection:

- Model bias, lack of interpretability, over-reliance on pretrained systems
- Visual misinterpretation, dataset bias, perception uncertainty, and challenges in grounding perception to real-world actions.
- Hallucination risks, mismatch between reasoning and physical execution, reliability and safety concerns in embodied decision-making.
- Real-world uncertainty, safety in human environments, embodiment limitations
- Accountability, trust, and real-world failure consequences

Mini Project (Mandatory)

Students will design a robotics system utilizing foundation models.

Examples:

- Language-guided object manipulation in simulation
- Vision-language-based navigation system
- Instruction-following robotic assistant

Mandatory Requirement:

All projects must demonstrate grounding of model outputs into robotic actions (simulation or real-world).

Students must analyze:

- System design and architecture
- AI model integration
- Task reasoning capability
- Robustness and limitations
- Ethical and safety considerations

Evaluation Focus

- System Design Clarity
- Level of Autonomy Achieved
- Grounding Fidelity
- Robustness Under Uncertainty
- Failure Handling and Recovery

Recommended Tools

- Python
- OpenAI / HuggingFace APIs
- Integration with ROS-based pipelines (optional but strongly encouraged)
- Simulation tools (Gazebo, PyBullet, Isaac Sim)

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 Tool Usage for Teaching and Learning

AI tools will be used in this course as structured pedagogical support to enhance understanding, system design, and problem-solving.

Instructor Use (AI as Co-Teacher)

- Generate alternative explanations, examples, and case studies
- Demonstrate system workflows, debugging strategies, and design variations

Student Use (AI as Teaching Assistant)

- Concept clarification and understanding
- Code assistance and debugging (with explanation)
- System design exploration and documentation support

Guidelines for Use

- All AI-assisted work must be understood and explainable by the student

- Blind use of AI-generated content is not acceptable
- Students must critically evaluate AI outputs and identify errors or limitations

Evaluation Integration

- Viva and project discussions will assess individual understanding
- Students may be asked to explain or modify AI-assisted solutions

Suggested

Reading Text

Books

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

3. Thrun, S., Burgard, W., Fox, D., Probabilistic Robotics, MIT Press, 2005
4. Dieter Fox, Wolfram Burgard, and Sebastian Thrun, Robotics: State Estimation and Learning (selected readings).

E-Resources:

1. Recent survey papers on foundation models in robotics (e.g., embodied AI surveys)
2. Google RT-2: Vision-Language-Action Models
3. SayCan: Language to Robot Action Grounding
4. PaLM-E: Embodied Multimodal Models
5. Recent publications from ICRA, RSS, CoRL (Post-2020)

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AI FOR AGRICULTURE

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

SEMESTER – VII

Subject Code	:	26AM4714	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 Hours for Project)
L–T–P–S		2–0–0–2	**CIE**	:	100 Marks

Course Vision:

To empower with knowledge and skills in Artificial Intelligence for developing smart, sustainable, and technology-driven agricultural solutions that enhance productivity, efficiency, and food security. To nurture innovation and research mindset for transforming modern farming through intelligent systems and data-driven decision-making.

Course Description:

This course explores AI applications in precision agriculture, crop monitoring, predictive analytics, and smart farming technologies. Students learn intelligent solutions for sustainable agricultural practices. The course focuses on technology-driven agricultural innovation.

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 :

AI in Agriculture introduces the application of Artificial Intelligence technologies in transforming traditional farming into smart and sustainable agriculture. The course covers machine learning models for crop prediction, computer vision for disease detection, IoT sensors for soil and weather monitoring, and robotics for automated farming operations.

The Course explore how AI supports precision agriculture, optimizes resources, improves productivity, and reduces environmental impact. Topics include predictive analytics, deep learning, drones, autonomous tractors, agricultural data mining, and future trends in smart farming ecosystems.

Module – 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). ***Applications:*** Smart irrigation, crop advisory systems, farm monitoring.

Module – 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 ***Applications:*** Disease diagnosis, automated spraying, crop quality grading.

Module – 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. ***Applications:*** Smart irrigation, autonomous farming machines, precision spraying.	
Module – 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. ***Applications***: Yield estimation, crop planning, market forecasting.	
Module – 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. ***Applications:*** Smart villages, climate-resilient farming, agri-business intelligence.	

Course Outcome:

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:

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
CO-1	3	2	1	-	2	-	1	-	-	-	2	1	1
CO-2	3	3	2	1	3	-	-	-	-	-	2	2	2
CO-3	3	3	3	2	3	-	-	-	-	-	2	2	2
CO-4	3	3	3	2	3	1	1	2	1	-	2	2	3
CO-5	3	3	2	2	2	2	3	1	1	1	3	2	2

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

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 INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**
  - AI-based farm decision systems
  - Deep learning for crop disease detection
  - IoT and robotics in agriculture
  - ML for crop yield and weather prediction
  - Sustainable AI farming ecosystems.

- **Authentic Intelligence Reflection:**
  - Evaluate reliability of AI crop prediction models
  - Identify bias in agricultural datasets
  - Analyze ethical impact of farm automation
  - Reflect on sustainability of AI farming tools
  - Assess rural adoption challenges.

RESEARCH INTEGRATION TEACHING

1. Case study review on smart farming startups.
2. Paper review on crop disease detection datasets.
3. Seminar on AI in Indian agriculture.
4. Mini presentations on drones and robotics.
5. Critical analysis of sustainable agriculture systems.

AI-POWERED ASSIGNMENTS:

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: Crop Disease Detection

Prompt AI tool to generate disease classification model using CNN. Students must verify dataset quality and accuracy.

Assignment 2: Yield Prediction Study

Compare regression models for crop yield prediction. Students evaluate performance metrics.

Assignment 3: Smart Irrigation Design

Use AI tool to generate IoT irrigation logic.
Students refine practical implementation.

Assignment 4: Drone Data Analytics

Use AI visualization tools for crop aerial data analysis.

Assignment 5: Sustainable Farming Evaluation

Compare AI farming solutions based on cost, water usage, and efficiency

Suggested Reading:

Primary Textbooks

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.

Additional Resources

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

3. IEEE research articles

E-Resources : (Recommended Tools)

- Python/OpenCV
- Tensorflow/ PyTorch
- Scikit-learn
- Kaggle Agricultural Datasets
- Drone Mapping Software

Activity Based Learning (Suggested Activities in Class)

1. Group discussion on AI applications in crop monitoring, irrigation, and disease detection.

2. Collaborative mini project in teams of 4 students such as smart irrigation, pest detection, or crop yield prediction system.

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MULTIMODAL AND MULTILINGUAL LANGUAGE PERCEPTION

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

SEMESTER – VII

Subject Code	:	26AM4715	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45 (15 Hrs for Project)
L–T–P–S		2–0–0–2	**CIE**	:	100 Marks

Course Vision:

To empower with knowledge and skills in Artificial Intelligence for developing smart, sustainable, and technology-driven solutions that enhance productivity, efficiency, and Language. To nurture innovation and research mindset for transforming modern intelligent systems and data-driven decision-making.

Course Description:

This course focuses on AI systems capable of understanding multiple forms of communication across languages and modalities. Students learn multimodal fusion, multilingual NLP, and intelligent perception systems. The course supports inclusive and advanced communication technologies.

Course Learning 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)

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

1. **Real-World Examples:** Multimodal AI systems used in translation, speech assistants, and vision-language tasks
2. **Problem-Solving Sessions:** Designing models for multilingual and multimodal perception
3. **Reflective Learning**: Discussions on bias, inclusivity, and ethical challenges in multilingual AI

MODULE – I :	**10 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.

MODULE– II :	**10 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.

MODULE – III :	**11 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.
MODULE – IV : **10 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.
MODULE – V : **11 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.

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**

Course Outcome:

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

Mapping Levels of COs to POs / PSOs:

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
CO-1	3	2	1	-	2	-	1	-	-	-	2	1	1
CO-2	3	3	2	1	3	-	-	-	-	-	2	2	2

CO-3	3	3	3	2	3	-	-	-	-	-	2	2	2
CO-4	3	3	3	2	3	1	1	2	1	-	2	2	3
CO-5	3	3	2	2	2	2	3	1	1	1	3	2	2

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

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

E-Resources:

1. https://nptel.ac.in/courses/106105235
2. https://ieeexplore.ieee.org/document/10953521/
3. https://www.geeksforgeeks.org/MLP-tutorials/
4. MLP - Course (nptel.ac.in)

Activity Based Learning (Suggested Activities in Class)

Hands on activity, Quiz, Seminar

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HUMAN-CENTRIC AUTOMATION AND INDUSTRY 5.0

SEMESTER – VII

Subject Code	:	26OEXXXX	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs Project)
L–T–P–S	:	3–0–0–0	**CIE+SEE**	:	60+40 MARKS

Course Learning Objectives:

This course will enable students to:

1. Analyse the transition from Industry 4.0 to Industry 5.0
2. Evaluate human–machine collaboration models in modern industries
3. Apply AI, robotics, and IoT concepts in human-centric automation
4. Critically assess ethical, social, and sustainability challenges

Teaching – Learning Process:

This course provides an advanced understanding of Industry 5.0, emphasising the integration of human intelligence with smart automation systems. Students explore collaborative robotics, AI-driven industrial systems, digital twins, and human-in-the-loop frameworks. The course focuses on designing systems that enhance human capabilities, ensure sustainability, and maintain ethical standards. Case studies, industry practices, and research-oriented learning prepare students for leadership roles in future industries.

