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ताळगांव पठार,
गोंय - ४०३ २०६
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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2026-27/125 Date: 08.06.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/322 dated 12.08.2025

In supersession to the above referred Circular, the syllabus of Semester III and IV of the **Master of Science in Artificial Intelligence** Programme approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

Further, the Syllabus of Semester I and II approved earlier by the Academic Council in its meeting held on 13th & 14th June 2025 is also attached.

The Dean & Vice-Dean (Academic) of the Goa Business School are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.06.08 14:41:05 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Goa Business School, Goa University.
2. The Vice-Dean (Academic), Goa Business School, Goa University.

Copy to:

3. Chairperson, BoS in Data Science and Artificial Intelligence, Goa University.
4. Programme Director, M.Sc. Artificial Intelligence, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN ARTIFICIAL INTELLIGENCE

(Effective from the Academic Year 2025-2026)

ABOUT THE PROGRAMME

The M.Sc. in Artificial Intelligence is a two-year postgraduate program designed to provide in-depth expertise in core AI areas such as machine learning, deep learning, natural language processing, computer vision, and data science. The curriculum blends theoretical foundations with hands-on lab work, covering both foundational and advanced topics like generative AI, agentic AI, and AI engineering. It also includes interdisciplinary applications, ethical considerations, and industry-relevant skills through electives, research components, and internships. The program prepares graduates for roles such as AI engineers, data scientists, machine learning researchers, and innovators in AI-driven domains.

OBJECTIVES OF THE PROGRAMME

1. M.Sc. in AI Programme provides in-depth knowledge of Machine Learning, Deep Learning, and Data Science while offering hands-on experience in building and deploying AI solutions.
2. It emphasizes ethical AI practices, problem-solving, and interdisciplinary applications in industries like healthcare and finance.
3. The program prepares students for careers as AI Engineers, Data Scientists, and Machine Learning Researchers while fostering innovation through research and industry collaboration.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	**Core AI Competencies** – Develop a strong foundation in key AI concepts, including machine learning, deep learning, neural networks, and data science.
PSO 2.	**Practical Implementation** – Gain hands-on experience in designing, implementing, and optimizing AI models for real-world applications.
PSO 3.	**Interdisciplinary Applications** – Apply AI techniques across various domains, such as engineering, healthcare, finance, and business analytics.
PSO 4.	**Ethical and Responsible AI** – Understand ethical considerations, bias mitigation, AI governance, and societal impact for responsible AI development.
PSO 5.	**Problem-Solving with AI** – Apply AI methodologies to solve complex challenges across multiple sectors and innovate new solutions.
PSO 6.	**AI System Deployment** – Learn to integrate AI solutions in industry and optimize performance for scalability and efficiency.
PSO 7.	**Career Readiness** – Develop the skills needed for roles like AI Engineer, Data Scientist, Machine Learning Researcher, and Robotics Engineer. It also encourages AI start-ups and entrepreneurship
PSO 8.	**Research and Innovation** – Conduct original research in AI, contribute to advancements in the field, and publish academic papers.

PROGRAMME STRUCTURE

Master of Science in Artificial Intelligence

Effective from Academic Year 2025-26

Bridge Course			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	CSI-1000	Fundamentals of Python Programming	2

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSI-5000	Fundamentals of Artificial Intelligence	2T	400
2	CSI-5001	Mathematical Foundation for AI	2T	400
3	CSI-5002	Pattern Recognition and Machine Learning	2T	400
4	CSI-5003	Algorithm Design and Data Structures	2T	400
5	CSI-5004	Fundamentals of Artificial Intelligence Lab	2P	400
6	CSI-5005	Mathematical Foundation for AI Lab	2P	400
7	CSI-5006	Pattern Recognition and Machine Learning Lab	2P	400
8	CSI-5007	Algorithm Design and Data Structures Lab	2P	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits) (any 1)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSI-5201	Fundamentals of Natural Language Processing	4T	400
2	CSI-5202	Fundamentals of Robotics	4T	400
3	CSI-5203	Computer Vision	4	400
4	CSI-5204	Speech Processing	4	400
5	CSI-5205	Data Science and Data Engineering	4	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSI-5008**	Fundamentals of Deep Learning and Generative AI Techniques	2T	500
2	**CSI-5009**	Reinforcement Learning	2T	500
3	**CSI-5010**	Big Data Frameworks	2T	500
4	**CSI-5011**	MLOp	2T	500
5	**CSI-5012**	Fundamentals of Deep Learning and Generative AI Techniques Lab	2P	500
6	**CSI-5013**	Reinforcement Learning Lab	2P	500
7	**CSI-5014**	Big Data Frameworks Lab	2P	500
8	**CSI-5015**	MLOp Lab	2P	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSI-5206**	Machine Translation	4T	400
2	**CSI-5207**	Robotic motion planning and control	4T	400
3	**CSI-5208**	Interpretable Machine learning	4T	400
4	**CSI-5209**	Explainable Artificial Intelligence (XAI)	4	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

SEM$STER III				
Research Specific Elective (RSE) Courses (12 credits) (from any one set of 12 credits to be opted)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
Set 1 AI User Engineering (Application)				
1	**CSI-6000**	AI for Medical Specialization	3T	500
2	**CSI-6001**	AI for Agriculture	3T	500
3	**CSI-6002**	Algorithmic Foundation for Big Data Biology	3T	500
4	**CSI-6003**	AI for life science Lab	3P	500
Set 2 AI core Research				
5	**CSI-6004**	Agentic AI	3T	500
6	**CSI-6005**	AI Engineering	3T	500
7	**CSI-6006**	LLM Engineering	3T	500
8	**CSI-6007**	Advanced AI core Lab	3P	500
Set 3 AI Extension subjects (Enablers) any 3				
9.	**CSI-6008**	Quantum computing for AI	4T	500
10	**CSI-6009**	Tensor computation for data science	4T	500
11	**CSI-6010**	AI Product Development	4T	500
12	**CSI-6011**	Graph Neural Network	4T	500
13	**CSI-6012**	Bayesian Learning and Probabilistic Model	4T	500
More RSE				
14	**CSI-6013**	Research methodology	4T	500
Total Credits for RSE Courses in Semester III			**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits) (any 2)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSI-6401**	Prompt Engineering	2T +2P	500
2	**CSI-6402**	Cloud Based AI Deployment	2T +2P	500
3	**CSI-6403**	Computational Linguistics	2T+2P	500
4	**CSI-6404**	Environmental Data Analytics	2T+2P	500
Total Credits for DSVE Courses in Semester III			**8**	
Total Credits in Semester III			**20**	

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1		Research methodology and Advance courses from RSE	**8**	**500**
2	**CSI-6501**	Dissertation-related course to be decided in consultation with research supervisor- suggested - 1. AI for Finance 2. AI for Health care 3. AI for Sustainability 4. Reinforcement Learning for Agents 5. Advanced topics in Autonomous AI 6. AI Deployment	**32**	**500**
		Dissertation work	**40**	**500**

SEMESTER IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSI-6201**	Cloud computing	4T	500
2	**CSI-6202**	Web technology	4T	500
3	**CSI-6203**	Cyber security	4T	500
4	**CSI-6204**	Design thinking	4T	500
5	**CSI-6205**	Educational technology	4T	500
Total Credits for GE Courses in Semester IV			**20**	

Discipline Specific Dissertation (DSD)/ Internship (20 Credit Dissertation) (any one)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSI-6502**	Dissertation-related course (in consultation with guide) suggested ones - 1. AI for Finance 2. AI for Health Care 3. AI for Sustainability 4. Reinforcement Learning for Agents 5. AI Deployment	20	500
Total Credits in Semester IV			**20**	

BRIDGE COURSE

Title of the Course	Fundamentals of Python Programming
Course Code	CSI-1000
Number of Credits	1T+1P
Theory/Practical	Theory/Practical
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	Yes (Bridge Course)
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	The objective of the course is to equip students with a foundational understanding of Python programming, enabling them to write and execute basic Python programs.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember Python programming constructs.		PSO1, PSO5, PSO7	
	CO 2. Apply variables, control structures, and functions in programs.		PSO2, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Problem Solving & Python Basics** ● **Problem-Solving Approach**: Understanding the problem, Algorithm design	**15**	CO1	K1, K2

	(pseudocode& flowcharts) ● **Python Fundamentals**: Variables, expressions, statements, data types, operators, Input/output operations, Basic syntax & indentation ● **Control Structures:** Boolean values and operators, Conditional statements ● **Iteration**: Loops, Nested loops & pattern printing exercises **Functions** ● function and its use, pass keyword, flow of execution, parameters and arguments **Strings** ● Strings, String manipulation methods, String formatting			
Module 2:	**Practical Work** ● Assignments to practice input/output and use of basic data types. ● Assignments to practice arithmetic operations and expressions. ● Assignments to practice control structures, branch and loops ● Assignments to practice writing modular code ● Assignments to practice strings and string manipulation functions	**30**	CO2	K3, K4, K6
Pedagogy:	Mentoring/ Assignments/ Flipped Classroom			
Texts:	1. Downey, A., Meyer, C., &Elkner, J. (2016). How to think like a computer scientist: learning with Python. Green Tea Press. 2. Barry, P. (2016). Head first Python: a brain-friendly guide. O'reilly.			
References/ Readings:	1. Hill, C. (2020). *Learning scientific programming with Python*. Cambridge University Press. 2. Lee, K. D. (2014). Python programming fundamentals. Springer.			
Web Resources:	1. W3Schools.com.(n.d.). https://www.w3schools.com/python/ 2. GeeksforGeeks. (2025, May 3). Python tutorial | Learn Python programming language. Retrieved May 16, 2025, from https://www.geeksforgeeks.org/python-programming-language-tutorial/			

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SEMESTER I

Discipline Specific Core Courses

Title of the Course	Fundamentals of Artificial Intelligence
Course Code	CSI-5000
Number of Credits	2T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course is aimed at developing a foundational understanding of AI concepts and techniques, including search algorithms, intelligent agents, machine learning, and probabilistic reasoning, while gaining the skills to design ethical and effective AI solutions for real-world problems.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Apply foundational AI concepts and techniques, including intelligent agents, search strategies, and problem formulation, to select appropriate search algorithms for goal-oriented tasks.	PSO1, PSO5, PSO7

	CO 2. Apply knowledge representation and reasoning techniques such as propositional logic, first-order logic, and constraint satisfaction methods to model and solve structured problems.		PSO1, PSO5, PSO6	
	CO 3. Create basic machine learning models using supervised and unsupervised learning approaches, including decision trees, k-NN, and neural networks, incorporating understanding of training mechanisms and evaluation metrics.		PSO1, PSO2, PSO6, PSO7	
	CO 4. Evaluate probabilistic reasoning models and decision-making frameworks including Bayesian networks and Markov decision processes, and assess the ethical implications of AI systems with focus on explainability and responsible AI.		PSO1, PSO4, PSO5, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Artificial Intelligence and Intelligent Agents** • **AI Basics**: Definitions, history, and goals • **AI Tribes**: Symbolic, Connectionist, Bayesian, Evolutionary, Analogizer • **Intelligent Agents**: Definitions, environments, PEAS (Performance, Environment, Actuators, Sensors) • **Agent Types**: Reactive, Model-based, Goal-based, Utility-based • **Problem-Solving by SearchFormulation**: States, actions, goals, **Uninformed Search**: BFS, DFS **Knowledge and Logical Reasoning in AI** • **Knowledge Representation**: Concepts and structures • **Logic in AI**: Propositional & First-order Logic • **Ontological Engineering**: Basics and applications • **Inference Techniques**: Forward & Backward Chaining, Resolution, Unification • **Constraint Satisfaction Problems (CSPs)**: Problem formulation,Solving via Backtracking & Constraint Propagation.	**15**	CO1, CO2	K1, K2, K3, K4, K5

Module 2:	**Learning and Decision-Making in AI** • **Intro to Machine Learning**: Concepts, features, labels, train/test split • **Types of Learning**: Supervised, Unsupervised, Reinforcement • **Algorithms**: Decision Trees, k-NN, Neural Networks (Perceptrons, MLPs) • **Training Basics**: Loss functions, Gradient Descent • **Evaluation Metrics**: Accuracy, Precision, Recall, F1-score **Probabilistic Reasoning** • **Probability Basics**: Conditional probability, Bayes' Theorem • **Bayesian Networks**: Structure and inference • **Utility Theory**: Preferences and rational decision-making • **Markov Decision Processes (MDPs)**: States, actions, rewards, policies **AI Applications, Explainability, and Ethics** **Natural Language Processing (NLP)** • Tokenization, Stemming, Lemmatization • N-gram Models, Information Retrieval & Extraction • Machine Translation, Speech Recognition **Explainable AI (XAI)** • Black-box Models, Transparency, Interpretability • Rule-based Explanations, Feature Importance **Ethics in AI** • Bias, Fairness, Accountability • Ethical Dilemmas, Case Studies • Social Implications of AI	**15**	CO3, CO4	K2, K3, K4, K5
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Russell, S. J., &Norvig, P. (2010). *Artificial intelligence: A modern approach* (3rd ed.). Pearson Education. 2. Rich, E., & Knight, K. (2017). *Artificial intelligence* (3rd ed.). McGraw-Hill Education			

References/ Readings:	1. Nilsson, N. J. (1997). *Artificial intelligence: A new synthesis*. Elsevier. 2. Luger, G. F. (2002). *Artificial intelligence: Structures and strategies for complex problem solving* (4th ed.). Pearson Education. *(Note: Title and edition inferred based on standard editions; please adjust if your copy is different.)* 3. Padhy, N. P. (2005). *Artificial intelligence*. Oxford University Press.
Web Resources:	1. Stanford University. (2024). CS221: Artificial intelligence: Principles and techniques. Retrieved May 16, 2025, from https://cs221.stanford.edu 2. Massachusetts Institute of Technology. (2010). 6.034: Artificial intelligence. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/6-034-artificial-intelligence-fall-2010/

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Title of the Course	Mathematical Foundations for AI
Course Code	CSI-5001
Number of Credits	2T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	The aim of the course is to introduce the fundamental concepts of probability, statistics, linear algebra, and calculus, and to emphasize their importance in solving problems and making decisions in Artificial Intelligence.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember basic probability principles.		PSO1, PSO5	
	CO 2. Understand statistical data analysis techniques.		PSO1, PSO2, PSO5	
	CO 3. Apply linear algebra for solving mathematical problems.		PSO1, PSO5	
	CO 4. Analyze multivariable functions using calculus.		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**Probability:** • Basic concepts of probability, conditional probability, law of total probability, independence of events, Bayes' theorem, random variables (discrete and continuous), expectation, moments, moment generating functions, commonly used probability distributions, joint and conditional distributions, transformation of random variables, covariance and correlation. **Statistics:** • Sampling techniques, sampling distributions, parameter estimation, hypothesis testing, mixture models, expectation-maximization (EM) algorithm.	**15**	CO1, CO2	K2, K3, K4
Module 2	**Basics of Linear Algebra:** • Representation of vectors and matrices, linear dependence and independence, vector spaces and subspaces (definition, examples, and basis), linear transformations, range and null space, special types of matrices, eigenvalues and eigenvectors, diagonalization, singular value decomposition (SVD), least squares and minimum norm solutions, applications to data analysis. **Gradient Calculus:** • Basic concepts of calculus, partial derivatives, gradient, directional derivatives, Jacobian, Hessian. **Optimization:** • Introduction to Optimization, Convex Sets and Convex Functions, Unconstrained Optimization, Derivative-Free Methods (Golden Section Method, Fibonacci Search), Gradient-Based Methods (Steepest Descent Method, Newton's Method), Constrained Optimization, and Penalty Function Methods.	**15**	CO3 CO4	K2, K4, K5
Pedagogy	Lectures/ Assignments/ Flipped Classroom			
Texts:	Deisenroth, M. P., Faisal, A. A., &Ong, C. S. (2020). Mathematics for machine learning. Cambridge University Press.			
References/ Readings:	1. Axler, S. (2024). Linear algebra done right (p. 390). Springer Nature. 2. Johnson, R. A., Miller, I., & Freund, J. E. (2000). Probability and statistics for engineers. *Proc. Miller Freund's*,			

	546-554. 3. Kreyszig, E., Stroud, K., & Stephenson, G. (2008). Advanced engineering mathematics. *Integration*, *9*(4), 1014. 4. C. Mohan and K. Deep: "Optimization Techniques", New Age Publishers, New Delhi.
Web Resources:	1. Massachusetts Institute of Technology. (2018). RES.6-012: Introduction to probability. MIT OpenCourseWare. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/ 2. Harvard University. (2024). Statistics and R. Harvard Professional and Lifelong Learning. Retrieved May 16, 2025, from https://pll.harvard.edu/course/statistics-and-r

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Title of the Course	Pattern Recognition and Machine Learning
Course Code	CSI-5002
Number of Credits	2T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To introduce students to the fundamental principles of machine learning, including decision-making models and ensemble techniques, and to develop their ability to apply regression, classification, and advanced methods for data analysis and optimization.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember foundational ML and decision models.		PSO1, PSO2, PSO5	
	CO 2. Understand regression and classification techniques.		PSO1, PSO2, PSO5	
	CO 3. Apply machine learning models to datasets.		PSO1, PSO2, PSO5, PSO3	
	CO 4. Analyze clustering and model accuracy.		PSO1, PSO2, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**Introduction to Concept Learning**: • Version Space, Decision Tree, Random Forest Algorithm **Linear Models for Regression:** • Linear Basis Function Models, Maximum likelihood and least squares, Geometry of least squares, Sequential learning, Regularized least squares, Multiple outputs, The Bias-Variance Decomposition, Bayesian Linear Regression. **Linear Models for Classification:** • Discriminant Functions, Two classes, Multiple classes, Least squares for classification, Fisher's linear discriminant, Relation to least squares, Fisher's discriminant for multiple classes, Binary class Logistic Regression, Multiclass Logistic Regression. **Neural Networks:** • The perceptron algorithm, Feed-forward Network Functions, Weight-space symmetries, Network Training, Parameter optimization, Local quadratic approximation, Use of gradient information, Gradient descent optimization, Error Backpropagation, Evaluation of error-function derivatives, A simple example, Efficiency of backpropagation, The Jacobian matrix, The Hessian Matrix,	**15**	CO1, CO2	K2, K3, K4
Unit/ Module 2:	**Sparse Kernel Machines:** • Maximum Margin Classifiers, Overlapping class distributions, Relation to logistic regression, Multiclass SVMs, SVMs for regression. **Mixture Models for EM:** • K-means Clustering, Image segmentation and compression, Mixtures of Gaussians, Maximum likelihood, EM for Gaussian mixtures, EM algorithm. **Continuous Latent Variable:** • Principal Component Analysis, Maximum variance formulation, Minimum-error formulation, Applications of PCA, PCA for high-	**15**	CO3, CO4	K3, K4, K5

	dimensional data. **Sequential Data:** • Markov Models, Hidden Markov Models, Maximum likelihood for the HMM, The forward-backward algorithm, The sum-product algorithm for the HMM, Scaling factors, The Viterbi algorithm. **Ensemble Learning:** • Voting classifier, bagging and boosting			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	Bishop, C. M., &Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.			
References/ Readings:	1. Starmer, J. (2022). The Statquest illustrated guide to machine learning. 2. Mitchell, T. M. (1997). Machine learning (Vol. 1). McGraw-hill New York. 3. Flach, P. (2012). Machine learning: the art and science of algorithms that make sense of data. Cambridge university press. 4. Geron A. (2022) Hands-on Machine Leaning with Sci-Learn, Keras&TensorFlow. Shroff/O'Reilly.			
Web Resources:	1. Kaggle. (n.d.). Kaggle Learn. Retrieved May 16, 2025, from https://www.kaggle.com/learn 2. Google. (n.d.). Google AI: For developers. Retrieved May 16, 2025, from https://ai.google/get-started/for-developers/			

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Title of the Course	Algorithm Design and Data structures
Course Code	CSI-5003
Number of Credits	2T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-1000			
Course Objectives:	The aim of the course is to introduce the fundamental concepts of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember various data structures.		PSO1	
	CO 2. Understand their functional differences and uses.		PSO1, PSO2	
	CO 3. Apply them in solving problems.		PSO2	
	CO 4. Analyze algorithms and computing their complexity.		PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	• **Introduction:** Three-Level Approach : Application/User level, Abstract/ Logical level, Physical/ Implementation Level. • **Abstract Data Types (ADTs):** Concept of ADTs, Data Structure definition, Data type v/s data structure, Applications of data structures. • **Algorithms analysis and its complexity**: Best case, worst case, and Average case performance, time-space tradeoff, Asymptotic Analysis, Big-o notation. • **Linear Data Structures**: Array and its application: Polynomials, Sparse matrices, String-pattern Matching. Linked Lists, Doubly linked list, Circular linked list, Stack and Queues.	**15**	CO1, CO2, CO3	K1, K2, K3, K4
Module 2	**Nonlinear Data Structures**: • **Trees**: Binary tree representation, Binary Search Trees, AVL Trees, M-way Search Trees, B-trees, B tree algorithms, Heap Structures. • **Graphs**: Graph representations; Graph Traversals **Algorithms:** • **Complexity of Searching & Sorting algorithms**: Bubble sort, Quick sort, Selection sort, Insertion sort, Merge sort and Heap sort. An Empirical Comparison of Sorting Algorithms, Lower Bounds for Sorting. Linear search, binary search. • **Dynamic programming and Greedy algorithms**: Assembly line scheduling, Matrix-chain multiplication, Prim's Algorithm, Kruskal's Algorithm	**15**	CO2, CO3, CO 4	K1, K2, K4, K5, K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Dr. BasantAgarwal, &Baka, B. (2018). Hands-On Data Structures and Algorithms with Python. Packt Publishing Ltd. 2. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). Introduction to algorithms. The Mit Press.			
References/ Readings:	1. Dasgupta, S., Papadimitriou, C. H., &Vazirani, U. V. (2006). Algorithms. McGraw-Hill Publishing. 2. Mark Allen Weiss. (2003). Data structures & algorithm analysis in C++. Pearson Education.			

