

CENTRAL UNIVERSITY OF KARNATAKA KALABURAGI



CENTRAL UNIVERSITY OF KARNATAKA

COURSE STRUCTURE FOR M. Tech. in Artificial Intelligence and Machine Learning (AIML)

(Effective from the Academic Year 2026 –27)

**School of Computer Sciences
Department of Computer Sciences**

PREFACE

The rapid advancements in Artificial Intelligence (AI), Machine Learning (ML), Deep Learning, Generative AI, Data Engineering, and Intelligent Automation are transforming industries, research, governance, healthcare, agriculture, cybersecurity, education, and society at an unprecedented pace. In view of these technological developments and the growing demand for highly skilled AI professionals and researchers, the Department of Artificial Intelligence and Machine Learning has designed the M.Tech. AIML curriculum with a strong emphasis on research, innovation, interdisciplinary learning, and industry relevance.

The curriculum is framed in alignment with the principles of the National Education Policy (NEP) 2020, Outcome Based Education (OBE), and contemporary academic practices adopted by leading institutions including IITs, NITs, IIITs, and other premier universities. The programme aims to develop competent professionals capable of addressing complex real-world challenges using advanced Artificial Intelligence and Machine Learning techniques.

The curriculum integrates fundamental theoretical concepts with practical implementation through laboratory courses, mini projects, internships, research activities, industry interaction, and dissertation work. Emerging areas such as Deep Learning, Reinforcement Learning, Generative AI & Large Language Models (LLMs), MLOps, Edge AI, Intelligent Systems, Data Engineering, and AI Deployment are incorporated to ensure that students remain aligned with evolving technological trends and industry requirements.

Special emphasis has been given to:

- Research-oriented learning and innovation
- Skill development and employability
- Industry collaboration and practical exposure
- Publication and patent/IPR activities
- Ethical and responsible AI practices
- Lifelong learning and multidisciplinary education

The programme also encourages students to undertake research publications in reputed Scopus/Web of Science indexed journals and conferences, participate in hackathons and innovation activities, and develop AI-based solutions for societal and industrial applications.

The curriculum structure consists of Professional Core Courses, Professional Electives, Laboratory Courses, MOOCs/NPTEL-based learning, Seminar, Internship, and Dissertation phases designed to provide flexibility, specialization, and advanced domain knowledge.

The Department sincerely acknowledges the valuable suggestions and inputs received from academicians, industry experts, researchers, alumni, and members of the Board of Studies during the framing of this curriculum.

It is expected that this curriculum will contribute significantly toward producing competent AI professionals, researchers, innovators, entrepreneurs, and academicians capable of contributing effectively to national and global technological advancement.

ABOUT THE PROGRAMME

The M.Tech. in Artificial Intelligence and Machine Learning (AIML) is a postgraduate programme designed to provide advanced knowledge, research competency, and practical expertise in the rapidly evolving domains of Artificial Intelligence, Machine Learning, Data Science, and Intelligent Systems.

The programme focuses on developing analytical, computational, and research skills necessary for designing intelligent solutions to complex engineering and societal problems. It combines strong theoretical foundations with hands-on implementation using modern AI tools, frameworks, cloud platforms, and deployment technologies.

The curriculum is carefully structured to address current and emerging technological areas such as:

- Artificial Intelligence
- Machine Learning
- Deep Learning
- Reinforcement Learning
- Generative AI and Large Language Models
- Computer Vision
- Natural Language Processing
- Data Engineering and Big Data Analytics
- MLOps and AI Deployment
- Edge AI and Intelligent Systems
- Intelligent IoT Applications

The programme adopts an Outcome Based Education (OBE) approach where learning outcomes are clearly defined to ensure attainment of professional competencies, research aptitude, ethical practices, innovation capability, and lifelong learning skills.

The curriculum includes:

- Advanced theory courses
- Practical laboratory sessions
- Research paper analysis
- Seminar
- Internship/Industrial Training
- Major dissertation/project work

Students are encouraged to engage in interdisciplinary research, industrial problem-solving, startup activities, and collaborative innovation projects. The programme prepares graduates for careers in:

- AI and ML industries
- Research and Development organizations
- Data Science and Analytics companies
- Intelligent Automation sectors
- Academic and research institutions
- Startups and entrepreneurship
- Government and public sector organizations

The programme also aims to develop socially responsible AI professionals capable of designing ethical, sustainable, secure, and inclusive intelligent systems for the benefit of society.

Eligibility Criteria

B.Tech./B.E (Hons) degree in Computer Science and Engineering/Information Science and Engineering/ equivalent degree in Computer Science and Engineering from UGC / AICTE / MHRD recognized University or foreign university (as per the AIU foreign equivalence list) with at least 50% marks aggregate (45% for OBC {NON CREAMY LAYER}, SC, ST, PWD and Kashmiri Migrant and non-migrants Students) at graduate level. 50% of seats will be filled based on CUET and remaining 50% with GATE score. In Case of non-availability of GATE students, the same will be filled with CUET candidates.

Admission Process

Admissions will be carried out through the following modes:

- **50% of the seats** shall be filled based on **CUET-PG score**.
- **Remaining 50% of the seats** shall be filled based on **valid GATE score**.

Note:

- In case sufficient number of eligible GATE-qualified candidates are not available, the vacant seats under the GATE category will be filled through **CUET-PG merit**.

Central University of Karnataka

Objective:

The university houses bright students across the country and talented faculty committed to high standards of excellence in the teaching and research.

Vision

Committed to Universal Values and Knowledge

Mission

1. To strengthen and expand knowledge in all its expressions
2. To integrate and innovate with all stake-holders of knowledge and education in a holistic and inclusive fashion
3. To contribute meaningfully in terms of enriching the human capital of the country.

Programme Outcomes (POs)

At the time of completion of the M.Tech. in Artificial Intelligence and Machine Learning programme, the student will be able to:

- PO 1 :** An ability to independently carry out research / investigation and development work to solve practical problems.
- PO 2 :** An ability to write and present a substantial technical report / document.
- PO 3 :** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.

Programme Specific Outcomes (PSOs)

After successful completion of the M.Tech. in Artificial Intelligence and Machine Learning programme, the graduates will be able to:

- PSO 1:** Apply advanced concepts of Artificial Intelligence, Machine Learning, Deep Learning, Data Engineering, and Natural Language Processing to analyze and solve complex real-world problems.
- PSO 2:** Design, develop, and deploy AI-driven systems using modern tools, MLOps frameworks, Generative AI, and emerging intelligent technologies.
- PSO 3:** Conduct research, innovation, and interdisciplinary projects in domains such as Computer Vision, Natural Language Processing, Edge AI, Cyber Security, Intelligent IoT, and Autonomous Systems.

Programme Educational Objectives (PEOs)

The graduates of the M.Tech. in Artificial Intelligence and Machine Learning programme will be able to:

- PEO 1:** To provide graduates with strong foundations in Artificial Intelligence, Machine Learning and emerging intelligent technologies for solving complex engineering and societal problems.
- PEO 2:** To develop research, analytical, and innovation capabilities for designing, developing, and deploying AI-driven solutions using modern tools and technologies.
- PEO 3:** To prepare graduates for successful careers in industry, research organizations, academia, entrepreneurship, and multidisciplinary domains related to Artificial Intelligence and Machine Learning.
- PEO 4:** To inculcate professional ethics, leadership qualities, teamwork, effective, communication skills, and lifelong learning necessary for continuous professional growth and societal contribution.



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COURSE STRUCTURE - M. TECH Artificial Intelligence and Machine Learning

(Effective from the academic year 2026-27) – Programme Code: PAM

I SEMESTER										
Course code	Course Type	Course Title	Teaching Hrs./Week				Examination			Credits
			Theory Lecture	Tutorial	Practical	Total	IA Marks	End Sem Marks	Total Marks	
			L	T	P					
PAMTC10400	CC	Mathematical Foundations for AI	4	-	-	4	40	60	100	4
PAMCC10401	CC	Advanced Machine Learning	4	-	2	6	50	75	125	5
PAMCC10402	CC	Data Structures & Algorithms for AI	3	-	2	5	40	60	100	4
PAMCA10300	AEC	Research Methodology & IPR	2	-	2	4	25	50	75	3
PAMCL10400	PE-I	Big Data Analytics & Data Engineering	3	-	2	5	40	60	100	4
PAMCL10401		Computer Vision & Image Processing								
PAMCL10402		Internet of Things Architecture & Systems								
PAMCL10403		Foundations of Cyber Security & Cryptography								
PAMRS10400	SEC	Seminar	-	-	4	4	20	30	50	2
Total			15	01	12	28	215	335	550	22
Note: CC-Core Course, PE-Professional Elective, AEC-Ability Enhancement Course, SEC- Skill Enhancement Course, ESE-Employability skills enhancement courses										



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II SEMESTER										
Course code	Course Type	Course Title	Teaching Hrs./Week				Examination			Credits
			Theory /Lecture	Tutorial	Practical	Total	IA Marks	End Sem Marks	Total Marks	
			L	T	P					
PAMCC20500	CC	Deep Learning	3	-	2	5	40	60	100	4
PAMCC20501	CC	Natural Language Processing	3	-	2	5	40	60	100	4
PAMCC20502	CC	Applied Artificial Intelligence	3	-	2	5	40	60	100	4
PAMCL20500	PE-II	MLOps & AI Deployment	3	-	2	5	40	60	100	4
PAMCL20501		Reinforcement Learning								
PAMCL20502		Edge AI & Intelligent IoT Systems								
PAMCL20503		AI & ML for Cyber Security								
PAMCC20503	CC	Generative AI & Large Language Models (LLMs)	3	-	2	5	40	60	100	4
PAMRS20500	SEC	Mini Project	-	-	4	4	20	30	50	2
Total			15		14	29	220	330	550	22
Note: CC-Core Course, PE-Professional Elective, AEC-Ability Enhancement Course, SEC- Skill Enhancement Course, ESE-Employability skills enhancement courses.										



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III SEMESTER										
Course code	Course Type	Course Title	Teaching Hrs./Week				Examination			Credits
			Theory /Lecture	Tutorial	Practical	Total	IA Marks	End Sem Marks	Total Marks	
PAMNL306XX	PE	Professional Elective III*	4	-	-	4	NPTEL		100	04
PAMNL306XX	PE	Professional Elective IV*	4	-	-	4	EXAM		100	04
PAMRC30600	CC	M. Tech. Project-Stage-I	-	-	20	20	100	150	250	10
Total			8		20	28	100	150	450	18
Note: CC-Core Course, PE-Professional Elective, AEC-Ability Enhancement Course, SEC- Skill Enhancement Course, ESE-Employability skills enhancement courses.										
* Students shall complete NPTEL/SWAYAM course from the list approved by the Board of Studies (BoS) as part of Elective–III and Elective–IV.										