Course Modules :

UNIT – I : Industry 5.0 – Concepts and Frameworks	**09 Hours**

Evolution from Industry 1.0 to 5.0, comparison of Industry 4.0 and 5.0, human-centric design principles, resilience and sustainability, industrial frameworks and standards.
Applications: Smart factories, resilient manufacturing systems, mass personalisation. Focus on worker-centric production and customisation.

UNIT – II : Human–Machine Collaboration Systems	**09 Hours**

Collaborative robots (COBOTS), human-in-the-loop systems, augmented intelligence, ergonomics, safety, and cognitive automation. **Applications:** Cobots in assembly lines, assistive robotics, adaptive workplaces. Focus on productivity with safety and comfort.

UNIT – III : Advanced Enabling Technologies	**09 Hours**

AI in industrial automation, Industrial IoT (IIoT), digital twins, edge computing, cyber-physical systems, and real-time analytics.V-Model , Software in the Loop, Hardware in the Loop
Applications: Predictive maintenance, intelligent manufacturing, and real-time monitoring. Focus on data-driven industrial decisions.

UNIT – IV : Ethics, Sustainability	**09 Hours**

Ethical AI, workforce transformation, reskilling and upskilling, sustainability, circular economy, policies and governance. **Applications**: Green manufacturing, sustainable supply chains, responsible automation.

UNIT – V : Human-Centric Industrial Design & Innovation	**09 Hours**

Human-centered system design, human-AI collaboration frameworks, adaptive automation, innovation in Industry 5.0 systems. **Applications:** Personalized production systems, human-robot teamwork, smart industrial design.

Course Outcome:

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

Mapping Levels of COs to POs / PSOs:

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
CO-1	3	3	3	2	3	2	1	2	2	2	1	3	2
CO-2	3	3	3	2	3	2	1	2	2	2	1	3	2
CO-3	3	3	3	2	3	2	1	2	2	2	1	3	2
CO-4	3	3	3	2	3	2	1	2	2	2	1	3	2
CO-5	3	3	3	2	3	2	1	2	2	2	1	3	2

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

Evaluation Scheme

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**
  - AI-based industrial analytics
  - Human-in-the-loop AI systems
  - Predictive maintenance models
  - AI-driven sustainability optimization.
- **Authentic Intelligence Reflection:**
  - Understanding human role in automation
  - Evaluating trust and safety in AI systems
  - Analyzing risks of over-automation
  - Ethical responsibility and sustainability awareness

RESEARCH INTEGRATION TEACHING

- Paper Review on Industry 5.0 and human–robot collaboration
- Case Studies on smart factories and automation systems

- Mini Presentation on emerging industrial technologies
- AI-assisted research analysis
- Critical reflection on ethical and industrial challenges

ASSESSMENT SCHEME :

Criteria	Weightage of Marks
Continuous Assessment Tool (CAT)	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment "Or" Mini Project*	10
Total	**100 marks**

AI-POWERED ASSIGNMENTS:

Assignment 1: Industry 5.0 System Analysis

- Analyze a smart factory using AI toolsEvaluate human involvement

Assignment 2: Human-in-the-Loop Design

- Design a collaborative human-AI system
- Justify decision-making process

Assignment 3: Predictive Maintenance Evaluation

- Analyze AI-generated outputs
- Evaluate reliability and risks

Assignment 4: Ethical Automation Case Study

- Study real-world automation issues
- Suggest responsible solutions

Suggested Reading :

Primary Textbooks

- Liermann, Volker – The Impact of Digital Transformation and FinTech on Finance Professionals
- Boukherouaa, E. et al. – Powering the Digital Economy: AI in Finance

Additional Resources

- Bazarbash, Majid – Fintech in Financial Inclusion
- Ng, Jeffrey & Shah, Subhash – Hands-On Artificial Intelligence for Banking
- Dixon, Matthew F. et al. – Machine Learning in Finance
- Choi, Paul Moon Sub & Huang, Seth H. – FinTech with AI, Big Data, and Blockchain
- Chishti, Susanne – The AI Book

<u>E-Resources : (Recommended Tools)</u>

- ChatGPT / AI simulation tools
- IoT platforms (conceptual)
- Python / Excel
- Visualization tools

Activity Based Learning (Suggested Activities in Class)

- Group discussion on human–machine collaboration

Mini project on smart industrial system design

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CONVERSATIONAL AI AND SPOKEN LANGUAGE UNDERSTANDING

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

SEMESTER – VII

Subject Code	:	26OEXXXX	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for Project)
L–T–P–S	:	**3**–0–0–0	**CIE+SEE**	:	60+40 Marks

Course Vision: Fundamentals of Artificial Intelligence, Machine Learning concepts, Probability and Statistics, Natural Language Processing. Familiarity with Python programming language is desirable. Prior exposure to optimization or deep learning and Neural Network concepts will be an added advantage.

Course Description:

This course explores AI-driven conversational systems, speech recognition, and intelligent dialogue management. Students learn techniques for developing voice-enabled assistants and interactive AI systems. The course focuses on natural and intelligent human-computer communication.

Course Learning 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.

MODULE – I : Foundations of Conversational AI	**8 Hours**

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.

MODULE – II : Natural Language Understanding & Representation Learning	**8 Hours**

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

MODULE – III : Dialogue Management, Generation & LLMs	**8 Hours**

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.

MODULE – IV : Advanced Conversational AI Systems	**8 Hours**

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)

MODULE – V : Deployment, Evaluation, Ethics & Future Trends	**7 Hours**

Evaluation metrics, human evaluation of conversational agents, deployment architectures and APIs, MLOps for conversational AI, security issues, future research directions and open challenges.

Course Outcomes

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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	-	-	-	-	-	-	2	2
CO-2	2	3	2	3	2	-	-	-	-	-	-	2	3
CO-3	2	3	3	3	2	-	-	-	1	1	_	2	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	3	2

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

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

TEXTBOOKS:

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. **"Effective Conversational AI" by Andrew Freed, Cari Jacobs, Eniko Rozsa, Foreword by Jesús Mantas, April 2025.**
2. "Designing Bots: Creating Conversational Experiences" by Amir Shewat, June 2017.
3. **The Definitive Guide to Conversational AI with Dialogflow and Google Cloud by Lee Boonstra, 2021.**

E-Resources:

1. **Conversational AI: LLM Driven Development for Beginners – course by udemy**
2. **Getting started with Conversational AI - https://www.youtube.com/watch?v=OsbY7ju o KgI**
3. **Conversational AI (2024): A Comprehensive Guide - https://www.gupshup.ai/resources/guide/conversational-ai- comprehensive-guide/**

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AI FOR PSYCHOLOGY

SEMESTER – VII

Subject Code	:	26OEXXXX	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 hrs for project)
L–T–P–S	:	3–0–0–0	**CIA+SEE**	:	60+40 Marks

Course Learning Objectives:

This course will enable students to:

1. Understand basic concepts of Artificial Intelligence in psychological contexts.
2. Explore applications of AI in cognition, behavior, and mental health systems.
3. Analyze human–AI interaction and behavioral changes.
4. Evaluate ethical and societal issues of AI in psychology.

Course Vision:

This course introduces students to the intersection of Artificial Intelligence and Psychology, focusing on how AI technologies influence human cognition, behavior, and mental health. It covers fundamental AI concepts and their applications in cognitive science, behavioral analysis, and psychological research.

Students explore areas such as human-AI interaction, emotional AI, and AI-driven mental health tools. The course emphasizes real-world applications like chatbots for therapy, behavioral prediction systems, and digital mental health platforms. A unique AI^2 pedagogy is followed, where students actively use AI tools and critically evaluate their outputs. The course highlights biases, ethical risks, and limitations of AI in sensitive psychological contexts.

Through case studies, discussions, and research-based learning, students develop both technical understanding and human-centered thinking. The course prepares students to responsibly use AI in psychological and social domains.

Course Description:

This course introduces students to the intersection of Artificial Intelligence and Psychology, focusing on how AI technologies influence human cognition, behavior, and mental health. It covers fundamental AI concepts and their applications in cognitive science, behavioral analysis, and psychological research.

Students explore areas such as human-AI interaction, emotional AI, and AI-driven mental health tools. The course emphasizes real-world applications like chatbots for therapy, behavioral prediction systems, and digital mental health platforms. A unique AI^2 pedagogy is followed, where students actively use AI tools and critically evaluate their outputs. The course highlights biases, ethical risks, and limitations of AI in sensitive psychological contexts.

Through case studies, discussions, and research-based learning, students develop both technical understanding and human-centered thinking. The course prepares students to responsibly use AI in psychological and social domains.

Course Modules :

MODULE – I : Introduction to AI in Psychology	**09 Hours**
Basics of Artificial Intelligence, history and evolution, role of AI in psychology, introduction to cognitive science and computational thinking. **Applications**: AI-based cognitive modeling, behavior prediction systems.	
MODULE – II : Cognitive Science and Mental Health	**09 Hours**
AI applications in cognition, perception, memory, and learning; AI-based mental health tools, therapy chatbots, emotion detection systems. **Applications:** Digital mental health platforms, AI-based diagnosis support.	
MODULE -III : Human–AI Interaction and Behavioural Analysis	**09 Hours**
Human-AI interaction, user behavior analysis, emotional AI, social robots, trust and dependency on AI systems. **Applications:** Virtual assistants, human behavior tracking, adaptive interfaces.	