	3. Horowitz, E., &Sahni, S. (1976). Fundamentals of Data Structures. Computer Science Press, Incorporated.
Web Resources:	1. Massachusetts Institute of Technology. (2011). 6.006 Introduction to algorithms. MIT OpenCourseWare. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-fall-2011/ 2. GeeksforGeeks. (2025, April 25). DSA tutorial: Learn data structures and algorithms. Retrieved May 16, 2025, from https://www.geeksforgeeks.org/dsa-tutorial-learn-data-structures-and-algorithms/

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Title of the Course	Fundamentals of Artificial Intelligence Lab
Course Code	CSI-5004
Number of Credits	2P
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course is aimed at imparting students with hands-on experience in implementing, evaluating, and designing AI systems, enabling them to solve real-world problems using algorithms, machine learning, probabilistic reasoning, and ethical AI practices.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Apply uninformed and informed search algorithms, logic-based reasoning, and constraint satisfaction techniques to solve structured AI problems.	PSO1, PSO2, PSO5
	CO 2. Evaluate machine learning models—including decision trees, k-NN, and neural networks—for classification and regression tasks.	PSO1, PSO2, PSO5, PSO7
	CO 3. Create probabilistic models (e.g., Bayesian networks) and perform inference and decision-making under uncertainty.	PSO1, PSO3, PSO5

	CO 4. Synthesize ethical principles and explainability techniques into AI systems using model interpretation and fairness metrics.		PSO2, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Lab 1: Problem-solving by Searching** ● Implement uninformed search algorithms (BFS, DFS). ● Solve a pathfinding problem (e.g., maze navigation) using A* algorithm. **Lab 2: Knowledge Representation and Reasoning** ● Build a simple expert system using propositional logic. ● Solve a constraint satisfaction problem (e.g., Sudoku or map coloring) using backtracking.	**30**	CO1, CO2, CO3	K3, K4
	Lab 3: Machine Learning Basics ● Implement and evaluate decision trees and k-nearest neighbors (k-NN) on a dataset (e.g., Iris or Titanic dataset). ● Train a multi-layer perceptron (MLP) using TensorFlow/Keras for a classification task. **Lab 4: Probabilistic Reasoning** ● Build a Bayesian network for a real-world scenario (e.g., medical diagnosis). ● Perform inference on the network using a library like PyMC3 or pgmpy.			
Module 2:	**Lab 5: Natural Language Processing** ● Perform text preprocessing (tokenization, stemming, lemmatization) using NLTK. ● Build a simple language model (n-grams) for text generation or classification. **Lab 6: Explainable AI** ● Use SHAP or LIME to explain predictions of a machine learning model. ● Analyze feature importance in a decision tree or neural network.	**30**	CO1, CO3 CO3, CO4	K3, K5, K6

	Lab 7: Ethics in AI ● Analyze bias in a dataset (e.g., gender or racial bias in hiring data). ● Implement fairness metrics (e.g., demographic parity, equal opportunity) using AI Fairness 360 or Fairlearn. **Mini Project:** The capstone project integrates concepts from the course into a comprehensive AI application. Students work in teams to solve a real-world problem, demonstrating their ability to design, implement, and evaluate an AI system. The project involves Problem definition, Data collection and preprocessing, Model Development, Evaluation etc			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	1. Russell, S. J., &Norvig, P. (2010). *Artificial intelligence: A modern approach* (3rd ed.). Pearson Education. 2. Rich, E., & Knight, K. (2017). *Artificial intelligence* (3rd ed.). McGraw-Hill Education.			
References/ Readings:	1. Raschka, S., &Mirjalili, V. (2019). *Python machine learning* (2nd ed.). Packt Publishing. 2. Géron, A. (2019). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media. 3. Bird, S., Klein, E., &Loper, E. (2009). *Natural language processing with Python*. O'Reilly Media.			
Web Resources:	1. GitHub. (n.d.). Artificial intelligence projects. Retrieved May 16, 2025, from https://github.com/topics/artificial-intelligence-projects 2. DataCamp. (2023, July 14). 7 AI projects for all levels. Retrieved May 16, 2025, from https://www.datacamp.com/blog/7-ai-projects-for-all-levels			

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Title of the Course	Mathematical Foundations for AI (Lab)
Course Code	CSI-5005
Number of Credits	2P
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To provide students with hands-on experience in applying mathematical concepts, including linear algebra, statistics, and optimization, using Python to solve real-world problems in AI and Data Science.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember Python libraries used in data science.		PSO1, PSO2, PSO5	
	CO 2. Understand visualizations like bar plots and histograms.		PSO1, PSO2, PSO5	
	CO 3. Apply statistical methods to datasets.		PSO1, PSO5	
	CO 4. Analyze linear algebra and optimization techniques.		PSO1, PSO2, PSO3, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**Assignment 1:** Introduction the following Python libraries and their core functionalities: • **NumPy**: Array-based numerical computing using ndarray, including statistical routines. • **SciPy**: Scientific computing built on NumPy, with modules like scipy.stats for statistical analysis. • **Pandas**: Data handling using Series (1D) and DataFrame (2D) structures, built on NumPy. • **Matplotlib**: Data visualization library compatible with NumPy, SciPy, and Pandas. **Assignment 2** – Understanding Exploratory Data Analysis (EDA) concepts using Python Libraries. **Assignment 3** – Sampling, Variables in Statistics, Frequency Distributions. Generate frequency distribution tables, generate grouped frequency distribution tables and visualize frequency distributions. Generate bar plots, pie charts, and histograms. Employ bar plots, pie charts and histograms. (6 hours) **Assignment 4** – Comparing Frequency Distributions: grouped bar plots, step-type histogram, kernel density estimate plots, strip plots and box plots. (6 hours) **Assignment 5** – Multidimensional image operations, solving differential equations and the Fourier transform using SciPy. **Assignment 6** – Optimization algorithms using SciPy. **Assignment 7** – Linear algebra using SciPy.	**30**	CO1, CO2	K1, K2, K3, K4
Module 2:	**Assignment 8** – Program in Python to implement the concepts such as: Vector space, subspace, span, column space, row space, null space, left-null space, rank, basis, orthogonal matrix, symmetric matrix. **Assignment 9** – Implement Eigen value decomposition in Python. **Assignment 10** – Implement SVD using Python. **Assignment 11** – Implement some optimization algorithms using Python libraries	**30**	CO3, CO4	K1, K2, K3, K6

	(e.g., SciPy, TensorFlow, PyTorch). **Assignment 12:** Mini Project			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	Deisenroth, M. P., Faisal, A. A., &Ong, C. S. (2020). Mathematics for machine learning. Cambridge University Press.			
References/ Readings:	1. Axler, S. (2024). Linear algebra done right (p. 390). Springer Nature. 2. Johnson, R. A., Miller, I., & Freund, J. E. (2000). Probability and statistics for engineers. *Proc. Miller Freund's*, 546-554. 3. Kreyszig, E., Stroud, K., & Stephenson, G. (2008). Advanced engineering mathematics. *Integration*, *9*(4), 1014.			
Web Resources:	1. Massachusetts Institute of Technology. (2018). RES.6-012: Introduction to probability. MIT OpenCourseWare. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/ 2. Harvard University. (2024). Statistics and R. Harvard Professional and Lifelong Learning. Retrieved May 16, 2025, from https://pll.harvard.edu/course/statistics-and-r			

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Title of the Course	Pattern Recognition and Machine Learning Lab
Course Code	CSI-5006
Number of Credits	2P
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide hands-on experience in implementing and applying machine learning techniques, including decision trees, neural networks, and advanced models for classification, clustering, and dimensionality reduction.	
Course Outcomes:	At the end of the course, the students will be able to:	**Mapped to PSO**
	CO 1. Remember core ML algorithms like decision trees and regression.	PSO1, PSO2, PSO5
	CO 2. Understand classification models and neural networks.	PSO1, PSO2, PSO5
	CO 3. Apply SVM and EM clustering methods.	PSO1, PSO2, PSO3, PSO5
	CO 4. Evaluate dimensionality reduction and ensemble models.	PSO1, PSO2, PSO5, PSO6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Experiment 1: EDA and Data Visualization** Analyze and visualize datasets (e.g., Iris, Titanic) using tools like Pandas and Matplotlib. **Experiment 2: k-Nearest Neighbors (k-NN)** Implement k-NN classification on datasets like Iris, tuning k and evaluating accuracy. **Experiment 3: Linear Regression** Predict continuous targets (e.g., Boston Housing) and explore feature selection techniques. **Experiment 4: Logistic Regression** Perform binary classification (e.g., Breast Cancer) and evaluate using precision, recall, and ROC-AUC. **Experiment 5: Decision Trees and Random Forests** Build and compare tree-based models on datasets like Titanic, analyzing feature importance. **Experiment 6: Support Vector Machines (SVM)** Classify data using SVM with different kernels (e.g., Iris, MNIST) and tune hyperparameters. **Experiment 7: Clustering (k-Means and Hierarchical)** Cluster data (e.g., Mall Customer Segmentation) and evaluate using silhouette score.	**30**	CO1, CO2	K3 K4, K5
Module 2:	**Experiment 8: Principal Component Analysis(PCA)** Reduce dimensions of high-dimensional data (e.g., MNIST) and visualize results. **Experiment 9: Neural Networks** Build a basic neural network for image classification (e.g., MNIST, CIFAR-10).	**30**	CO3, CO4	K3, K4, K6

	Experiment 10: End-to-End Machine Learning Pipeline Develop a complete pipeline (data preprocessing, modeling, evaluation) on a real-world dataset**.**			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	Bishop, C. M., &Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.			
References/ Readings:	1. Starmer, J. (2022). The Statquest illustrated guide to machine learning. 2. Mitchell, T. M. (1997). Machine learning (Vol. 1). McGraw-hill New York. 3. Flach, P. (2012). Machine learning: the art and science of algorithms that make sense of data. Cambridge university press. 4. Geron A. (2022) Hands-on Machine Learning with Sci-Learn, Keras&TensorFlow. Shroff/O'Reilly.			
Web Resources:	1. Google. (n.d.). Machine learning crash course. Retrieved May 16, 2025, from https://developers.google.com/machine-learning/crash-course 2. Kaggle. (n.d.). Kaggle learn. Retrieved May 16, 2025, from https://www.kaggle.com/learn			

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Title of the Course	Algorithm Design and Data Structures Lab
Course Code	CSI-5007
Number of Credits	2P
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-1000			
Course Objectives:	The course objective is to provide hands-on exposure to various data structures and algorithm analysis, including lists, stacks, queues, trees, and various sorting and searching algorithms.			
Course Outcomes:	At the end of the course, the students will be able to:			**Mapped to PSO**
	CO 1. Remember standard data structures such as stacks and queues.			PSO2, PSO5
	CO 2. Understand complex structures like AVL and B-trees.			PSO2, PSO5
	CO 3. Apply appropriate structures to solve given problems.			PSO3
	CO 4. Evaluate data structure choices in software development.			PSO7
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**List of suggested assignments:** 1. Object-Oriented Design Goals, Object-Oriented Design Principles. The programming assignment should introduce and enforce the concepts of encapsulation, polymorphism and Inheritance. 2. Implement Singly Linked Linear Lists and circular linked lists 3. Implement Doubly Linked Linear Lists and Circular linked List 4. Implement Stack using linked list 5. Implement Queue using linked list 6. Implement Binary Trees 7. Implement Binary Search Trees 8. Implement AVL Trees 9. Implement B-Trees and its variants	**30**	CO1, CO2	K3
Module 2	1. Program to convert the given infix expression to postfix expression using stack 2. Program to evaluate a postfix expression using stack 3. Program to traverse a binary tree in the following way: Pre- order, In-order, Post-order 4. Write a program to implement Huffman encoding using Binary tree. 5. Write a program to create a binary tree for the given infix expression. 6. Write a program that reads a list of names and telephone number from a textfile and inserts them into an AVL tree. Write afunction to allow the user to search the tree. Searching and sorting 7. Program to implement Binary search technique using Iterative method and Recursive methods. 8. Programs to implement following sorting algorithm-Bubble sort, Selection sort, Insertionsort, Quicksort, Mergesort and Heap sort	**30**	CO3, CO4	K3, K5, K6

	9. Implement assembly line scheduling 10. Implement Matrix-chain multiplication 11. Implement Prim's Algorithm and Kruskal's Algorithm			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	1. Dr. BasantAgarwal, &Baka, B. (2018). Hands-On Data Structures and Algorithms with Python. Packt Publishing Ltd. 2. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). Introduction to algorithms. The Mit Press.			
References/ Readings:	1. Dasgupta, S., Papadimitriou, C. H., &Vazirani, U. V. (2006). Algorithms. McGraw-Hill Publishing. 2. Mark Allen Weiss. (2003). Data structures & algorithm analysis in C++. Pearson Education. 3. Horowitz, E., &Sahni, S. (1976). Fundamentals of Data Structures. Computer Science Press, Incorporated.			
Web Resources:	1. Massachusetts Institute of Technology. (2011). 6.006 Introduction to algorithms. MIT OpenCourseWare. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-fall-2011/ 2. GeeksforGeeks. (2025, April 25). DSA tutorial: Learn data structures and algorithms. Retrieved May 16, 2025, from https://www.geeksforgeeks.org/dsa-tutorial-learn-data-structures-and-algorithms/			

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Discipline Specific Elective (DSE) Courses

Title of the Course	Fundamentals of Natural Language Processing
Course Code	CSI-5201
Number of Credits	4T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	To understand the fundamentals of Natural Language Processing (NLP).	
Course Outcomes:	After the completion of this course, the students will be able to	**Mapped to PSO**
	CO 1. Remember core NLP terminologies.	PSO1, PSO2, PSO3
	CO 2. Understand NLP tasks and processing steps.	PSO1, PSO3, PSO5
	CO 3. Apply NLP techniques in real-world applications.	PSO2, PSO5, PSO6
	CO 4. Evaluate outcomes of NLP-based systems.	PSO2, PSO3, PSO4, PSO7, PSO8

Content:		No of hours	Mapped to CO	Cognitive Level
Module 2:1	● **Introduction:** Definition, Natural Language Understanding, Natural Language Generation, Three generations of NLP, NLP trinity, Corpora and their construction, concordance, collocation, regular expressions, Issues and Challenges, NLP applications. ● **Word Sense Disambiguation:** Lexical knowledge networks, Princeton WordNet, Indian language wordnet, WordNet relations, WordNet applications, Idioms and Metaphors. ● **Computational Morphology:** Definition, Agglutination, Types of Morphology.	**15**	CO1, CO2	K1, K2,
Module 2	● **Shallow Parsing:** POS tagging, Chunking, Multi-word expressions, Named entity recognition – techniques, challenges, and applications. ● **Deep parsing:** Constituency parsing, Statistical parsing, Dependency parsing, Scope ambiguity, Attachment ambiguity, rule-based parsing, and statistical parsing.	**15**	CO1, CO2	K1, K2, K3
Module 3:	● **Sentiment Analysis:** Ambiguity – lexical, syntactic, semantic, discourse, pragmatic; Lexicons – manual creation, automatic creation; Rule-based – word level, sentence level, document level; Statistical – Naïve Bayes, Support Vector Machine. ● **Neural networks for NLP:** Review of neural networks basics (Perceptron, Feed forward networks, Back-propagation algorithm). ● **Word embeddings:** Word2vec, Glove, FastText.	**15**	CO2, CO3	K1, K2, K3, K4
Module 4:	**Tutorials and Mini-Projects:** **Suggested Tutorials:** ● Tokenization – word, sentence, character, sub-word, using stop words as delimiter ● Stop word removal, Punctuation removal	**15**	CO4	K1, K2, K3, K4, K5, K6

	• Use of Stemmer and Lemmatizer • Extracting all nouns in a text • Finding cosine similarity between two texts **Suggested Mini projects:** • Develop a POS tagger using a statistical technique. • Implement a morphological analyzer. • Implement a model to analyze the sentiment of a given text. • Generate a summary for a given document. • Implement a Language Detection system for any 4 languages of your choice. • Implement a Named Entity Recognition system to identify the named entities from a given text. • Implement a model to identify the multi-word expressions in a given text. • Implement a model to identify if the given phrase is used in an idiomatic sense or a regular sense.			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	Bhattacharyya, Pushpak and Joshi, Aditya, Natural Language Processing, 2023.			
References/ Readings:	1. Allen, James, Natural Language Understanding, Second Edition, Benjamin/Cumming, 1995. 2. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993. 3. Jurafsky, Dan, and Martin, James, Speech and Language Processing, Second Edition, Prentice Hall, 2008. 4. Manning, Christopher, and Heinrich, Schutze, Foundations of Statistical 5. Natural Language Processing, MIT Press, 1999.			
Web Resources:	1. Bhattacharyya, P. (n.d.). Natural language processing [Course]. NPTEL, IIT Bombay. Retrieved May 16, 2025, from https://nptel.ac.in/courses/106101007 2. IIT Madras. (n.d.). Introduction to natural language processing (i-NLP) [Course]. Retrieved May 16, 2025, from https://study.iitm.ac.in/ds/course_pages/BSCS5002.html 3. Goayal, P. (n.d.). Natural language processing [Course]. NPTEL, IIT Kharagpur. Retrieved May 16, 2025, from			

	https://onlinecourses.nptel.ac.in/noc19_cs56/preview

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Title of the Course	Fundamentals of Robotics
Course Code	CSI-5202
Number of Credits	4T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	This course introduces robotics fundamentals and applications, covering robotic hardware, motion control systems, communication protocols, and hands-on development of robotics applications using microcontrollers.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the fundamental concepts and evolution of robotics.	PSO1, PSO3, PSO7
	CO 2. Analyze robotic hardware and their drive mechanisms	PSO2, PSO3, PSO6
	CO 3. Work with different sensors and actuators in robotics applications.	PSO2, PSO3, PSO5, PSO6, PSO7
	CO 4. Design and develop robotics applications using embedded systems and AI.	PSO1, PSO2, PSO3, PSO4, PSO5, PSO6, PSO7, PSO 8

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1	**Fundamentals of Robotics** o Definition and Evolution of Robotics o Types of Robots (Industrial, Mobile, Humanoid, Swarm, Soft Robots) o Applications of Robotics (Healthcare, Manufacturing, Defense, Agriculture) o Overview of Robot Kinematics and Dynamics o Degrees of Freedom, Joints, and Configurations o Actuators and Motion Mechanisms	**15**	CO1	K1, K2, K4
Module 2	**Hardware Components in Robotics** o Battery Types & Power Systems o Li-ion, LiPo, NiMH, Lead-Acid Batteries o Charging Circuits for 2S, 3S, 4S Batteries o Balance Charging, Battery Management Systems (BMS) o Motors & Drive Systems o DC Motors, DC Geared Motors, Servo Motors, Stepper Motors o Different Drive Mechanisms: Differential, Ackermann, Mecanum, Omni-Wheel Drive o Planetary Gear Systems, Reduction Gear Mechanisms o Motor Drivers: L298N, DRV8825, TB6612FNG, ESC (Electronic Speed Controller) o Voltage Levels & Converters o Step-up (Boost) and Step-down (Buck) Converters o Voltage Regulators, Linear & Switching Regulators	**15**	CO2, CO3	K2, K3,K4

	○ Logic Level Shifters			
Module 3:	**Sensors and Communication in Robotics** • Types of Sensors • Proximity Sensors: Ultrasonic, IR, Lidar, Time-of-Flight Sensors • Human Detection: PIR Sensors, Thermal Cameras • Positioning & Navigation: IMU (Inertial Measurement Unit), Accelerometers, Gyroscopes, GPS • Environmental Sensors: Temperature, Humidity, Air Quality, Water Level Sensors • Line Following & Light Sensors • Communication Protocols for Robotics • Wired Communication: UART, I2C, SPI • Wireless Communication: Bluetooth, NRF24L01, Wi-Fi, 2.4 GHz RF Modules • LoRa and Zigbee-based Communication	**15**	CO3	K2,K3, K4
Module 4:	**Robotics Lab - Prototyping & Application Development** • Experiments and Projects: • Comparative study of Arduino Microcontroller and Raspberry Pi SoC and its application in Smart Robotics. • Line follower robot. • Develop a system for a smart dustbin. • Develop a system for a smart solar panel. • Develop a system for a firefighting robot. • Develop a system for a smart irrigation system. • Study of AI-based Virtual Reality Robotic Gadgets. • Case study of Smart Industry and its applications.	**15**	CO3,CO4	k3,k4,K6

	• Case study of Robotic Defense applications. • Application with MQTT. • Develop a system for a surveillance robot. • Develop a mobile app-controlled home cleaning robot. • Develop a system for a gesture-based smart robotic arm. • To develop an obstacle avoidance robot. • To develop an edge detection robot. • To develop a pathfinding robot.			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	**Dr. Robotics. (n.d.).** *Smart robots: Fundamentals, technologies, and applications*.			
References/ Readings:	1. Hunt, V. D. (2011). *Smart robots: A handbook of intelligent robotic systems* (1st ed.). Springer-Verlag New York Inc. 2. Correll, N., Hayes, B., & Wingate, D. (n.d.). *Introduction to autonomous robots*. 3. Siciliano, B., Sciavicco, L., Villani, L., &Oriolo, G. (2010). *Robotics: Modelling, planning and control*. Springer.			
Web Resources:	1. IEEE Spectrum. (n.d.). Robotics. IEEE Spectrum. https://spectrum.ieee.org/topic/robotics/ 2. Asada, H., & Leonard, J. (2005). 2.12 Introduction to Robotics. MIT OpenCourseWare. https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/			

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Title of the Course	Computer Vision
Course Code	CSI-5203
Number of Credits	4T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Linear Algebra, Calculus, Probability			
Course Objectives:	To understand the basics of computer vision to enable computers to interpret and extract meaningful information from images or videos.			
Course Outcomes:	At the end of the course, the student will be able to		**Mapped to PSO**	
	CO 1. Understand the foundational concepts of Computer Vision.		PSO1	
	CO 2. Apply the basics of image formation, processing, and analysis.		PSO1, PSO2	
	CO 3. Analyze key concepts of different domains and models.		PSO1, PSO2, PSO3, PSO5, PSO8	
	CO 4. Create computer vision applications, including mining of visual content, image rendering, camera surveillance, etc.		PSO3, PSO4, PSO5, PSO6, PSO7, PSO8	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	• Introduction to computer vision, Image formation fundamentals, Radiometry — measuring light, Sources, shadows and shading, Color.	**15**	CO1, CO2, CO3	K1, K2, K3
Module 2:	• Image Models, Geometric and Analytical Image Features • Linear filters and convolution, Edge detection. • Segmentation by clustering: Human vision, applications, segmentation by graph-theoretic clustering. Segmentation by fitting a model, Hough transform, fitting lines, and fitting curves;	**15**	CO2, CO3	K1, K2, K3, K4
Module 3:	• Tracking and Motion • The Basics of Tracking, Corner Finding, Subpixel Corners, Invariant Features, Optical Flow, Mean-Shift &Camshift Tracking, Motion Templates, Estimators, Lucas-Kanade • algorithm for optical flow, Multi-scale Lucas-Kanade algorithm, Comparison of Horn-Shunck and Lucas-Kanade algorithms, Applications of optical flow	**15**	CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 4:	• Camera Models and Calibration • Developing Camera Model, Calibration -Concept of camera calibration and the basic aim of • Camera calibration, Motivation for camera calibration - implications for 3D • reconstruction using two calibrated cameras, Un-distortion, Putting Calibration Together, Rodrigues Transform	**15**	CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	David A Forsynth and Jean Ponce, “Computer vision- A modern approach”, Pearson education series, 2003.			
References/ Readings:	1. Milan Sonka, Vaclav Hlavac and Roger Boyle , “Digital image processing and computer vision”, Cengage Learning, 2008. 2. Schalkoff R. J., “Digital image processing and computer vision”, John Wiley, 2004.			