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IV SEMESTER										
Course code	Course Type	Course Title	Teaching Hrs./Week				Examination			Credits
			Theory /Lecture	Tutorial	Practical	Total	IA Marks	End Sem Marks	Total Marks	
			L	T	P					
PAMRC40600	CC	M. Tech. Project-Stage-II	-	-	28	28	140	210	350	14
PAMRI40500	ESE	Internship**	-	-	-	-	40	60	100	04
Total					28	28	180	270	450	18
Note: CC-Core Course, PE-Professional Elective, AEC-Ability Enhancement Course, SEC- Skill Enhancement Course, ESE-Employability skills enhancement courses.										
**Internship must be undertaken during the vacation period between the 1 st and 4th semesters, with a total duration of 8 weeks, from a reputed Industry or an AICTE Internship Portal (or) a certification course approved by the department related to AIML.										



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Electives Track

Elective -I	Elective -II
Big Data Analytics & Data Engineering	MLOps & AI Deployment
Computer Vision & Image Processing	Reinforcement Learning
Internet of Things Architecture & Systems	Edge AI & Intelligent IoT Systems
Foundations of Cyber Security & Cryptography	AI & ML for Cyber Security

List of NPTEL for Elective -III & IV

GPU Architectures and Programming. (PAMNL30601) https://nptel.ac.in/courses/106105220	Foundations of Virtual Reality(PAMNL30602) https://nptel.ac.in/e-learning/preview/noc25_cs87	Introduction to Industry 4.0 and Industrial Internet of Things(PAMNL30603) https://nptel.ac.in/courses/106105195	Responsible & Safe AI Systems (PAMNL30604) https://nptel.ac.in/courses/106106472
Distributed Optimisation and Machine Learning (PAMNL30605) nptel.ac.in/courses/106101466	Modern Computer Vision (PAMNL30606) https://nptel.ac.in/courses/108106189	Real-Time Systems (PAMNL30607) https://nptel.ac.in/noc25_cs156/preview	Practical Cyber Security for Cyber Security Practitioners (PAMNL30608) https://nptel.ac.in/courses/106104467



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Course Credit Distribution		
Course Type	Credits	Percentage
CC-Core Course	53	66
PE- Professional Elective Course	16	20
AEC-Ability Enhancement Course	03	04
SEC- Skill Enhancement Course	04	05
Employability skills enhancement courses	04	05
Total	80	100

Semester wise Course -Credit Distribution					TOTAL CREDITS
Course Type	Sem-1	Sem-2	Sem-3	Sem-4	
CC-Core Course	13	16	10	14	53
PE- Professional Elective	04	04	08	00	16
AEC-Ability Enhancement Course	03	00	00	00	03
SEC- Skill Enhancement Course	02	02	00	00	04
Employability skills enhancement courses	00	00	00	04	04
Total	22	22	18	18	80



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Mathematical Foundations for AI

Semester	:	I	Internal Assessment	:	40
Course Code	:	PAMTC10400	End Sem. Exam	:	60
Teaching Hours/Week (L:T:P)	:	4:0:0	Exam Duration (Hours)	:	2.5
Credits : 4					

COURSE OUTCOMES

Engineering Mathematics, Basic Programming using Python, Fundamentals of Probability and Linear Algebra
After completing this Course, the students should be able to:

1. Apply vector and matrix operations in AI and ML applications.
2. Analyze eigenvalues, eigenvectors, and matrix decompositions used in machine learning.
3. Apply calculus and optimization methods for AI model training.
4. Analyze probabilistic and statistical methods used in AI systems.
5. Model graph-based AI problems and implement graph traversal techniques.

UNIT-I

Linear Algebra for Artificial Intelligence: Vectors and Vector Spaces, Linear Independence, Basis and Dimension, Matrix Operations, Rank of Matrix, Systems of Linear Equations, Gaussian Elimination, Orthogonality, Inner Product Spaces, Eigenvalues and Eigenvectors, Singular Value Decomposition (SVD), Principal Component Analysis (PCA).

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-II

Calculus and Optimization for Machine Learning: Functions of Single and Multiple Variables, Partial Derivatives, Chain Rule, Jacobian and Hessian Matrices, Convex Functions, Optimization Problems, Gradient Descent, Stochastic Gradient Descent, Lagrange Multipliers, Backpropagation Mathematics.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Probability and Statistics for AI: Probability Theory, Conditional Probability, Bayes Theorem, Random Variables, Probability Distributions (Binomial, Poisson, Gaussian), Expectation, Variance, Covariance, Correlation, Central Limit Theorem, Hypothesis Testing, Maximum Likelihood Estimation.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-IV

15 Hours

Graph Theory and Mathematical Models for AI: Graphs and Networks, Directed and Undirected Graphs, Graph Representation, Adjacency Matrix, Incidence Matrix, Graph Traversal Algorithms (BFS and DFS), Shortest Path Algorithms, Trees and Spanning Trees, Markov Chains, Hidden Markov Models, Introduction to Graph Neural Networks (GNNs).

RBT Levels: L1, L2, L3, L4

15 hours.

TEXT BOOKS

1. Gilbert Strang, Introduction to Linear Algebra, Sixth Edition, Wellesley-Cambridge Press, 2023.
2. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
3. Sheldon Ross, A First Course in Probability, Pearson Education.
4. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill.



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REFERENCE BOOKS

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer.
2. Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, PHI.

ONLINE RESOURCES

1. MIT OpenCourseWare – Linear Algebra: <https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/>
2. NPTEL – Mathematics for Machine Learning: <https://nptel.ac.in/courses/106106179>
3. Stanford CS229 Mathematics Notes: <https://cs229.stanford.edu/section/cs229-linalg.pdf>
4. Khan Academy – Probability and Statistics: <https://www.khanacademy.org/math/statistics-probability>
5. DeepLearning.AI – Mathematics for Machine Learning: <https://www.deeplearning.ai/courses/mathematics-for-machine-learning-and-data-science-specialization/>
6. NPTEL – Graph Theory: <https://nptel.ac.in/courses/111106050>



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Advanced Machine Learning

Semester :	I	Internal Assessment :	50
Course Code :	PAMCC10401	End Sem. Exam :	75
Teaching Hours/Week (L:T:P) :	4:0:2	Exam Duration (Hours) :	2.5
Credits : 5			

COURSE OUTCOMES

Mathematics for Artificial Intelligence, Machine Learning, Probability and Statistics, Data Structures and Algorithms, Python Programming

After completing this Course, the students should be able to:

1. Analyze advanced supervised and unsupervised learning algorithms.
2. Apply ensemble and probabilistic learning techniques for predictive analytics.
3. Design and implement deep neural network architectures for AI applications.
4. Evaluate optimization strategies and scalable learning methods.
5. Develop AI solutions using advanced machine learning frameworks and tools.

UNIT-I

Advanced Supervised Learning and Ensemble Methods: Review of Supervised Learning, Bias–Variance Tradeoff, Regularization Techniques, Ridge Regression, LASSO Regression, Elastic Net, Support Vector Machines (SVM), Kernel Methods, Ensemble Learning, Bagging, Random Forests, AdaBoost, Gradient Boosting, XGBoost, Stacking Methods.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-II

Probabilistic and Unsupervised Learning: Gaussian Mixture Models (GMM), Expectation Maximization (EM) Algorithm, Bayesian Learning, Hidden Markov Models (HMM), Markov Decision Processes, Hierarchical Clustering, DBSCAN, Dimensionality Reduction Techniques, Principal Component Analysis (PCA), t-SNE, Autoencoders.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Deep Learning Architectures: Artificial Neural Networks, Multilayer Perceptron (MLP), Backpropagation Algorithm, Optimization Techniques for Deep Learning, Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Attention Mechanism, Transformers, Transfer Learning, Generative Adversarial Networks (GANs).

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-IV

Scalable and Emerging Machine Learning Systems: Distributed Machine Learning, Federated Learning, Reinforcement Learning Fundamentals, Q-Learning, Explainable AI (XAI), Ethical AI, Hyperparameter Optimization, MLOps Concepts, Edge AI, Graph Neural Networks (GNNs), Foundation Models and Large Language Models (LLMs).

RBT Levels: L1, L2, L3, L4

15 hours.



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List of Experiments Suggested:

1. Ensemble Learning using Random Forest and XGBoost
2. Gaussian Mixture Models and EM Algorithm
3. PCA and t-SNE for Dimensionality Reduction
4. Autoencoder Implementation using TensorFlow/PyTorch
5. CNN for Image Classification
6. RNN and LSTM for Sequence Prediction
7. Transfer Learning using Pre-trained Deep Learning Models
8. GAN-based Image Generation
9. Reinforcement Learning using Q-Learning
10. Federated Learning Simulation
11. Explainable AI using SHAP and LIME
12. Hyperparameter Optimization using Grid Search and Bayesian Optimization

TEXT BOOKS

1. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
3. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.
4. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer.

REFERENCE BOOKS

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, O'Reilly.
2. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press.
3. Charu C. Aggarwal, Neural Networks and Deep Learning, Springer.
4. Sergios Theodoridis, Machine Learning: A Bayesian and Optimization Perspective, Academic Press.

ONLINE RESOURCES

1. NPTEL – Advanced Machine Learning: <https://nptel.ac.in/courses/106106202>
2. Stanford CS229 – Machine Learning: <https://cs229.stanford.edu/>
3. MIT Introduction to Deep Learning: <https://introtodeeplearning.com/>
4. DeepLearning.AI Specialization: <https://www.deeplearning.ai/courses/deep-learning-specialization/>
5. Fast.ai Practical Deep Learning: <https://course.fast.ai/>



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Data Structures and Algorithms for AI

Semester :	I	Internal Assessment :	40
Course Code :	PAMCC10402	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2
Credits : 4			

PREREQUISITES

Machine Learning, Python Programming.

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Select suitable data structures for AI applications
2. Design efficient algorithms using advanced paradigms.
3. Apply graph and search algorithms for intelligent systems.
4. Implement scalable and optimized AI solutions.
5. Analyze computational efficiency in machine learning systems.