MODULE – IV :Ethical and Social Implications of AI in Psychology	09 Hours
Ethical AI, privacy concerns, bias in AI systems, psychological risks of AI, societal impact of AI in mental health. **Applications:** Responsible AI in therapy, ethical AI-based decision systems.	
MODULE – V : AI for Psychological Research and Future Trends	**09 Hours**
AI in psychological research, data-driven behavioral studies, future of AI in psychology, human-AI collaboration in mental health. **Applications:** AI-assisted research, personalized mental health solutions.	

Course Outcomes

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain fundamental AI concepts relevant to psychology	L2
2	Identify AI applications in cognitive science and mental health	L3
3	Analyze behavioral changes due to human–AI interaction	L4
4	Evaluate ethical and societal implications of AI in psychology	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	1	2	1	-	-	-	-	-	-	2	2
CO-2	2	3	2	3	2	-	-	-	-	-	-	2	3
CO-3	2	3	3	3	2	-	-	-	1	1	_	2	3
CO-4	1	2	3	3	3	-	-	-	2	2	1	3	3
CO-5	1	2	2	3	2	1	1	3	2	2	2	3	2

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

AI INTEGRATION & AUTHENTIC INTELLIGENCE REFLECTION:

- **AI Integration:**
  - AI-based behavioral analysis tools
  - Emotion recognition systems
  - Mental health chatbots
  - AI-driven cognitive modeling
- **Authentic Intelligence Reflection:**
  - Understanding human emotions vs AI predictions
  - Evaluating trust in AI-based mental health systems
  - Identifying risks of over-dependence on AI

- Ethical use of AI in sensitive psychological data

RESEARCH INTEGRATION TEACHING

- Paper review on AI in mental health and cognitive science
- Case studies on AI therapy systems and behavioral analytics
- Mini presentations on emotional AI and social robotics
- AI-assisted research and comparison
- Critical reflection on ethical and psychological challenges

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

A. *AI-POWERED ASSIGNMENTS:*

AI^2 Pedagogy: It is a structured teaching-learning approach where students use AI tools for problem-solving while simultaneously developing Authentic Intelligence through critical evaluation, ethical reasoning, and responsible decision-making.

Assignment 1: AI-Based Behavior Analysis
- Use AI to analyze human behavior patterns
- Evaluate accuracy and limitations

Assignment 2: Mental Health Chatbot Evaluation
- Analyze AI chatbot responses
- Identify emotional accuracy and bias

Assignment 3: Human-AI Interaction Study
- Study behavioral changes using AI tools
- Evaluate trust and dependency

Assignment 4: Ethical Case Study
- Analyze ethical issues in AI-based mental health systems
- Suggest responsible solutions

Suggested Reading:

1. Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig, Prentice Hall, Third Edition, 2009.
2. Human-Centered AI, Ben Shneiderman, Oxford University Press, 2022.
3. Thinking, Fast and Slow, Daniel Kahneman, Farrar, Straus and Giroux, 2011.
4. Artificial Intelligence in Behavioral and Mental Health Care, David D. Luxton,

Academic Press, 2016.
5. The Cambridge Handbook of Artificial Intelligence, Keith Frankish and William M. Ramsey, Cambridge University Press, 2014.
6. Affective Computing, Rosalind W. Picard, MIT Press, 1997.
7. The Oxford Handbook of Cognitive Science, Susan F. Chipman, Oxford University Press, 2013.

E-Resources : (Recommended Tools)

- ChatGPT / AI tools
- Basic Python (optional)
- Survey & behaviour analysis tools
- Visualization tools

Activity Based Learning (Suggested Activities in Class)

- Group discussion on AI impact on human behavior
- Case study on AI in mental health systems

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Generative AI / LLM

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

SEMESTER -VII

Subject Code	:	26OEXXXX	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	45(15 Hours for project)
L–T–P–S	:	3–0–0–0	**CIA+SEE**	:	60+40 Marks

Course Objectives:

This course will enable students to:

1. Explain the concepts of Generative AI, Agentic AI, and Transformer architectures
2. Understand how LLMs process and generate data.
3. Apply prompt engineering, Build basic LLM-powered applications using modern frameworks
4. Implement Retrieval-Augmented Generation (RAG) systems ,Develop AI agents for multi-step reasoning tasks.
5. Understand AI deployment pipelines ,Use tools like NVIDIA NIM, Docker, and APIs for scalable systems.

Course Vision:

To develop skilled learners who can design, build, and deploy intelligent AI systems using modern Generative AI, Large Language Models (LLMs), and agent-based architectures, while fostering the ability to apply AI solutions to real-world problems with efficiency, scalability, and ethical awareness.

Course Description:

This course introduces generative AI systems and large language model technologies for intelligent content generation and automation. Students learn prompt engineering, AI application development, and responsible AI practices. The course focuses on modern AI-driven innovation.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.

Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them

Course Modules :

MODULE – I :	**09 Hours**

Introduction to Transformer-Based Natural Language Processing and Generative AI

Topics: Agentic AI concepts ,Generative AI fundamentals ,Transformer-based LLMs (NER, classification, QA).

Applications: Chatbots ,Text summarization tools , Email/Content generation ,Basic AI assistants.

MODULE – II : Word Embeddings, Tokens, and NLP	**09 Hours**

LLM Development & Prompt Engineering

Topics: Natural Language Processing and Language Models [NCA-GENL], Tokens and Tokenization [NCA-GENL], Word Embeddings [NCA-GENL], [NCA-GENM] **Applications:** Resume generators ,ChatGPT-like apps ,Q&A systems, Code assistants.

MODULE -III : Large Language Models and the Transformer	**09 Hours**

RAG & Agent Systems **Topics:** Retrieval-Augmented Generation (RAG) ,Vector databases , AI agents (multi-step reasoning) ,Research agents **Applications:** Document search systems ,Chatbots with memory ,Legal/medical assistants Research

automation tools.	
MODULE – IV :Multimodal Learning and its Applications	**09 Hours**
NVIDIA NIM™ Microservices **Topics:** NVIDIA NIM microservices ,Model deployment pipelines ,Inference optimization Latency vs throughput, LLM Architecture Variants [NCA-GENL], [NCA-GENM] Scaling Laws in Training LLMs [NCA-GENL] Training Data for Larger LLMs [NCA-GENL], [NCA-GENM **Applications:** Production AI systems ,Real-time chatbots , AI-powered web apps Enterprise AI deployment.	
MODULE – V : Diffusion Models in Generative AI	**09 Hours**
Advanced AI, Optimization & Specialization **Topics:** Agentic AI, NVIDIA Nemotron reasoning models and test-time scaling, Agentic workflows and human-in-the-loop systems, Pruning, Knowledge Distillation,Quantization Model Deployment and Benchmarking, Image Generation and GANs [NCA-GENL], [NCA-GENM] ets and Diffusion Models [NCA-GENL], [NCA-GENM] IP and Latent Diffusion [NCA-GENL], [NCA-GENM] **Applications:** Image generation (AI art) ,Healthcare AI (BioNeMo) , Data augmentation Personalized AI systems.	

AUTHENTIC INTELLIGENCE:

1. Understanding how models "think" using attention ,Choosing right model for right task ,Identifying bias & hallucination risks.
2. Designing effective prompts (few-shot, chain-of-thought) Understanding user intent vs model output , Building usable AI products (not just demos).
3. Combining search + reasoning ,Reducing hallucinations using RAG
4. Designing multi-step AI workflows.
5. Thinking in terms of scalability & performance , Cost vs performance trade-offs, Designing production-ready AI systems
6. Optimizing models for real-world constraints , Applying AI in domain-specific problems , Understanding efficiency vs accuracy trade-offs

AI INTEGRATION :

1. Transformer models (BERT, GPT-like) ,Basic LLM APIs ,Python + NLP libraries
2. LangChain ,Hugging Face ,PyTorch ,Prompt templates
3. LangChain + LangGraph ,Vector DBs (Milvus, Redis) , APIs + document loaders
4. NVIDIA RAG Blueprints.
5. NVIDIA NIM , Docker, Kubernetes , FastAPI , Monitoring tools (Grafana, Prometheus) NVIDIA NeMo ,Diffusion pipelines ,Model optimization tools MLFlow, Docker

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the fundamentals of Generative AI, LLMs, and transformer architectures.	L2
2	Apply prompt engineering and develop LLM-based applications using modern frameworks	L4

3	Design and implement RAG systems and AI agents for real-world problem solving.	L4

4	Analyze and deploy scalable AI systems using NVIDIA tools and infrastructure..	L3
5	Evaluate and optimize AI models using advanced techniques like compression, synthetic data, and multi-modal learning..	L5

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

CO S	Program Outcomes (POs)											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO-1	3	2	2	–	2	2	–	3	–	–	2	3	3
CO-2	3	3	2	–	3	3	–	3	–	–	–	3	3
CO-3	3	2	2	–	3	3	–	3	–	–	–	3	3
CO-4	3	2	3	2	3	3	–	3	2	–	–	3	3
CO-5	3	–	2	–	3	3	–	3	2	2	2	3	3

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

Evaluation Scheme

Criteria	Weightage of Marks
Continuous Internal Assessment- CAT Assessment	20
Mid-Semester Examination (MSE)	30
AI-powered Assignment / Mini Project*	10
Total	**60 marks**

TEXT BOOKS:

1. Coleman, J. S. (2005). *Introducing speech and language processing*. Cambridge university press.
2. Rothman, D., & Gulli, A. (2021). *Transformers for natural language processing* (Vol. 384). Packt Publishing.