	3. Sonka M., Hlavac V., Boyle R., "Image processing analysis and machine design". PWS Publishers 4. Ballard D., Brown C., "Computer vision", Prentice Hall
Web Resources:	1. GeeksforGeeks. (n.d.). *Computer vision*. Retrieved May 16, 2025, from https://www.geeksforgeeks.org/computer-vision/ 2. IIT Hyderabad. (n.d.). *Deep learning for computer vision* [Course]. NPTEL. Retrieved May 16, 2025, from https://onlinecourses.nptel.ac.in/noc20_cs88/preview

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Title of the Course	Speech Processing
Course Code	CSI-5204
Number of Credits	4T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Mathematics for Computer Science and Machine Learning	
Course Objectives:	The objective of the course is to study fundamental concepts of automatic speech recognition.	
Course Outcomes:	After completion of this course, students will be able to:	**Mapped to PSO**
	CO 1. Remember foundational speech processing concepts.	PSO1, PSO8
	CO 2. Understand signal processing techniques for feature extraction.	PSO2, PSO5, PSO6
	CO 3. Apply speech models like HMM and DNN.	PSO2, PSO3, PSO5, PSO7
	CO 4. Evaluate ASR systems using performance metrics.	PSO2, PSO4, PSO5, PSO6, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	● Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production, Digital models for speech signals. ● Introduction, Window considerations, Short time energy and average magnitude, Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing, Pitch period estimation using a parallel processing approach, The short time autocorrelation function, The short time average magnitude difference function, Pitch period estimation using the autocorrelation function. ● Basic principles of Linear Predictive Analysis: The Autocorrelation Method, The Covariance Method, Solution of LPC Equations: Cholesky Decomposition Solution for Covariance Method, Durbin's Recursive Solution for the Autocorrelation Equations, Pitch Detection and using LPC Parameters.	**15**	CO1, CO2	K1, K2, K3
Module 2	● Introduction, Homomorphic Systems for Convolution: Properties of the Complex Cepstrum, Computational Considerations, The Complex Cepstrum of Speech, Pitch Detection, Formant Estimation, Mel frequency cepstrum computation. ● Nature of interfering sounds, Speech enhancement techniques: spectral subtraction, Enhancement by resynthesis, Comb filter, Wiener filter. ● Basic pattern recognition approaches, Parametric representation of speech, Evaluating the similarity of speech patterns, Isolated digit Recognition System, Continuous digit Recognition System.	**15**	CO2, CO3	K1, K2, K3, K4
Module 3:	● Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMs, Adapting to variability in speech (DTW), Language models.	**15**	CO2, CO3, CO4	K1, K2, K3, K4, K5

	• Issues in speaker recognition and speech synthesis of different speakers. Text to speech conversion, Calculating acoustic parameters, synthesized speech output performance and characteristics of text-to-speech, Voice processing hardware and software architectures.			
Module 4:	**Suggested tutorial assignments**: Discuss the programs to implement the following: 1. Nature of Speech Signal 2. Time Domain Methods For Speech Processing 3. Frequency Domain Methods For Speech Processing 4. Linear Predictive Coding of Speech 5. Homomorphic Speech Analysis	**15**	CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Quatieri, T. F. (2002). Discrete-time speech signal processing: principles and practice. Pearson Education India. 2. Martin, J. H., &Jurafsky, D. (2009). Speech and language processing: An introduction to natural language processing, computational linguistics, and speech recognition (Vol. 23). Upper Saddle River: Pearson/Prentice Hall.			
References/ Readings:	1. Rabiner, L. R. (2003). Digital processing of speech signals. Pearson Education India. 2. O'shaughnessy, D. (1999). Speech communications: Human and machine (IEEE). Universities press. 3. Rabiner, L. R., &Juang, B. H. (1999). *Fundamentals of speech recognition*. Tsinghua University Press..			
Web Resources:	1. IIT Madras. (n.d.). Speech signal processing [Course]. NPTEL. Retrieved May 16, 2025, from https://onlinecourses.nptel.ac.in/noc22_ee117/preview 2. Massachusetts Institute of Technology. (2003). 6.345 Automatic speech recognition [Course]. MIT OpenCourseWare. Retrieved May 16, 2025, from https://ocw.mit.edu/courses/6-345-automatic-speech-recognition-spring-2003/			

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Title of the Course	Data Science and Data Engineering
Course Code	CSI-5205
Number of Credits	4T
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	This course provides a solid foundation in data science and engineering, covering essential techniques such as data collection, cleaning, processing, and scalable pipeline development. It also emphasizes practical applications, equipping learners with hands-on experience in data visualization, and industry-standard tools to tackle real-world challenges.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Analyze the complete data lifecycle and differentiate between structured, semi-structured, and unstructured data.	PSO1, PSO3, PSO 5
	CO 2. Apply SQL, NoSQL, Hadoop, and Spark for data processing, and configure cloud storage solutions like AWS S3 and Google BigQuery.	PSO1, PSO2, PSO3, PSO5, PSO6, PSO7
	CO 3. Apply data cleaning, transformation, and visualization techniques using Python libraries like Pandas, NumPy, Matplotlib, and Seaborn to uncover insights from	PSO1, PSO2, PSO3, PSO5, PSO7

	real-world datasets.			
	CO 4. Create ETL/ELT data pipelines, orchestrate workflows with Apache Airflow, and deploy models using cloud platforms, Docker, and Kubernetes.		PSO1, PSO2, PSO3, PSO5, PSO6, PSO7	
	CO 5. Evaluate machine learning models using Scikit-learn and process large-scale datasets using distributed computing frameworks like Hadoop and Spark.		PSO1, PSO2, PSO3, PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Data Science and Data Engineering** ● Introduction to Data Science and Data Engineering: Definitions, scope, and organizational impact ● Overview of the data lifecycle: Data collection, cleaning, processing, analysis, and visualization ● Types of data: Structured, semi-structured, and unstructured data ● Essential tools and technologies: Python, SQL, Hadoop, and Spark ● Database systems: Relational databases (SQL) vs. NoSQL databases (MongoDB, Cassandra) ● Modern data storage solutions: Data lakes, data warehouses, and cloud platforms (AWS S3, Google BigQuery) ● Data quality issues: Missing data, outliers, inconsistencies ● Data transformation techniques: Normalization, scaling, encoding ● Specialized data types: Handling time-series and text data ● Exploratory Data Analysis (EDA): Descriptive statistics, summary metrics ● Data visualization tools and techniques: Matplotlib, Seaborn, Plotly, Tableau	**15**	CO1, CO2, CO3	K2, K3, K4, K6
Module 2	**Unit 2: Machine Learning, Big Data Processing, and Deployment** ● Introduction to Machine Learning: Supervised, unsupervised, and reinforcement learning	**15**	CO4, CO5	K2, K3, K4, K5

	● Common ML algorithms: Linear regression, decision trees, k-means clustering ● Model evaluation metrics: Accuracy, precision, recall, F1-score, ROC-AUC ● Big Data fundamentals: The four Vs – Volume, Velocity, Variety, Veracity ● Distributed computing frameworks: Hadoop and Spark ● Scalable data pipeline architecture: ETL and ELT processes ● Workflow orchestration tools: Apache Airflow, Luigi ● Stream processing systems: Kafka, Apache Flink ● Cloud platforms for data engineering: AWS, Azure, Google Cloud Platform ● Containerization and orchestration: Docker, Kubernetes ● Infrastructure as Code (IaC): Terraform ● Overview of end-to-end deployment strategies in data projects			
Module 3:	Lab Experiments (Data Engineering) 1. **Basic ETL Process** Create a simple ETL pipeline using Python to extract data from CSV files, transform it (clean missing values, normalize columns), and load it into a SQLite database. Analyze the transformation steps and their impact on data quality. 2. **Database Query Optimization** Compare the performance of optimized versus unoptimized SQL queries on a medium-sized dataset. Experiment with adding appropriate indexes and measure execution time improvements. 3. **Data Visualization Dashboard** Build a basic dashboard using Python libraries (Matplotlib, Plotly) to visualize insights from a dataset, incorporating interactive elements that	**15**	CO4, CO5	K3, K4, K5, K6

	allow filtering and drill-down capabilities. 4. **File Format Comparison** Analyze the same dataset stored in different formats (CSV, JSON, Parquet) and compare processing speed, storage efficiency, and query performance across each format. 5. **Simple Data Pipeline Scheduling** Implement a scheduled data pipeline using tools like cron or Airflow that automatically extracts data at regular intervals, performs basic transformations, and updates a target database with new information.			
Module 4:	**Data Science Practical Lab Experiments** 1. **Exploratory Data Analysis** Analyze a real-world dataset using Python (pandas, matplotlib) to identify patterns, outliers, and relationships. Create visualizations that highlight key insights and present a summary of findings. 2. **Classification Model Comparison** Build and compare multiple classification algorithms (Decision Tree, Logistic Regression, Random Forest) on the same dataset. Evaluate performance using metrics like accuracy, precision, and recall. 3. **Clustering for Customer Segmentation** Apply K-means clustering to a customer dataset to identify natural groupings. Visualize the clusters, interpret their characteristics, and suggest how these segments might guide business decisions. 4. **Time Series Forecasting** Use historical time series data to build a simple forecasting model (moving averages, ARIMA) that predicts future values. Evaluate forecast accuracy and visualize predictions against actual values.	**15**	,CO3, CO4	K3,K4.K5
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Reis, J., &Housley, M. (2022). *Fundamentals of data engineering: Plan and build robust data systems* (Grayscale			

	Indian Edition). 2. Grus, J. (2019). *Data science from scratch: First principles with Python*. O'Reilly Media.
References/ Readings:	1. McKinney, W. (2022). *Python for Data Analysis: Data Wrangling with pandas, NumPy, and IPython* (3rd ed.). O'Reilly Media. 2. Géron, A. (2022). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems* (3rd ed.). O'Reilly Media. 3. Grus, J. (2019). *Data Science from Scratch: First Principles with Python* (2nd ed.). O'Reilly Media. 4. Bruce, P., Bruce, A., &Gedeck, P. (2020). *Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python* (2nd ed.). O'Reilly Media. 5. Leskovec, J., Rajaraman, A., & Ullman, J. D. (2020). *Mining of Massive Datasets* (3rd ed.). Cambridge University Press.
Web Resources:	1. KDNuggets. (n.d.). KDNuggets: News. Retrieved May 19, 2025, from https://www.kdnuggets.com/news/index.html 2. Towards Data Science. (n.d.). Towards Data Science. Retrieved May 19, 2025, from https://www.towardsdatascience.com

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SEMESTER II

Discipline Specific Core Courses

Title of the Course	Fundamentals of Deep Learning and Generative AI Techniques
Course Code	CSI-5008
Number of Credits	2T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	N0
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5000, CSI-5001,CSI-5002	
Course Objectives:	This course covers deep learning fundamentals including MLPs, CNNs, and RNNs, with focus on generative models like VAEs and GANs. Students learn optimization techniques, regularization methods, and advanced strategies such as WGAN, applying these skills to real-world image, text, and music generation tasks while exploring AI's creative potential.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Apply foundational deep learning techniques such as MLPs, CNNs, and RNNs to solve classification and sequence modeling problems.	PSO 1, PSO5

	CO 2. Create generative models including VariationalAutoencoders (VAEs) and Generative Adversarial Networks (GANs) for image, text, and music generation.		PSO2, PSO6	
	CO 3. Apply advanced optimization strategies like regularization, batch normalization, and learning rate scheduling to fine-tune deep learning models for improved performance.		PSO3, PSO5	
	CO 4. Evaluate generative models in creative applications by addressing challenges like mode collapse and applying models such as WGAN and CycleGAN.		PSO4, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations and Core Architectures** ● History of Deep Learning McCulloch-Pitts Neuron, Perceptron Algorithm MLPs, Sigmoid Neurons Gradient Descent, Backpropagation Optimization (GD, Momentum, Adam) CNN Architectures (LeNet, AlexNet, VGG, ResNet) RNNs: BPTT, LSTM, GRU **Model Optimization and Regularization** ● Feedforward NN training ● Batch Normalization Regularization (L1/L2, dropout) Learning Rate Scheduling Autoencoders (Basic, Denoising, Sparse) Comparison: Autoencodersvs PCA	**15**	CO1, CO3	K2, K3, K4, K5
Module 2	**Generative Deep Learning Models** ● Introduction to Generative Models Generative vs Discriminative VariationalAutoencoders (VAEs) Latent Space Arithmetic, Face Generation	**15**	CO2, CO4	K3, K4, K5

	GAN Architecture (Generator, Discriminator) GAN Training Challenges (Mode Collapse, etc.) **Advanced Generative Models and Applications** WGAN, WGAN-GP CycleGAN for Style Transfer Neural Style Transfer Text Generation with LSTM Music Generation with MuseGAN Transformer Architecture (Self-Attention, Positional Encoding) Applications: BERT, GPT, Vision Transformers (ViT)			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Goodfellow, I., Bengio, Y., &Courville, A. (2016). *Deep learning*. MIT Press. 2. Foster, D. (2020). *Generative deep learning: Teaching machines to paint, write, compose, and play* (1st ed.). O'Reilly Media.			
References/ Readings:	1. Géron, A. (2019). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media. 2. Bishop, C. M. (2006). *Pattern recognition and machine learning* (1st ed.). Springer. 3. Chollet, F. (2021). *Deep learning with Python* (2nd ed.). Manning Publications.			
Web Resources:	1. DeepLearning.AI. (n.d.). DeepLearning.AI. Retrieved May 19, 2025, from https://www.deeplearning.ai 2. fast.ai. (n.d.). fast.ai. Retrieved May 19, 2025, from https://www.fast.ai			

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Title of the Course	Reinforcement Learning
Course Code	CSI-5009
Number of Credits	2T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To enable the student to understand core concepts of reinforcement learning.			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember RL principles and terminology.		PSO1, PSO4	
	CO 2. Understand Markov Decision Processes.		PSO1, PSO5	
	CO 3. Apply model-based and model-free techniques.		PSO1, PSO2, PSO5	
	CO 4. Analyze real-world tasks as RL problems.		PSO2, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction**	15	CO1, CO2	K1, K2,

	● Background, Supervised, Unsupervised and Reinforcement Learning, RL framework, Limitations, Examples. **Multi-Arm Bandits** ● k-armed bandit problem, Exploration and Exploitation, Greedy, Epsilon greedy, Upper Confidence Bound, Gradient Bandit algorithms, Contextual Bandits. **Finite Markov Decision Processes** ● Agent, Environment, Goals, Rewards, Return, Episodic and Continuing tasks, Policies, Value functions, Optimal policies and value functions, Bellman Equations, Backup diagrams. **Dynamic Programming** ● Policy evaluation, Policy improvement, Policy iteration, Value iteration, Asynchronous Dynamic Programming. **Monte Carlo Methods** ● Monte Carlo Prediction, Action value estimation, Control, Off-policy prediction, Off-policy control. **Temporal Difference Learning** ● TD Prediction, Advantages, On-policy TD control – SARSA, Off-policy TD control – Q learning, Expected SARSA, Maximization bias and double learning, n-step TD prediction, n-step SARSA, n-step off-policy learning.			K3, K4, K5
Module 3:	**Planning and Learning** ● Models, Dyna, Prioritized sweeping, Expected vs. Sample updates, Trajectory Sampling, Real time DP, Heuristic search, Rollout algorithms, Monte Carlo tree search. **On-policy Prediction with Approximation** ● Value function approximation, prediction objective, Stochastic-gradient and Semi-gradient Methods, Linear Methods, Non-linear function approximation, Memory based function approximation, Kernel based	15	CO3, CO4	K3, K4, K5, K6

	function approximation. **On-policy Control with Approximation** ● Episodic Semi-gradient Control, Semi-gradient n-step Sarsa, Deprecating the Discounted Setting, Differential Semi-gradient n-step Sarsa. **Off-policy Methods with Approximation** ● Semi-gradient Methods, Off-policy Divergence, The Deadly Triad, Bellman Error, Gradient-TD Methods, Emphatic-TD Methods, Eligibility Traces. **Policy Gradient Methods** ● Policy Approximation, Advantages, Policy Gradient Theorem, REINFORCE, Actor–Critic Methods, Policy Parameterization.			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	Sutton, R. S., &Barto, A. G. (1998). *Reinforcement learning: An introduction* (Vol. 1, No. 1, pp. 9-11). Cambridge: MIT press.			
References/ Readings:	1. Szepesvári, C. (2022). Algorithms for reinforcement learning. Springer nature. 2. Lattimore, T., &Szepesvári, C. (2020). Bandit algorithms. Cambridge University Press. 3. Lapan, M. (2024). Deep Reinforcement Learning Hands-On. Packt Publishing Ltd.			
Web Resources:	Hugging Face. (n.d.). Introduction to Deep Reinforcement Learning [Online course]. Retrieved May 19, 2025, from https://huggingface.co/learn/deep-rl-course/unit0/introduction			

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Title of the Course	Big Data Frameworks
Course Code	CSI-5010
Number of Credits	2T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-1000	
Course Objectives:	The course objective is to equip students with a comprehensive understanding of Big Data, the challenges faced in storing and analyzing it, and the workings of big data platforms, with a specific focus on Apache Hadoop and its ecosystem & Apache Spark.	
Course Outcomes:	At the end of the course, the students will be able to:	**Mapped to PSO**
	CO 1. Remember big data concepts and architectures.	PSO1
	CO 2. Understand big data analytics platforms.	PSO1
	CO 3. Apply distributed frameworks like Hadoop and Spark.	PSO2, PSO3, PSO5, PSO6
	CO 4. Evaluate real-world case studies using big data tools.	PSO5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Introduction to Big Data** ● Big Data and its characteristics, Big Data Analytics, Challenges faced in storage, querying and analysis of big data; need for big data frameworks **Hadoop Framework:** ● **Apache Hadoop Basics**: Introduction, Hadoop 1 v/s Hadoop 2, Use cases and anti-patterns, Main components of Hadoop, Hadoop Ecosystem ● **Hadoop Distributed Filesystem (HDFS):** HDFS Architecture, HDFS daemons and their roles, data blocks, replication policy, Handling node & disk failures, Namenode startup operation, checkpointing process, HDFS file read & write process, Error handling in read/write, NameNode resilience ● **Mapreduce:** Introduction to MapReduce framework, Map, Shuffle-Sort and Reduce Phases, Input Splits, Word Count problem, Data Flow & Daemons in MapReduce, Partitions, Combiner Functions. ● **Apache YARN:** YARN applications, YARN daemons, Anatomy of a YARN application run	**15**	CO1, CO2, CO3	K1, K2, K3, K4
Module 2	**MapReduce Programming** ● **Mapreduce Programming in Java:** Hadoop Data Types, Input & Output formats, Record Reader, Record Writer, Sample Mapreduce programs ● **Advanced Mapreduce:** Chaining jobs, Joining data (reduce-side join, replicated joins, semi-join), Secondary sorting. **Hadoop Ecosystem:** ● **Apache PIG**: PIG and its use, Execution Modes, Grunt Shell and Grunt commands, Data Model (Relations, Bags, Tuples, Fields), Pig Latin Basics. ● **Apache Hive**: Introduction and need, Hive Architecture, Metastore, Schema on Read, Hive Tables (Managed and External), Partitions, Buckets. ● **Apache HBase:** Introduction and need, Data Model, Architecture, Metadata,	**15**	CO 2, CO 3, CO 4	K1, K2, K4, K5, K6

	API (Get, Put, Scan) **Apache Spark:** ● **Apache Spark Basics**: Introduction and Need, Spark v/s Hadoop, Use Cases and antipatterns, Spark Components, Spark Program Flow, Resilient Distributed Dataset (RDD), Actions & Transformations on Basic and Pair RDD. ● **SparkQL:** Spark SQL vs. Traditional SQL Databases, DataFrames and Datasets, Spark SQL Functions and Queries			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. White, T. (2015). Hadoop: The Definitive Guide (4th ed.). O'Reilly Media 2. Jean Georges Perrin. (2020). Spark in Action. Manning Publications Company.			
References/ Readings:	1. Lam, C. (2011). Hadoop in Action. Manning Publications. 2. Holmes, A. (n.d.). Hadoop in Practice. 3. Deroos, D., Zikopoulos, P., Brown, B., Coss, R., &Melnyk, R. B. (2014). Hadoop for Dummies. John Wiley & Sons, Inc.			
Web Resources:	1. Overview. (2017). Apache.org. https://pig.apache.org/docs/latest/index.html 2. RDD Programming Guide - Spark 3.0.0 Documentation. (n.d.). Spark.apache.org. https://spark.apache.org/docs/latest/rdd-programming-guide.html			

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Title of the Course	MLOp
Course Code	CSI-5011
Number of Credits	2T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5002, CSI-5006	
Course Objectives:	1. To equip students with the knowledge and skills to design, implement, and manage end-to-end machine learning operations (MLOps) pipelines 2. It also enables them to deploy, monitor, and maintain scalable, reliable, and ethical ML systems in production environments.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Create end-to-end MLOps pipelines and ML workflows.	PSO1, PSO2, PSO5, PSO6
	CO 2. Apply containers, cloud platforms, and CI/CD tools to deploy ML models.	PSO2, PSO6, PSO7
	CO 3. Analyze ML systems through logging, drift detection, and performance tracking.	PSO2, PSO4, PSO6,
	CO 4. Evaluate ethical challenges including bias mitigation, fairness, and operational	PSO4, PSO5,PSO8

	excellence in ML systems.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to MLOps :** ● Evolution and Importance, Definition, Goals, and Key Components, MLOps vs DevOps, MLOps Hierarchy of Needs (Data, Model, Code, Infrastructure) ● MLOps Foundations: Bash& Linux Command Line (Basic commands, scripting),Cloud Computing Basics (AWS, GCP, Azure),Minimal Python for MLOps, Descriptive Statistics and Optimization ● Introduction to MLOps Pipelines: Data ingestion, Model training, Model deployment **MLOps in Production** ● Containers & Edge Devices: Docker (Basics, Best Practices),Model Serving (APIs over HTTP),Edge AI (Coral, Azure Percept, TFHub),Porting models to Edge ● Continuous Delivery for ML: Packaging Models,Infrastructure as Code (Terraform, CloudFormation),Controlled Rollout (Canary, A/B Testing),Testing (Unit, Integration, Model Validation)	**15**	CO1, CO2	K2, K3, K4, K5
Module 2	**Advanced MLOps Tools and Practices :** ● AutoML and Continuous Improvement:AutoML Tools (Google AutoML, Azure AutoML, Ludwig, FLAML). KaizenML ● Feature Stores and Explainability:Versioning and managing features,Interpretable ML Techniques ● Monitoring and Logging:Observability in MLOps,Logging in Python.Model Monitoring (Data drift, Performance degradation).Drift Monitoring Tools (SageMaker, Azure ML) ● MLOps Applications and Interoperability : ● MLOps on AWS:SageMaker, Lambda, EC2,Serverless MLOps (Flask, AWS	**15**	CO3,CO4	K2,K3 ,K4,K6

	SAM) ● Interoperability and Microservices:ONNX (Conversion, Deployment),Python Packaging,CLI Tools for MLOps,Microservices and Authentication ● Case Studies and Challenges:Real-WorldMLOps Case Studies,Ethics in MLOps (Bias, Fairness),Operational Challenges			
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Treveil, M., Omont, N., Stenac, C., Lefevre, K., Phan, D., &Zentici, J. (2020). Introducing MLOps: How to Scale Machine Learning in the Enterprise. O'Reilly Media. 2. Burkov, A. (2020). Machine Learning Engineering. True Positive Inc.3.			
References/ Readings:	1. Treveil, M., Omont, N., Stenac, C., Lefevre, K., Phan, D., &Zentici, J. (2020). Introducing MLOps: How to Scale Machine Learning in the Enterprise. O'Reilly Media. 2. Burkov, A. (2020). Machine Learning Engineering. True Positive Inc. 3. Hapke, H., & Nelson, C. (2020). Building Machine Learning Pipelines: Automating Model Life Cycles with TensorFlow. O'Reilly Media.			
Web Resources:	1. Neptune.ai. (n.d.). How to learn MLOps. Retrieved May 19, 2025, from https://neptune.ai/blog/how-to-learn-mlops 2. DataCamp. (n.d.). 10 awesome resources for learning MLOps. Retrieved May 19, 2025, from https://www.datacamp.com/blog/10-awesome-resources-for-learning-mlops			

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Title of the Course	Fundamentals of Deep Learning and Generative AI Techniques Lab
Course Code	CSI-5012
Number of Credits	2P
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5000, CSI-5001, CSI-5002	
Course Objectives:	This course provides practical experience in building, training, and evaluating deep learning and generative models, enabling students to translate theoretical knowledge into real-world AI applications involving image, text, and audio data.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Apply core deep learning architectures such as MLPs, CNNs, and RNNs.	PSO1, PSO2
	CO 2. Apply optimization, regularization, and training strategies effectively.	PSO1, PSO6
	CO 3. Evaluate generative models like VAEs and GANs.	PSO1, PSO5, PSO7
	CO 4. Create creative AI applications in image, text, and audio domains.	PSO3, PSO4, PSO5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Lab 1: Implementing Perceptrons and MLPs** ● Train and test perceptrons on binary classification tasks. ● Implement MLPs with different hidden layers for XOR problem. **Lab 2: Training Deep Networks** ● Implement gradient descent and backpropagation manually. ● Compare optimizers (SGD, Adam, RMSProp) on MNIST. **Lab 3: Autoencoders** ● Build and train a basic autoencoder. ● Apply denoising and sparse variants on image datasets. **Lab 4: CNN Architectures and Visualization** ● Train CNNs (LeNet, VGG) on CIFAR-10. ● Visualize filters, feature maps, and use DeepDream.	**30**	CO1, CO2, CO3, CO4	K3, K4, K6
Module 2:	**Lab 5: Sequence Modeling with RNNs** ● Implement LSTM for sentiment classification. ● Build encoder-decoder model for sequence translation. **Lab 6: VariationalAutoencoders** ● Build and train a VAE on face dataset. ● Visualize latent space interpolation and morphing. **Lab 7: Generative Adversarial Networks** ● Implement a basic GAN for MNIST. ● Experiment with WGAN and WGAN-GP. **Lab 8: Creative Applications with Generative Models** ● Train CycleGAN for image style transfer.	**30**	CO2, CO3, CO4	K3, K4,K6

	• Use LSTM for poem generation. • Compose polyphonic music using MuseGAN.			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	1. Goodfellow, I., Bengio, Y., &Courville, A. (2016). *Deep learning*. MIT Press. 2. Foster, D. (2020). *Generative deep learning: Teaching machines to paint, write, compose, and play* (1st ed.). O'Reilly Media.			
References/ Readings:	1. Géron, A. (2019). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media. 2. Bishop, C. M. (2006). *Pattern recognition and machine learning* (1st ed.). Springer. 3. Chollet, F. (2021). *Deep learning with Python* (2nd ed.). Manning Publications.			
Web Resources:	1. DeepLearning.AI. (n.d.). DeepLearning.AI. Retrieved May 19, 2025, from https://www.deeplearning.ai/ 2. Keras. (n.d.). Keras: The Python deep learning API. Retrieved May 19, 2025, from https://keras.io/ 3. PyTorch. (n.d.). PyTorch tutorials. Retrieved May 19, 2025, from https://pytorch.org/tutorials/ 4. Sourcell, S. (n.d.). llSourcell'sGitHub repositories. GitHub. Retrieved May 19, 2025, from https://github.com/llSourcell			

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Title of the Course	Reinforcement Learning Lab
Course Code	CSI-5013
Number of Credits	2P
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To enable the student to implement the core concepts of reinforcement learning.	
Course Outcomes:	At the end of the course, the students will be able to:	**Mapped to PSO**
	CO 1. Remember libraries used in RL implementations.	PSO2, PSO5
	CO 2. Understand the application flow of RL models.	PSO1, PSO2, PSO5
	CO 3. Apply RL techniques to complex tasks.	PSO2, PSO5
	CO 4. Evaluate performance metrics of RL algorithms.	PSO2, PSO5, PSO6

Content:		No of hours	Mapped to CO	Cognitive level
Module 1:	**RL Task Formulation:** Designing a real-world problem into the RL framework by defining action space, state space, agent, environment, rewards, and other components. **Multi-Arm Bandits:** Implementing MAB algorithms for balancing exploration and exploitation in RL problems. **Dynamic Programming:** Implementing dynamic programming algorithms for policy optimization in RL problems. **Monte Carlo Methods:** Implementing Monte Carlo algorithms for policy evaluation in RL problems. **Temporal Difference Learning:** Implementing TD learning methods for policy evaluation and improvement in RL problems.	**30**	CO1, CO2	K3, K4, K5, K6
Module 2:	**Off-policy Model-Free Algorithm:** Implement Q-learning for solving RL problems. **On-Policy Model-Free Algorithm:** Implement SARSA for solving RL problems. **Deep Q-Learning:** Implement DQN to solve a simple environment in OpenAI Gym. **Policy Gradient Methods:** Implement REINFORCE algorithm for direct policy optimization in RL. **Actor-Critic Methods:** Implement Actor-Critic methods and compare performance with Q-learning and SARSA.	**30**	CO3, CO4	K3, K4, K5, K6
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	Sutton, R. S., &Barto, A. G. (1998). *Reinforcement learning: An introduction* (Vol. 1, No. 1, pp. 9-11). Cambridge: MIT press.			