UNIT-I

Advanced Data Structures and Algorithmic Foundations: Advanced analysis of algorithms including asymptotic notations, recurrence relations, and computational complexity for intelligent systems. Tree-based and hierarchical data structures for AI and machine learning including balanced trees, tries, suffix trees, k-d trees, and quad trees. Sparse data representations, tensor-based storage models, and memory-efficient data structures for large-scale AI applications. Feature indexing, nearest neighbor search, similarity search, and computational aspects of high-dimensional data processing.

RBT Levels: L1, L2, L3

15hours

UNIT-II

Graph Algorithms and Intelligent Search: Graph-based data structures and algorithms for AI applications including graph traversal, shortest path algorithms, connectivity analysis, and network flow concepts. Knowledge graphs, semantic networks, and graph representations for intelligent reasoning and recommendation systems. AI search techniques including heuristic search, best-first search, A* algorithm, beam search, local search, and state-space exploration methods. Optimization techniques for intelligent systems including constraint satisfaction problems, gradient-based optimization, simulated annealing, and genetic algorithms.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Scalable Machine Learning and Distributed AI Systems: Data structures and computational models for scalable machine learning including sparse matrices, tensors, feature embeddings, and high-dimensional data representations. Computational aspects of clustering, classification, regression, and deep learning algorithms. Streaming algorithms, online learning concepts, and distributed machine learning frameworks. Parallel and GPU-aware computing for AI applications, with case studies in natural language processing, computer vision, predictive analytics, and real-time intelligent systems, emphasizing efficient and ethical AI computation.

RBT Levels: L1, L2, L3, L4

15 hours.



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Data Structures and Algorithms for AI Laboratory:

1. **Implementation of Priority Queue for AI Task Scheduling:** Develop a priority queue using heaps to simulate task scheduling in intelligent systems and compare insertion and deletion complexities.
2. **Graph Traversal for Knowledge Representation:** Implement Breadth First Search (BFS) and Depth First Search (DFS) on graph datasets representing social or semantic networks.
3. **A Search Algorithm for Path Finding*:** Design and implement the A* search algorithm for shortest path identification in maze solving or robotic navigation applications.
4. **Trie-Based Word Prediction System:** Develop a trie data structure for autocomplete and predictive text applications used in natural language processing systems.
5. **k-d Tree for Nearest Neighbor Search:** Implement a k-d tree to perform nearest neighbor searches for multidimensional datasets used in recommendation systems.
6. **Genetic Algorithm for Optimization Problems:** Implement a genetic algorithm to solve optimization problems such as function minimization or route optimization.
7. **Bloom Filter for Fast Membership Checking:** Develop a bloom filter and analyze false positive rates for large-scale AI data retrieval applications.
8. **Mini Recommendation System Using Graph Algorithms:** Build a recommendation engine using graph similarity or collaborative filtering techniques on sample user-item datasets.
9. **Streaming Data Processing using Sliding Window Algorithms :** Implement streaming algorithms for real-time analytics such as moving average computation or anomaly detection.
10. **Performance Comparison of Search Algorithms:** Compare BFS, DFS, Hill Climbing, and A* algorithms based on execution time, memory usage, and path optimality for AI search problems.

TEXT BOOKS

1. Introduction to Algorithms, MIT Press, 4th Edition, 2022.
2. Algorithms, Addison-Wesley, 4th Edition, 2011..
3. Artificial Intelligence: A Modern Approach, Pearson, 4th Edition, 2021..
4. Data Structures and Algorithm Analysis in C++, Pearson, 4th Edition, 2014.

REFERENCE BOOKS

1. Algorithm Design, Pearson, 2nd Edition, 2013.
2. Mining Massive Datasets, Cambridge University Press, 3rd Edition, 2020.
3. Advanced Data Structures, Cambridge University Press, 2008.



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Research Methodology and Intellectual Property Rights (IPR)

Semester :	I	Internal Assessment :	30
Course Code :	PAMCA10300	End Sem. Exam :	45
Teaching Hours/Week (L:T:P) :	2:0:2	Exam Duration (Hours) :	1.5
Credits : 3			

COURSE OUTCOMES

Basic knowledge of Writing , Grammer , English and other aspects of Editing Softwares.

After completing this Course, the students should be able to:

1. Identify and formulate research problems in Artificial Intelligence and Machine Learning.
2. Conduct systematic literature surveys using scientific databases and citation tools.
3. Analyze experimental and research data using statistical and computational methods.
4. Demonstrate ethical research practices and plagiarism-free technical writing.
5. Understand patent drafting, filing procedures, copyrights, trademarks, and technology commercialization.

UNIT-I

Research Methodology : Introduction to Research, Types of Research, Research Process Defining Research Problem & Research Gap Identification ,Literature Review & Research Design ,Sampling Concepts & Data Collection Methods ,Measurement, Data Processing & Statistical Analysis ,Hypothesis Testing (t-test, Chi-square, ANOVA basics) ,Interpretation of Results & Report Writing(LaTeX basics, referencing styles, abstract writing, and presentation skills) ,Research Ethics, Plagiarism & Publication Process.

RBT Levels: L1, L2, L3,L4

15 hours

UNIT-II

Intellectual Property Rights: Introduction to Intellectual Property Rights (IPR), patents, copyrights, trademarks, software patents, Patents and Filing of Patents, Indian Patent System, Patent Specification Provisional and Complete Specifications; Structure of a Patent Specification—Title, Abstract, Description, Claims, Detailed procedure for Filing of Patents in India with suitable Case Studies .

RBT Levels: L1, L2, L3, L4

15 hours

List of Experiments Suggested:

1. Identification and formulation of a research problem in AI/ML.
2. Conducting literature review using IEEE Xplore, Scopus, Google Scholar, and ACM Digital Library.
3. Bibliometric and citation analysis using Mendeley/Zotero.
4. Plagiarism checking using Turnitin/Open-source tools.
5. Preparation of research paper in IEEE format using LaTeX/Overleaf.
6. Statistical analysis and visualization using Python/SPSS/MATLAB.
7. Preparation of a mini research proposal.
8. Patent prior-art search using Google Patents/WIPO/Indian Patent Database.
9. Drafting of a sample patent document related to AI/ML innovation.
10. Seminar presentation and viva on emerging AI research trends.



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TEXT BOOKS

1. C. R. Kothari and Gaurav Garg, Research Methodology: Methods and Techniques, New Age International.
2. T. Ramappa, Intellectual Property Rights under WTO, S. Chand.
3. Deborah E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets, Cengage Learning.

REFERENCE BOOKS

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in the New Technological Age.
2. Daniel Jurafsky and James H. Martin, Speech and Language Processing (for AI research case studies).
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. WIPO Intellectual Property Handbook.
5. IEEE Author Center Guidelines for Research Publications.

ONLINE RESOURCES

1. NPTEL – Research Methodology: <https://nptel.ac.in/courses/109105115>
2. WIPO Academy Courses: <https://www.wipo.int/en/web/wipo-academy/>
3. IEEE Author Resources: <https://journals.ieeeauthorcenter.ieee.org/>
4. Elsevier Researcher Academy: <https://researcheracademy.elsevier.com/>
5. Nptel : https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr25_ed87



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Big Data Analytics and Data Engineering

Semester :	I	Internal Assessment :	40
Course Code :	PAMCL10400	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits: 4			

PREREQUISITES

Machine Learning, Python programming and Database Management Systems

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Develop and analyze advanced deep learning architectures, including convolutional neural networks Design and implement scalable big data architectures using distributed computing frameworks and data engineering pipelines for processing structured, semi-structured, and unstructured data.
2. Apply advanced data analytics techniques, including machine learning, statistical modeling, and real-time stream processing, to extract actionable insights from large-scale datasets.
3. Develop and optimize data storage, ingestion, transformation, and retrieval mechanisms using technologies such as Hadoop, Spark, NoSQL databases, and cloud-based data platforms.
4. Evaluate the performance, reliability, security, and fault tolerance of big data systems while addressing challenges related to data governance, privacy, and scalability.
5. Analyze emerging trends and research advancements in big data analytics and data engineering, and propose efficient solutions for complex industrial and research-oriented applications.

UNIT-I

Big Data Foundations and Distributed AI Systems: Introduction to Big Data, characteristics, challenges, and analytics lifecycle. Structured, semi-structured, and unstructured data for AI applications. Distributed computing concepts including parallel processing, cluster computing, scalability, and fault tolerance. Hadoop ecosystem, HDFS architecture, MapReduce framework, YARN architecture, Introduction to MapReduce, Processing data with Hadoop using MapReduce, Introduction to YARN, Architecture, Managing Resources and Applications with Hadoop YARN.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Data Engineering and Scalable Processing for AI/ML: Data engineering concepts including data ingestion, ETL pipelines, data cleaning, transformation, and metadata management for machine learning systems. Apache Spark architecture, RDDs, DataFrames, Spark SQL, and Spark Streaming for distributed analytics. Big Data tools including Kafka, Flume, Sqoop, and workflow orchestration using Airflow/Oozie. Data lakes, lakehouse architecture, and cloud-based Big Data platforms for scalable AI and ML workloads.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Data Engineering and Analytics Tools: Power BI Overview of Business Intelligence (BI): Introduction to Business Intelligence, role of BI in Data Engineering and Analytics, data-driven decision making, BI ecosystem and architecture. Introduction to Power BI: Overview of Power BI platform, Power BI components, Power BI Desktop, Power BI Service, Power BI Mobile, Power BI Gateway, installation and configuration, Power BI workflow.

Introduction to Tableau: Overview of Tableau platform, Tableau Desktop, Tableau Server and Tableau Cloud, Tableau Public, Tableau ecosystem and workflow.

Connecting to Data Sources: Structured and unstructured data sources, database connectivity using SQL Server, MySQL, and PostgreSQL, working with Excel, CSV, JSON, and XML files, cloud-based data sources, data import and live connection techniques.

RBT Levels: L2, L3, L4

15 hours



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TEXT BOOKS

1. Tom White “Hadoop: The Definitive Guide” Third Edit on, O’reily Media, 2012.
2. Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015.
3. "Power Pivot and Power BI: The Excel User's Guide to DAX, Power Query, Power BI & Power Pivot" by Rob Collie and Avichal Singh (For Power BI and DAX)
4. "Tableau Your Data!: Fast and Easy Visual Analysis with Tableau Software" by Daniel G. Murray (For Tableau)

REFERENCE BOOKS

1. Mining of Massive Datasets – Cambridge University Press.
2. Data Mining: Concepts and Techniques – Elsevier.
3. Professional Hadoop Solutions – Wiley Publications.
4. Machine Learning with Spark – Packt Publishing.
5. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – O’Reilly Media.