REFERENCE BOOKS:

1. Krishnamoorthy, C. S., & Rajeev, S. (2018). *Artificial intelligence and expert systems for engineers*. CRC press.
2. Rothman, D., & Gulli, A. (2021). *Transformers for natural language processing* (Vol. 384). Packt Publishing.

E-RESOURCES:

1. NVIDIA DLI Courses (Official Catalog)
2. Hugging Face Course – https://huggingface.co/course

3. LangChain Docs – https://docs.langchain.com
4. OpenAI / LLM APIs Documentation
5. Papers with Code – https://paperswithcode.com
6. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX- 07+V1
7. https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-FX- 09+V1

RECOMMENDED TOOLS

Python 3.10+ ,PyTorch ,Hugging Face Transformers ,LangChain / LangGraph ,NVIDIA NIM Docker, FastAPI ,Vector DB (FAISS / Redis)

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CAPSTONE PROJECT I

SEMESTER – VII

Subject Code	:	26AM4703	**Credits**	:	04
Hours / Week	:	04 Hours	**Total Hours**	:	60 Hours
L–T–P–S	:	0–0–0–8	**CIE+SEE**	:	60 +40 MARKS

Course Learning Objectives:

This course will enable students to:

1. To encourage students to identify and work on real-world problems through innovative and research-oriented project topics.
2. To enable faculty to guide students with effective research methodologies, technical expertise, and continuous evaluation.
3. To develop students' skills in literature review, critical analysis, and technical/paper writing.
4. To ensure systematic project execution across phases with regular monitoring and timely completion.
5. To promote originality, teamwork, and commitment in carrying out high-quality research and development work.

Course vision :

The Final Year Research Project is designed to provide students with an opportunity to engage in in-depth, research-oriented problem solving by addressing real-world challenges. The course emphasizes the identification and formulation of meaningful problem statements, encouraging students to explore innovative ideas aligned with current technological and societal needs. Under the guidance of experienced faculty, students learn to define project scope, objectives, and expected outcomes while maintaining academic rigor.

The course focuses on the application of appropriate research methodologies, tools, and technical knowledge to design and implement effective solutions. Students are trained to conduct comprehensive literature reviews, critically analyse existing work, and synthesize relevant information to support their research. Emphasis is placed on systematic project execution across multiple phases, ensuring proper planning, continuous monitoring, and timely completion.

Additionally, the course promotes originality, teamwork, and professional responsibility in carrying out research and development activities. Students develop essential skills in technical documentation, report writing, and research publication. The course also highlights ethical considerations, industry relevance, and the importance of producing high-quality outcomes that contribute to both academic research and practical applications.

Course Description:

Capstone Project Phase II is designed to extend and deepen the work initiated in Phase I by focusing on advanced implementation, experimentation, and validation of the proposed solution. The course emphasizes refining the problem statement and enhancing the solution by incorporating multiple techniques, models, and datasets to address real-world challenges more effectively. Under the guidance of experienced faculty, students are expected to strengthen the scope, objectives, and impact of their project while maintaining high academic and research standards.

The course focuses on applying advanced research methodologies, tools, and technical knowledge to develop optimized and scalable solutions. Students perform comparative analysis using different approaches and datasets, conduct rigorous testing, and evaluate system performance using appropriate

metrics. Emphasis is placed on systematic execution, benchmarking, continuous monitoring, and timely completion of the project with improved accuracy, reliability, and generalizability.
Additionally, the course promotes innovation, originality, and professional responsibility in research and development activities. Students enhance their skills in technical documentation, report writing, and research publication, while also exploring opportunities for intellectual property creation such as patents. The course highlights ethical considerations, industry relevance, and the importance of delivering high-quality, impactful outcomes that contribute to both academic advancement and real-world applications.

Course Modules :

1. The research topic proposed by both the guide and the student team should be approved by the department chairman and Project Co-ordinator to proceed further.
2. A degree of industrial 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 partners.
3. The problem statement should be big enough to be carried out in two phases over the two semesters i.e., VII and VIII semesters in the IV 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 for the research proposal:

1. Department staff as course guide
   1. Ability to provide research direction to the student in the chosen field of interest
   2. Ability to design an appropriate research strategy and methodology to carry out the research by student
   3. Ability to provide and evaluate the strong literature review document for the chosen research topic
   4. Ability to train students on research paper / technical writing skills
   5. Conduct reviews in regular time period and submit the evaluation to department chairman

b. Student Team
   1. To be dedicated and committed to work on a new research topic by learning new technical skills
   2. To have fair knowledge on what is product development or research topic
   3. To have constant interaction with allocated guide by providing weekly updates
   4. To be committed to complete the project and submitting the technical paper within the stipulated time framed by the university

Evaluation:

1. The problem statement selected in Capstone Project Phase - I (VII semester) will be carried in the VII and VIII semesters respectively.
2. Phase 2 comprises the detailed design, implementation, and testing results during the internal and external review.
3. Each Project team 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
4. There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department.

Course Outcome

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Identify and formulate real-world problems into well-defined, research-oriented project topics.	L2
2	Apply appropriate research methodologies, tools, and technical knowledge to design and implement effective solutions.	L3
3	Analyze and synthesize literature to support problem-solving, demonstrating critical thinking and research aptitude.	L4
4	Apply structured planning and execution strategies to carry out projects across multiple phases, ensuring continuous progress monitoring and timely completion.	L3
5	Demonstrate originality, teamwork, and professional commitment while developing high-quality research outputs and technical documentation.	L4

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs

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

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

ASSESSMENT SCHEME :

1. "**Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    1. **Project Reviews & Progress:** Evaluation of problem definition, methodology, and implementation through periodic reviews.
    2. **Documentation:** Assessment of literature review, reports, and technical writing quality.
2. **Implementation & Professional Practice:** Evaluation of design,

Implementation, innovation, teamwork, and adherence to timelines.

3. "**External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of Deep Learning concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Review 1 Presentation	20M
Review 2 Presentation	20 M
Review 3 Presentation	20 M
Total	**60 marks**

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VIII SEMESTER – ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

VIII SEMESTER													
Sl.no	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours/Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIA Marks	SEE Marks	Total Marks	Credits
					L	T	P	J					
1	PEC	26AM48XX	Professional Elective V / MOOC	AI&ML	2	0	0	2	03	100	--	100	3
2	PCC	26AM4801	Leadership, Policy & Authentic Intelligence	AI&ML	2	0	0	0	02	100	--	100	2
3	INT	26AM4802	Internship (Industry / Research / CoE-based)	AI&ML	0	0	0	4	02	60	40	100	2
4	CPR	26AM4803	Capstone Project II	AI&ML	0	0	0	20	08	60	40	100	10
			Total		4	0	0	26	15	280	120	400	17

*PCC- Program Core Course , IPCC- Integrated Program Core Course, PEC – Professional Elective Course, OEC- Open Elective Course, SEC- Skill Enhancement Course, MCC – Mandatory Core Course

Professional Elective Courses Offering (PEC-V)

SL	Course Type	Course Code	Course Name	Teaching Hours / Week				Examination			
				Lecture	Tutorial	Practical	Project	CIE Marks	SEE Marks	Total Marks	Credits
				L	T	P	J				
1	PEC	26AM4804	NPTEL/MOOC	2	0	0	2	100	--	100	03
2	PEC	26AM4805	Operationalizing Agentic AI Systems	2	0	0	2	100	--	100	03
3	PEC	26AM4806	Multi-modal interaction and speech interfaces	2	0	0	2	100	--	100	03
4	PEC	26AM4807	Human-Centric Automation and Industry 5.0	2	0	0	2	100	--	100	03
5	PEC	26AM4808	Blockchain for Data Security	2	0	0	2	100	--	100	03
6	PEC	26AM4809	Building Transformer-Based Natural Language Processing Applications	2	0	0	2	100	--	100	03

Leadership, Policy & Authentic Intelligence

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

SEMESTER VIII

Subject Code	: 26AM 4801	**Credits**:	02
Hours / Week	: 02 Hours	**Total Hours** :	30 Hours
L–T–P–S	: 2–0–0–0	**CIE:**	100 Marks

Course Vision:

This condensed 2-credit version of LPAI retains the full conceptual scope of the original 5-unit course while compressing delivery into 10 weeks and 30 contact hours. The three core lenses — technical leadership, technology policy, and AI ethics — are preserved and integrated from the outset, with a streamlined capstone.

Course Description:

This course develops leadership abilities, strategic thinking, and understanding of AI governance and policy frameworks. Students learn ethical leadership, technology policy, and responsible innovation practices. The course prepares students for leadership roles in the AI-driven future.

Course Objectives:

This course will enable students to:

1. Understand the fundamentals of engineering and society leadership.
2. Apply tools of AI ethics, policy
3. Develop governance frameworks.
4. Analyze ethical, societal, and reliability issues in AI systems**.**

Teaching-Learning Process (General Instructions):

These are sample new pedagogical methods that a teacher can use to accelerate the attainment of the various course outcomes:

1. Lecture method: Along with the traditional lecture method, different types of teaching methods may be adopted to develop the course outcomes.
2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and role-playing.
3. Showing video/animation films to explain the functioning of various concepts.
4. Encourage collaborative (group learning) learning in the class.
5. To foster critical thinking by asking higher-order thinking questions in the class in the form of quizzes and writing programs with complex solutions.
6. Showing different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.