References/ Readings:	1. Szepesvári, C. (2022). Algorithms for reinforcement learning. Springer nature. 2. Lattimore, T., &Szepesvári, C. (2020). Bandit algorithms. Cambridge University Press. 3. Lapan, M. (2024). Deep Reinforcement Learning Hands-On. Packt Publishing Ltd.
Web Resources:	Hugging Face. (n.d.). Introduction to Deep Reinforcement Learning [Online course]. Retrieved May 19, 2025, from https://huggingface.co/learn/deep-rl-course/unit0/introduction

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Title of the Course	Big Data Frameworks Lab
Course Code	CSI-5014
Number of Credits	2P
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-1000			
Course Objectives:	The course objective is to provide hands-on experience in the storage and processing of big data with the help of tools like Apache Hadoop, Pig, Hive and Apache Spark			
Course Outcomes:	At the end of the course, the students will be able to:		**Mapped to PSO**	
	CO 1. Remember file storage and access methods in Hadoop/Spark.		PSO2	
	CO 2. Understand data flow in distributed systems.		PSO2, PSO5	
	CO 3. Apply big data analytics to large datasets.		PSO2, PSO5	
	CO 4. Create complete big data solutions using Spark or Hadoop ecosystem.		PSO2, PSO5, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**List of suggested assignments:** 1. Install Hadoop and configure it to run in the pseudo-distributed mode. Understand the different startup scripts and configuration files. 2. Using HDFS commands, implement file management tasks in Hadoop such as adding files and directories, retrieving files, deleting files, copying files, moving files, merging files, and appending content to files. 3. Run a basic Word Count MapReduce program to understand the MapReduce paradigm. 4. Write MapReduce programs to a. Find the average rating of movies. b. Find the number of times each user of age > 25 has rated a movie. c. Implement Matrix Multiplication d. Mine weather data. 5. Install Pig and write a Pig Latin script to sort, group, join, project, and filter your data. 6. Install and run Hive, then use Hive to create, alter, and drop databases, tables, views, functions, and indexes. Using HiveQL, sort, group, join, project, and filter your data.	**30**	CO1, CO2, CO3, CO4	K3, K4, K5
	7. Install pySpark (can be done using Docker container) and create RDDs, perform actions and transformations on the RDDs 8. Using pySpark, load a text file as a RDD and perform word count. 9. Convert a JSON file into a DataFrame. Run SQL queries to to sort, group, join, project, and filter your data. **10. Mini project** Solve some real-life big data problems. ● Traffic control using big data ● Medical insurance fraud detection ● Recommendation system	**30**		

	• Anomaly detection in cloud servers • Tourist behavior analysis • Web server log analysis			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	1. White, T. (2015). Hadoop: The definitive guide (4th ed.). O'Reilly Media 2. Jean Georges Perrin. (2020). Spark in Action. Manning Publications Company.			
Web Resources:	1. Apache Hadoop 3.3.1 – Hadoop: Setting up a Single Node Cluster. (n.d.). Hadoop.apache.org. https://hadoop.apache.org/docs/stable/hadoop-project-dist/hadoop-common/SingleCluster.html 2. Overview. (2017). Apache.org. https://pig.apache.org/docs/latest/index.html 3. RDD Programming Guide - Spark 3.0.0 Documentation. (n.d.). Spark.apache.org. https://spark.apache.org/docs/latest/rdd-programming-guide.html			

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Title of the Course	MLOP Lab
Course Code	CSI-5015
Number of Credits	2P
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5002, CSI-5006	
Course Objectives:	• Enable students to build complete MLOps pipelines covering data ingestion, model training, deployment, and automation. • Provide experience in deploying scalable and reliable ML models using cloud platforms, containers, and monitoring tools. • Instil practices for maintaining ethical, fair, and responsible AI systems in real-world production environments.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Create MLOps pipelines with end-to-end workflows for data ingestion, model training, and deployment.	PSO1, PSO2, PSO5, PSO6
	CO 2. Apply containers, cloud platforms, and CI/CD tools to deploy ML models in production for scalable deployments.	PSO2, PSO6, PSO7
	CO 3. Apply logging, monitoring, and drift detection techniques to monitor and maintain	PSO2, PSO6, PSO4

	ML systems.			
	CO 4. Evaluate ethical and operational challenges by detecting bias, ensuring fairness, and balancing accuracy with operational excellence.		PSO4, PSO2, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Lab 1: Introduction to MLOps Tools (4 hours)** ● Set up Python environment (Anaconda, Jupyter Notebook). ● Explore MLOps tools (MLflow, DVC, Kubeflow). ● Version control for ML projects using Git and DVC. **Lab 2: Data Pipeline Development (6 hours)** ● Ingest and preprocess data using Pandas and PySpark. ● Build a data pipeline with Apache Airflow or Prefect. ● Version datasets using DVC. **Lab 3: Model Training and Experiment Tracking (6 hours)** ● Train a machine learning model (e.g., Scikit-learn, TensorFlow). ● Track experiments using MLflow. ● Log metrics, parameters, and artifacts. **Lab 4: Containerization with Docker (4 hours)** ● Docker basics: Create and run containers. ● Containerize a trained ML model. ● Push Docker images to a container registry (Docker Hub, AWS ECR).	**30**	CO1, CO2	K2, K3, K4
Module 2:	**Lab 5: CI/CD for ML Pipelines (6 hours)** ● Set up CI/CD pipelines using GitHub Actions or GitLab CI. ● Automate testing and deployment of ML models. ● Integrate with cloud platforms (AWS/GCP/Azure). **Lab 6: Model Deployment and Serving (6 hours)**	**30**	CO1, CO2, CO3 CO4,	K3, K4, K5, K6

	● Deploy models as REST APIs using Flask/FastAPI. ● Serve models using Kubernetes(Minikube or cloud-managed Kubernetes). ● Monitor API performance with Prometheus and Grafana. **Lab 7: Monitoring and Logging (4 hours)** ● Set up logging for ML models using Python's logging module. ● Monitor model performance and data drift using Evidently or WhyLabs. ● Visualize metrics with dashboards (Grafana, TensorBoard). **Lab 8: Ethical AI and Fairness (4 hours)** ● Detect bias in datasets using AI Fairness 360 or Fairlearn. ● Mitigate bias using reweighting or adversarial debiasing. ● Evaluate fairness metrics (demographic parity, equal opportunity). Mini Capstone Project The capstone project integrates concepts from the labs into a comprehensive MLOps workflow. Students work in teams to solve a real-world problem.			
Pedagogy:	Hands-on/ Tutorials/ Presentation			
Texts:	1. **Treveil, M., Omont, N., Stenac, C., Lefevre, K., Phan, D., &Zentici, J.** (2020). *Introducing MLOps: How to Scale Machine Learning in the Enterprise*. O'Reilly Media. 2. **Burkov, A.** (2020). *Machine Learning Engineering*. True Positive Inc.			
References/ Readings:	1. **Hapke, H., & Nelson, C.** (2020). *Building Machine Learning Pipelines: Automating Model Life Cycles with TensorFlow*. O'Reilly Media. 2. **Gift, N., &Deza, A.** (2021). *Practical MLOps: Operationalizing Machine Learning Models*. O'Reilly Media.			
Web Resources:	1. MLOps Community. (n.d.). MLOps. Retrieved May 19, 2025, from https://mlops.community/MLOps 2. AlmaBetter. (n.d.). MLOps tutorials. Retrieved May 19, 2025, from https://www.almabetter.com/bytes/tutorials/mlops			

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Discipline Specific Elective Courses

Title of the Course	Machine Translation
Course Code	CSI-5206
Number of Credits	4T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basics of NLP, Basics of Machine Learning and Deep Learning	
Course Objectives:	To provide students with a thorough understanding of machine translation paradigms, models, and evaluation techniques, enabling them to analyze and implement various MT approaches including rule-based, statistical, example-based, and neural machine translation.	
Course Outcomes:	After the completion of this course, the students will be able to	**Mapped to PSO**
	CO 1. Remember machine translation approaches and architectures.	PSO1, PSO5, PSO6
	CO 2. Understand evaluation methods for MT systems.	PSO1, PSO2, PSO3, PSO4, PSO5
	CO 3. Apply tools to build translation models.	PSO1, PSO2, PSO3, PSO6, PSO8

	CO 4. Create components for MT or preprocessing pipelines.		PSO2, PSO3, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• **Introduction**: History of MT, MT Applications, Data-driven MT, MT Approaches, Language divergence, three major paradigms of MT. • **Word-Based Models**: Translating Words, Lexical Translation Models, Higher IBM Models, Word Alignment. • **Phrase-Based Models**: Standard Model, Phrase Translation Table, Translation Model extensions, Reordering Model extensions, EM Training of Phrase-Based Models.	**15**	CO1 K1, K2	CO1 K1, K2
Module 2:	• **Decoding**: Translation Process, Beam Search, Future Cost Estimation. • **Rule-Based Machine Translation (RBMT)**: Kinds, UNL, Interlingua and Word Knowledge, UNL conversion, Transfer-based MT.	**15**	CO2, CO3, CO4	K1, K2, K3, K6
Module 3:	• **Example-Based Machine Translation (EBMT)**: Essential steps of EBMT, Text similarity computation, Translation memory, Statistical Machine Translation • **MT Evaluation**: Manual Evaluation, Automatic Evaluation, Hypothesis Testing, Task-Oriented Evaluation	**15**	CO2, CO3, CO4	K1, K2, K3, K5, K6
Module 4:	• **Introduction to NMT**: History of NMT, Challenges in NMT • **Neural Language Models**: Feed-Forward Neural Language Models, Word Embedding, RNN, GRU, LSTM • **Neural Translation Models**: Encoder-Decoder Approach, Alignment Model, Beam Search, CNN, CNN with attention	**15**	CO2, CO3, CO4	K1, K2, K3, K4, K5
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	Machine Translation by Pushpak Bhattacharyya, Chapman and Hall/CRC, February 2015			

References/ Readings:	1. Machine Translation on Coursera by Prof. Alexander Waibel and Jan Niehueshttps: //www.coursera.org/learn/machinetranslation 2. An Open Source Neural Machine Translation System https://opennmt.net/ 3. Bhashini Project – https://bhashini.gov.in/bhashadaan/en/likho-india
Web Resources:	1. Bhattacharyya, P. (n.d.). Introduction to machine translation and its evaluation [Video]. YouTube. Retrieved May 19, 2025, from https://www.youtube.com/watch?v=8BTk9ERyEKI 2. Coursera. (n.d.). Machine translation [Online course]. Retrieved May 19, 2025, from https://www.coursera.org/learn/machinetranslation 3. GeeksForGeeks. (n.d.). Machine translation in AI. Retrieved May 19, 2025, from https://www.geeksforgeeks.org/machine-translation-of-languages-in-artificial-intelligence/

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Title of the Course	Robotic motion planning, control and Programming
Course Code	CSI-5207
Number of Credits	4
Theory/Practical	theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5202, CSI-5001			
Course Objectives:	To equip students with foundational knowledge of robotics fundamentals, design, programming, sensors, and hardware integration using ROS, Arduino, and Raspberry Pi.			
Course Outcomes:	At the end of the course, the student will be able to:		**Mapped to PSO**	
	CO 1. Understand robotics design, kinematics, dynamics, and motion control.		PSO1, PSO3,PSO5	
	CO 2. Apply robotic programming and ROS fundamentals.		PSO1, PSO2, PSO 6	
	CO 3. Analyze appropriate sensors and actuators for robotic applications.		PSO 1, PSO 3, PSO 5	
	CO 4. Design robotic systems using ROS integrated with Arduino and Raspberry Pi.		PSO 2, PSO 6, PSO7, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	**Fundamentals** ● Introduction – Components, Degrees of Freedom, Joints, Coordinates, Mechanisms, Controller. **Kinematics** ● Position and Orientation of Objects, Coordinate Transformation, Joint Variables and Position of End ● Effector, Inverse Kinematics Problem, Jacobian Matrix, Statics and Jacobian Matrices. **Dynamics** ● Lagrangian and Newton-Euler Formulations, Derivation of Dynamics Equations Based on Lagrangian ● Formulation, Derivation of Dynamic Equations Based on Newton-Euler, Formulation, Use of Dynamics ● Equations and Computational Load, Identification of Manipulator Dynamics. **Manipulability** ● Manipulability Ellipsoid and Manipulability Measure, Best Configurations of Robotic Mechanisms from ● Manipulability Viewpoint, Various Indices of Manipulability, Dynamic Manipulability.	**15**	CO1	K2, K3, K4, K5
Module 2:	**Position Control** ● Generating a Desired Trajectory, Linear Feedback Control, Two-Stage Control by Linearization and Servo ● Compensation, Design and Evaluation of Servo Compensation, Decoupling Control, Adaptive Control. **Force Control** ● Impedance Control - Passive-Impedance Method, Active-Impedance Method-One- Degree-of- Freedom ● Case, Active-Impedance Method-General Case.	**15**	CO1, CO4	K3, K4, K5

	Hybrid Control ● Hybrid Control - Hybrid Control via Feedback Compensation, Dynamic Hybrid Control.			
Module 3:	**Programming Assignments 1** 1. Understanding programmable robot simulator in Hill, C. (2020). Learning scientific programming with Python. Cambridge University Press. 2. Programming different capabilities control concerns of the robot like moving around free space. 3. Write a program to control inputs from sensors. 4. Write a program to control outputs of the robot. 5. Understanding and using API for robot simulator	**15**	CO2, CO3, CO4	K2, K3, K4
Module 4:	**Programming Assignments 2** 1. Write a program to apply physics rules to robot movements. 2. Write a program to implement collision with obstacles. 3. Implementing a simple model of a robot. Assumptions: Terrain is always flat and even, obstacles are never round, Wheels never slip, Sensors never fails or give false reviews, The wheels always turn when they are told to. • Write a program to program the behavior inside the robot. • Write a program to implement the control aspects of a robot i.e : Apply control signal, message the results, generate new control signals to bring to our goal.	**15**	CO1, CO2, CO4	K2, K3, K4, K5, K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	**Text Book(s)** 1. Tsuneo Yoshikawa, "Foundations of Robotics Analysis and Control", The MIT Press Cambridge,1990. 2. Saeed B Niku, “Introduction to Robotics Analysis, Control, Applications”, 3rd Edition, Wiley, 2020. 3. Lentin Joseph, Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy, 1 st Edition, APress, 2018. 4. Jonathan Cacace; Lentin Joseph, Mastering ROS for Robotics Programming: Design, build, and simulate complex			

	robots using the Robot Operating System, 2nd Edition, Packt Publishing, 2018.
References/ Readings:	1. Robert J. Schilling, "Fundamentals of Robotics, Analysis and Control", Prentice Hall India, 2003. 2. John J. Craig, "Introduction to Robotics, Mechanics and Control", 3rd Edition, Pearson Prentice Hall,2005. 3. Hughes, C. and Hughes, T., Robot programming: a guide to controlling autonomous robots. Que Publishing, 2016 4. Quigley, M., Gerkey, B. and Smart, W.D., Programming Robots with ROS: a practical introduction to the Robot Operating System. " O'Reilly Media, Inc.", 2015 5. Anil Mahtani, Luis Sanchez, Enrique Fernandez, Aaron Martinez, Lentin Joseph. ROS Programming: Building Powerful Robots. Packt Publishing, 2018.
Web Resources:	Toptal. (n.d.). Programming a robot: An introductory tutorial. Retrieved May 19, 2025, from https://www.toptal.com/robotics/programming-a-robot-an-introductory-tutorial

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Title of the Course	Interpretable Machine Learning
Course Code	CSI-5208
Number of Credits	4T
Theory/Practical	theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5002, CSI-5006	
Course Objectives:	This course is aimed at developing foundational knowledge and practical skills in model interpretability, ethical assessment, and explainability in machine learning, with a focus on emerging trends and MLOps integration.	
Course Outcomes:	At the end of the course, the student will be able to:	**Mapped to PSO**
	CO 1. Understand key concepts of interpretation, interpretability, and explainability.	PSO1, PSO2, PSO3
	CO 2. Apply interpretation methods to tabular, image, and text data.	PSO1, PSO2, PSO3
	CO 3. Evaluate bias, fairness, and robustness in machine learning models.	PSO1, PSO2, PSO3
	CO 4. Analyze model interpretability for real-world deployment.	PSO1, PSO2

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Foundations of Interpretability:** ● Interpretation vs. Interpretability vs. Explainability, White-box vs. Black-box, Business relevance, Interpreation, model agnostic interpretation	**15**	CO1	K2, K3
Module 2:	**Interpretation Methods and Challenges** ● Model-agnostic interpretation (global/local), glass-box models (EBM, GAMI-Net), trade-offs	**15**	CO4	K4,K5
Module 3:	**Domain-Specific Interpretability Techniques**: ● CNNs, Transformers, NLP, Time Series, Feature Selection, Visualization techniques	**15**	CO2, CO4	K3, K4,K5
Module 4:	**Ethics, Bias, Robustness, and Future of Interpretability:** ● Bias mitigation, causal inference, fairness constraints, adversarial robustness, future outlook	**15**	,CO3, CO4	k4.K5.K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Christoph Molnar, *Interpretable Machine Learning*, 2nd Edition. 2. Mark Molloy et al., *Machine Learning Interpretability in Action*, Manning Publications			
References/ Readings:	1. Patrick Hall, Navdeep Gill, *Machine Learning Interpretability*, O'Reilly. 2. Been Kim et al., *Interpretability and Explainability in AI Systems*, Springer. 3. Finale Doshi-Velez et al., *Accountability in AI: Interpretable Machine Learning*, MIT Press.			
Web Resources:	1. Ribeiro, M. T. (n.d.). LIME: Local Interpretable Model-agnostic Explanations [GitHub repository]. GitHub. Retrieved May 19, 2025, from https://github.com/marcotcr/lime 2. Lundberg, S. M. (n.d.). SHAP: SHapley Additive exPlanations [GitHub repository]. GitHub. Retrieved May 19, 2025, from https://github.com/shap/shap			

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Title of the Course	Explainable Artificial Intelligence (XAI)
Course Code	CSI-5209
Number of Credits	4T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSI-5000			
Course Objectives:	This course is aimed at learning to apply foundational XAI techniques to interpret model behavior across data types and communicate explainability insights effectively to diverse stakeholders.			
Course Outcomes:	At the end of the course, the student will be able to:		**Mapped to PSO**	
	CO 1. Understand the fundamental concepts, types, and stakeholders of Explainable AI.		PSO1, PSO4	
	CO 2. Apply explainability techniques to various machine learning models and data types.		PSO2, PSO3, PSO6	
	CO 3. Compare explainability methods using appropriate metrics.		PSO8, PSO4	
	CO 4. Evaluate the communication, regulatory, ethical, and usability aspects of XAI.		PSO4, PSO7	
Content:		**No of hours**	**Mapped to CO**	

Module 1:	**Foundations of Explainable AI:** ● Introduction to XAI, importance, stakeholders, types of explanations (premodeling, local/global, post hoc), interpretability, taxonomy	**15**	CO1	K1, K2, K3, K4
Module 2:	**Explainability for Structured and Visual Data:** ● Explainability for tabular and image data using SHAP, PDP, ICE, Grad-CAM, LIME, Guided Backprop, XRAI, etc.	**15**	CO2	K3, K4, K5
Module 3:	**Explainability for Text and Advanced Topics**: ● LIME for text, embeddings, attention, LRP, alternative and multimodal explainability, time series, evaluation methods	**15**	CO2, CO3	K3, K4, K5, K6
Module 4:	**Deployment, Interaction, and Future Directions:** ● Presenting explanations, interacting with stakeholders, pitfalls, regulatory aspects, ML lifecycle, and future of explainability	**15**	CO3, CO4	K4, K5, K6
Pedagogy:	Lectures/ Assignments/ Flipped Classroom			
Texts:	1. Munn, M., & Pitman, D. (2022). *Explainable AI for practitioners: Designing and implementing explainable ML solutions* (Grayscale Indian ed.). O'Reilly Media. 2. Dan Becker, Margaret Mitchell – *Interpretable Machine Learning with Python* (O'Reilly Media, 2023)			
References/ Readings:	1. Sameer Singh et al. – *Explainable AI in Practice* (Springer, 2021) 2. Patrick Hall et al. – *Machine Learning for High-Stakes Decisions* (O'Reilly, 2024) 3. WojciechSamek – *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning* (Springer, 2019)			
Web Resources:	1. IBM. (n.d.). Explainable AI. Retrieved May 19, 2025, from https://www.ibm.com/think/topics/explainable-ai 2. TDAN. (n.d.). Explainable AI: 5 open-source tools you should know. Retrieved May 19, 2025, from https://tdan.com/explainable-ai-5-open-source-tools-you-should-know/31589			

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	AI for Medical Specialization
Course Code	CSI-6000
Number of Credits	3T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Artificial Intelligence, Machine Learning and Programming Skills	
Course Objectives:	To apply AI in medical imaging for 2D and 3D data, enabling multi-class classification, image segmentation, and predicting patients' future health.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply AI and machine learning algorithms to diagnose diseases from medical images.	PSO1, PSO3

	CO 2. Analyze patient health data to develop and evaluate predictive models for survival rate estimation and risk assessment.		PSO1, PSO3, PSO4, PSO7	
	CO 3. Design models for estimating individualized treatment effects using data from randomized clinical trials.		PSO3, PSO4, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**AI for Diagnosis** 1.1 **Introduction - Diagnosis examples** - Model training on chest x-rays - Training, prediction, and loss - Class imbalance - Binary cross entropy loss function - Resampling methods - Multi-task loss - Transfer learning and data augmentation - Model testing 1.2 Evaluation metrics - Accuracy in terms of conditional probability - Sensitivity, specificity, and prevalence - Confusion matrix - ROC curve - Threshold (operating point) - Confidence intervals - Width of confidence intervals and sample size - Using a sample to estimate the population 1.3 Representing MRI data - Image registration - 2D and 3D segmentation - 3D U-Net - Data augmentation for segmentation - Loss function for image segmentation – Softdice loss - External validation - Retrospective vs. prospective data - Working with cleaned vs. raw data - Measuring patient outcomes - Algorithmic bias - Model influence on medical decision-making	**15**	CO1, CO2	K1, K2 , K3
Module 2:	**AI for Prognosis** 2.1 Examples of prognostic tasks - Patient profile to risk score - Risk score for atrial fibrillation - Liver disease mortality - Calculate 10-year risk of heart disease - Risk score computation - Evaluating prognostic models - Concordant pairs - Risk ties - Permissible pairs - C-index interpretation	**15**	CO1, CO2	K1, K2, K5

	2.2 Decision trees for prognosis - Predicting mortality risk - Dividing the input space - Non-linear associations - Class boundaries of a decision tree - Random forest - Ensemble methods - Survival data - Problems with dropping incomplete rows - Dropping incomplete case changes the distribution - Imputation - Mean imputation - Regression imputation 2.3 Survival function - Censoring - Collecting time data - Heart attack data - Estimating the survival function - Using censored data - Chain rule of conditional probability - Derivation - Calculating probabilities from the data - Comparing estimates - Kaplan Meier Estimate Hazard functions - Survival to hazard - Cumulative hazard - Individualized predictions - Individual vs. baseline hazard - Smoker vs. non-smoker - Effect of age on hazard - Factor risk increase or decrease - Survival trees - Nelson Aelen estimator - Mortality score - Evaluating survival models - Permissible pair examples - Harrell's concordance index			
Module 3:	**AI for medical treatment** 3.1 Treatment effect estimation - Randomized control trials - Average risk reduction - Individualized treatment effect - T-Learner and S-Learner - C-for-benefit 3.2 Information extraction from medical reports - Rules-based label extraction - Text matching - Negation detection - Dependency parsing - Question-Answering with BERT 3.3 Machine Learning Interpretation - Interpret CNN models with GradCAM - Aggregate and Individual feature importance - Permutation Importance - Shapley Values - Interpret random forest models	**15**	CO1 CO3 CO4	K1 K2 K3 K5
Pedagogy:	Lectures/tutorials/ assignments/ PPT presentations/ case studies/ class discussions.			
Texts:	1. Villani, C., Nordlinger, B., & Rus, D. (2021). Healthcare and artificial intelligence. Springer.			