Online Resources

1. Apache Spark Documentation – Official documentation for Spark SQL, MLlib, Streaming, and DataFrames. (Apache Spark)
2. Apache Hadoop Documentation – Official Hadoop ecosystem documentation including HDFS and MapReduce.
3. TensorFlow Tutorials – Official tutorials and hands-on notebooks for machine learning and deep learning applications. Community discussions also strongly recommend these tutorials for beginners and advanced learners. (Reddit)
4. MongoDB University – Free courses on NoSQL databases and data engineering.
5. Databricks Learning Platform – Tutorials and learning materials for Apache Spark and big data analytics.
6. Kaggle Learn – Practical exercises and datasets for machine learning and big data analytics.
7. Coursera Big Data Specialization – University-level online courses on Big Data technologies and analytics.
8. edX Data Engineering Courses – Professional courses on data engineering, analytics, and cloud platforms.



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Computer Vision & Image Processing

Semester :	I	Internal Assessment :	40
Course Code :	PAMCL10401	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Machine Learning, Python programming fundamentals

After completing this Course, the students should be able to:

- 1 Apply image processing techniques for enhancement, restoration, segmentation, and feature extraction in digital images.
- 2 Design and implement computer vision algorithms for object detection, recognition, tracking, and scene understanding.
- 3 Develop deep learning-based vision models using CNNs, transformers, and transfer learning techniques for real-world applications.
- 4 Evaluate image analysis and computer vision systems using appropriate performance metrics, optimization methods, and deployment strategies.
- 5 Analyze recent advancements and research trends in computer vision, including medical imaging, autonomous systems, and intelligent visual analytics.

UNIT-I

Fundamentals of Digital Image Processing and Visual Feature Engineering: Introduction to digital image processing, image representation, sampling, quantization, image acquisition systems, and visual perception fundamentals. Image enhancement techniques including histogram processing, contrast enhancement, spatial filtering, frequency domain filtering, Fourier transform, wavelet transform, image restoration, noise reduction, denoising, edge detection, morphological operations, and color image processing. Image compression techniques, feature extraction methods, texture analysis, shape analysis, corner and edge detection, feature descriptors including SIFT, SURF, ORB, HOG, and image registration techniques. Fundamentals of pattern recognition and image representation for intelligent vision systems. Introduction to OpenCV and AI-enabled image processing frameworks for large-scale visual data analytics. **Applications:** Medical imaging, industrial inspection, remote sensing, biometric systems, intelligent image retrieval, and visual analytics.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Deep Learning for Computer Vision and Intelligent Scene Understanding: Fundamentals of computer vision, image classification, object detection, object tracking, motion analysis, and scene understanding. Convolutional Neural Networks (CNNs), transfer learning, residual networks, EfficientNet, and attention-based vision architectures. Semantic segmentation, instance segmentation, region-based CNNs, YOLO, SSD, Mask R-CNN, and vision transformers (ViT). Sequence-based visual intelligence including video understanding, activity recognition, spatio-temporal modeling, and multimodal vision-language systems. Deep learning frameworks for computer vision including TensorFlow, PyTorch, OpenCV-DNN, and Hugging Face Vision models. Optimization techniques, hyperparameter tuning, data augmentation, model evaluation metrics, and GPU-aware vision computing. **Applications:** Autonomous vehicles, facial recognition, intelligent surveillance, smart healthcare imaging, robotics, and augmented reality systems.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Advanced Vision Systems, Generative AI, and Emerging Trends: Advanced computer vision systems including 3D vision, stereo imaging, depth estimation, SLAM, autonomous vision systems, intelligent robotics vision, and edge AI for real-time visual analytics. Video analytics, visual tracking, gesture recognition, human-computer interaction, and explainable AI for vision systems. Generative AI for computer vision including Generative Adversarial Networks (GANs), diffusion models, image synthesis, image captioning, visual question answering, multimodal generative systems, and Vision-Language Models (VLMs). Medical image analysis, cybersecurity vision analytics, drone vision systems, intelligent manufacturing, and AI-enabled smart city applications. Ethical issues in computer vision including privacy, bias, surveillance ethics, fairness, responsible AI, and trustworthy visual intelligence systems. Emerging trends including edge vision AI, federated computer vision, autonomous multimodal systems, embodied AI, and future directions in intelligent visual computing. **Applications:** Autonomous systems, healthcare diagnostics, AI surveillance systems, multimodal AI assistants, drone analytics, and smart infrastructure monitoring.

RBT Levels: L2, L3, L4

15 hours



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TEXT BOOKS

1. *Digital Image Processing* – Rafael C. Gonzalez and Richard E. Woods, Pearson.
2. *Computer Vision: Algorithms and Applications* – Richard Szeliski, Springer..
3. *Deep Learning for Computer Vision* – Rajalingappaa Shanmugamani, Packt Publishing.
4. *Learning OpenCV* – Gary Bradski and Adrian Kaehler, O'Reilly Media.

REFERENCE BOOKS

1. *Computer Vision: A Modern Approach* – David A. Forsyth and Jean Ponce, Pearson..
2. *Multiple View Geometry in Computer Vision* – Richard Hartley and Andrew Zisserman, Cambridge University Press..
3. *Programming Computer Vision with Python* – Jan Erik Solem, O'Reilly Media.
4. *Hands-On Computer Vision with TensorFlow 2* – Packt Publishing.
5. *Deep Learning* – Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press.

Reinforcement Learning



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Semester :	II	Internal Assessment :	40
Course Code :	PAMCL20501	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	3.0
Credits: 4			

PREREQUISITES

Machine Learning, Probability and Statistics, Linear Algebra, Python Programming, and basic knowledge of Optimization Techniques.

COURSE OUTCOMES

After completing this Course, the students should be able to:

- Understand the fundamentals of reinforcement learning and recognize how it complements other ML techniques.
- Acquire knowledge of different RL algorithms and apply them in practical applications
- Learn to model tasks as reinforcement learning problems within the framework of Markov Decision Processes and develop solutions
- Implement RL algorithms using a scientific programming language

UNIT-I

Fundamentals of Reinforcement Learning

Introduction to Reinforcement Learning, relationship with supervised and unsupervised learning, applications and challenges, elements of reinforcement learning, agent-environment interaction, rewards and returns, exploration and exploitation, multi-armed bandit problem, action-value methods, optimistic initialization, Upper Confidence Bound (UCB), gradient bandit methods, Markov Decision Processes (MDPs), policies and value functions, optimal policies and optimal value functions, Bellman equations, and Dynamic Programming including policy evaluation, policy improvement, policy iteration, and value iteration.

RBT Levels: L2,L3,L4

UNIT-II

Model-Free Reinforcement Learning

Monte Carlo methods for prediction and control, on-policy and off-policy learning, importance sampling, Temporal Difference learning, TD prediction, SARSA, Q-learning, Double Q-learning, n-step Temporal Difference methods, n-step SARSA, planning and learning with tabular methods, model-based reinforcement learning, and an introduction to Monte Carlo Tree Search.

RBT Levels: L3, L4

UNIT-III

Function Approximation and Deep Reinforcement Learning

Function approximation, value function approximation, linear and nonlinear approximation methods, stochastic gradient and semi-gradient methods, eligibility traces, TD(λ), SARSA(λ), policy gradient methods, Actor-Critic methods, Deep Reinforcement Learning, Deep Q-Networks (DQN), Double DQN, and applications of reinforcement learning in robotics, autonomous systems, gaming, and intelligent decision-making.

RBT Levels: L3, L4.

List of Experiments Suggested:

- Study and Installation of Reinforcement Learning Libraries using Python (NumPy, Gymnasium/OpenAI Gym)
- Implementation of Multi-Armed Bandit Problem using ϵ -Greedy Method
- Simulation of Markov Decision Process (MDP) for Simple Grid World Problem
- Implementation of Value Iteration Algorithm for Optimal Policy Selection
- Implementation of Policy Iteration Algorithm in Finite State Environment
- Implementation of Temporal Difference (TD) Learning for Value Prediction
- Implementation of Monte Carlo Prediction Method for Reward Estimation
- Implementation of Q-Learning Algorithm for Maze/Grid Navigation Problem



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9. Implementation of SARSA Algorithm and Comparison with Q-Learning
10. Implementation of Simple Actor-Critic Method using Function Approximation

TEXT BOOKS

1. Sutton and Barto, Reinforcement Learning: An Introduction, The MIT Press Cambridge, Massachusetts London, England, 2015
1. Csaba Szepesvari, Algorithms for Reinforcement Learning, Morgan & Claypool, United States, 2010.

REFERENCE BOOKS

2. Xiao, Z. (2024). Reinforcement Learning: Theory and Python Implementation. Springer, 2024, ISBN 9789811949326.
3. Li, S. E. Reinforcement Learning for Sequential Decision and Optimal Control. 2024, ISBN 9789811689093.

ONLINE RESOURCES

1. NPTEL – https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs81.



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Internet of Things Architecture & Systems

Semester :	I	Internal Assessment :	40
Course Code :	PAMCL10402	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Machine Learning, Python programming fundamentals

After completing this Course, the students should be able to:

1. Understand IoT architecture and enabling technologies.
2. Analyze communication protocols and networking models for IoT systems.
3. Design secure and scalable IoT-based intelligent applications.
4. Apply cloud, edge, and analytics techniques for IoT data processing.
5. Develop integrated IoT solutions for real-world industrial and societal applications.