MODULE – I	**10 Hours**

Foundations + Leadership

Topics: What is authentic intelligence? Beyond artificial intelligence, Engineering in society: roles, responsibilities, and power, Systems thinking for engineers — feedback loops and Stakeholder mapping, History of technology governance and the leadership– policy–AI nexus, Leadership models: transformational, servant, and distributed, Decision- making under uncertainty and high-stakes environments, managing diverse, interdisciplinary teams, communicating technical ideas to non-technical stakeholders, Ethical leadership: when to dissent, when to escalate.**Application:** Analyze real-world socio-technical problems using systems thinking and stakeholder mapping, Communicate complex technical ideas effectively to non-technical stakeholders, Demonstrate ethical leadership by identifying when to question, dissent,

or escalate decisions.	
MODULE – II	**10 Hours**
Policy, Governance & AI Ethics **Topics:** How policy is made: legislative, regulatory, and standards processes, Key frameworks: EU AI Act, India's DPDP Act 2023, IEEE standards, Engineers as policy actors: testimony, consultation, design advocacy, Comparative case: Aadhaar — governance lessons for engineers, Public interest technology and responsible innovation, Ethical theories applied to AI: consequentialism, deontology, virtue ethics, Bias, fairness, and representation in algorithmic systems, Authentic intelligence: human judgment augmented by AI, Accountability gaps: who is responsible when AI fails?, Designing for human dignity, autonomy, and informed consent, Policy memo writing workshop and India AI regulatory landscape mapping, Mock regulatory hearing and comparative analysis paired activity, Ethics case carousel (3 cases, 3 groups) and bias detection exercise, AI ethics canvas workshop and Socratic philosophical dialogue **Applications:** Build predictive models for real-world problems such as customer churn, credit risk, and predictive maintenance, Conduct ethical analysis of case studies involving real-world technologies and governance challenges, Evaluate AI systems for bias, fairness, accountability,and ethical compliance.	
MODULE – III	**10 Hours**
Capstone: Integrated Design Challenge **Topics:** Revisiting your Unit 1 problem brief — what has changed? Integrating leadership, policy, and ethics into one design response, Stakeholder consultation and co-design methods, Prototyping governance structures and technical safeguards, writing forpublic audiences: op-eds and policy explainers, Structuring a policy pitch for decision-makers, Visual communication: slides, infographics, and data stories, Structured peer review and iteration under time pressure **Applications:** Design end-to-end solutions integrating technical models with governance and ethical safeguards, Create policy pitches, op-eds, and explainers for non-technical and decision- making audiences, Conduct stakeholder consultations and iterative refinement of proposed solutions.	

Authentic Intelligence

1. Applying human judgment and ethical leadership alongside systems thinking in decision- making
2. Integrating ethical reasoning and human values into policy and governance decisions.
3. Combining leadership, ethics, and stakeholder perspectives into a responsible solution.

AI Integr
ation

1. Using AI as a support tool for analyzing complex systems and aiding team decisions.
2. Aligning AI systems with regulations while ensuring fairness and accountability.
3. Embedding AI into solution design with proper safeguards, communication, and decision support.

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply authentic intelligence, systems thinking, and leadership models in socio-technical contexts.	L3
2	Apply ethical principles to address bias, fairness, and accountability in AI systems.	L4
3	Implement AI policy frameworks and governance principles in real-world scenarios.	L3
4	Apply ethical principles to address bias, fairness, and accountability in AI systems.	L5
5	Develop solutions using leadership, policy, and ethical considerations for real-world challenges.	L6

Mapping Levels of COs to POs / PSOs

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
CO-1	2	3	2	–	–	2	–	3	2	2	–	2	-
CO-2	2	3	–	2	–	3	2	3	–	–	–	2	-
CO-3	2	2	3	2	2	3	2	3	–	2	2	3	2
CO-4	2	3	–	3	–	3	3	3	–	–	–	2	2
CO-5	3	3	3	2	2	3	2	3	3	3	3	3	3

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

ASSESSMENT 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 BOOKS:

1. *Hendrycks, D. (2025). Introduction to AI safety, ethics, and society (p. 562). Taylor & Francis. Lara, F., & Deckers, J. (Eds.). (2024). Ethics of artificial intelligence. Springer Nature.*

REFERENCE BOOKS:

1 Kalish, S. (2023). *Awarding Equitably: a process design framework for city grantmakers*. Massachusetts Institute of Technology.

E-RESOURCES:

1. Recommendation on the Ethics of Artificial Intelligence | UNESCO

2. niti.gov.in/sites/default/files/2023-03/National-Strategy-for-Artificial- Intelligence.pdf

RECOMMENDED TOOLS

Google Colab (AI prototyping & experimentation) —

https://colab.research.google.com Jupyter Notebook (data analysis & modeling)

— https://jupyter.org

IBM AI Fairness 360 (bias detection & fairness evaluation) — https://aif360.mybluemix.net

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CAPSTONE PROJECT II

SEMESTER – VIII

Subject Code	:	26AM4803	**Credits**	:	10
Hours / Week	:	08 Hours	**Total Hours**	:	60 Hours
L–T–P–S	:	0–0–0–20	**CIE+SEE**	:	60+40 Marks

Course Learning Objectives:

This course will enable students to:

1. To extend and enhance the work carried out in Capstone Project Phase I by incorporating advanced implementation, multiple techniques, and diverse datasets.
2. To apply in-depth technical knowledge and research methodologies for developing optimized, scalable, and robust solutions.
3. To perform comparative analysis using multiple models and datasets to improve accuracy, reliability, and generalizability.
4. To strengthen analytical, experimental, and problem-solving skills through systematic testing, validation, and benchmarking.
5. To promote innovation and intellectual property development by generating high-quality research outputs, including publications and potential patents.

Course Description:

Capstone Project Phase II is designed to extend and deepen the work initiated in Phase I by focusing on advanced implementation, experimentation, and validation of the proposed solution. The course emphasizes refining the problem statement and enhancing the solution by incorporating multiple techniques, models, and datasets to address real-world challenges more effectively. Under the guidance of experienced faculty, students are expected to strengthen the scope, objectives, and impact of their project while maintaining high academic and research standards.

The course focuses on applying advanced research methodologies, tools, and technical knowledge to develop optimized and scalable solutions. Students perform comparative analysis using different approaches and datasets, conduct rigorous testing, and evaluate system performance using appropriate metrics. Emphasis is placed on systematic execution, benchmarking, continuous monitoring, and timely completion of the project with improved accuracy, reliability, and generalizability.

Additionally, the course promotes innovation, originality, and professional responsibility in research and development activities. Students enhance their skills in technical documentation, report writing, and research publication, while also exploring opportunities for intellectual property creation such as patents. The course highlights ethical considerations, industry relevance, and the importance of delivering high-quality, impactful outcomes that contribute to both academic advancement and real-world applications.

Course Outcome:

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Identify and formulate real-world problems into well-defined, research-oriented project.	L2
2	Apply appropriate research methodologies, tools, and technical knowledge to design and implement effective solutions.	L3

3	Analyze and synthesize literature to support problem-solving, demonstrating critical thinking and research aptitude.	L4
4	Apply structured planning and execution strategies to carry out projects across multiple phases, ensuring continuous progress monitoring and timely completion.	L3
5	Demonstrate originality, teamwork, and professional commitment while developing high-quality research outputs and technical documentation.	L4

Course Modules:

1. The research topic proposed by both the guide and the student team should be approved by the department chairman and Project Co-ordinator to proceed further.
2. A degree of industrial 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 partners.
3. The problem statement should be big enough to be carried out in two phases over the two semesters i.e., VII and VIII semesters in the IV 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 for the research proposal:

1. Department staff as course guide
   1. Ability to provide research direction to the student in the chosen field of interest.
   2. Ability to provide and evaluate the strong literature review document for the chosen research topic.
   3. Ability to design an appropriate research strategy and methodology to carry out the research by student.
   4. Ability to train students on research paper / technical writing skills
   5. Conduct reviews in regular time period and submit the evaluation to department chairman

b. Student Team

1. To be dedicated and committed to work on a new research topic by learning new technical skills
2. To have fair knowledge on what is product development or research topic
3. To have constant interaction with allocated guide by providing weekly updates
4. To be committed to complete the project and submitting the technical paper within the stipulated time framed by the university

Evaluation:

1. The problem statement selected in Capstone Project Phase - I (VII semester) will be carried in the VII and VIII semesters respectively.
2. Phase 2 comprises of the detailed design, implementation, and testing results during the internal and external review.

Each Project team 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

There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department.

Mapping Levels of COs to POs / PSOs

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
CO-1	2	1	-	-	1	-	-	1	1	1	-	1	1
CO-2	3	2	1	-	1	-	-	1	1	1	-	1	1
CO-3	3	2	1	-	2	-	-	2	2	1	-	1	1
CO-4	3	2	1	-	2	-	-	2	2	1	-	1	1
CO-5	3	2	1	-	2	-	-	3	3	1	-	1	1

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

ASSESSMENT SCHEME :

1. "**Internal Assessment (IA)"** refers to the Continuous Internal Assessment (CIA) with a weightage of 60%. It includes:
    1. **Project Reviews & Progress:** Evaluation of problem definition, methodology, and implementation through periodic reviews.
    2. **Documentation:** Assessment of literature review, reports, and technical writing quality.
2. **Implementation & Professional Practice:** Evaluation of design, Implementation, innovation, teamwork, and adherence to timelines.
3. "**External Assessment (EA)"** refers to the Semester End Examination (SEE) with a weightage of 40%. This examination evaluates students' overall understanding of Deep Learning concepts, application skills, and their ability to analyze and solve problems effectively.