	2. Chang, A. C. (2020). Intelligence-based medicine: Artificial intelligence and human cognition in clinical medicine and healthcare. Academic Press. 3. Mahajan, P. S. (2022). Artificial intelligence in healthcare. Academic Press. 4. Emereo. (2020). Artificial intelligence in healthcare (2nd ed.). Emereo Publishing.
References/ Readings:	1. Elsevier. (2021). Artificial intelligence in healthcare. Elsevier. 2. Springer Nature. (2021). Healthcare and artificial intelligence. Springer Nature.
Webpages:	1. MONAI, P. (n.d.). Monai—Medical open network for ai. Retrieved October 13, 2025, from https://monai.io/ 2. Stave, C. (n.d.). AI tools and resources for biomedical research: AI tools in action. Stanford University Libraries. https://laneguides.stanford.edu/AI/tools 3. https://www.coursera.org/specializations/ai-for-medicine?msockid=2b6cf870f41762531c1dee59f5e563c9

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Title of the Course	AI for Agriculture
Course Code	CSI-6001
Number of Credits	3T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Artificial Intelligence, Machine Learning and Programming Skills	
Course Objectives:	To equip students to build and evaluate apply AI technologies in agriculture for improving crops, livestock, and food systems while addressing practical challenges.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the fundamental concepts, benefits, and challenges of artificial intelligence in agriculture, including crop production, protected cultivation, and soil and water management.	PSO1, PSO3

	CO 2. Apply AI technologies to improve livestock management, animal productivity, welfare, and breeding, and analyze challenges in implementing AI solutions on farms.		PSO1, PSO3, PSO4, PSO7	
	CO 3. Evaluate AI applications in horticulture supply chains and agri-food systems, and design solutions while considering technical, data, and policy challenges.		PSO3, PSO4, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Introduction: AI in agriculture, examples of AI in agriculture, benefits of AI in agriculture, challenges in adopting AI in agriculture, smart agriculture, challenges in data collection, activities in the agriculture value chain, AI for smart agriculture 1.2 AI and Protected Cultivation: Plant phenotypes of horticultural crops, use of crop sensors, autonomous growing and protection systems, digital twins, decision support for market-oriented production, challenges in protected cultivation 1.3 AI in Field Crop Production: Vehicle automation, smart field operations, expert systems, decision support applications, intelligent crop planning, challenges in field crop production 1.4 AI in Soil and Water Management: AI in irrigation management, water budgeting at local or regional level, management of aquifers and river catchments, challenges in soil and water applications	**15**	CO1	K1, K2
Module 2:	**2.1 AI in animal production**– AI technology impacting animal production--hardware of AI processing on liver stock farms -AI for improving animal productivity , animal welfare, animal health , and breeding – challenges for AI solutions on live stock farms.	**15**	CO2	K1, K2, K5

Module 3:	**3.1 AI in supply chain management of horticulture products** -AI in online sorting and grading of fruits and vegetables -AI for linking post harvest quality to pre harvest conditions -digital twins of horticulture supply chain – challenges in supply chain management of horticulture products 3.2Barriers and outlook for AI in Agri food – technical developments to reduce barriers for AI in agrifood -challenges for models, data and analytics -policy options for use and simulation of AI in agriculture food sector – issues in applications of AI agriculture food sectors and actions and regulations	**15**	CO3	K2, K3, K4, K5
Pedagogy:	Lectures/tutorials/ assignments/ PPT presentations/ case studies/ class discussions.			
Texts:	1. Marwala, T., & Miao, M. (2020). Artificial intelligence in agriculture. CRC Press. 2. Leventakis, G. (2019). AI in agriculture: A practical introduction. Apress. 3. Halford, N. G. (2018). Digital agriculture: The role of artificial intelligence and biotechnology in food security. Burleigh Dodds Science Publishing.			
References/ Readings:	1. Zhang, Q. (2019). *Precision agriculture technology for crop farming.* Academic Press. 2. Camporeale, E., & Wing, S. (2018). *Machine learning techniques for space weather.* Elsevier.			
Webpages:	1. Johnston, B. (2018, April 24). Awesome agriculture: A curated list of open-source technology for agriculture, farming, and gardening. GitHub. https://github.com/brycejohnston/awesome-agriculture 2. Project AgML. (2025, March 26). AgML: Centralized framework for agricultural machine learning. GitHub. https://github.com/Project-AgML/AgML			

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Title of the Course	Algorithmic Foundation for Big Data Biology
Course Code	CSI-6002
Number of Credits	3T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Artificial Intelligence, Machine Learning and Programming Skills	
Course Objectives:	To equip students with the knowledge and skills to analyze biological data, implement algorithms for sequence analysis, and apply computational methods to solve problems in genomics, phylogenetics, and advanced bioinformatics.	
Course Outcomes:	CO 1. Explain the fundamental concepts of biological data, sequencing technologies, and algorithms for exact and approximate sequence analysis.	PSO1, PSO3
	CO 2. Apply genome-scale data structures, alignment, and assembly techniques to analyze large-scale genomic data and discover biological patterns.	PSO1, PSO3, PSO4, PSO7

	CO 3. Evaluate and implement computational approaches in phylogenetics, transcriptomics, and other advanced genomics applications using algorithmic and machine learning methods.		PSO3, PSO4, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Biological Data and Sequence Analysis Algorithms** 1.1 Introduction: Basics of biological data, high-throughput DNA/RNA sequencing, biotechnological breakthroughs 1.2 Data structures and algorithms warm-up 1.3 Exact string pattern matching: Z algorithm, Knuth-Morris-Pratt, Boyer-Moore 1.4 Approximate string pattern matching: Hamming distance, edit distance, dynamic programming, pairwise and multiple sequence alignment	**15**	CO1	K1, K2, K3
Module 2:	**Genome-scale Data Structures and Assembly** 2.1 Genome-scale index structures: suffix tries, suffix trees, Burrows-Wheeler Transform, FM-Index 2.2 Alignment-free sequence comparison: co-linear chaining problem, whole-genome comparison 2.3 Genome assembly: de Bruijn graphs, overlap graphs, haplotype assembly and phasing 2.4 Pattern discovery: Hidden Markov models, gene finding	**15**	CO2	K1, K2, K5
Module 3:	**Phylogenetics and Advanced Genomics** 3.1 Phylogenetics: algorithms for evolutionary tree reconstruction, distance-based phylogeny, neighbor-joining algorithm 3.2 Trending topics: cancer genomics, deep learning in genomics, transcriptomics, single-cell omics, population genomics	**15**	CO3	K2, K3, K4
Pedagogy:	Lectures/tutorials/ assignments/ PPT presentations/ case studies/ class discussions.			

Texts:	1. Jones, N. C., & Pevzner, P. (2004). *An introduction to bioinformatics algorithms*. MIT Press. 2. Mäkinen, V., Navarro, G., Sirén, J., & Välimäki, N. (2015). *Genome-scale algorithm design*. Cambridge University Press.
References/ Readings:	1. Gusfield, D. (1997). Algorithms on strings, trees, and sequences: Computer science and computational biology. ACM SIGACT News, 28(4), 41–60. 2. Durbin, R., Eddy, S. R., Krogh, A., &Mitchison, G. (1998). Biological sequence analysis: Probabilistic models of proteins and nucleic acids. Cambridge University Press. 3. Aluru, S. (Ed.). (2005). Handbook of computational molecular biology. CRC Press.
Webpages:	1. Johnston, B. (2018, April 24). Awesome agriculture: A curated list of open-source technology for agriculture, farming, and gardening. GitHub. https://github.com/brycejohnston/awesome-agriculture 2. Project AgML. (2025, March 26). AgML: Centralized framework for agricultural machine learning. GitHub. https://github.com/Project-AgML/AgML

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Title of the Course	AI for Life science lab
Course Code	CSI-6003
Number of Credits	3
Theory/Practical	Practical
Level	500
Effective from AY	2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	yes

Pre-requisites for the Course:	Fundamentals of AI, Programming and basic knowledge of life sciences	
Course Objectives:	Equip students with the knowledge and skills to apply AI, machine learning, and deep learning techniques to solve real-world problems in medical science, agriculture, and biology, including data analysis, prediction, automation, and model interpretation.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Analyze and interpret medical, agricultural, and biological datasets using AI, machine learning, and deep learning techniques to derive actionable insights.	PSO1, PSO2, PSO3, PSO4, PSO5
	CO 2. Develop and implement predictive and classification models, including CNNs, tree-based models, and genome analysis algorithms, for solving domain-specific problems.	PSO1, PSO2, PSO3, PSO5, PSO6
	CO 3. Evaluate the performance of AI models and apply model interpretation and automation techniques to optimize decision-making in medicine, agriculture, and biology.	PSO1, PSO2, PSO3, PSO5, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**AI for medical science** Suggested Lab Assignments 1. Collect data and implement ML supervised or unsupervised algorithms to implement the following 2. Diagnose diseases from x-rays and 3D MRI brain images using supervised machine learning algorithms. 3. Predict patient survival rates more accurately using tree-based models. 4. Estimate treatment effects on patients using data from randomized trials. 5. Automate the task of labeling medical datasets using natural language processing. 6. create convolutional neural network image classification and segmentation models to make diagnoses of lung and brain disorders. 7. build risk models and survival estimators for heart disease using statistical methods and a random forest predictor to determine patient prognosis. 8. build a treatment effect predictor, apply model interpretation techniques and use natural language processing to extract information from radiology reports. 9. use decision trees to model non-linear relationships, which are commonly observed in medical data, and apply them to predicting mortality rates more accurately. 10. apply machine learning interpretation methods to explain the decision-making of complex machine learning models. 11. use natural language entity extraction and question-answering methods to automate the task of labeling medical datasets.	**30**	CO1	K3, K4, K5, K6
Module 2:	**AI for agriculture** 1. classifying the different species of plants using ML and DL algorithms like CNN , Naïve bayes, and KNN 2. Plant leaf classification -classifying plant leaf using ML and DL algorithms like CNN, Naïve bayes and KNN.	**30**	CO2	K3, K6

	3. Health level predication of crop-predicting health and growth of crop based on time duration using various parametres like humidity , temperature etc – at least of 10 species 4. Controlling the use of pesticides in agriculture-predicting the quality of pesticides required for particular crop based on various parameters which effect the need of pesticides 5. Live monitoring of the crop-live monitoring of the crop including cation generation or prediction -of what is happening in the farm where the crops are and taking the live images from camera 6. Flower classification -classifying the different flowers using ML and DL algorithms			
Module 3:	**AI for biology** Suggested Lab Assignments 1. String Pattern Matching: 2. Implement and compare Z, KMP, and Boyer–Moore algorithms for DNA motif search in genomic sequences. 3. Genome Indexing: Construct suffix arrays, suffix trees, and FM-index using Burrows–Wheeler Transform for efficient genome querying. 4. Sequence Alignment: Apply dynamic programming for pairwise and multiple sequence alignment; explore alignment-free genome comparison. 5. Genome Assembly & Gene Finding: Simulate genome assembly using de Bruijn graphs and implement Hidden Markov Models (HMMs) for gene prediction. 6. Phylogenetics & Deep Genomics: Build phylogenetic trees using neighbor-joining and explore deep learning or ML models in cancer or population genomics.	**30**	CO3	K3, K4, K6
Pedagogy:	Hands on / Lab work/ presentation			
Texts:	1. Aluru, S. (Ed.). (2005). *Handbook of computational molecular biology*. CRC Press. 2. Chang, A. C. (2020). *Intelligence-based medicine: Artificial intelligence and human cognition in clinical medicine and healthcare*. Academic Press. 3. Durbin, R., Eddy, S. R., Krogh, A., &Mitchison, G. (1998). *Biological sequence analysis: Probabilistic models of*			

	proteins and nucleic acids. Cambridge University Press. 4. Emereo. (2020). *Artificial intelligence in healthcare* (2nd ed.). Emereo Publishing. 5. Jones, N. C., & Pevzner, P. A. (2004). *An introduction to bioinformatics algorithms*. MIT Press. 6. Mahajan, P. S. (2022). *Artificial intelligence in healthcare*. Academic Press. 7. Marwala, T., & Miao, M. (2020). *Artificial intelligence in agriculture*. CRC Press. 8. Mäkinen, V., Navarro, G., Sirén, J., & Välimäki, N. (2015). *Genome-scale algorithm design*. Cambridge University Press. 9. Villani, C., Nordlinger, B., & Rus, D. (2021). *Healthcare and artificial intelligence*. Springer.
References/ Readings:	1. Elsevier. (2021). Artificial intelligence in healthcare. Elsevier. 2. Springer Nature. (2021). Healthcare and artificial intelligence. Springer Nature.Gusfield, Dan. 3. "Algorithms on strings, trees, and sequences: Computer science and computational biology." AcmSigact News 28.4 (1997): 41-60. 4. AI in Agriculture: A Practical Introduction" by George Leventakis (Apress, 2019) 5. Digital Agriculture: The Role of Artificial Intelligence and Biotechnology in Food Security" by Nigel G. Halford (Burleigh Dodds Science Publishing, 2018) 6. Precision Agriculture Technology for Crop Farming" by Qin Zhang (Academic Press, 2019) 7. Machine Learning Techniques for Space Weather by Enrico Camporeale and Simon Wing (Elsevier, 2018)
Web Resources:	1. MONAI, Project. (n.d.). *MONAI – Medical Open Network for AI.* Retrieved October 15, 2025, fromhttps://monai.io/ 2. Coursera. (n.d.). *AI for medicine.* Retrieved October 15, 2025, fromhttps://www.coursera.org/learn/ai-for-medicine 3. Coursera. (n.d.). *Machine learning for soil and crop management.* Retrieved October 15, 2025, fromhttps://www.coursera.org/learn/machine-learning-for-soil-and-crop-management 4. Coursera. (n.d.). *Algorithms in computational biology and sequence analysis.* Retrieved October 15, 2025, fromhttps://www.coursera.org/learn/algorithms-in-computational-biology-and-sequence-analysis

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Title of the Course	Agentic AI
Course Code	CSI-6004
Number of Credits	3T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Fundamentals of AI and Deep Learning	
Course Objectives:	To equip students with the knowledge and practical skills to design, build, and deploy intelligent AI systems using large language models (LLMs), retrieval-augmented generation (RAG), function calling, and agentic architectures for real-world, context-aware, and multi-task applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the foundational concepts of large language models, tokenization, embeddings, and evaluation metrics.	PSO1, PSO4
	CO 2. Apply conversational AI systems and RAG-enabled applications using LangChain, vector databases, and external APIs.	PSO1, PSO2, PSO3, PSO5, PSO6, PSO7
	CO 3. Analyse multi-step workflows and function-calling pipelines to automate tasks using LLMs.	PSO1, PSO2, PSO3, PSO5, PSO6, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Foundations of Large Language Models and Conversational AI** ● Introduction to LLMs: Architecture, training data, pretraining vs. fine-tuning, and transfer learning. ● Key Models: GPT-3, GPT-4, BERT, and notable alternatives. ● Tokenization and Embeddings: Text preprocessing and representation techniques. ● Evaluation Metrics: Accuracy, perplexity, F1 score, and performance interpretation. ● Conversational AI Basics: Dialogue flow, context retention, intent recognition, and error handling	**15**	CO1, CO2	K2, K3
Module 2	**Retrieval-Augmented Generation (RAG) and Contextual Systems** ● RAG Fundamentals: Blending retrieval and generation for improved answers. ● Document Indexing and Search: Vector databases (Pinecone, MongoDB Atlas), embeddings, and retrieval systems. ● System Integration: Designing applications that leverage RAG for real-world tasks. **Workflow Automation with Chains and Function Calling** ● Langchain Chains: Sequential vs. parallel workflows and pipeline construction. ● Multi-Step Task Management: Context handling, multi-tasking vs. single-tasking. ● Function Calling in LLMs: Triggering APIs, enhancing task-oriented responses, debugging, and validation.	**15**	CO2, CO3	K3, K4, K5, K6
Module 3	**Agentic AI and Multi-Agent Collaboration** ● Agentic AI Concepts: Definitions, agent autonomy, architecture, and control. ● LangGraph Overview: Constructing agent workflows. ● Multi-Agent Frameworks: CrewAI and AutoGen for coordinated and adaptive task handling. ● Real-World Agent Systems: Use cases for collaborative agents in service scenarios. ● agentic system combining RAG, function calls, and multi-agent workflows.	**15**	CO3, CO4	K4, K5, K6

Pedagogy:	Lectures/ Assignments/ Programming assignments/ mini project work
Texts:	1. Bornet, P., Wirtz, J., Davenport, T. H., De Cremer, D., & Others. (2025). *Agentic artificial intelligence: Harnessing AI agents to reinvent business, work and life*. 2. Winston, T. (2025). *Mastering agentic AI: A practical guide to building self-directed AI systems that think, learn, and act independently*. 3. Kimothi, A. (2025). *Simple guide to retrieval of augmented generation*. Manning Publications.
References/ Readings:	1. Alammar, J., & Grootendorst, M. (2024). *Hands-on large language models: Language understanding and generation (Full colour edition)* 2. Auffarth, B. (2023). *Generative AI with LangChain: Build large language model (LLM) apps with Python, ChatGPT, and other LLMs*. Packt Publishing.
Web Resources:	1. "The Agentic AI Handbook: A Beginner's Guide to Autonomous Intelligent Agents." *freeCodeCamp.Org*, 28 May 2025, https://www.freecodecamp.org/news/the-agentic-ai-handbook/. 2. "AI Agents for Beginners." *YouTube*, http://www.youtube.com/playlist?list=PLlrxD0HtieHgKcRjd5-8DT9TbwdlDO-OC. Accessed 10 Oct. 2025.

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Title of the Course	AI Engineering
Course Code	CSI-6005
Number of Credits	3T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Machine Learning, Neural Networks, Probabilistic concepts	
Course Objectives:	To equip students with the skills and knowledge to build practical applications using foundation models for solving real-world problems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply advanced techniques to design, implement, and optimize AI applications built on foundation models.	PSO1-PSO8
	CO 2. Construct effective prompts, retrieval-augmented generation (RAG) pipelines, and intelligent agent systems for task-specific applications.	PSO1-PSO3, PSO5, PSO7, PSO8
	CO 3. Analyze and preprocess data for model training and inference, including tasks such as data curation, augmentation, and optimization.	PSO1, PSO3, PSO5, PSO7, PSO8

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Introduction to Building AI applications with foundation models:** The rise of AI Engineering-foundation Model use cases –planning use cases – planning AI applications – The AI Engineering stack. Understanding foundation models – Training data-Modelling – Post training – sampling. Evaluation Methodology – challenges of Evaluating Foundation Models-Understanding Language models metrics – Exact Evaluation- AI As a Judge –Ranking Models with comparative Evaluation. Evaluating AI systems –Evaluation criteria-model selection-Design your evaluation pipeline	**15**	CO1, CO4	K3, K5
Module 2	**Prompt Engineering** Introduction to Prompting-Prompt Engineering best practices –Defensive Prompt Engineering. RAG and Agents RAG –RAG architecture-Agents. Fine tuningFinetuning overview – when to finetune –memory bottlenecks-Fine tuning techniques	**15**	CO1, CO2	K3-K6
Module 3	**Dataset Engineering** Data curation Data Augmentation and synthesis Data processing Inference optimization understanding inference optimization inference optimization. AI Engineering Architecture and user feedback	**15**	CO3, CO4	K3-K6
Pedagogy:	Lecture / Hands On sessions / Programming Assignments / Project Based assignments			
Texts:	1. Huyen, C. (2025). AI Engineering: Building Applications with Foundation Models. O'Reilly. 2. Morrow, J. (2024). Be data literate: The data literacy skills everyone needs to succeed. Kogan Page Publishers.			
References/ Readings:	1. Huyen, C. (2024). AI Engineering: Building Applications with Foundation Models. O'Reilly Media, Incorporated. 2. Morrow, J. (2024). Be data literate: The data literacy skills everyone needs to succeed. Kogan Page Publishers.			
Web Resources	1. Singh, Ashish Pratap. *Ashishps1/Learn-Ai-Engineering*. 11 Apr. 2025. 10 Oct. 2025. *GitHub*, https://github.com/ashishps1/learn-ai-engineering. 2. Huyen, Chip. *Chiphuyen/Aie-Book*. 3 Dec. 2024, Jupyter Notebook. 10 Oct. 2025. *GitHub*, https://github.com/chiphuyen/aie-book.			