UNIT-I

Architectures and Intelligent System Foundations Introduction to Internet of Things (IoT), characteristics, enabling technologies, and IoT ecosystem. IoT architecture models including three-layer, five-layer, and cloud-centric architectures. Components of IoT systems: sensors, actuators, embedded controllers, gateways, and middleware platforms. Smart objects, machine-to-machine communication, cyber-physical systems, wearable devices, interoperability requirements, and scalable IoT design principles. Overview of industrial IoT applications and intelligent connected systems.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

IoT Communication Protocols and Intelligent Data Processing: IoT communication models and networking technologies including RFID, NFC, ZigBee, Bluetooth Low Energy, Wi-Fi, LoRaWAN, and cellular IoT. IPv6 addressing mechanisms and application layer protocols such as MQTT, CoAP, AMQP, HTTP, and WebSocket. Routing, quality of service, and energy-efficient communication in constrained IoT environments. Edge and fog computing concepts, IoT platforms including Arduino, Raspberry Pi, and ESP32, sensor data acquisition, cloud integration, and IoT data analytics for intelligent decision-making.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Intelligent IoT Systems, Security, and Emerging Applications: Security and privacy in IoT systems including authentication, encryption, access control, secure communication, blockchain concepts, and trust management. Integration of Artificial Intelligence and Machine Learning with IoT systems for predictive analytics and autonomous decision-making.. Emerging trends including Industrial IoT, digital twins, 5G-enabled IoT, sustainable IoT architectures, and autonomous connected systems..

RBT Levels: L2, L3, L4

15 hours

TEXT BOOKS

- 1 Internet of Things: A Hands-On Approach, Universities Press, 1st Edition, 2014.
- 2 Internet of Things, MIT Press, 2015.
- 3 Designing the Internet of Things, Wiley, 2nd Edition, 2014.
- 4 Building the Internet of Things, Wiley, 2016.

REFERENCE BOOKS

- 1 Architecting the Internet of Things, Springer, 2011.
- 2 IoT Fundamentals, Cisco Press, 2017.
- 3 Practical Internet of Things Security, Packt Publishing, 2016.
- 4 Fundamentals of Wireless Sensor Networks, Wiley, 2010.



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Foundations of Cyber Security & Cryptography

Semester :	I	Internal Assessment :	40
Course Code :	PAMCL10403	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Python Programming, Machine Learning Fundamentals, Computer Networks, Operating Systems, Basics of Linear Algebra and Probability.

After completing this Course, the students should be able to:

1. Analyze the fundamental concepts of cyber security including confidentiality, integrity, availability, cryptography, authentication, digital signatures, certificates, SSL/TLS, and secure communication protocols..
2. Apply cryptographic algorithms, key exchange mechanisms, hash functions, and public/private key systems to design secure communication and data protection solutions.
3. Evaluate advanced security protocols such as Zero Knowledge Proofs, Secure Multi-party Computation, SSH, IP Security, Wireless LAN Security, and Electronic Mail Security for real-world cyber defense applications.
4. Implement AI and machine learning techniques for cyber security applications including intrusion detection, malware analysis, anomaly detection, and intelligent threat prediction.
5. Design and develop secure AI-enabled cyber security solutions using cryptographic libraries, secure protocols, and intelligent analytics for modern networked environments..

UNIT-I

Security Concepts: Confidentiality, Integrity, and Availability, Cryptography, Confusion vs Diffusion, Stream vs Block ciphers, Private-Key vs Public Key Cryptography, Cryptanalysis. Feistel Networks and Non Feistel Networks, Key Exchange, Public Key Encryption systems. Hash Functions, Message Digest, Signing and Verification, X509 certificates, SSL, TLS, HTTPS, Open SSL.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Introduction to AI for Cyber security Applying AI in cyber security, The evolution from expert systems to data mining and AI, The different forms of automated learning, The characteristics of algorithm training and optimization, Introducing AI in the context of cyber security

RBT Levels: L2, L3, L4

15 hours

UNIT-III

Advanced Protocols: Zero knowledge Proofs, Identity based public key, Secure elections, Secure multi-party computation, Digital cash. Secure Socket Layer: Web Traffic Security Approaches SSL Architecture, SSL Handshake Protocol, SSL Handshake Protocol Actions, Handshake Messages, Security Capability Negotiation, Cryptographic Computations, SSL Change Cipher Spec Protocol, SSL Alert Protocol, SSL Record Protocol Services, SSL Record Protocol Operation. Transport Level Security (TLS): HTTPS, HTTPS Use, Secure Shell (SSH), SSH Protocol Stack, SSH Transport Layer Protocol, SSH User Authentication Protocol, SSH Connection Protocol, Port Forwarding. Wireless Network Security: Wireless Network Threats, Countermeasures Mobile Device Security Wi-Fi Operation IEEE 802.11 Architecture IEEE 802.11 Services Wired Equivalent Privacy (WEP), 802.11i Wireless LAN Security. Electronic Mail Security, IP Security, Intrusion Detection, Malicious Software.

RBT Levels: L3, L4, L5

15 hours



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List of Experiments Suggested:

- RSA)
1. Implementation of Classical and Modern Cryptographic Algorithms (Caesar Cipher, Vigenère Cipher, AES, DES,
 2. Implementation of Hash Functions and Digital Signature Verification using SHA-256/SHA-512
 3. SSL/TLS and HTTPS Configuration with Secure Web Communication Analysis
 4. Public Key Infrastructure (PKI) and X.509 Certificate Generation and Verification
 5. Wireless Network Security Analysis using WEP/WPA/WPA2 and Packet Monitoring
 6. Development of AI-based Intrusion Detection System (IDS) using Machine Learning Algorithms
 7. Malware Detection and Classification using Machine Learning Techniques
 8. Network Traffic Analysis and Intrusion Detection using Wireshark and AI Techniques

TEXT BOOKS

1. William Stallings, Cryptography and Network Security: Principles and Practice, Pearson.
2. Nina Godbole and Sunit Belapure, Cyber Security, Wiley.
3. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography.
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
5. Alessandro Parisi, Hands-On Artificial Intelligence for Cyber security: Implement smart AI systems for preventing cyber attacks and detecting threats and network anomalies, Packt Publication

REFERENCE BOOKS

1. Ross Anderson, Security Engineering, Wiley.
2. Bruce Schneier, Applied Cryptography, Wiley.
3. Michael T. Goodrich and Roberto Tamassia, Introduction to Computer Security.
4. Nicolas Papernot et al., Adversarial Machine Learning.
5. Ian Foster et al., Trustworthy AI Systems.

ONLINE RESOURCES

1. NPTEL – Cyber Security: <https://nptel.ac.in/courses/106105217>
2. Stanford Cryptography Course: <https://crypto.stanford.edu/~dabo/courses/OnlineCrypto/>
3. OWASP Foundation: <https://owasp.org/>
4. TensorFlow Privacy: https://www.tensorflow.org/responsible_ai/privacy/guide
5. IBM Adversarial Robustness Toolbox: <https://adversarial-robustness-toolbox.org/>
6. OpenSSL Documentation: <https://www.openssl.org/docs/>



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Seminar

Semester	:	I	Internal Assessment	:	20
Course Code	:	PAMRS10400	End Sem. Exam	:	30
Teaching Hours/Week (L:T:P)	:	0:0:4	Exam Duration (Hours)	:	2
Credits: 2					

PREREQUISITES

Basic knowledge of Research Methodology, and Technical Communication Skills.

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Identify emerging technologies and recent research trends in Artificial Intelligence and Machine Learning domains.
2. Perform literature surveys and analyze technical research papers related to selected seminar topics.
3. Develop technical presentation, communication, and documentation skills for presenting advanced technological concepts.
4. Evaluate and present innovative ideas related to future mini projects, dissertation work, internships, or research areas.

Guidelines

Technical Seminar is intended to provide students with exposure to emerging technologies, recent research trends, and advanced applications in the field of Artificial Intelligence and Machine Learning. In this course, each student shall individually select one technical topic, preferably in the area in which they intend to carry out their future project/ dissertation, internship, startup idea, or research work.

Students are expected to study the selected topic through literature survey, research papers, technical articles, case studies, and online resources. Based on the study, students shall analyze existing methodologies, identify research gaps, challenges, and future scope, and present their understanding through seminar presentations and technical documentation.

Students shall prepare:

- Seminar abstract
- Literature survey
- PPT presentation
- Technical report/documentation
- Final seminar presentation and viva



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Deep Learning

Semester	:	II	Internal Assessment	:	40
Course Code	:	PAMCC20500	End Sem. Exam	:	60
Teaching Hours/Week (L:T:P)	:	3:0:2	Exam Duration (Hours)	:	2.5
Credits : 4					

COURSE OUTCOMES

Machine Learning, Python programming fundamentals

After completing this Course, the students should be able to:

1. Develop and analyze advanced deep learning architectures, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), transformers, and autoencoders for complex engineering applications.
2. Design, implement, and optimize deep learning models using modern frameworks such as TensorFlow and PyTorch for tasks involving image processing, natural language processing, and time-series analysis.
3. Evaluate the performance of deep learning models using appropriate metrics, hyperparameter tuning techniques, regularization methods, and validation strategies to improve generalization and efficiency.
4. Apply deep learning techniques to solve real-world research and industrial problems involving large-scale datasets, feature extraction, representation learning, and intelligent decision-making systems.
5. Critically analyze recent advancements, research trends, ethical considerations, and deployment challenges in deep learning, including explainable AI, model interpretability, and computational resource management.

UNIT-I

Foundations of Deep Learning and Neural Network Architectures: Introduction to Artificial Intelligence, Machine Learning, Deep Learning, and Representation Learning. Mathematical foundations for deep learning including linear algebra, probability, optimization, and gradient-based learning. Computational graphs and automatic differentiation. Introduction to TensorFlow, PyTorch, Keras, and GPU-enabled deep learning environments. Linear classifiers, loss functions, gradient descent, stochastic gradient descent, momentum, Adam, and learning rate scheduling.

Artificial Neural Networks: Perceptron, multilayer perceptron, backpropagation algorithm, activation functions including Sigmoid, Tanh, ReLU, Leaky ReLU, GELU, and Softmax. Weight initialization, normalization methods, regularization techniques, dropout, batch normalization, vanishing and exploding gradient problems, optimization challenges, and model evaluation metrics. Introduction to representation learning, embedding techniques, feature learning, and hyperparameter optimization for scalable AI systems

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Advanced Deep Learning Models for Vision and Sequential Intelligence: Convolutional Neural Networks (CNNs): convolution operations, pooling methods, padding, stride, feature extraction, transfer learning, residual networks, DenseNet, EfficientNet, and attention mechanisms in computer vision. Deep learning techniques for image classification, image segmentation, object detection, facial recognition, and video analytics. Recurrent Neural Networks (RNNs): sequence modeling, unfolded RNNs, Backpropagation Through Time (BPTT), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), encoder-decoder architectures, Seq2Seq learning, attention mechanisms, and sequence prediction.