A. Professional Core Courses (Theory)

Criteria	Weightage of Marks
Review 1 Presentation	20M
Review 2 Presentation	20 M
Review 3 Presentation	20 M
Total	**60 marks**

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OPERATIONALIZING AGENTIC AI SYSTEMS

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

SEMESTER-VIII

Course Code	:	26AM4805	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45(15 hrs for project)
L–T–P-J	:	2-0-0-2	**CIE:**		100 Marks

Course Vision: To enable learners to apply Artificial Intelligence techniques for understanding, analyzing, and influencing human behavior and social systems, fostering the development of responsible, ethical, and human-centered AI solutions for real-world societal challenges

Course Description: This course focuses on deploying, monitoring, and managing autonomous AI agent systems in real-world environments. Students learn orchestration, scalability, governance, and performance optimization of agentic AI frameworks. The course emphasizes enterprise-ready intelligent systems.

Course Objectives:

This course will enable students to:

1. Understand the fundamental principles of artificial intelligence as applied to social and behavioral science domains.
2. Analyze human behavior, social interactions, and decision-making processes using AI-driven models.
3. Apply machine learning, natural language processing, and network analysis techniques to real-world social and behavioral data.
4. Evaluate AI-based social systems with respect to fairness, ethics, privacy, interpretability, and societal impact.
5. Develop the ability to design responsible, human-centered AI solutions for behavioral prediction, social intervention, and policy support.

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**: 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
7. healthcare, transportation, and public systems.

MODULE – I	**9 Hours**

AI FOR SOCIAL AND BEHAVIORAL SCIENCE

Topics: Overview of social and behavioral sciences. Scope and objectives of computational social science. Role of artificial intelligence in understanding human behavior and social systems.Types of social and behavioral data: surveys, census data, digital traces, sensor data, and social media data. Human-centered AI and behavioral modeling. Differences between traditional statistical methods and AI-driven approaches. Challenges in social data analysis: bias, subjectivity, uncertainty, causality, and interpretability.

Case Study: AI-based analysis of public behavior during large-scale social or societal events.

MODULE – II	**9 Hours**

AI for Behavioral Analysis

Topics: 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.

Case Study: Predicting student engagement and dropout patterns using educational and interaction data.

MODULE – III	**9 Hours**

Natural Language Processing for Social Intelligence

Topics: Text as a primary source of social data. Natural language processing pipeline for social and behavioral analysis. Sentiment analysis, emotion detection, and opinion mining. Stance detection and topic modeling. Discourse and narrative analysis. Detection of misinformation, fake news, and hate speech. Applications and limitations of large language models in social science research.

Case Study: Public opinion analysis using social media data during elections or public debates.

MODULE – IV	**9 Hours**

Social Network and Group Behavior Analytics

Topics: Fundamentals of social network theory. Graph representation of social systems. Network measures such as centrality, cohesion, and connectivity. Community detection and influence modeling. Information diffusion, rumor spreading, and social contagion. Homophily, echo chambers, and polarization. Multi-agent systems for modeling collective and group behavior.

Case Study: Modeling information diffusion and influence propagation on online social platforms.

MODULE – V	**9 Hours**

Agent AI Systems for Social Impact

Topics: 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, andmental health. Behavioral nudging, persuasive AI, andsocial impactassessment. Regulatory frameworks and future directions in responsible and human-centric AI.

Case Study: Ethical evaluation of AI-based predictive policing and social risk assessment systems.

Course Outcome

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

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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	–	1	1	–	–	–	–	–	–	2	1
CO-2	2	3	2	2	2	–	–	–	1	–	–	3	2
CO-3	2	3	3	2	3	–	–	–	2	1	–	3	2
CO-4	2	3	2	3	2	–	–	–	2	1	–	2	2
CO-5	2	3	2	3	2	2	1	2	2	2	1	2	3

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

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 Integration:

AI integration in this unit is achieved through analysis of real-world social datasets and AI-driven behavioral models using tools such as Python and Google Colab. Students explore social data sources like surveys and social media, applying AI techniques to understand human behavior and societal patterns. Case studies involving large-scale events help learners connect theoretical concepts with practical applications.

This unit integrates AI through implementation of machine learning models for predicting and analyzing human behavior. Students use libraries such as Scikit-learn and TensorFlow to perform classification, clustering, and anomaly detection. Practical exercises include behavioral prediction and fairness-aware model evaluation using real datasets.

AI integration focuses on analyzing textual data from social platforms using NLP techniques. Students implement sentiment analysis, opinion mining, and topic modeling using tools like NLTK and spaCy. They also explore large language model capabilities for social data interpretation, including detecting misinformation and hate speech.

This unit integrates AI through graph-based modeling of social systems using tools such as NetworkX. Students analyze network structures, community detection, and information diffusion. Simulation of multi-agent interactions helps understand collective behavior and influence propagation in social environments.

AI integration in this unit emphasizes evaluation and design of responsible AI systems. Students

analyze ethical issues such as bias, fairness, and privacy using real-world case studies. Tools for explainability and fairness assessment are introduced, enabling learners to evaluate AI systems in domains like healthcare, governance, and public policy.

TEXT BOOKS:

1. Russell, S., & Norvig, P. Artificial Intelligence: A Modern Approach. Pearson, 2021.
2. Salganik, M. J. Bit by Bit: Social Research in the Digital Age. Princeton University Press, 2020.
3. Aggarwal, C. C. Social Network Data Analytics. Springer, 2022.
4. Jurafsky, D., & Martin, J. Speech and Language Processing. Pearson, 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.
4. Barocas, S., Hardt, M., & Narayanan, A. Fairness and Machine Learning. MIT Press, 2023.
5. Salganik, M. J. Bit by Bit: Social Research in the Digital Age. Princeton University Press, 2020.
6. Pentland, A. Social Physics: How Social Networks Can Make Us Smarter. Penguin Books, 2015.
7. Lazer, D. et al. Computational Social Science. Science, 2009.

E-RESOURCES:

1. NVIDIA AI Learning Resources – https://developer.nvidia.com/ai
2. Coursera AI & Data Science Courses – https://www.coursera.org
3. NPTEL AI Courses – https://nptel.ac.in
4. Stanford Online AI Programs – https://online.stanford.edu
5. Hugging Face NLP & LLM Resources – https://huggingface.co/learn

RECOMMENDED TOOLS :

Python, Jupyter Notebook, Google Colab, Scikit-learn, TensorFlow, NLTK, spaCy, NetworkX

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MULTIMODAL INTERACTION AND SPEECH INTERFACES

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

SEMESTER-VIII

Course Code	:	26AM4806	**Credits**	:	03
Hours / Week	:	03	**Total Hours**	:	45(15 hrs for Project)
L–T–P-J	:	2-0-0-2	**CIE:**	**100**	Marks

Course Vision: This course develops an in-depth understanding of multimodal speech interfaces by integrating speech processing, machine learning, and human-computer interaction, enabling students to design intelligent systems that combine speech with visual, gesture, and contextual modalities

Course Description :

This course focuses on the design and development of multimodal interaction systems integrating speech with visual, textual, and gesture-based interfaces. It covers speech processing, multimodal fusion, and machine learning techniques to build intelligent, user-centric applications. Students also explore real-world applications, usability, and ethical considerations in speech-enabled systems.

Course Objectives:

This course will enable students to:

2. Understand the fundamental principles of artificial intelligence as applied to social and behavioral science domains.
3. Analyze human behavior, social interactions, and decision-making processes using AI-driven models.
4. Apply machine learning, natural language processing, and network analysis techniques to real-world social and behavioral data.
5. Evaluate AI-based social systems with respect to fairness, ethics, privacy, interpretability, and societal impact.
6. Develop the ability to design responsible, human-centered AI solutions for behavioral prediction, social intervention, and policy support.

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 combined with interactive discussions
2. Brainstorming, group activities, and case-based learning
3. Demonstrations using audio-visual tools and datasets
4. Problem-solving sessions and analytical exercises
5. Encouraging critical thinking through real-world scenarios and design challenges

MODULE – I	**8 Hours**

Foundations of Multimodal Speech Interfaces :

Topics: Introduction to Human–Computer Interaction (HCI), evolution of multimodal interfaces, modalities (speech, text, vision, gesture, touch), characteristics of speech as a modality, multimodal interaction models, advantages and challenges of multimodal systems, overview of speech-enabled systems.

Applications: Voice assistants, smart devices, conversational agents, assistive technologies.

MODULE – II	**9 Hours**

Speech Signal Processing and Recognition

Topics: Speech production and perception, digital representation of speech signals, feature extraction techniques (MFCC, LPC, PLP), noise reduction and speech enhancement, speech datasets and corpora, automatic speech recognition (ASR) architecture, acoustic, language, and pronunciation models, HMM, GMM, DNN-based ASR, Text-to-Speech (TTS) systems, evaluation metrics (WER, MOS).