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Title of the Course	LLM Engineering
Course Code	CSI-6006
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Machine Learning,Deep Learning and NLP Fundamentals	
Course Objectives:	This course aims to develop a strong understanding of large language models (LLMs) and their practical applications, enabling learners to design, implement, fine-tune, and evaluate LLM-based systems while applying ethical and responsible AI practices in real-world scenarios.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the internal architecture, tokenization, embeddings, and generation mechanisms of modern large language models.	PSO1, PSO3, PSO4, PSO8
	CO 2. Use and fine-tune pretrained models to perform practical tasks like classification, clustering, text generation, and retrieval.	PSO1, PSO2, PSO3, PSO5, PSO6, PSO7
	CO 3. Construct prompt engineering pipelines, RAG systems, and multi-step chains that integrate semantic search with generation.	PSO1, PSO2, PSO3, PSO5, PSO6, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Introduction to LLMs :** Language AI History of language AI -moving definition of LLM -training paradigm of LLM-LLM applications- responsible LLM development and usage Tokens and Embeddings: LLM Tokenization -Token Embeddings-word embedding -Text embedding Transformer Architecture: An overview of Transformer Models-the input and output of a trained transformer LLM-the components of the forward pass- sampling/decoding-parallel token processing and context size-speeding up generation by caching keys and values	**15**	CO1, CO2	K2, K4
Module 2	**Using Pretrained Language Models**: Text Classification -Text classification with representation models, model selection - classification that leverage embeddings, text classification with generative models, Text clustering and Topic Modelling - A common pipeline for text clustering, Embedding documents-reducing dimensionality of embeddings - cluster the reduced embeddings, inspecting clusters From text clustering to topic modelling -***BERTopic***: A modular topic modeling Framework - adding a special Lego Block -Text generation Lego block Prompt Engineering Using text generation model-	**15**	CO1, CO2, CO4	K3, K5

	introduction to Prompt Engineering -advanced Prompt Engineering-Reasoning with Generative Models-output verification Advanced Text Generation techniques and tools -Model I/O-chains-Memory - Agents Semantic search and RAG -Semantic search with language Models -Dense retrieval Reranking - retrieval Evaluation metrics - Retrieval Augmented Generation -from search to RAG-Advanced RAG techniques - RAG Evaluation Multimodal Large language models -transformer for vision-multimodel Embedding models - CLIP-Open CLIP-Making Text generation model multimodal - BLIP 2: bridging the modality gap -preprocessing multimodal inputs			
Module 3	**Training and Fine-tuning Language models** Generating Text Embedding Models -Embedding models-contrastive Learning -SBERT-Fine tuning an Embedding Model -unsupervised Learning Fine-Turing representation models for classification -supervised classification -few shot classification	**15**	CO2, CO3, CO4	K4,K5,K6

	-continued pretraining with masked language modelling -Named Entity recognition Fine tuning generation models – three LLM training step – pretraining , supervised fine turning - preference tuning -supervised fine tuning-full fine tuning – parameter efficient fine-tuning -instruction tuning with QLoRA -Evaluating Generative models - preference fin tuning /alignment / RLHF-Automated Preference evaluation using reward models -Preference tuning with DPO			
Pedagogy:	Teaching Theory/lab /Guided Experiments			
Texts:	1. Alammar, J. (2023). *Hands-on large language models*. O'Reilly Media.First Edition 2. Rothman, D. (2021). *Transformers for natural language processing*. Packt Publishing.			
References/ Readings:	Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, Ł., &Polosukhin, I. (2017). *Attention is all you need*. *Advances in Neural Information Processing Systems, 30,* 5998–6008.			
Web Resources:	1. KDnuggets. (n.d.). The ultimate roadmap to becoming an LLM engineer. https://www.kdnuggets.com/the-ultimate-roadmap-to-becoming-an-llm-engineer 2. Indian Institute of Technology Madras. (n.d.). Introduction to large language models. https://cse.iitm.ac.in/~miteshk/llm-course.html			

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Title of the Course	Advanced AI core lab
Course Code	CSI-6007
Number of Credits	3
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Fundamentals of AI, Machine learning and Deep Learning	
Course Objectives:	The course is aimed at 1. Providing hands-on experience in designing and developing intelligent systems using Large Language Models (LLMs), incorporating techniques such as tokenization, embeddings, retrieval-augmented generation (RAG), and function calling for context-aware applications. 2. Enabling learners to build and experiment with agentic AI systems, including autonomous and multi-agent architectures, demonstrating reasoning, planning, collaboration, and adaptability in dynamic environments. 3. Familiarizing students with AI engineering practices for deploying, optimizing, and managing foundation model–based applications, while emphasizing ethical, explainable, and responsible AI in real-world scenarios.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Develop and deploy agentic AI systems, including autonomous and multi-agent architectures, capable of planning, reasoning, collaboration, and decision-making across complex, real-world tasks.	PSO1, PSO2, PSO3, PSO5,PSO6

	CO 2. Engineer and optimize foundation model–driven AI workflows through scalable deployment, monitoring, and evaluation, ensuring ethical, interpretable, and responsible AI practices in system lifecycle management.		PSO1, PSO2, PSO4, PSO6	
	CO 3. Design and implement Large Language Model (LLM) pipelines using tokenization, embeddings, retrieval-augmented generation (RAG), and function calling for building intelligent, context-aware applications		PSO1, PSO2, PSO3, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Agentic AI lab Suggested lab Assignments 1. **Intelligent Task Assistant** -Implement a single-agent assistant capable of using tools (e.g., weather lookup, calculator) via OpenAI function calling. 2. **Retrieval-Augmented Question Answering System** -Build a RAG chatbot for domain-specific Q&A using LangChain, embeddings, and vector stores. 3. **Domain Knowledge Tutor-** Develop a contextual conversational tutor with memory and prompt templates. 4. **Collaborative Report Generation System:** Multi-agent writing and reviewing pipeline (Researcher, Writer, Reviewer agents). 5. **Startup Simulation Multi-Agent Decision Making -**Agents (CEO, Finance, Tech, Marketing) coordinate to design a business proposal for an AI product**.** 6. **Scientific Paper Summarization Workflow** Visualize multi-agent flow for paper summarization and critical review using LangGraph. 7. **Smart News Monitoring System-** Automate fetching, summarizing, and reporting of daily domain news via CrewAI orchestration 8. **Autonomous Research Workflow-** Multi-agent workflow for research topic selection → data gathering → report writing → review. 9. **AI Policy Advisor System** -Build an advisory system that drafts, evaluates, and refines AI policy documents using external APIs 10. End-to-End Agentic System Integration Project- Combine multiple frameworks to	**30**	CO1	K5, k6

	build a full AI pipeline — data access, reasoning, decision-making, and reporting.			
Module 2	AI Engineering suggested lab assignments 1. Promp Engineering :Design and evaluate zero-shot, few-shot, and chain-of-thought prompts to analyze LLM output quality and sensitivity. 2. Data Engineering and synthesis :Perform data cleaning, augmentation, and synthetic data generation to enhance dataset quality for model fine-tuning. 3. Evaluation Framework for LLM :Develop an automated evaluation pipeline using metrics (ROUGE, BLEU, embeddings) and AI-as-a-judge methods. 4. RAG :Implement a retrieval + generation pipeline using document embeddings to improve factual accuracy of responses. 5. Parametre_efficent finetuning :Fine-tune small LLMs using LoRA/adapters on domain-specific data and compare with full fine-tuning. 6. Agent :Create an autonomous agent that plans and executes multi-step tasks using APIs and tool invocation. 7. Multi_agent collaboration :Simulate specialized agents (e.g., searcher, summarizer, visualizer) coordinating to solve complex problems. 8. inference optimization :Profile model inference and apply optimizations such as quantization, batching, and caching for latency reduction. 9. Feedback loop :Collect user feedback and integrate it for iterative prompt refinement or model improvement. 10. Monitoring and deployment :Deploy an AI model as a service with logging and monitoring for latency, drift, and performance tracking.	**30**	CO2	K3, k5
Module 3	**LLM Engineering** Suggested Lab assignments 1. Setup Anaconda, JupyterLab, and OpenAI API for interactive coding. 2. Web scraping with BeautifulSoup to extract content. 3. Text summarization using GPT-4 and BeautifulSoup. 4. Creative LLM applications: personalized tutor, leadership prompts.	**30**	CO3	K4, k6

	5. AI UIs with Gradio for GPT, Claude, Gemini. 6. Multi-model chat interfaces streaming GPT & Claude responses. 7. AI chatbots for customer support with conversation history. 8. AI airline assistant integrating external tools with GPT-4 Mini. 9. Personal AI knowledge worker using RAG, vectorization, and local models. 10. Mini Project: Agentic & Generative AI System integrating RAG, fine-tuned models, and seven-agent UI.			
Pedagogy:	Lab Assignments/Hands on/Mini project			
Texts:	1. Bornet, P., Wirtz, J., Davenport, T. H., De Cremer, D., & Others. (2025). Agentic artificial intelligence: Harnessing AI agents to reinvent business, work and life. 2. Winston, T. (2025). Mastering agentic AI: A practical guide to building self-directed AI systems that think, learn, and act independently. 3. Kimothi, A. (2025). Simple guide to retrieval of augmented generation. Manning Publications. 4. Huyen, C. (2025). AI Engineering: Building Applications with Foundation Models. O'Reilly. 5. Morrow, J. (2024). Be data literate: The data literacy skills everyone needs to succeed. Kogan Page Publishers. 6. Alammar, J. (2023). Hands-on large language models. O'Reilly Media.First Edition 7. Rothman, D. (2021). Transformers for natural language processing. Packt Publishing.			
References/ Readings:	1. Alammar, J., & Grootendorst, M. (2024). Hands-on large language models: Language understanding and generation (Full colour edition) 2. Auffarth, B. (2023). Generative AI with LangChain: Build large language model (LLM) apps with Python, ChatGPT, and other LLMs. Packt Publishing. 3. Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, Ł., &Polosukhin, I. (2017). Attention is all you need. Advances in Neural Information Processing Systems, 30, 5998–6008.			
Web Resources:	1. "The Agentic AI Handbook: A Beginner's Guide to Autonomous Intelligent Agents." freeCodeCamp.Org, 28 May 2025, https://www.freecodecamp.org/news/the-agentic-ai-handbook/. 2. "AI Agents for Beginners." YouTube, http://www.youtube.com/playlist?list=PLlrxD0HtieHgKcRjd5-8DT9TbwdlDO-OC. Accessed 10 Oct. 2025. 3. Singh, Ashish Pratap. Ashishps1/Learn-Ai-Engineering. 11 Apr. 2025. 10 Oct. 2025. GitHub, https://github.com/ashishps1/learn-ai-engineering.			

	4. Huyen, Chip. Chiphuyen/Aie-Book. 3 Dec. 2024, Jupyter Notebook. 10 Oct. 2025. GitHub, https://github.com/chiphuyen/aie-boo 5. KDnuggets. (n.d.). The ultimate roadmap to becoming an LLM engineer. https://www.kdnuggets.com/the-ultimate-roadmap-to-becoming-an-llm-engineer 6. Indian Institute of Technology Madras. (n.d.). Introduction to large language models. https://cse.iitm.ac.in/~miteshk/llm-course.htm

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Title of the Course	Introduction to Quantum computing
Course Code	CSI-6008
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Linear algebra	
Course Objectives:	This course provides Introduction to Quantum Computation, starting with basic concepts such as superposition and entanglement, to discussing the quantum circuit model of computation and basic Quantum algorithms that demonstrate the power of computing with quantum bits	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the fundamentals of quantum computing, qubits, quantum gates, and quantum circuits, and explain IBM Quantum's tools and perspectives.	PSO1, PSO3
	CO 2. Apply Qiskit and IBM Quantum Composer to design, simulate, and visualize quantum circuits and perform basic quantum experiments.	PSO1, PSO2, PSO6
	CO 3. Analyze and implement key quantum algorithms, including Deutsch-Jozsa and Grover's algorithms, and evaluate their computational advantages over classical algorithms.	PSO1, PSO2, PSO5

	CO 4. Understand and apply advanced quantum computing concepts such as quantum error correction, NISQ-era algorithms (VQE, QAOA), and explore real-world industrial applications.		PSO1, PSO2, PSO5, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Quantum Computing and IBM Quantum Perspective Introduction to quantum computing: motivation, history, and roadmap Quantum computing applications: cryptography, optimization, simulation, machine learning IBM Quantum mission in India – invited talk / industry perspective Basics of quantum mechanics for computing: qubits, superposition, entanglement, measurement Quantum gates and circuits: Pauli gates, Hadamard, CNOT, phase gates Introduction to Qiskit and IBM Quantum Composer interface	**15**	CO1	K2
Module 2	Quantum Programming and Hands-on with Qiskit Setting up and navigating IBM Quantum Lab Creating and simulating simple quantum circuits Quantum state visualization: Bloch sphere, probability amplitudes Measurement and state collapse in practice basic quantum gates, circuits, and experiments Introduction to quantum noise and decoherence	**15**	CO2	K3
Module 3	Quantum Algorithms Quantum Oracles and Deutsch-Jozsa Algorithm: concept, implementation, and analysis Grover's Search Algorithm: theory, circuit design, and hands-on simulation Quantum Fourier Transform and applications (optional expansion) Introduction to algorithmic complexity and speedup in quantum algorithms	**15**	CO3	K4, K5

Module 4	Advanced Quantum Computing Concepts and Applications Quantum Error Correction: basics, bit-flip, phase-flip, Shor code NISQ (Noisy Intermediate-Scale Quantum) era algorithms Variational Quantum Eigensolver (VQE) and Quantum Approximate Optimization Algorithm (QAOA) Industrial applications of quantum computing in chemistry, finance, and optimization Future directions: scalable quantum computers, quantum supremacy, and hybrid quantum-classical systems	**15**	CO4	K3, K5
Pedagogy:	Lectures/ Presentation/Quiz/Assignments			
Texts:	Qiskit Textbook: https://qiskit.org/textbook/preface.html			
References/ Readings:	1. Quantum Computation and Quantum Information, Textbook by M. A. Nielsen and I. Chuang, Cambridge University Press (2010).			
Web Resources:	1. YouTube. (n.d.). *Quantum learning series* [Video playlist]. Retrieved October 15, 2025, fromhttps://www.youtube.com/playlist?list=PLOFEBzvs-Vvp2xg9-POLJhQwtVktlYGbY 2. NPTEL. (n.d.). *Introduction to quantum computing.* Retrieved October 15, 2025, fromhttps://onlinecourses.nptel.ac.in/noc21_cs103/preview			

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Title of the Course	Tensor computation for data science
Course Code	CSI-6009
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Linear algebra and programming	
Course Objectives:	To provide foundational knowledge of matrix and tensor algebra and their decomposition techniques for efficient representation and analysis of multi-dimensional data, with applications in scientific computing, image processing, and deep neural networks.	
Course Outcomes:		**Mapped to PSO**
	CO1: Understand and apply fundamental concepts of matrices and tensors, including tensor operations and basic properties.	PSO1, PSO2
	CO2: Analyze and implement various tensor decomposition techniques such as CP, Tucker, HOSVD, HT, and tensor-train for solving multilinear problems.	PSO1, PSO2, PSO5
	CO3: Apply tensor decompositions to real-world problems, including image processing, anomaly detection, and compressed sensing.	PSO2, PSO3 and PSO5
	CO4: Design and implement tensor-based deep neural network architectures using tensor	PSO1, PSO2,

	networks and advanced tensor decomposition methods.		PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Fundamentals of Matrices and Tensors Basic matrix concepts: norms, rank, trace, inner products, Kronecker product, similarity matrix Fast Fourier Transform, matrix diagonalization Toeplitz and circulant matrices: eigenvalues, eigenvectors Block matrix computation and warm-up algorithms Introduction to tensors: tensor definitions, tensor operations (mode-n product, Kronecker product, element product, tensor trace, tensor convolution, quantitative tensor product, Khatri-Rao product, outer product, Einstein product, t-product) Examples: identity tensor, symmetric tensor, orthogonal tensor, tensor rank, block tensor	**15**	CO1	K2, K3
Module 2	Tensor Decompositions ● Block tensor decomposition ● Canonical Polyadic (CP) decomposition ● Tucker decomposition, higher-order SVD (HOSVD) ● Hierarchical Tucker (HT) decomposition ● Tensor-train (TT) decomposition ● Eigenvalue decomposition and singular value decomposition via t-product and Einstein product ● Truncated tensor SVD, tensor inversion, Moore-Penrose inverse ● Power tensor and solving systems of multilinear equations	**15**	CO2	K4, K5
Module 3	Applications of Tensor Decompositions ● Low-rank tensor approximation ● Robust principal tensor component analysis for background removal	**15**	CO3	K3, K4

	• Image deblurring and compression • Compressed sensing with robust regression • Higher-order statistical moments for anomaly detection • Solving elliptic partial differential equations			
Module 4	Tensors in Deep Neural Networks • Deep neural networks and tensor networks • Tensor decompositions for DNNs: CP, Tucker, HT, TT, tensor ring decomposition • Transform-based tensor decomposition for neural network optimization and efficiency	**15**	CO4	K5, K6
Pedagogy:	Teaching/Assignments/Hand on assignments			
Texts:	1. Liu, Y. (Ed.). Tensors for Data Processing: Theory, Methods, and Applications. Academic Press. (2021) 2. Liu Y, Liu J, Long Z, Zhu C. Tensor Computation for Data Analysis. Springer; 2022. 3. T. G. Kolda and B. W. Bader. Tensor decompositions and applications. SIAM Rev., 51(3):455–500, 2009.			
References/ Readings:	1. C. D. Martin, R. Shafer, B. Larue. An order-p tensor factorization with applications in imaging. SIAM J Sci Comput. 2013;35(1): A474–90. 2. M. Brazell, N. Li, C. Navasca, et al. Solving multilinear systems via tensor inversion. SIAM J. Matrix Anal Appl. 2013;34(2):542–570. 3. Ji, Y., Wang, Q., Li, X., & Liu, J. (2019). A survey on tensor techniques and applications in machine learning. IEEE Access, 7, 162950-162990			
Web Resources:	1. TensorLy. (n.d.). *TensorLy: Tensor learning in Python.* Retrieved October 15, 2025, fromhttps://tensorly.org/stable/ 2. Kolda, T. G., & Bader, B. W. (2009). *Tensor decompositions and applications.SIAM Review, 51*(3), 455–500. https://doi.org/10.1137/07070111X 3. MIT OpenCourseWare. (n.d.). *MIT OpenCourseWare.* Retrieved October 15, 2025, fromhttps://ocw.mit.edu			

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Title of the Course	AI Product Development
Course Code	CSI-6010
Number of Credits	4
Theory/Practical	4T
Level	500
Effective from AY	2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	AI fundamentals	
Course Objectives:	1. Equip students with the knowledge and skills to develop AI products that align with business goals and leverage modern AI/ML technologies. 2. Enable students to design, implement, and evaluate AI systems responsibly, ensuring ethical, explainable, and user-centered solutions.	
Course Outcomes:		**Mapped to PSO**
	CO1: Analyze business problems and map them to AI-driven solutions aligned with strategic goals.	PSO1, PSO2, PSO3, PSO5, PSO7
	CO2: Demonstrate understanding of core AI/ML concepts and their application in real-world use cases.	PSO1, PSO2, PSO3
	CO3: Design and manage AI product lifecycles integrating experimentation, development, and deployment workflows.	PSO2, PSO6, PSO7

	CO4: Evaluate AI systems for explainability, ethics, performance, and human-centered design.		PSO4, PSO6, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Strategic Foundation of AI Product Development** Introduction: Creating Successful AI Products — A Nine-Step Framework The Evolution of AI Product Management-A Personal Journey Through AI-The Nine-Step Framework Mapping Problems to Business Goals for AI Products Understanding the Role of AI in Business Problem-Solving-Aligning AI Solutions with Business Goals-Problem Analysis-Frameworkramework for AI Implementation Decisions-Practical Examples of AI in Action-The Revolutionization of Generative AI	**15**	CO1, CO2, CO3, CO4	K2, K3, K4, K5
Module 2	**AI Concepts, Use Cases, and Experimentation Mindset** Curiosity to Learn AI Use Cases and Emerging ML Concepts Machine Learning Foundations-Deep Learning and Generative AI Innovations-Model Training Process Demystified-Advanced AI and Real-World ApplicationsExperimentation Mindset and Room in the Roadmap to Innovate-Principles of Experimentation in AI Projects-Integrating Innovation into the Product Roadmap-Case Studies in AI Experimentation-Traditional AI vs. Generative AI	**15**	CO2, CO3	K2, K3, K5
Module 3	**Implementation, Integration, and Operations** Integrating MDLC with SDLC-Understanding MDLC and SDLC-Synchronizing Model and Software Development Lifecycles-Collaboration between AI and Software Teams-Case Studies of Integration Success-Scaling Research to Production-Research Mindset and Prototyping-Transitioning from Research to Scalable AI Solutions-Generative AI and Traditional AI in Scaling-Acceptance Criteria in the World of AI-Defining Functional and Performance Standards-Data Quality, Scalability, and Compliance-Deployment	**15**	CO2, CO3	K3, K4, K5
Module 4	**Sustainable Excellence, Ethics, and Human-Centered Innovation** Patience and Plan to Surpass Human-Level Performance-Innovator's Dilemma in AI-	**15**	CO2, CO3,	K2, K3, K4, K5,

	Strategic Planning for Long-Term Success-Model Explainability, Interpretability, Ethics, and Bias-Understanding Explainability and Fairness-Ethical AI Practices and Governance-Model Operations — Model Drift Management-Monitoring, Retraining, and Continuous Improvement-AI Is the New UX: Transforming Human Interaction-AI-First Product Management-Multimodal and Conversational Interfaces-Understanding Generative AI for Product Management-Practical Applications of Generative AI-Future of AI Product Creation		CO4	K6
Pedagogy:	Class room teaching/ Practical use case demonstrations/assignments			
Texts:	1. Agarwal, S. (2024). *Creating successful AI products: A nine-step framework* (1st ed.). Wiley. 2. Lipenkova, J. (2024). The art of AI product development: Delivering business value. Manning Publications. 3. Naithani, K., Tiwari, S., & Kumari, S. (2024). AI for product development. CRC Press. 4. Kumar, A., & Jha, S. (2023). AI product development: From research to real-world deployment. Springer. 5. Nika, M. (2025). Building AI-powered products: The essential guide to AI and GenAI product management. O'Reilly Media.			
References/ Readings:	1. Gupte, R. (2023). Designing human-centric AI products. Apress. 2. Banavar, G. (2022). Building AI products: A hands-on guide. O'Reilly Media. 3. Raji, I. D., & Mitchell, M. (2023). Responsible AI: Building ethical and trustworthy systems. MIT Press. 4. Shroff, G. (2021). The intelligent product manager: Leading AI and data-driven products. Routledge.			
Web Resources:	1. https://www.productboard.com/blog/ai-for-product-managers/ 2. https://www.productboard.com/blog/ai-for-product-managers/ 3. https://www.monterail.com/blog/ai-in-product-development-lifecycle 4. https://ai.google/build/			

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Title of the Course	Graph Neural Network
Course Code	CSI-6011
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Machine Learning / Deep Learning / Linear Algebra / Graph Theory.	
Course Objectives:	To equip students with a comprehensive understanding of graph theory, graph neural network architectures, and advanced learning techniques for analyzing and modeling complex graph-structured data in real-world applications.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the fundamental principles, structures, and theoretical concepts of graphs and graph neural networks.	PSO 1, PSO 5
	CO2: Develop graph neural network models and algorithms for node embeddings, community detection, and graph representation learning.	PSO2, PSO 5
	CO3: Apply advanced GNN architectures and techniques such as GCN, GAT, MPNN, and hierarchical pooling for solving complex graph-based problems.	PSO2, PSO5, PSO6

	CO4: Evaluate and optimize graph neural network models in terms of performance, scalability, and applicability to heterogeneous and large-scale graph data.		PSO 2, PSO 5, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Machine Learning for Graphs, Structure of Graphs, Node Embeddings, Random Graphs with Arbitrary Degree Distributions and Their Applications, Properties of Networks and Random Graph Models, Motifs and Structural Roles in Networks, Simple Building Blocks of Complex Networks, Community Structure in Networks, Fast Unfolding of Communities in Large Networks, Overlapping Community Detection at Scale: A Nonnegative Matrix Factorization Approach, Spectral Clustering, Message Passing and Node Classification, Graph Representation Learning.	**15**	CO1, CO2, CO3	K1, K2,
Module 2	Theory of Graph Neural Networks, Architectures—GCN, GAT, MPNN & Design Space, Deep Generative Models for Graphs, Link Analysis: PageRank, Network Effects and Cascading Behaviour, Probabilistic Contagion and Models of Influence, Influence Maximization in Networks, Outbreak Detection in Networks, Network Evolution, Reasoning over Knowledge Graphs, Applications of Graph Neural Networks.	**15**	CO2, CO3	K2, K3
Module 3	Efficient Graphlet Kernels for Large Graph Comparison, Semi-Supervised Classification with Graph Convolutional Networks, Inductive Representation Learning on Large Graphs, Graph Attention Networks, GNN Augmentation and Training, Hierarchical Graph Representation Learning with Differentiable Pooling.	**15**	CO3, CO4	K3, K5
Module 4	Machine Learning with Heterogeneous Graphs, Modeling Relational Data with Graph Convolutional Networks, Heterogeneous Graph Transformer, Advanced Topics in GNNs, Algorithm for Training Deep and Large Graph Convolutional Networks.	**15**	CO3, CO4	K4, K5
Pedagogy:	Lecture / Hands On sessions / Programming Assignments / Project Based assignments			

Texts:	1. Hamilton, W. L. (2020). *Graph representation learning*. McGill University. 2. Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge University Press.
References/ Readings:	1. Negro, A. (2021). Graph-powered machine learning. Simon and Schuster. 2. Pósfai, M., &Barabási, A.-L. (2016). Network science. Cambridge University Press.
Web Resources:	1. "Graph Neural Networks." YouTube, http://www.youtube.com/playlist?list=PLSgGvve8UweGx4_6hhrF3n4wpHf_RV76_. 2. "Graph Neural Networks: Hands-on Guide." ProjectPro, https://www.projectpro.io/article/graph-neural-networks/956. 3. Tutorial Graph Neural Networks on Social Networks. https://kaggle.com/code/awadelrahman/tutorial-graph-neural-networks-on-social-networks. 4. Packt. PacktPublishing/Hands-On-Graph-Neural-Networks-Using-Python. 20 May 2022, Jupyter Notebook. 9 Oct. 2025. GitHub, https://github.com/PacktPublishing/Hands-On-Graph-Neural-Networks-Using-Python.