Transformer Architectures: self-attention, multi-head attention, positional encoding, BERT, GPT, Vision Transformers (ViT), and large language models (LLMs). Applications in Natural Language Processing including sentiment analysis, machine translation, text summarization, speech recognition, and conversational AI systems.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

Generative AI, Reinforcement Learning, and Scalable Deep Learning Systems: Autoencoders, sparse autoencoders, denoising autoencoders, variational autoencoders (VAE), and representation learning techniques. Generative Adversarial Networks (GANs), conditional GANs, diffusion models, and synthetic data generation. Deep Reinforcement Learning concepts including Markov Decision Processes (MDP), Q-learning, Deep Q Networks (DQN), policy gradient methods, actor-critic models, and intelligent autonomous systems. Scalable Deep Learning Systems: distributed deep learning, parallel processing, GPU/TPU-aware computing, model compression, pruning, quantization, federated learning, edge AI, and cloud-based AI deployment.



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Explainable AI (XAI), interpretability, fairness, bias mitigation, ethical AI principles, privacy-preserving deep learning, and energy-efficient AI computing. Case studies in healthcare AI, autonomous systems, cybersecurity analytics, recommendation systems, generative AI applications, and predictive analytics.

RBT Levels: L2, L3, L4**15 hours**

List of Experiments Suggested:

1. Implementation of Multilayer Perceptron (MLP) for classification problems.
2. CNN-based image classification using CIFAR-10 or custom datasets.
3. Transfer learning using ResNet, VGG16, or EfficientNet.
4. Object detection using YOLO or Faster R-CNN.
5. Sequence prediction using RNN, LSTM, and GRU models.
6. Sentiment analysis using transformer-based architectures such as BERT.
7. Autoencoder-based dimensionality reduction and anomaly detection.
8. Generative image synthesis using GANs or diffusion models.
9. Transformer-based language modeling and text summarization.
10. Deep Reinforcement Learning using DQN or policy gradient methods.
11. Federated learning and distributed training experiments.
12. Explainable AI and model interpretability analysis.

TEXT BOOKS

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville — Deep Learning, MIT Press.
2. Francois Chollet — Deep Learning with Python, Manning Publications.
3. Christopher Bishop — Pattern Recognition and Machine Learning, Springer

REFERENCE BOOKS

1. Charu C. Aggarwal — Neural Networks and Deep Learning, Springer.
2. Dive into Deep Learning — Aston Zhang et al.
3. Richard S. Sutton and Andrew G. Barto — Reinforcement Learning: An Introduction.
4. Jurafsky and Martin — Speech and Language Processing.

ONLINE RESOURCES

1. NPTEL – Deep Learning: https://onlinecourses.nptel.ac.in/noc25_cs81/
2. TensorFlow Official Documentation: <https://www.tensorflow.org/learn>
3. PyTorch Official Tutorials: <https://docs.pytorch.org/tutorials/>
4. Stanford University – CS231n: Convolutional Neural Networks for Visual Recognition: <https://cs231n.stanford.edu/>
5. DeepLearning.AI Specialization: <https://www.deeplearning.ai/specializations/deep-learning>



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Natural Language Processing

Semester :	II	Internal Assessment :	40
Course Code :	PAMCC20501	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Python Programming, Data Structures and Algorithms, Probability and Statistics, Machine Learning Fundamentals, Linear Algebra
After completing this Course, the students should be able to:

1. Analyse linguistic structures and implement preprocessing techniques for NLP applications.
2. Develop statistical, deep learning, and transformer-based NLP models for intelligent text processing.
3. Design advanced NLP systems using embeddings, attention mechanisms, and large language models.
4. Apply generative AI and conversational intelligence techniques for real-world AI applications.
5. Evaluate ethical, scalable, and explainable NLP systems for multilingual and domain-specific applications.

UNIT-I

Foundations of NLP and Statistical Language Processing

Introduction to NLP: Introduction to Natural Language Processing, Challenges in NLP and ambiguity in natural language, Multilingual and Indian language processing, NLP pipeline and applications, Basics of computational linguistics, Syntax, semantics, and pragmatics

Text Preprocessing and Linguistic Analysis: Tokenization, Stemming and lemmatization, Stop-word removal and text normalization, Spelling correction, Regular expressions, Morphological analysis, Word classes, Part-of-Speech (POS) tagging: rule-based and statistical approaches.

Language Modeling and Information Retrieval: Grammar-based and statistical language models, N-gram models and smoothing techniques, Hidden Markov Models (HMM), Introduction to neural language models, Basics of Information Retrieval and semantic search

Applications: Search engines, intelligent assistants, document processing, and text analytics.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Deep Learning and Transformer Architectures for NLP

Representation Learning: Distributed representations, Word embeddings: Word2Vec, GloVe, FastText, Contextual embeddings

Deep Learning for NLP: Artificial Neural Networks (ANN), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Sequence-to-Sequence (Seq2Seq) models, Attention mechanisms

Transformers and Generative AI: Transformer architecture, Self-attention and multi-head attention, Positional encoding, Pretraining and transfer learning, BERT and GPT models, Introduction to Large Language Models (LLMs), Prompt engineering and Retrieval-Augmented Generation (RAG)

Applications: Machine translation, text summarization, sentiment analysis, chatbots, and question-answering systems.

RBT Levels: L2, L3, L4

15 hours

UNIT-III

Intelligent NLP Systems and Emerging Trends

Syntactic and Semantic Analysis: Context-Free Grammar (CFG), Constituency and dependency parsing, Named Entity Recognition (NER), Semantic Role Labeling (SRL), Relation extraction

Text Analytics and Information Retrieval: Latent Semantic Analysis (LSA), Semantic similarity, Text classification, Vector Space Model, Information Retrieval systems, Ranking and evaluation metrics

NLP Resources and Emerging Trends: WordNet and multilingual corpora, Knowledge graphs (overview), Multimodal AI and conversational AI, Responsible AI, bias, and AI safety, Case studies of Large Language Models and AI assistants

Applications: AI-powered search, recommendation systems, healthcare analytics, legal analytics, and conversational AI.

RBT Levels: L3, L4, L5

15 hours



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List of Experiments Suggested:

1. Text preprocessing and tokenization using NLTK/spaCy.
2. POS tagging and morphological analysis.
3. N-gram language modeling and smoothing techniques.
4. Named Entity Recognition (NER) implementation.
5. Dependency parsing and semantic analysis.
6. Word embedding generation using Word2Vec and FastText.
7. Text classification using deep learning models.
8. Sentiment analysis using LSTM and transformer models.
9. Transformer-based text summarization using BERT/T5.
10. Chatbot and question-answering system implementation.
11. Retrieval-Augmented Generation (RAG) based NLP application.
12. Fine-tuning Large Language Models for domain-specific tasks.

TEXT BOOKS

1. Daniel Jurafsky and James H. Martin, Speech and Language Processing, Pearson.
2. Christopher Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, MIT Press.
3. Jacob Eisenstein, Introduction to Natural Language Processing, MIT Press.
4. Delip Rao and Brian McMahan, Natural Language Processing with PyTorch, O'Reilly.

REFERENCE BOOKS

1. Yoav Goldberg, Neural Network Methods for Natural Language Processing.
2. Lewis Tunstall, Leandro von Werra, Thomas Wolf, Natural Language Processing with Transformers, O'Reilly.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. Sebastian Raschka, Build a Large Language Model from Scratch, Manning.

ONLINE RESOURCES

1. Steven Bird, Ewan Klein, Edward Loper, Natural Language Processing with Python, O'Reilly. Stanford CS224N – NLP with Deep Learning: <https://web.stanford.edu/class/cs224n/>
2. Hugging Face NLP Course: <https://huggingface.co/learn/llm-course/chapter1/1>
3. NPTEL – Natural Language Processing: <https://nptel.ac.in/courses/106106211>
4. spaCy Documentation: <https://spacy.io/usage>
5. TensorFlow NLP Tutorials: <https://www.tensorflow.org/text/tutorials>



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Applied Artificial Intelligence

Semester :	II	Internal Assessment :	40
Course Code :	PAMCC20502	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Machine Learning, Python Programming, Data Structures, Probability & Statistics

After completing this Course, the students should be able to:

1. Understand fundamental concepts, tools, and frameworks of Applied AI.
2. Analyze AI applications in healthcare, agriculture, and smart systems.
3. Design AI-based models for finance, cybersecurity, and industrial applications.
4. Evaluate emerging AI technologies and propose domain-specific intelligent solutions

UNIT-I

Foundations and AI Development Frameworks: Evolution and scope of Artificial Intelligence, AI vs Machine Learning vs Deep Learning, and AI development lifecycle. Data-driven intelligent systems, AI ecosystems, and AI frameworks. AI tools and platforms including TensorFlow, PyTorch, Keras, and Scikit-learn. Explainable AI, Responsible AI, ethical challenges, Agentic AI and future trends in Applied AI.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

AI Applications in Healthcare, Agriculture, and Smart Systems: AI applications in healthcare including disease prediction, diagnosis, medical image analysis, smart patient monitoring, telemedicine, and wearable systems. Precision agriculture using AI for crop prediction, yield analysis, soil monitoring, irrigation management, and pest detection using computer vision. AI applications in smart cities, intelligent transportation systems, drone analytics, and satellite image processing.

RBT Levels: L2, L3, L4

15 hours

UNIT-III

Advanced AI Applications and Emerging Technologies: AI applications in banking, fintech, fraud detection, risk assessment, and cybersecurity including anomaly and malware detection. AI-driven Industry 4.0 applications such as intelligent robotics, automation, predictive maintenance, and industrial monitoring. Generative AI, Large Language Models (LLMs), recommendation systems, AI chatbots, Edge AI, TinyML, autonomous systems, and AI applications in governance, education, multimedia, and environmental monitoring. Research challenges and future directions in Applied AI.

RBT Levels: L3, L4, L6.

15 hours

List of Experiments Suggested:

As a part of practical implementation, students shall individually develop a mini project related to Applied Artificial Intelligence. The project shall include problem identification, literature survey, dataset collection, preprocessing, AI model development, training and testing, performance evaluation, result analysis, and final demonstration/presentation.