Applications: Speech recognition systems, voice-controlled interfaces, transcription systems.

MODULE – III	**9 Hours**

Multimodal Representation and Fusion
Topics: Multimodal data representation, feature extraction across modalities (speech, text, vision), fusion strategies (early, late, hybrid), joint embedding spaces, alignment techniques, attention mechanisms, multimodal dialogue systems, context awareness, user modeling, ambiguity resolution. **Applications:** Multimodal assistants, emotion-aware systems, interactive AI systems..

MODULE – IV	**11 Hours**
Machine Learning for Multimodal Interfaces **Topics:** Supervised and unsupervised learning for multimodal data, deep learning models (CNN, RNN, Transformers), attention-based multimodal fusion, transfer learning, multimodal embeddings, pre- trained models, real-time processing challenges, system optimization. **Applications:** Speech-enabled AI systems, intelligent interfaces, adaptive systems..	
MODULE – V	**11 Hours**
Applications, Evaluation, and Ethical Considerations **Topics:** Applications in healthcare, education, automotive, and smart environments, usability testing and user experience evaluation, accessibility in multimodal systems, privacy and security issues, bias in speech systems, ethical considerations, fairness and inclusivity, emerging trends in multimodal speech interfaces.. **Case Study:** Healthcare assistants, educational tools, autonomous systems, accessibility technologies	

AI Integration:
AI-based speech recognition and synthesis systems Deep learning models for multimodal fusion Transformer-based architectures for speech and multimodal tasks Pretrained speech and multimodal models
Evaluation using benchmark datasets and performance metrics

Authentic Intelligence:
Limitations of speech recognition in diverse environments Bias in speech datasets and accent variability
Challenges in multimodal fusion and interpretation
Ethical concerns in voice-based systems (privacy, surveillance) Reliability and trust in intelligent multimodal system

Course Outcome

Course Outcomes (COs)	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Understand fundamentals of speech processing and multimodal interaction	L1
2	Analyze speech recognition and multimodal interface techniques	L2
3	Apply multimodal fusion and machine learning methods	L3
4	Evaluate multimodal speech systems using performance metrics	L4

5	Design and assess real-world multimodal speech applications	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	1	–	–	–	–	–	–	–	–	–	1	2
CO-2	3	3	2	2	2	–	–	–	–	–	–	–	2
CO-3	2	3	2	2	2	–	–	–	–	–	–	–	3
CO-4	2	3	2	2	3	–	–	–	1	–	–	–	3
CO-5	1	2	2	3	3	–	–	–	2	1	–	2	2

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

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 BOOKS:

1. Jurafsky, D., & Martin, J. H., *Speech and Language Processing*, Pearson
2. Oviatt, S. et al., *The Handbook of Multimodal–Multisensor Interfaces*, ACM

REFERENCE BOOKS:

1. Shneiderman, B. et al., *Designing the User Interface*, Pearson
2. Huang, X., Acero, A., & Hon, H., *Spoken Language Processing*, Prentice Hall

E-RESOURCES:

NPTEL courses on Speech Processing and AI
Lecture materials from IITs on Multimodal
Interaction Research papers from IEEE, ACM, and
Springer

RECOMMENDED TOOLS

- Programming: Python
- Libraries: TensorFlow, PyTorch
- Speech Tools: Kaldi, Librosa
- NLP Tools: NLTK, SpaCy
- Visualization: Matplotli

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HUMAN-CENTRIC AUTOMATION AND INDUSTRY 5.0

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

SEMESTER-VIII

Subject Code	26AM4807	**Credits**	:	03
Hours / Week	03 Hours	**Total Hours**	:	45 (15 hrs for project)
L–T–P–S	2–0–0–2	**CIE**		100 MARKS

Course Learning Objectives:

Students will:

1. Understand principles of human-centric automation and Industry 5.0
2. Analyze human-robot interaction and collaboration models
3. Apply safety, ergonomics, and human factors in system design
4. Design automation systems with humans in the loop
5. Evaluate real-world systems for usability, safety, and effectiveness

Course Vision:

To develop the ability to design and evaluate human-centric automation systems by integrating human factors, safety, and interaction principles into robotic and automated systems. The course aims to shift the focus from full autonomy to human–robot collaboration, enabling students to design deployable systems that balance efficiency, safety, and human well-being in real-world environments.

Course Description :

This course focuses on the design and deployment of human-centric automation systems with humans in the loop.It complements autonomous and AI-driven robotics by addressing real-world deployment challenges involving human interaction, safety, and usability.Students will develop the ability to design deployable, human-aware automation systems that integrate human capabilities into system-level decision-making.

Course Outcome	Description	Bloom's Taxonomy Level
CO1	Analyze and describe the principles of Industry 5.0 and human-centric automation	L4
CO2	Analyze human-robot interaction mechanisms and interaction modeling approaches	L4
CO3	Apply safety, ergonomics, and human factors in system design	L3
CO4	Design human-in-the-loop automation systems	L6
CO5	Develop or evaluate real-world automation systems	L5
MODULE – I : Industry 5.0 and Human-Centric Automation		**09 Hours**

Practical limitations of purely autonomous robotic systems in real-world deployment, limitations of full automation, role of humans in automation, human-centric design principles, introduction to collaborative systems Applications: Smart manufacturing, assistive robotics, semi-autonomous industrial systems	
MODULE– II : Human-Robot Interaction (HRI)	**09 Hours**
Types of interaction (physical, cognitive), collaboration modes (coexistence, cooperation, collaboration), interaction modeling and human intent inference, interfaces (gesture, voice, wearable), shared autonomy. Applications: Collaborative robots (cobots), teleoperation, assistive robotic systems	
MODULE – III : Safety, Ergonomics, and Human Factors	**09 Hours**
Safety in Human-in-the-Loop systems, risk assessment, introduction to safety standards, ergonomics, usability and cognitive load, design trade-offs between safety, efficiency, and usability Applications: Industrial robot safety, exoskeletons, workspace design	
MODULE – IV : Human-in-the-Loop Automation Systems	**09 Hours**
Design and analysis of Human-in-the-Loop control architectures, system architectures with humans in the loop, decision sharing, supervisory control, adaptive automation, failure handling. Applications: Semi-autonomous vehicles, industrial supervision systems, AI-assisted control	
MODULE – V : Industrial Applications and Deployment	**09 Hours**
Human-centric manufacturing, service robotics, Overview of deployment challenges in real environments, system integration, validation and testing, evaluation metrics for human-centric systems, human performance vs system performance trade-offs, failure case analysis in Human-in-the-Loop systems. Applications: Industrial automation, healthcare robotics, logistics systems	

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
CO-1	3	1	–	–	–	–	–	–	–	–	–	1	2
CO-2	3	3	2	2	2	–	–	–	–	–	–	–	2
CO-3	2	3	2	2	2	–	–	–	–	–	–	–	3
CO-4	2	3	2	2	3	–	–	–	1	–	–	–	3
CO-5	1	2	2	3	3	–	–	–	2	1	–	2	2

Mapping Levels of COs to POs / PSOs

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

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 Integration & Authentic Intelligence Reflection (AI² Pedagogy)

AI Integration:

- Adaptive automation, AI-assisted decision support, content recognition, learning from demonstration
- Predictive safety systems, human monitoring
- Reinforcement learning with human feedback, adaptive policies
- Adaptive workflows, real-time decision systems

Authentic Intelligence Reflection:

- Trust in automation, ethical implications of human replacement vs augmentation
- ransparency, explainability, human trust
- thical responsibility in safety-critical systems, inclusivity
- ccountability, human override mechanisms
- Societal impact, sustainability, workforce considerations

Mini Project (Mandatory)

Projects must explicitly demonstrate Human-in-the-Loop interaction and its measurable impact on system performance.

Examples

- Collaborative robot workflow
- Human-in-the-loop control system
- Ergonomic assistive robotic system

Minimum Requirement (Mandatory for all)

- System Definition
- Human–System Interaction Design
- System Architecture
- Safety and Risk Analysis
- Ergonomics and Usability
- Implementation / Simulation
- Failure Handling
- Evaluation Metrics

Evaluation Focus

- Clarity of System Design
- Quality of Human Integration
- Safety and Risk Consideration

- Usability and Ergonomic Design
- Technical Implementation / Simulation
- Failure Handling and Robustness
- Real-World Relevance

Recommended Tools

- Simulation tools (Gazebo, Webots)
- ROS (optional)
- Human-in-the-loop simulation frameworks
- Visualization tool

AI Tool Usage for Teaching and Learning

AI tools will be used in this course as structured pedagogical support to enhance understanding, system design, and problem-solving.

Instructor Use (AI as Co-Teacher)

- Generate alternative explanations, examples, and case studies
- Demonstrate system workflows, debugging strategies, and design variations

Student Use (AI as Teaching Assistant)

- Concept clarification and understanding
- Code assistance and debugging (with explanation)
- System design exploration and documentation support

Guidelines for Use

- All AI-assisted work must be understood and explainable by the student
- Blind use of AI-generated content is not acceptable
- Students must critically evaluate AI outputs and identify errors or limitations

Evaluation Integration

- Viva and project discussions will assess individual understanding
- Students may be asked to explain or modify AI-assisted solutions

Suggested Reading

1. European Commission – Industry 5.0: Towards a Sustainable, Human-Centric and Resilient European Industry, 2021
2. ISO 10218 & ISO/TS 15066 – Collaborative Robot Safety Standards
3. Goodrich & Schultz – Human-Robot Interaction: A Survey, Foundations and Trends in HCI
4. Recent IEEE / Springer / Elsevier papers on Human-Robot Interaction and Industry 5.0

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BLOCKCHAIN FOR DATA SECURITY

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

SEMESTER – VIII

Subject Code	:	26AM4808	**Credits**:	03
Hours / Week	:	03 Hours	**Total Hours**:	45(15Hrs for Project)
L–T–P–S	:	2–0–0–2	**CIE :**	100 MARKS

Course Vision:

To equip learners with the knowledge of blockchain technology to enhance cybersecurity and ensure secure, transparent data privacy solutions. To enable the design of decentralized systems that protect data integrity, prevent cyber threats, and build trust in digital environments.