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Title of the Course	Bayesian Learning and Probabilistic Model
Course Code	CSI-6012
Number of Credits	4T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Fundamentals of Probability theory and Statistics	
Course Objectives:	To equip students with an understanding of probabilistic reasoning and Bayesian inference, enabling them to select, implement, and analyze advanced inference methods for complex probabilistic models.	
Course Outcomes:		**Mapped to PSO**
	CO1: Understand statistical models using the principles of probabilistic reasoning and Bayesian learning	PSO1, PSO6
	CO2: apply various techniques related to exact and approximate inference	PSO2, PSO3, PSO5

	CO3: analyze the applied techniques in various domain		PSO2, PSO4, PSO7, PSO8	
	CO4: create models that will be dealing with real life scenario		PSO3, PSO4, PSO7, PSO8	
Content:		**No. of hours**	**Mapped to CO**	**Cognitive level**
Module 1:	**Probability and Bayesian foundation** ● Review of probability: Basic concepts, rules, and fundamental theorems. ● Bayes' theorem: The theoretical basis for Bayesian inference, including the concepts of priors, likelihood, and posteriors. ● Probability distributions: Discrete and continuous distributions (e.g., Binomial, Normal, Poisson, Exponential). ● Random variables: Expected value, variance, ● Introduction to probabilistic Programming Language	**15**	CO1 CO3	K1 K2 K5
Module 2:	**Probabilistic graphical models and Exact Inference** ● Introduction to graphical models: Understanding how to represent a joint probability distribution using a graph. ● Bayesian networks: ● Fundamentals and semantics. ● Constructing networks from data and expert knowledge. ● Markovnetworks:Fundamentals. Comparison with Bayesian networks. ● Variable elimination: A fundamental algorithm for exact inference. ● Complexity of inference: Analyzing the computational challenges of exact inference in graphical models. ● Sum-product and junction tree algorithms: More advanced methods for exact inference.	**15**	CO1 CO2	K1 K2 K3

Module 3:	**Bayesian learning and Approximate Inference** ● Maximum a posteriori (MAP): Finding the most probable hypothesis given the observed data. ● Maximum likelihood estimation (MLE): Parameter estimation for Bayesian networks. ● Naive Bayes classifier: A practical, widely-used application of Bayesian principles for classification. ● Bayesian regression and classification models: ● Variational inference. ● Bayesian linear regression. ● Logistic regression. ● Need for approximation: When exact inference is intractable, particularly with large, complex models. ● Monte Carlo methods:Markov Chain Monte Carlo (MCMC). Sequential Monte Carlo and amortised inference. ● Implementing inference algorithms for SPP programs – an operational semantic account. ● Gibbs sampling. ● Variational inference: A deterministic method for approximating posteriors ● Denotational semantics of SPP programs.	**15**	CO2 CO3 CO4	K1 K2 K3 K5
Module 4:	**Advances Theoretical models and applications** ● Expectation-Maximization (EM) algorithm: For learning with latent variables. ● Gaussian processes: Non-parametric Bayesian methods for regression and classification. ● Hierarchical Bayesian models: For modelling data with nested structures. ● Applications: Real-world uses in fields like finance, healthcare, and natural language processing.	**15**	CO2 CO3 CO4	K2 K3 K4 K5 K6
Pedagogy:	Lectures/tutorials/ assignments/ mini-projects/ PPT presentations/ case studies/ class discussions.			

Texts:	1. Tabak, J. (2004). Probability and statistics: The science of uncertainty (1st ed.). Infobase Learning. 2. Antonisamy, B., et al. (2017). Principles and practice of biostatistics [E-book]. Elsevier India. 3. Pishro-Nik, H. (2023). Practical uncertainty: Useful ideas in decision-making, risk, randomness & AI (1st U.S. ed.). Kappa Research. 4. Pishro-Nik, H. (2014). Introduction to probability, statistics, and random processes. Amazon Fulfillment/Kappa Research. 5. Christensen, R. (2001). Introduction to graphical modeling. Journal of the American Statistical Association, 96(456), 1524–1525.
References/ Readings:	Gelman, Andrew, et al. *Bayesian Data Analysis*. Third edition, CRC Press, Taylor & Francis Group, 2014. Texts in Statistical Science Series.
References/ Readings:	*Probabilistic Graphical Models: Principles and Techniques*. 17 Mar. 2020,https://online.stanford.edu/courses/cs228-probabilistic-graphical-models-principles-and-techniques.

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Title of the Course	Research Methodology
Course Code	CSI-6013
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic computer knowledge / Problem-solving and analytical skills / Familiarity with algorithmic thinking	
Course Objectives:	This course is designed to provide a comprehensive understanding of research methodology, encompassing techniques for defining research problems and the associated methods and considerations within the research process.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the basic concepts of research, types of research, research design, and the role of reasoning in solving research problems.	PSO 1, PSO 2, PSO 3
	CO2: Formulate research problems, objectives, and questions, and apply literature review, referencing, and information retrieval techniques.	PSO2, PSO4, PSO 6
	CO3: Apply statistical methods to analyze data, interpret numerical and graphical results, and validate experiments.	PSO2, PSO5, PSO 6
	CO4: Prepare research reports and manuscripts, use proper citations and illustrations, and	PSO 6, PSO 7, PSO 8

	follow ethical and intellectual property guidelines.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to research, Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research.	**15**	CO1	K1, K2
Module 2	Problem Formulation, Understanding Modeling& Simulation, Literature Review, Referencing, Information Sources, Information Retrieval, Indexing and abstracting services, Citation indexes, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Interpretation of Results.	**15**	CO2	K2, K3, K4
Module 3	Statistics: 15 hours Probability & Sampling distribution, Estimation, Measures of central Tendency, Arithmetic mean, Median, Mode, Standard deviation, Co efficient of variation (Discrete serious and continuous serious), Hypothesis testing & application, Correlation & regression analysis, Orthogonal array, ANOVA, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One way and two way classified data, 'F' test.	**15**	CO3	K3, K4
Module 4	Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents. Intellectual property rights (IPR) patents copyrights Trademarks Industrial design geographical indication. Ethics of Research Scientific Misconduct Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.	**15**	CO4	K4, K5
Pedagogy:	Lectures, Assignments, mini projects, student presentations.			
Texts:	1. Bordens, K. S., & Abbott, B. B. (2002). *Research design and methods: A process approach*. McGraw-Hill.			

	2. Douglas, C. M., & George, C. R. (2007). *Applied statistics & probability for engineers* (3rd ed.). Wiley. 3. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
References/ Readings:	1. Robert, P. M., Peter, S. M., & Mark, A. L. (2012). *Intellectual property in the new technological age* (6th ed.). Aspen Law & Business. 2. Shirore, C. (2015). *A beginner's guide to LaTeX*.
Web Resources:	1. Bezet, Amanda. *LibGuides: The Research Process: Explore Web Resources*. https://resources.nu.edu/researchprocess/webresources. 2. "Research Methodology Lecture Series." *YouTube*, http://www.youtube.com/playlist?list=PLdo0loeoFpNDSR2n-raiKa4E8i1yMMg16.

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Discipline Specific Vocational Elective (DSVE) Courses

Title of the course	Prompt Engineering
Course Code	CSI-6401
Number of Credits	2T+ 2P
Theory/Practical	Theory and Practical
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Fundamentals of Artificial Intelligence	
Course Objectives:	To equip learners with the knowledge and skills to design, optimize, and defend prompts for Generative AI applications, enabling effective task-specific generation, reasoning, and multimodal output while ensuring responsible AI usage.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the principles, structures, and methodologies of prompt engineering for Generative AI.	PSO1, PSO3, PSO4
	CO2: Develop and refine effective prompts for text, image, and multimodal AI generation tasks.	PSO1, PSO2, PSO3, PSO5, PSO6
	CO3: Apply advanced reasoning-based prompting techniques such as Chain-of-Thought and	PSO1, PSO2,

	Tree-of-Thought for complex problem-solving.		PSO3, PSO5, PSO6	
	CO4: Evaluate, defend, and optimize prompt strategies to ensure robustness, reproducibility, and secure AI outputs.		PSO1-PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Prompt Engineering for Generative AI** Introduction to prompt engineering and its significance – Understanding prompt structure and formulation – Basic ingredients of a prompt – Potential complexity of prompts – System prompt and user prompt – Instruction-based prompting – In-context learning: zero-shot and few-shot prompting – Context length and context efficiency – Exploring AI prompting interfaces and tools – Designing effective and context-aware prompts – Persona-based prompting patterns – Principles and best practices for crafting prompts – Industry perspectives on effective prompt design – Emerging applications and future use cases of prompt engineering.	**15**	CO1, CO2	K2, K3
	Lab Assignment 1: Exploring Prompt Structures and In-Context Learning Experiment with system and user prompts using zero-shot and few-shot examples for different generative tasks (e.g., summarization, translation, or creative writing). Analyze how context length and example selection influence response quality and relevance. **Lab Assignment 2:**Designing Context-Aware and Persona-Based Prompts Create prompts that define specific personas or roles (e.g., teacher, data analyst, or interviewer) to guide tone and content generation. Evaluate prompt effectiveness using clarity, consistency, and contextual appropriateness as key criteria.			
Module 2	**Prompt Engineering – Techniques and Approaches** Overview of prompting methodologies – Text-to-text prompt strategies – Interview pattern approach – Chain-of-Thought technique for logical reasoning – Tree-of-Thought approach for structured problem solving – Self-consistency in reasoning and response generation – Comparative analysis of Chain-of-Thought and Tree-of-Thought approaches – Selecting suitable prompting techniques for different tasks – Design considerations for prompt optimization – Developing and refining effective prompts for	**30**	CO2, CO3	K2, K3

	Generative AI applications.			
	Lab Assignment 1: Chain-of-Thought vs Tree-of-Thought Prompting Apply Chain-of-Thought and Tree-of-Thought prompting on logical reasoning tasks. Compare their performance based on reasoning depth, accuracy, and response diversity **Lab Assignment 2:**Designing and Optimizing Prompts for Generative AI Tasks Create and refine prompts using text-to-text, interview pattern, and self-consistency approaches for tasks like story generation, summarization, and code synthesis. Evaluate and optimize prompt effectiveness.			
Module 3	**Text-to-Image Prompting** Fundamentals of text-to-image prompting – Understanding the relationship between textual description and visual generation – Key elements of effective image prompts (subject, style, context, and constraints) – Techniques for creating accurate and expressive text-to-image prompts – Balancing creativity and control in visual prompt design – Evaluating and refining generated outputs – Integrating prompt engineering principles into multimodal AI systems.	**30**	CO2	K3, K4
	Lab Assignment 1: Designing Effective Text-to-Image Prompts Create and experiment with text prompts varying in subject, style, and context using a text-to-image model (e.g., DALL·E or Stable Diffusion). Analyze how prompt structure and wording influence image composition and quality. **Lab Assignment 2:**Refining and Evaluating Generated Visual Outputs Generate a series of images for the same concept using controlled prompt variations. Evaluate outputs for creativity, realism, and alignment with textual intent. Refine prompts iteratively to balance artistic expression and precision.			
Module 4	**Prompt Engineering Best Practices and Defensive Prompting** **Prompt Engineering Best Practices:** Write clear and explicit instructions – Provide sufficient context – Break complex tasks into simpler subtasks – Give the model time to think – Iterate and refine your prompts – Evaluate prompt engineering tools – Organize and version prompts for reproducibility	**15**	CO4	K5, K6

	and efficiency. **Defensive Prompt Engineering:** Understanding proprietary prompts and reverse prompt engineering – Jailbreaking and prompt injection – Information extraction risks – Defenses against prompt attacks – Consolidation of key concepts in prompt engineering – Application of best practices in prompt formulation – Designing comprehensive prompts for complex AI tasks.			
	Lab Assignment 1: Applying Prompt Engineering Best Practices Design prompts for complex multi-step tasks using clear instructions, contextual cues, and structured subtasks. Experiment with iterative refinement to improve model performance and reproducibility across versions. Lab Assignment 2: Defensive Prompting and Attack Mitigation Simulate prompt injection and information extraction attacks on a controlled LLM setup. Implement defensive strategies such as input sanitization, role-based prompting, and response filtering to safeguard proprietary or sensitive information.			
Pedagogy:	Teaching/lab hands on/ presentation /Mini project			
Texts:	1. Alammar, J. (2023). *Hands-on large language models*. O'Reilly Media. 2. Rothman, D. (2021). *Transformers for natural language processing*. Packt Publishing.			
References/ Readings:	Huyen, C. (2024). *AI engineering: Building applications with foundation models*. O'Reilly Media			
References/ Readings:	1. OpenAI. (n.d.). *Prompting best practices*. https://platform.openai.com/docs/guides/completion 2. LangChain Documentation. (n.d.). *Prompt templates and chains*. https://www.langchain.com/docs 3. Jay Alammar. (n.d.). *The Illustrated Guide to Transformers*. https://jalammar.github.io/illustrated-transformer/ 4. Microsoft Azure AI. (n.d.). *Responsible AI and prompt engineering guidance*. https://learn.microsoft.com/en-us/azure/ai-services/responsible-ai			

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Title of the Course	Cloud based AI deployment.
Course Code	CSI-6402
Number of Credits	2T+2P
Theory/Practical	Theory and Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Fundamentals of computing and programming	
Course Objectives:	The objective of this course is to understand the architectural patterns, strategic considerations, and operational principles required for deploying and managing robust AI systems in cloud environments. The course focuses on frameworks like MLOps, CI/CD, scaling and analysis and design scalable, reliable, and ethical AI solutions for real-world production scenarios.	
		Mapped to CO
Course Outcomes:	CO1: Understand the concept of cloud computing with AI architecture and its deployment	PSO1, PSO4, PSO8
	CO2: Apply the concept of deployment of cloud architecture with AI using the infrastructure	PSO3, PSO6

	CO3: Analyze the operations and deployment of Artificial Intelligence with cloud computing		PSO5, PSO8	
	CO4: Create reliable, and ethical AI solutions for real-world using cloud computing.		PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of cloud and AI architecture** Cloud computing paradigms: Cloud Deployment Models, Cloud Service Models, AI lifecycle theory, AI workloads in the cloud, MLOps principles and theory Practical: 1. Set up a machine learning environment on a cloud platform (AWS, Azure, or GCP) and deploy a simple AI workload. 2. Implement the stages of the AI lifecycle using a sample dataset—covering data ingestion, training, and validation within a cloud notebook.	**15**	CO1	K1 K2
Module 2:	**Deployment and serving patterns** Model serving paradigms, Deployment strategies, Containerization principles, Orchestration theory, Automated ML pipelines (CI/CD) Practical: 1. Containerize a trained ML model using Docker and deploy it as a REST API endpoint. 2. Build and automate an ML pipeline using CI/CD tools (e.g., GitHub Actions, Jenkins, or Azure ML pipelines).	**30**	CO1 CO2	K1 K2 K3
Module 3:	**Operations and reliability of cloud AI** Model monitoring and observability, Model retraining strategies, Ethical AI in practice, Cloud AI security principles, Scalability and cost management Practical: 1. Implement model monitoring using cloud monitoring tools (e.g., Prometheus, AWS CloudWatch, or Azure Monitor) to track drift and latency. 2. Conduct a cost and scalability analysis for a deployed AI model and apply optimization measures for efficient resource utilization.	**30**	CO1 CO3	K3 K5 K6

	Practical: 1. Implement model monitoring using cloud monitoring tools (e.g., Prometheus, AWS CloudWatch, or Azure Monitor) to track drift and latency. 2. Conduct a cost and scalability analysis for a deployed AI model and apply optimization measures for efficient resource utilization.			
Module 4:	**Advanced topics and the future of cloud AI** Foundation model deployment, Generative AI systems, Hybrid and edge AI architectures, AI governance and regulations, AI and sustainability Practical: 1. Deploy a foundation or generative AI model (e.g., GPT, Stable Diffusion) using an open-source API on a cloud platform. 2. Design a conceptual architecture for a sustainable and regulation-compliant hybrid AI deployment integrating edge devices.	**15**	CO3 CO4	K3 K4 K5 K6
Pedagogy:	Lectures/tutorials/ assignments/ mini-projects/ PPT presentations/ case studies/ class discussions.			
Texts:	1. Buyya, Rajkumar. *Cloud Computing: Principles and Paradigms*. With James Broberg and Andrzej M. Goscinski, 1st ed, John Wiley & Sons, Incorporated, 2011. Wiley Series on Parallel and Distributed Computing Ser, v. 87			
Webpages:	1. *Foundation of Cloud IoT Edge ML - Course*. https://onlinecourses.nptel.ac.in/noc23_cs65/preview. Accessed 10 Oct. 2025. 2. "Architecture of Cloud Computing." *GeeksforGeeks*, 10 Mar. 2021, https://www.geeksforgeeks.org/cloud-computing/architecture-of-cloud-computing/.			

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Title of the Course	Computational Linguistics
Course Code	CSI-6403
Number of Credits	2T+2P
Theory/Practical	Theory and Practical
Level	500
Effective from AY	2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Python programming / basic NLP / Mathematical foundations / linguistics fundamentals	
Course Objectives:	To equip students with how computers understand and process human language, including speech, words, grammar, meaning, and applications like machine translation, search, and text analysis, with focus on Indian languages.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the basics of language, linguistics, and NLP and their applications.	PSO 1, PSO 3
	CO2: Use text processing and annotation tools for tokenization, POS tagging, stemming, and parsing.	PSO 2, PSO 3, PSO 5
	CO3: Analyse linguistic structures and perform morphological and corpus-based annotation, especially for Indian languages.	PSO2, PSO3, PSO 6, PSO 7
	CO4**:** Create POS-annotated corpora and morphological analysers and evaluate NLP tools on text and speech data.	PSO 4, PSO 5, PSO 6, PSO 8

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Foundations of Language, Linguistics & NLP Overview:** Language as a structured system, Components of linguistic knowledge: Phonology, Morphology, Syntax, Semantics, Pragmatics, Overview of linguistics: goals and applications, History and evolution of NLP and Linguistics, Basics of MT, IR, IE, Dialogue Systems, Speech Technology. **Linguistic Structures, Text Processing & Annotation:** Basics of Linguistic Structures, Morphological structures: inflectional vs. derivational, Phrase structure grammar, Dependency grammar and parsing basics, Lexical resources: dictionaries, thesauri, ontologies (e.g., WordNet).	**15**	CO1	K1, K2
Module 2	**Introduction to Text Processing and Annotation:** Preprocessing techniques: Tokenization, Stemming, Parsing, Annotation: POS tagging, NER, Multiword Expressions, parsing overview, Annotated corpora: CoNLL, Universal Dependencies, Penn Treebank, Basic use of linguistic annotation tools. **NLP System Approaches & Machine Learning Fundamentals:** Rule-Based vs. Statistical Approaches, Rule-based NLP systems: architecture, pros and cons, Corpus-based methods and frequency distribution	**15**	CO2	K2, K3
Module 3	**Practical: Text Pre-processing and Linguistic Annotation:** ● Perform text pre-processing using Python libraries such as NLTK or spaCy (tokenization, stop-word removal, and stemming) ● Implement Tokenization, POS tagging, and Stemming on sample texts using NLTK or spaCy. ● Conduct linguistic annotation using tools such as WebAnno or INCEpTION for tagging tokens, POS, and dependencies. ● Mini-project: Create a small POS-annotated text collection in any Indian language. ● Case study: Analyze challenges in Indian language NLP, focusing on low-resource settings and limited linguistic tools.	**30**	CO3	K3, K4

Module 4	**Practical: Morphological Analysis and NLP Tools** ● Perform morphological analysis on a set of words using FST-based tools. ● Mini-project: Implement a small morphological analyser for an Indian language using computational tools. ● Explore and apply computational linguistics tools for text and speech data processing. ● Apply the above tools on Indian language datasets to understand practical challenges and evaluation methods.	**30**	CO4	K3, K4, K5
Pedagogy:	Lectures, Assignments, mini projects, student presentations.			
Texts:	1. Akmajian, A., Demers, R. A., Farmer, A. K., & Harnish, R. M. (Year). Linguistics: An introduction to language and communication. Publisher. 2. Bhattacharyya, P. (2022). Natural language processing: A Paninian perspective. PHI. 3. Bird, S., Klein, E., & Loper, E. (2009). Natural language processing with Python. O'Reilly. 4. Jurafsky, D., & Martin, J. H. (2023). Speech and language processing. Pearson.			
References/ Readings:	1. Grishman, R. (1986). Computational linguistics: an introduction. Cambridge University Press. 2. Hausser, R., & Hausser, R. (2001). Foundations of computational linguistics. Springer-Verlag Telos.			
Web Resources:	1. CoNLL shared tasks, Universal Dependencies Project, & Indic NLP Tools. (n.d.). Retrieved October 14, 2025, from https://martinweisser.org/corpora_site/comp_ling_resources.html 2. AI4Bharat. (n.d.). Indic NLP Catalog. Retrieved October 14, 2025, from https://github.com/AI4Bharat/indicnlp_catalog 3. Society for Natural Language Learning (SIGNLL). (2025). SIGNLL website. Retrieved October 14, 2025, from https://www.signll.org/2025			

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Title of the Course	Environmental Data Analytics
Course Code	CSI-6404
Number of Credits	2T+2P
Theory/Practical	Theory and Practical
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	yes

Pre-requisites for the Course:	Numerical algebra and Numerical optimization	
Course Objectives:	The course introduces and trains students in different Data Analytics techniques used in the Geosciences including Machine Learning and Deep Learning algorithms. Emphasis is laid on understanding the algorithms as well as using them in practice. The course is designed as research case studies from Ocean Modeling, Remote Sensing and Study of the Natural Environment with significant hands-on activit	
Course Outcomes:		**Mapped to PSO**
	CO1: Analyze and model spatiotemporal geoscience data using data-driven and computational approaches.	PSO1, PSO2, PSO3, PSO5
	CO2: Apply supervised and unsupervised machine learning methods for environmental and geospatial analytics.	PSO1, PSO2, PSO3
	CO3: Design and implement deep learning architectures (MLP, CNN, RNN) for remote sensing and environmental monitoring tasks.	PSO1, PSO2, PSO3, PSO6