Sample Mini Project Titles (but not limited to):

- AI-Based Disease Prediction System
- Smart Crop Disease Detection using Deep Learning
- AI Chatbot for Student Assistance
- Fraud Detection using Machine Learning
- Face Recognition Attendance System
- AI-Based Traffic Monitoring System



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- Medical Image Classification using CNN
- Stock Market Prediction using AI
- AI-Based Recommendation System
- Smart Irrigation System using AI and IoT
- Sentiment Analysis using Natural Language Processing
- Spam Email Detection using Machine Learning
- AI-Powered Resume Screening System
- Intrusion Detection System using AI
- AI-Based Video Surveillance System
- Predictive Maintenance for Industrial Equipment
- AI-Based Weather Forecasting System
- Handwritten Digit Recognition using Deep Learning
- AI-Based Voice Assistant
- Generative AI-Based Content Creation System

TEXT BOOKS

1. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press
3. Andreas C. Muller and Sarah Guido, *Introduction to Machine Learning with Python*, O'Reilly.
4. Bernard Marr, *Artificial Intelligence in Practice*, Wiley.
5. Denis Rothman, *Hands-On Artificial Intelligence for Beginners*, Packt Publication.

REFERENCE BOOKS

1. Tom M. Mitchell, *Machine Learning*, McGraw Hill.
2. Ethem Alpaydin, *Introduction to Machine Learning*, MIT Press.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements of Statistical Learning*, Springer.
4. Sandro Skansi, *Introduction to Deep Learning*, Springer..

ONLINE RESOURCES

1. NPTEL – <https://nptel.ac.in/courses/108103192>.
2. Coursera- <https://www.coursera.org/specializations/ai-for-medicine>.



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MLOps and AI Deployment

Semester	:	II	Internal Assessment	:	40
Course Code	:	PAMCL20500	End Sem. Exam	:	60
Teaching Hours/Week (L:T:P)	:	3:0:2	Exam Duration (Hours)	:	2.5
Credits : 4					

COURSE OUTCOMES

Machine Learning, Python programming fundamentals

After completing this Course, the students should be able to:

1. Design and implement scalable MLOps pipelines for development, training, testing, deployment, and monitoring of AI models.
2. Apply containerization, orchestration, and cloud technologies for reliable deployment and management of machine learning applications.
3. Develop automated workflows for continuous integration, continuous delivery (CI/CD), model versioning, and reproducible AI systems.
4. Evaluate model performance, monitoring strategies, security, and governance mechanisms for production-grade AI systems.
5. Analyze emerging trends in MLOps, responsible AI, edge deployment, and AI lifecycle management for industrial applications.

UNIT-I

Foundations of MLOps and AI Lifecycle Management: Introduction to MLOps and AI deployment, machine learning system lifecycle, DevOps and MLOps principles, challenges in production AI systems, data preparation and feature engineering pipelines, experiment tracking, model training and validation, reproducibility, model versioning, and collaborative AI development using Git, MLflow, and Data Version Control (DVC).

RBT Levels: L1, L2, L3

15 hours

UNIT-II

AI Model Deployment and Cloud-Native Infrastructure: Model deployment strategies for batch and real-time inference, API development using Flask and FastAPI, containerization using Docker, orchestration concepts with Kubernetes, model serving using TensorFlow Serving, TorchServe, and ONNX Runtime, microservices architecture for AI applications, and introduction to AI deployment on AWS, Microsoft Azure, and Google Cloud Platform.

RBT Levels: L1, L2, L3, L4

15 hours

UNIT-III

UNIT III: MLOps Automation, Monitoring, and Responsible AI: Continuous Integration and Continuous Deployment (CI/CD) for machine learning systems, workflow orchestration using Kubeflow and Apache Airflow, automated model retraining, model monitoring and observability, data drift and concept drift detection, AI security, governance, explainable and responsible AI practices, and industrial case studies in healthcare, finance, IoT, and smart manufacturing, including an overview of emerging trends in generative AI and distributed AI deployment.

RBT Levels: L2, L3, L4

15 hours

TEXT BOOKS



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1. Practical MLOps – Noah Gift and Alfredo Deza, O'Reilly Media.
2. Machine Learning Engineering with Python – Andrew P. McMahon, Packt Publishing.
3. Building Machine Learning Pipelines – Hannes Hapke and Catherine Nelson, O'Reilly Media.
4. Introducing MLOps – Mark Treveil and contributors, O'Reilly Media.

REFERENCE BOOKS

1. Designing Machine Learning Systems – Chip Huyen, O'Reilly Media.
2. Machine Learning Design Patterns – O'Reilly Media.
3. Kubeflow for Machine Learning – Trevor Grant et al., O'Reilly Media.
4. Hands-On MLOps with MLflow – Packt Publishing.
5. Data Science on AWS – O'Reilly Media.



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Edge AI & Intelligent IoT Systems

Semester :	II	Internal Assessment :	40
Course Code :	PAMCL20502	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits: 4			

COURSE OUTCOMES

Machine Learning, Python programming fundamentals

After completing this Course, the students should be able to:

1. Understand the architecture and components of Edge AI systems.
2. Apply lightweight AI models and optimization techniques on edge devices.
3. Analyze communication and security mechanisms in intelligent IoT systems.
4. Design scalable and real-time Edge AI applications for smart environments.
5. Develop efficient and secure intelligent IoT solutions using distributed AI techniques.

UNIT-I

Fundamentals of Edge AI and Intelligent IoT Architectures: Introduction to Edge AI, intelligent IoT systems, and distributed intelligence. Cloud, fog, and edge computing paradigms for AI-enabled IoT environments. Architecture of Edge AI systems including sensors, embedded processors, gateways, and cloud integration. Real-time processing, latency reduction, and energy-efficient computation for intelligent systems. Embedded AI hardware platforms such as Raspberry Pi, NVIDIA Jetson, ESP32, Google Coral, and AI accelerators with applications in healthcare, smart cities, transportation, and industrial automation.

UNIT-II

RBT Levels: L1, L2, L3

Edge AI Models, Optimization, and Intelligent Processing: Machine learning and deep learning models for edge environments. Model optimization techniques including pruning, quantization, compression, and knowledge distillation for resource-constrained devices. Lightweight neural networks, TinyML, real-time inferencing, edge analytics, and distributed AI processing. Deployment frameworks including TensorFlow Lite, PyTorch Mobile, and OpenVINO. Sensor data preprocessing, feature extraction, sensor fusion, and performance evaluation metrics such as latency, throughput, memory utilization, and power efficiency.

RBT Levels: L1, L2, L3, L4

UNIT-III

Scalable Edge Intelligence Systems: Scalable Edge AI applications for predictive maintenance, autonomous vehicles, smart agriculture, video analytics, anomaly detection, and intelligent monitoring systems. Emerging trends including blockchain-enabled edge systems, neuromorphic computing, autonomous edge intelligence, and AI-enabled cyber-physical systems.

RBT Levels: L2, L3, L4

List of experiments suggested for Edge AI & Intelligent IoT Systems Lab

1. Interface temperature, humidity, motion, and gas sensors with edge devices such as Raspberry Pi or Arduino. Perform local preprocessing, filtering, and threshold-based decision making before transmitting data to the cloud.
2. Implement lightweight object detection models using frameworks such as TensorFlow Lite on edge hardware. Detect common objects through a USB/web camera and evaluate inference latency and accuracy.
3. Develop an intelligent surveillance application capable of motion detection, human detection, and intrusion alerts using edge AI techniques. Store only relevant event data to reduce bandwidth consumption.
4. Simulate multiple IoT edge nodes collaboratively training a machine learning model without sharing raw data. Analyze communication overhead, privacy preservation, and model convergence.



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5. Collect vibration or temperature sensor data from motors or fans and develop a predictive maintenance model to identify abnormal operating conditions at the edge node.
6. Design a smart home automation system where edge devices control lighting and appliances based on occupancy and environmental conditions while minimizing power consumption.
7. Implement keyword spotting or voice command recognition using TinyML models on microcontrollers such as ESP32 or Arduino Nano 33 BLE Sense.
8. Acquire physiological parameters such as heart rate and body temperature through wearable sensors and perform anomaly detection locally on the edge device for real-time alerts.
9. Create a lightweight blockchain-enabled IoT framework to secure communication between edge devices. Evaluate transaction latency, integrity, and scalability.
10. Deploy AI-enabled IoT services in containers using Docker on an edge gateway. Demonstrate scalable deployment, service orchestration, and remote monitoring.

TEXT BOOKS

- 1 TinyML, O'Reilly Media, 2019.
- 2 Edge AI, CRC Press, 2022.
- 3 Internet of Things: A Hands-On Approach, Universities Press, 2014.
- 4 Deep Learning, MIT Press, 2016.

REFERENCE BOOKS

1. Artificial Intelligence for the Internet of Things, Academic Press, 2020.
2. Practical Edge AI, Packt Publishing, 2021.
3. Building the Internet of Things, Wiley, 2016.
4. Machine Learning with TensorFlow Lite, O'Reilly Media, 2021.
5. Industrial Internet of Things, Apress, 2016.



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AI & ML for Cyber Security

Semester :	II	Internal Assessment :	40
Course Code :	PAMCL20503	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

PREREQUISITES

Python Programming, Machine Learning Fundamentals, Foundations of Cyber Security, Probability and Statistics, Computer Networks.

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Explain AI and ML techniques applicable to cybersecurity problems.
2. Develop machine learning models for intrusion detection, malware analysis, and anomaly detection.
3. Apply deep learning techniques for intelligent cyber defense systems.
4. Analyze adversarial attacks and security vulnerabilities in AI models.
5. Design AI-enabled threat intelligence and cybersecurity analytics systems.
6. Implement practical AI-driven cybersecurity solutions using modern tools and frameworks.

UNIT-I

AI for Cyber security Arsenal Classification, Regression, Dimensionality reduction, Clustering, Speech recognition, Video anomaly detection, Natural language processing (NLP), Large-scale image processing, Social media analysis. Detecting Cyber security Threats with AI, How to detect spam with Perceptrons, Image spam detection with Support Vector Machines (SVMs), Phishing detection with logistic regression and decision trees, Spam detection with Naive Bayes, Spam detection adopting NLP

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Time Series Analysis and Ensemble Modeling Time series and its different classes, Time series decomposition, Analysis of time series in cyber security, Prediction of DDoS attack, Ensemble learning methods and voting ensemble methods to detect cyber attacks. Segregating Legitimate and Lousy URLs Understanding URLs and how they fit in the internet address scheme, Introducing malicious URLs, Looking at the different ways malicious URLs propagate, Using heuristics to detect malicious URLs, Using machine learning to detect malicious URLs Knocking Down CAPTCHAs Characteristics of CAPTCHAs, Using artificial intelligence to crack CAPTCHAs, Types of CAPTCHA, Solving CAPTCHAs with neural networks.