Course Description:

This course introduces blockchain technology, distributed ledgers, cryptographic mechanisms, and secure decentralized systems. Students learn blockchain applications in data integrity, security, and digital trust. The course focuses on secure and transparent computing solutions.

Course Learning 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)

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.*

MODULE – I	**9 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.

Application:*Using blockchain to enable secure, transparent transactions and decentralized data*

management across industries like finance, healthcare, and supply chains.	
MODULE – II	**9 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. ***Application:*** Using cryptographic techniques like hashing, encryption, and digital signatures to secure blockchain transactions and protect data integrity.	
MODULE – III	**9 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 ***Application:*** Using blockchain to enhance cybersecurity through decentralized identity management, secure authentication, and protection against threats like DDoS and intrusions.	
MODULE– IV	**9 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. Poly space Bug Finder Algorithm. **Application:** Applying privacy-preserving techniques in blockchain to protect sensitive data while ensuring compliance with regulations like GDPR.	
MODULE – V	**9 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. **Application:** Using smart contracts and blockchain to secure healthcare, finance, supply chain for transport, and IoT systems while addressing vulnerabilities and scalability challenges.	

AI Integration:

- Integrating AI with blockchain for intelligent data validation, fraud detection, and automated decision-making in decentralized systems.
- Integrating AI to enhance cryptographic security through anomaly detection, key management optimization, and threat prediction.
- Integrating AI with blockchain for intelligent threat detection, anomaly analysis, and automated response in distributed security systems.
- Integrating AI with blockchain to enhance data anonymization, detect privacy risks, and ensure secure handling of personal data in distributed systems.
- Integrating AI with blockchain to detect smart contract vulnerabilities, enhance security,

and optimize performance in emerging decentralized applications.

Authentic Intelligence:

- Ensuring trust, transparency, and data integrity through decentralized consensus, immutable ledgers, and ethically aligned AI-driven processes.
- Ensuring trustworthy and secure systems by applying robust cryptographic principles, safeguarding keys, and maintaining transparency and integrity in data protection.
- Ensuring secure, transparent, and trustworthy cybersecurity solutions through decentralized trust, strong authentication, and ethical AI-driven monitoring.
- Ensuring ethical and trustworthy data usage through strong privacy mechanisms, regulatory compliance, and transparent handling of user information.

Ensuring secure, reliable, and future-ready systems through robust smart contract design, continuous monitoring, and ethical, scalable blockchain innovations

Course Outcome :

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

Mapping Levels of COs to POs / PSOs

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

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

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 BOOKS:

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:

- https://nptel.ac.in/courses/106105235
- https://ieeexplore.ieee.org/document/10953521/
- https://www.geeksforgeeks.org/blockchain-tutorials/
- blockchain - Course (nptel.ac.in)

Building Transformer-Based Natural Language Processing Applications

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

SEMESTER – VIII

Course Code	:	26AM4809	**Credits**	:	3
Hours / Week	:	3	**Total Hours**	:	45(15 hrs for Project)
L–T–P-J	:	2–0–0-2	**CIE**	:	100 MARKS

Course Vision: The course "Building Transformer-Based Natural Language Processing Applications" aims to provide students with strong foundational and practical knowledge of transformer architectures and modern Artificial Intelligence-based natural language processing techniques. The course enables learners to design and develop intelligent NLP applications such as chatbots, language translation systems, summarizers, sentiment analyzers, and question-answering models using transformer frameworks. It emphasizes hands-on implementation of pre-trained language models, fine-tuning strategies, and real-world NLP deployment techniques. The course further prepares students to build scalable, efficient, and ethical AI-powered language applications for research and industry domains.

Course Description:

This course focuses on transformer architectures and their applications in natural language processing tasks. Students learn language modelling, fine-tuning, sequence processing, and AI application development. The course enables development of advanced NLP systems using transformer technologies

Course Objectives:

1. To provide a strong foundation in optimization concepts relevant to Natural Language Processing tasks.
2. To enable students to formulate NLP problems as mathematical optimization problems.
3. To study and apply classical and modern optimization algorithms used in NLP models.
4. To analyze optimization challenges in deep learning and transformer-based NLP architectures.
5. To develop the ability to select, implement, and evaluate efficient optimization strategies for large-scale NLP systems.

Teaching-Learning Process (General Instructions)

1. Classroom lectures using presentations and board work to explain theoretical concepts and mathematical foundations.
2. Proble m-solving sessions and numerical examples to strengthen understanding of optimization techniques in NLP.
3. Case studies and discussion of recent research papers related to optimization in modern NLP models.
4. Hands -on demonstrations, assignments, and mini-projects using Python-based NLP and deep learning frameworks.
5. Continuous assessment through quizzes, seminars, and student presentations to encourage self-learning and critical thinking.

MODULE– I	7 hours

Fundamentals of NLP and Optimization:Introduction to NLP tasks: text classification, sequence labeling, machine translation ,Mathematical formulation of NLP problems ,Review of linear algebra, probability, and information theory for NLP,Loss functions in NLP: cross-entropy, negative log-likelihood,Convex and non-convex optimization problems.

MODULE – II	7 hours
Classical Optimization Techniques for NLP: Gradient Descent and its variantsBatch-Stochastic, and Mini-batch Gradient Descent,First-order optimization methods,Second-order methods:	

Newton's Method, Quasi-Newton (BFGS, L-BFGS)Optimization in traditional NLP models -Logistic Regression,Conditional Random Fields (CRF),Maximum Entropy models.	
MODULE – III	7 hours
Optimization in Deep Learning for NLP: Backpropagation and computational graphs,Vanishing and exploding gradients,Advanced optimizers: Momentum, Adagrad, RMSProp, Adam, AdamW,Regularization techniques: dropout, weight decay, early stopping,Optimization for word embeddings: Word2Vec, GloVe.	
MODULE – IV	7 hours
Optimization for Sequence Models and Transformers: Optimization in RNNs, LSTMs, and GRUs,Attention mechanisms and optimization aspects,Transformer architecture and training challenges,Learning rate scheduling and warm-up, strategies,Fine-tuning vs pre-training optimization.	
MODULE – V	7 hours
Advanced and Scalable Optimization Techniques: Large-scale and distributed optimization,Gradient clipping and normalization,Mixed precision training,Hyperparameter optimization methods,Case studies from real-world NLP systems.	

Course Outcomes:

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Formulate NLP problems as optimization tasks	C6
2	Apply classical optimization techniques to NLP models	C3
3	Implement and analyze optimization strategies in deep NLP models	C4
4	Optimize transformer-based language models	C5
5	Evaluate optimization methods for scalable NLP applications	C5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	1	–	–	–	–	–	–	–	–	–	1	2
CO-2	3	3	2	2	2	–	–	–	–	–	–	–	2
CO-3	2	3	2	2	2	–	–	–	–	–	–	–	3
CO-4	2	3	2	2	3	–	–	–	1	–	–	–	3
CO-5	1	2	2	3	3	–	–	–	2	1	–	2	2

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

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 BOOKS (TB):

1 .Jurafsky, D., & Martin, J. H., *Speech and Language Processing*, 3rd Edition (Draft), Pearson.

2. Goodfellow, I., Bengio, Y., & Courville, A., *Deep Learning*, MIT Press.

REFERENCE BOOKS:

1.Boyd, S., & Vandenberghe, L., *Convex Optimization*, Cambridge University Press. 2.Goldberg, Y., *Neural Network Methods for Natural Language Processing*, Morgan & Claypool.

3.Murphy, K. P., *Machine Learning: A Probabilistic Perspective*, MIT Press.

4.Bottou, L., Curtis, F. E., & Nocedal, J., *Optimization Methods for Large-Scale Machine Learning*, SIAM Review.

E-Resources:

https://blog.truegeometry.com/tutorials/education/15970c4fdbca1fc48c5b412d94e798c0/JSON_TO_ARTCL_Optimization_in_Natural_Language_Processing_in_context_of_Optimiza.html?utm_source=chatgpt.com

Activity Based Learning (Suggested Activities in Class)

1.Real-world problem solving using group discussion– Students analyze real NLP problems (text classification, sentiment analysis, machine translation) and discuss suitable optimization strategies.

2.Role play activity– Role play of optimizer components such as gradient descent, learning rate scheduler, loss function, and model parameters to understand optimization flow.

3.Demonstration of solution through programming– Instructor-led and student-driven demonstrations using Python (PyTorch/TensorFlow) to show optimization techniques like SGD, Adam, and learning rate tuning in NLP models.

4.Flipped classroom activity– Students study assigned research papers or video lectures on optimization methods (e.g., AdamW, transformer fine-tuning) and discuss insights in class.