	CO4: Evaluate and integrate advanced probabilistic and reinforcement learning techniques for dynamic, data-driven environmental systems.		PSO1, PSO2, PSO3, PSO5, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Data-Driven Modelling and Computational Approaches in the Geosciences 1.2 Introduction to data-driven approaches for geoscientific problem formulation 1.3 Computational modeling methodologies for Earth and environmental systems 1.4 Handling and analysis of spatiotemporal geoscience data: 1.5 Remote sensing data and satellite observations 1.6 In-situ measurement systems and observational networks 1.7 Integration with physics-based models and primitive equation frameworks 1.8 Challenges in uncertainty, scaling, and data fusion in geoscience modeling	**15**	CO1	K2, K3, K4, K5
Module 2	2.1 Bayesian and Reinforcement Learning Approaches for Environmental Systems 2.2Fundamentals of Bayesian inference for environmental data analysis 2.3 Data assimilation in physics-based dynamic systems 2.4 Probabilistic modeling and uncertainty quantification 2.5 Reinforcement learning for adaptive environmental sensing and ocean monitoring Case studies in data-driven decision-making for environmental management	**15**	CO4	K2, K3, K4, K5, K6
Module 3	3.1 Machine Learning Applications in Environmental Analytics 3.2 Supervised learning methods: Linear and nonlinear regression/classification techniques Performance evaluation and model interpretability 3.3 Unsupervised learning methods: Clustering for pattern discovery in geoscience data Dimensionality reduction and feature extraction (PCA, t-SNE, etc.) Applications to environmental and climatic datasets	**30**	CO1, CO2	K3, K4

	Suggested lab assignments Lab 1: Perform data preprocessing and exploratory analysis on environmental datasets using Python. Lab 2: Apply linear regression and logistic regression for environmental prediction and classification tasks. Lab 3: Implement nonlinear models (Decision Trees, Random Forests, SVM) for complex environmental relationships. Lab 4: Use clustering algorithms (K-Means, DBSCAN) to identify environmental zones or patterns. Lab 5: Apply dimensionality reduction (PCA, t-SNE) to analyze high-dimensional spatiotemporal data.			
Module 4	4.1 Deep Learning and Advanced Computational Methods in Remote Sensing Implementation of deep learning architectures: Multi-Layer Perceptron (MLP) 4.2 Convolutional Neural Networks (CNN) for spatial feature extraction 4.3 Recurrent Neural Networks (RNN/LSTM) for temporal data modeling Case studies: Remote sensing for land use, ocean color, and climate monitoring 4.4 Integrating deep learning with Bayesian and reinforcement learning frameworks Capstone lab: Building a hybrid data-driven environmental modeling pipeline Suggested Lab assignments Deep Learning and Advanced Computational Methods in Remote Sensing Lab 1: Build and train a Multi-Layer Perceptron (MLP) for temperature or soil moisture prediction. Lab 2: Implement CNNs for land cover classification using satellite imagery. Lab 3: Develop RNN/LSTM models for time-series forecasting of environmental variables. Lab 4: Integrate CNN and LSTM architectures for spatiotemporal modeling of drought or flood prediction.	**30**	CO3	K3, K4

Pedagogy:	Class room teaching/Lab assignments/ mini project	
Texts:	1. Davis, J. D. (2023). Introduction to environmental data science (1st ed.). CRC Press. ISBN: 978-1032322186. 2. Dormann, C. (2020). Environmental data analysis: An introduction with examples in R (1st ed.). Springer Nature Switzerland AG. ISBN: 978-3030550196. 3. Zhang, Z. (2017). Environmental data analysis: Methods and applications (1st ed.). De Gruyter. ISBN: 978-3110424911	
References/ Readings:	1. **Menke, W.** (2022). *Environmental data analysis with MATLAB or Python: Principles, applications, and prospects* (3rd ed.). Elsevier. ISBN: 978-0323955768. 2. **Hewitt, C. N.** (1992). *Methods of environmental data analysis*. Springer Science+Business Media. ISBN: 978-0412739903. 3. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. Second Edition. O'Reilly Media, 2019. 4. Särkkä, Simo. Bayesian Filtering and Smoothing. Cambridge University Press, 2013. 5. Murphy, Kevin P. Machine Learning: A Probabilistic Perspective. MIT Press, 2012. 6. Recent Literature, Selected Chapters, Material/Notes Provided by Instru	
Web Resources:	1. NASA Earthdata – Access to remote sensing and environmental datasets. https://earthdata.nasa.gov 2. USGS Earth Explorer – Satellite imagery and environmental data for research. https://earthexplorer.usgs.gov 3. Google Earth Engine – Cloud-based platform for planetary-scale geospatial analysis. https://earthengine.google.com 4. Kaggle Datasets – Environmental Science – Public datasets for environmental analytics. https://www.kaggle.com/datasets?search=environment 5. OpenStreetMap (OSM) – Free, editable spatial data useful for environmental modeling. https://www.openstreetmap.org 6. R-bloggers: Environmental Data Analysis Tutorials – Tutorials and examples in R for environmental data. https://www.r-bloggers.com 7. Python for Environmental Data Analysis – Example notebooks and tutorials for Python-based analysis.https://pythonfordatascience.org	

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SEMESTER IV

Generic Elective (GE) Courses

Title of the Course	Cloud Computing
Course Code	CSI-6201
Number of Credits	4T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Web Development, Programming
Course Objectives:	The course aims to equip students with an understanding of the fundamentals of Cloud Computing, enabling them to use and adopt cloud services and tools in real-life scenarios, explore major cloud platforms like Google Apps, Microsoft Azure, and Amazon Web Services, and gain knowledge in the practical applications of cloud computing.

			Mapped to PSO	
Course Outcomes:	CO1: Understand Cloud Computing, including its characteristics, challenges, benefits, and limitations.		PSO1, PSO3	
	CO2: Apply Platform as a Service (PaaS) in depth, understanding its service model, characteristics, benefits, and the enabling technologies		PSO1, PSO3, PSO4	
	CO3: Apply Data Analytics as a Service, including Hadoop as a service, MapReduce on Cloud, and Chubby locking Service.		PSO3, PSO4, PSO5, PSO6	
	CO4: Design, develop, and demonstrate real-world applications leveraging Cloud Computing technologies		PSO2, PSO3, PSO5, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Cloud Computing: Cloud Computing Overview: Characteristics – challenges, benefits, limitations, Evolution of Cloud Computing, Cloud computing architecture, Cloud Reference Model (NIST Architecture) Infrastructure as a Service: Service Model, Characteristics, Benefits, Enabling Technologies Case Study: AWS, OpenStack	**15**	CO1 CO2	K1 K2
Module 2:	Platform as a Service: Service Model, Characteristics, Benefits, Enabling Technologies Case Studies : IBM Bluemix, GAE, Microsoft Azure Software as a Service Service Model, Characteristics, Benefits, Enabling Technologies Case Study : Salesforce.com, CRM, Online Collaboration Services	**15**	CO1 CO2	K1 K2 K5
Module 3:	Data Analytics as a Service: Hadoop as a service, MapReduce on Cloud, Chubby locking Service	**15**	CO1 CO3CO4	K1 K2 K3 K5
Module 4:	Introduction to Public and Private Clouds Shared Resources – Resource Pool – Usage and Administration Portal – Usage Monitor – Resource Management– Cloud Security – Workload Distribution – Dynamic provisioning. Storage as a service Historical	**15**	CO1 CO3 CO4	K3 K4 K5

	Perspective, Datacenter Components, Design Considerations, Power Calculations, Evolution of Data Centers, Cloud data storage - CloudTM			K6
Pedagogy:	Lectures/tutorials/ assignments/ mini-projects/ PPT presentations/ case studies/ class discussions.			
Texts:	1. Hwang, K., Dongarra, J., & Fox, G. C. (2013). Distributed and cloud computing: from parallel processing to the internet of things. Morgan Kaufmann. 2. Shroff, G. (2010). Enterprise cloud computing: technology, architecture, applications. Cambridge university press. 3. Jamsa, K. (2013). Cloud Computing SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security, and More. 4. Buyya, R., Broberg, J., & Goscinski, A. M. (Eds.). (2010). Cloud computing: Principles and paradigms. John Wiley & Sons.			
References/ Readings:	1. Rhoton, J., V Haukioja, R. (2011). Cloud computing architected: solution design handbook. Recursive Press. 2. Reese, G. (2009). Cloud application architectures: building applications and infrastructure in the cloud. " O'Reilly Media, Inc.". 3. Manjunath, G., & Sitaram, D. (2011). Moving to the cloud: Developing apps in the new world of cloud computing. Elsevier. 4. Khan, S. U., & Zomaya, A. Y. (Eds.). (2015). Handbook on data centers.			
Web Resources	1. AWS Cloud Computing. https://www.w3schools.com/aws/aws_cloudessentials_cloudcomputing.php. Accessed 10 Oct. 2025. 2. Cloud Community. Cloudcommunity/Free-Books. 11 Aug. 2020. 5 Oct. 2025. GitHub, https://github.com/cloudcommunity/Free-Books.			

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Title of the Course	Web Technology
Course Code	CSI-6202
Number of Credits	4
Theory/Practical	4T
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic programming knowledge / Basic understanding of Internet and web concepts	
Course Objectives:	To establish a strong foundation in web development concepts and technologies, and enable students to design, develop, and deploy responsive and dynamic web applications using modern client-side and server-side frameworks effectively.	
Course Outcomes:		**Mapped to PSO**
	CO1: Describe how the Internet works, explain client–server architecture, and use basic web technologies.	PSO 2, PSO 3
	CO2: Apply design principles to create responsive and attractive web pages using CSS and design frameworks.	PSO2, PSO3, PSO 6
	CO3: Build interactive web pages using JavaScript, handle user actions, and exchange data using HTTP, XML, and JSON.	PSO2, PSO5, PSO6

	CO4: Develop complete web applications using server-side programming, manage sessions and databases, and use modern web architectures like MVC and REST.		PSO 2, PSO 5, PSO 6, PSO 7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Web Development:** Introduction, Evolution of Internet & World Wide Web, Client-Server Architecture, Revisit HTML & CSS, HTML5, CSS3	**15**	CO1	K1, K2
Module 2	**Front-End Design and Development** Good Design Rubrics, Separation of concerns for HTML & CSS (structure vs visual representation), HTML DOM, CSS Box Model, pseudo-classes & pseudo-elements, CSS animation, Adaptive & responsive design, Viewport & media queries, Mobile-first design, Introduction to a design library or framework (e.g. Bootstrap)	**15**	CO2	K3, K4
Module 3	**Client-Side Scripting and Communication** Dynamic Web Pages, JavaScript programming features, JavaScript events & functions, Manipulating DOM, Beyond ECMA 4, Introduction to a JavaScript library or framework (e.g. JQuery, ReactJS), HTTP, Request & Response, HTTP methods & error codes, Headers, URL encoding & decoding, XML, XPath, JSON	**15**	CO3	K4, K5
Module 4	**Server-Side and Advanced Web Development** Server instance, Request handling & response creation, HTML forms & file uploads, Session management & application data, Database connectivity, Introduction to a server-side library/template engine/framework (e.g. PHP-Laravel, JSP-Spring), Model-View-Controller (MVC), Model-View-ViewModel (MVVM), Web service architecture & micro-services, REST calls, Asynchronous JavaScript and XML (AJAX), Independent client-server web development, Server-side vs client-side rendering, Web stacks, JAM stack, Full stack development	**15**	CO4	K5, K6
Pedagogy:	Lectures / Coding Assignments / mini projects / student presentations.			

Texts:	1. Sebesta, R. W. (2014). *Programming the World Wide Web*. Pearson Education. 2. DT Editorial Services. (2016). *HTML 5 Black Book: Covers CSS 3, JavaScript, XML, XHTML, AJAX, PHP and jQuery* (2nd ed.).
References/ Readings:	1. Zammetti, F. W. (2020). *Modern Full-Stack Development*. Apress. 2. Dabit, N. (2020). Full Stack Serverless: Modern Application Development with React, AWS, and GraphQL. O'Reilly Media.
Web Resources:	1. W3Schools Online Web Tutorials. https://www.w3schools.com/ 2. Free Tutorials on Technical and Non Technical Subjects. https://www.tutorialspoint.com.

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Title of the Course	Cyber Security
Course Code	CSI-6203
Number of Credits	4T
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic programming skills and mathematics	
Course Objectives:	To provide students with a comprehensive understanding of the cybersecurity threat landscape, including cybercrimes, legal frameworks, and data protection	
Course Outcomes:		**Mapped to PSO**
	CO1: To understand the cyber security threat landscape	PSO1, PSO3
	CO2: To develop a deeper understanding and familiarity with various types of cyber attacks	PSO1, PSO3, PSO4, PSO7
	CO3: To understand about cyber crimes, vulnerabilities and remedies thereto.	PSO3, PSO4, PSO5,

			PSO6	
	CO4: To learn how to analyse and evaluate existing legal framework and laws on cyber security.		PSO2, PSO3, PSO5, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Overview of Cyber security Cyber security increasing threat landscape, Cyber security terminologies- Cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, hacker., Non-state actors, Cyber terrorism, Protection of end user machine, Critical IT and National Critical Infrastructure, Cyberwarfare, Case Studies.	**15**	CO1 CO2	K1 K2
Module 2:	Cyber Crimes Cyber crimes targeting Computer systems and Mobiles- data diddling attacks, spyware, logic bombs, DoS, DDoS, APTs, virus, Trojans, ransomware, data breach., Online scams and frauds- email scams, Phishing, Vishing, Smishing, Online job fraud, Online sextortion, Debit/credit card fraud, Online payment fraud, Cyberbullying, website defacement, Cyber-squatting, Pharming, Cyber espionage, Cryptojacking, Darknet- illegal trades, drug trafficking, human trafficking., Social Media Scams & Frauds- impersonation, identity theft, job scams, misinformation, fake news cyber crime against persons - cyber grooming, child pornography, cyber stalking., Social Engineering attacks, Cyber Police stations, Crime reporting procedure, Case studies. Platforms for reporting cyber crimes. Checklist for reporting cyber crimes online.	**15**	CO1 CO2	K1 K2 K5
Module 3:	Cyber Law Cyber crime and legal landscape around the world, IT Act,2000 and its amendments. Limitations of IT Act, 2000. Cyber crime and punishments, Cyber Laws and Legal and ethical aspects related to new technologies- AI/ML, IoT, Blockchain, Darknet and Social media, Cyber Laws of other countries, Case Studies.	**15**	CO1 CO3 CO4	K1 K2 K3 K5
Module 4:	Defining data, meta-data, big data, non-personal data. Data protection, Data privacy and data security, Personal Data Protection Bill and its compliance, Data protection principles, Big data security issues and challenges, Data protection regulations of other	**15**	CO1 CO3 CO4	K3 K4 K5

	countries- General Data Protection Regulations(GDPR),2016 Personal Information Protection and Electronic Documents Act (PIPEDA)., Social media- data privacy and security issues. issues. Setting privacy settings on social media platforms. Do's and Don'ts for posting content on Social media platforms. Registering complaints on a Social media platform Cyber security Management , Compliance and Governance Cyber security Plan- cyber security policy, cyber crises management plan., Business continuity, Risk assessment, Types of security controls and their goals, Cyber security audit and compliance, National cyber security policy and strategy. Prepare password policy for computer and mobile devices. List out security controls for computers and implement technical security controls in the personal computer. List out security controls for mobile phones and implement technical security controls in the personal mobile phone. Log into computer system as an administrator and check the security policy in the system			K6
Pedagogy:	Lectures/tutorials/ assignments/ mini-projects/ PPT presentations/ case studies/ class discussions.			
Texts:	1. Sunit, B., & Nina, G. (2011). Cyber Security: Understanding Cybercrimes, computer forensics and Legal Perspectives. Wiley India. 2. Denning, Dorothy Elizabeth Robling. *Information Warfare and Security*. 4. print, Addison-Wesley [u.a.], 2000.. 3. Venkataramanan, Nataraj. *Data Privacy: Principles and Practice*. CRC Press, 2017.			
References/ Readings:	1. Brotby, W. K. (2007). Information security governance: Guidance for information security managers. ISACA. 2. Weiss, M., & Solomon, M. G. (2015). Auditing IT infrastructures for compliance. Jones & Bartlett Publishers.			
Web Resources:	1. "Understanding Today's Threat Landscape & Mitigating Cyber Risk." Huntress, https://www.huntress.com/cybersecurity-101/topic/threat-landscape-defined. 2. "What Is Cybersecurity?" F5, Inc., https://www.f5.com/glossary/cybersecurity.			

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Title of the Course	Design Thinking
Course Code	CSI-6204
Number of Credits	4
Theory/Practical	4T
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic understanding of computational concepts / problem-solving and analytical skills / algorithmic thinking.	
Course Objectives:	The objective of this course is to introduce new ways of creative thinking and to explain the innovation cycle of the Design Thinking process for developing innovative and practical engineering products, preparing students for professional careers.”	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain and classify various learning styles and memory techniques, and apply them effectively in their engineering education.	PSO 1, PSO 3, PSO 7
	CO2: Analyze emotional experiences and evaluate emotional expressions to better understand users while designing innovative products.	PSO2, PSO3, PSO 6
	CO3: Develop creative thinking approaches and explain the innovation cycle of the design thinking process for product development.	PSO2, PSO5, PSO 6
	CO4: Create real-time innovative engineering product designs and apply appropriate frameworks,	PSO 5, PSO 6,

	strategies, and techniques during prototype development.		PSO 7, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**An Insight to Learning**: Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting **Remembering Memory:** Understanding the Memory process, Problems in retention, Memory enhancement techniques.	**15**	CO1,	K2, K3
Module 2	**Emotions: Experience & Expression:** Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers **Basics of Design Thinking:** Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – Empathize, Define, Ideate, Prototype, Test.	**15**	CO2, CO3	K2, K3, K4
Module 3	**Being Ingenious & Fixing Problem:** Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving Process of Product Design Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, Assignment – Engineering Product Design **Prototyping &Testing**: What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, Sample Example, Test Group Marketing **Celebrating the Difference:** Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences	**15**	CO3, CO4	K3, K4, K6
Module 4	**Design Thinking & Customer Centricity:** Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design	**15**	CO4	K5, K6

	Feedback, Re-Design & Re-Create: Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – "Solving Practical Engineering, Problem through Innovative Product Design & Creative Solution".			
Pedagogy:	Lectures, Assignments, mini projects, student presentations.			
Texts:	1. Knapp, J., Zeratsky, J., & Kowitz, B. (2016). *Sprint: How to solve big problems and test new ideas in just five days.* Simon & Schuster. 2. Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage.* Harvard Business Press. 3. Brown, T. (2009). *Change by design: How design thinking transforms organizations and inspires innovation.* Harper Business.			
References/ Readings:	1. Plattner, H., Meinel, C., & Leifer, L. (Eds.). (2011). *Design thinking: Understand – improve – apply.* Springer. 2. Mootee, I. (2013). *Design thinking for strategic innovation: What they can't teach you at business or design school.* John Wiley & Sons. 3. Liedtka, J., King, A., & Bennett, K. (2013). *Solving problems with design thinking: Ten stories of what works.* Columbia Business School Publishing. 4. Vianna, M., Vianna, Y., Adler, I. K., Lucena, B., & Russo, B. (2011). *Design thinking: Business innovation.* MJV Press. 5. Burgelman, R. A., Christensen, C. M., & Wheelwright, S. C. (2017). *Strategic management of technology and innovation* (5th ed.). McGraw-Hill Education.			
Web Resources:	1. *Kolb's Learning Styles & Experiential Learning Cycle*. 19 Mar. 2025, https://www.simplypsychology.org/learning-kolb.html. 2. "D.School Starter Kit - Design Workshop Activities, Templates & Guide." *Stanford d.School*, https://dschool.stanford.edu/tools/starter-kit. 3. *IDEO Design Thinking | IDEO | Design Thinking*. https://designthinking.ideo.com. 4. "Design Thinking [2024 Updated]." *YouTube*, http://www.youtube.com/playlist?list=PLEiEAq2VkUUIz01StTtLRDtXwNVwjj-Nc. 5. *-YouTube*. https://www.youtube.com/watch?v=lF0xkNyZluI&list=PLrtjkLnNjGHu39NvksxqnkZ3if1G0AQtK&index=1.			

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Title of the Course	Educational technology
Course Code	CSI-6205
Number of Credits	4
Theory/Practical	4T
Level	500
Effective from AY	2026
New Course	yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic computer skills / Familiarity with digital learning tools / Basic research and analytical skills	
Course Objectives:	To equip students with the knowledge and skills to design, implement, and evaluate AI-enhanced educational technologies and instructional systems grounded in learning theories, research methods, and ethical practices.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the fundamental concepts of educational technology, learning theories, instructional design models, and research methods, and analyze their application in AI-enhanced learning environments.	PSO 1, PSO 3
	CO2: Apply instructional design principles and AI-driven adaptive learning strategies to develop personalized, performance-oriented educational solutions.	PSO 2, PSO 3, PSO 5
	CO3: Utilize multimedia tools, online platforms, and AI-based systems to create, deliver, and evaluate interactive learning experiences for diverse learner groups.	PSO2, PSO3, PSO 6, PSO 7

	CO4: Design, implement, and critically assess AI-powered educational platforms, game-based and adaptive learning environments, considering ethical, privacy, and emerging technology aspects.		PSO 4, PSO 5, PSO 6, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Overview of educational technology field, history and trends, Learning theories (Behaviorism, Cognitivism, Constructivism), Bloom's Taxonomy and learning objectives, Constructivist and Situated learning theories, Factors affecting learning, Learning styles and personalization, Introduction to AI in education, Research methods: research problems, variables, hypotheses, literature review, sampling, data collection, ethics, reliability, Application of AI in educational research and instructional evaluation	**15**	CO1	K1, K2, K3
Module 2	Instructional design concepts and principles, Systematic instructional design approach, ID models (ADDIE, Dick & Carey, rapid prototyping), Needs assessment and task analysis, Performance environment analysis (learner, content, organization), Writing instructional goals and measurable learning objectives, Instructional strategies and methods, Integrating AI for personalized learning, Adaptive content delivery, Human Performance Technology for improved learning outcomes, Evaluation of instructional effectiveness using learning analytics	**15**	CO2	K2, K3, K5
Module 3	Multimedia tools (video, animations, simulations, interactive modules), Instructional design for multimedia, Principles of multimedia design and usability, Content delivery platforms (LMS: Moodle, Jhoomla), Online collaborative tools, Discussion forums, Open Educational Resources, AI applications: Intelligent Tutoring Systems, personalized learning engines, adaptive assessments, Recommendation systems, Integration of AI with online collaborative learning, Learner behavior tracking and AI-driven feedback, Evaluation and analytics of digital learning environments	**15**	CO3	K3, K4, K5
Module 4	Case studies of AI in education (NPTEL, OCW, PhET, OSCAR), Design and development of AI-powered educational platforms, Game-based learning and gamification strategies, Multimedia and video production for instructional purposes (scriptwriting, storyboarding, production, post-production, evaluation), Ethical considerations and privacy in AI-based education, Emerging trends in AI and	**15**	CO4	K4, K5, K6

	educational technology (Web 3.0, intelligent agents, adaptive learning systems, virtual and augmented reality, AI-enabled predictive learning analytics)			
Pedagogy:	Lectures / Assignments / mini projects / student presentations.			
Texts:	1. Januszewski, A., & Molenda, M. (2008). *Educational technology: A definition with commentary*. Routledge/Taylor & Francis Group. 2. Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. Pfeiffer. 3. Cheng, E. C. K., Wang, T., Schlippe, T., &Beligiannis, G. N. (2022). Artificial intelligence in education technologies: New development and innovative practices: Proceedings of 2022 3rd International Conference on Artificial Intelligence in Education Technology.			
References/ Readings:	1. National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures*. The National Academies Press. 2. McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. Penguin Books.			
Web Resources:	1. - Youtube. (n.d.). Retrieved October 14, 2025, from https://www.youtube.com/watch?v=B5HXH0QqpX8 2. Instructional design in e-learning: Models, principles, and benefits. (n.d.). Create an Online Course Easily | Easygenerator. Retrieved October 14, 2025, from https://www.easygenerator.com/en/guides/instructional-design-for-elearning/			

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