RBT Levels: L2, L3, L4

15 hours

UNIT-III

Malware Components: Malware Components , Distribution mechanisms, Malware Packers, Persistence mechanism, Network Communication, Detecting Network Communication, Code Injection, Process Hollowing, API Hooking, Stealth techniques and Rootkits. Malware Analysis and Classification: Static Analysis, Dynamic Analysis , Memory Forensics with Volatility, Malware Payload dissection and Classification.

RBT Levels: L3, L4, L5, L6

15 hours

List of Experiments Suggested:

1. Security log preprocessing and feature extraction.
2. Intrusion detection using machine learning algorithms.
3. Malware classification using supervised learning.
4. Anomaly detection using clustering and autoencoders.
5. Phishing detection using NLP techniques.
6. Network traffic analysis using ML models.
7. Time-series attack prediction using LSTM.



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8. Adversarial attack generation on ML models.
9. Explainable AI implementation for cyber threat analysis.
10. Federated learning security experiments.
11. Generative AI/LLM-based security assistant development.

TEXT BOOKS

1. Clarence Chio and David Freeman, Machine Learning and Security, O'Reilly.
2. Alessandro Parisi, Hands-On Artificial Intelligence for Cyber security: Implement smart AI systems for preventing cyber attacks and detecting threats and network anomalies, Packt Publication.
3. Clarence Chio and David Freeman, Machine Learning and Security: Protecting Systems with Data and Algorithms O'REILLY Publications
4. McKinney, W Brij B. Gupta and Quan Z. Sheng, Machine Learning for Computer and Cyber Security: Principle, Algorithms, and Practices (Cyber Ecosystem and Security), CRC Press Publication
5. Ahijit Mohanta, Anoop Saldanha, Malware Analysis and Detection Engineering: A Comprehensive Approach to Detect and Analyze Modern Malware, Apress Berkeley, CA, 2020
6. Michael Sikorski and Andrew Honig, "Practical Malware Analysis : The Hands-On Guide to Dissecting Malicious Software", No Starch Press, 2012

REFERENCE BOOKS

1. Aditya K. Sood and Richard Enbody, Targeted Cyber Attacks.
2. Nicolas Papernot et al., Adversarial Machine Learning.
3. Ross Anderson, Security Engineering.
4. Christopher Bishop, Pattern Recognition and Machine Learning.
5. Zhiqiang Lin et al., AI for Cybersecurity.

ONLINE RESOURCES

1. OWASP Foundation: <https://owasp.org/>
2. IBM Adversarial Robustness Toolbox: <https://adversarial-robustness-toolbox.org/>
3. TensorFlow Privacy: https://www.tensorflow.org/responsible_ai/privacy/guide
4. MITRE ATT&CK Framework: <https://attack.mitre.org/>
5. Stanford AI Security Resources: <https://ai.stanford.edu/>



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Generative AI and Large Language Models (LLMs)

Semester :	II	Internal Assessment :	40
Course Code :	PAMCC20503	End Sem. Exam :	60
Teaching Hours/Week (L:T:P) :	3:0:2	Exam Duration (Hours) :	2.5
Credits : 4			

COURSE OUTCOMES

Python Programming, Machine Learning Fundamentals, Deep Learning, Natural Language Processing, Linear Algebra and Probability.

After completing this Course, the students should be able to:

1. Explain the working principles and architectures of Generative AI and LLMs.
2. Implement inference, prompting, and fine-tuning techniques for transformer models.
3. Develop intelligent applications using Retrieval-Augmented Generation (RAG) and LLM agents.
4. Apply optimization and scaling strategies for efficient deployment of LLMs.
5. Evaluate Generative AI systems using appropriate metrics and benchmarks.

UNIT-I

Foundations of Generative AI and Transformer Architectures: Introduction to Generative AI, discriminative versus generative models, evolution of generative models, applications of Generative AI in intelligent systems. Foundations of neural language models and representation learning. **Transformer architecture:** self-attention, multi-head attention, positional encoding, encoder-decoder models, tokenization techniques, embeddings, and sequence modeling.

RBT Levels: L1, L2, L3

15 hours

UNIT-II

Large Language Models (LLMs): GPT family, BERT, T5, LLaMA, Mistral, open-source LLM ecosystem, foundation models, multimodal models, and Vision-Language Models (VLMs). LLM lifecycle including data collection, dataset preparation, pre-training, supervised fine-tuning, inference, evaluation, and deployment pipelines. Introduction to scaling laws, distributed training concepts, GPU/TPU-aware computing, model parallelism, and efficient deep learning infrastructure for large-scale AI systems. **Applications:** Conversational AI, AI copilots, intelligent assistants, content generation, code generation, enterprise AI systems, and multimodal AI applications

RBT Levels: L2, L3, L4

15 hours

UNIT-III

LLM Agents, AI Safety, and Emerging Trends in Generative AI: LLMs as intelligent agents: autonomous AI agents, multi-agent systems, reasoning and planning systems, agentic workflows, task decomposition, structured data handling, and AI workflow orchestration. Generative AI applications in scientific discovery, cybersecurity, healthcare, finance, robotics, and autonomous systems. **Evaluation of Generative AI systems:** benchmark datasets, perplexity, BLEU, ROUGE, BERTScore, human evaluation, hallucination detection, robustness testing, factuality evaluation, and explainability assessment. **Emerging trends in Generative AI:** diffusion models, multimodal generative systems, edge AI, federated LLMs, on-device AI, autonomous research agents, AI operating systems, energy-efficient AI computing, and future directions of Artificial General Intelligence (AGI).

RBT Levels: L3, L4, L5

15 hours

List of Experiments Suggested:

1. Text generation using transformer models.
2. Prompt engineering experiments using GPT/BERT models.
3. Zero-shot and few-shot learning tasks.
4. Fine-tuning transformer models using Hugging Face.
5. LoRA/PEFT implementation for efficient tuning.
6. Sentiment analysis and summarization using LLMs.



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7. Vector embeddings and semantic search implementation.
8. Retrieval-Augmented Generation (RAG) pipeline development.
9. Building conversational AI/chatbots.
10. LLM agents with tool calling and workflows.

TEXT BOOKS

1. Lewis Tunstall, Leandro von Werra, Thomas Wolf, Natural Language Processing with Transformers, O'Reilly.
2. Sebastian Raschka, Build a Large Language Model from Scratch, Manning.
3. Delip Rao and Brian McMahan, Natural Language Processing with PyTorch, O'Reilly.
4. Denis Rothman, Transformers for Natural Language Processing, Packt.

REFERENCE BOOKS

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
2. Christopher Bishop and Hugh Bishop, Deep Learning: Foundations and Concepts.
3. Jurafsky and Martin, Speech and Language Processing.
4. Chip Huyen, AI Engineering: Building Applications with Foundation Models.
5. Manning Publications, Generative Deep Learning.

ONLINE RESOURCES

1. Generative AI with Large Language Models: <https://www.coursera.org/learn/generative-ai-with-llms>
2. AWS and DeepLearning.AI Generative AI Course: <https://aws.amazon.com/blogs/aws/generative-ai-with-large-language-models-new-hands-on-course-by-deeplearning-ai-and-aws>
3. Hugging Face Transformers Documentation: <https://huggingface.co/docs/transformers/index>
4. LangChain Documentation: <https://docs.langchain.com/oss/python/langchain/overview>
5. OpenAI Platform Documentation: <https://developers.openai.com/api/docs>
6. Stanford CS324 – Large Language Models: <https://stanford-cs324.github.io/winter2022/>
7. DeepLearning.AI Generative AI Courses: <https://www.coursera.org/partners/deeplearning-ai>



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Mini Project

Semester	:	III	Internal Assessment	:	20
Course Code	:	PAMRS20500	End Sem. Exam	:	30
Teaching Hours/Week (L:T:P)	:	0:0:4	Exam Duration (Hours)	:	2
Credits: 2					

PREREQUISITES

Basic knowledge of Artificial Intelligence, Machine Learning, Research Methodology, Technical Paper Writing, and Presentation Skills.

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Identify research problems and emerging trends in Artificial Intelligence and Machine Learning domains.
2. Perform detailed literature survey and critically analyze research papers from reputed journals and conferences.
3. Design, develop, and evaluate AI/ML models, algorithms, or intelligent systems using appropriate tools, datasets, and methodologies.

Guidelines

The Mini Project is intended to provide students with hands-on experience in applying Artificial Intelligence and Machine Learning concepts to solve real-world problems. Each student or a group of students shall identify a problem in a relevant domain such as Healthcare, Agriculture, Cybersecurity, Smart Cities, Computer Vision, Natural Language Processing, Edge AI, Data Analytics, Robotics, or other emerging areas of AI and ML. The project should involve problem identification, literature survey, dataset collection/preparation, system design, model development, implementation, performance evaluation, and result analysis.

Students are expected to conduct a detailed review of relevant research papers, identify research gaps or practical challenges, and develop an innovative solution using appropriate AI/ML techniques. The project may include software development, simulation, prototype implementation, comparative analysis of algorithms, or proof-of-concept validation. The outcome of the project should demonstrate technical competence, analytical thinking, problem-solving ability, and research aptitude.

Each project group shall submit a project proposal, literature survey report, progress reports, technical documentation, source code, experimental results, project report, and presentation. The project shall be evaluated based on problem relevance, innovation, technical quality, implementation, documentation, presentation, and viva-voce performance.



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M. Tech. Project-Stage-I

Semester	:	III	Internal Assessment	:	100
Course Code	:	PAMRC30600	End Sem. Exam	:	150
Teaching Hours/Week (L:T:P)	:	0:0:20	Exam Duration (Hours)	:	2
Credits: 10					

PREREQUISITES

Knowledge of Artificial Intelligence, Machine Learning, Research Methodology, Programming Skills, Technical Documentation, and Problem-Solving Techniques.

COURSE OUTCOMES

After completing this Course, the students should be able to:

1. Develop and implement a complete AI/ML-based solution for the identified problem.
2. Evaluate system performance using suitable metrics and experimental analysis.
3. Prepare technical dissertation/report and present research findings effectively.
4. Demonstrate innovation, research contribution, and problem-solving skills in AI and ML applications.

Guidelines

M.Tech Project – Stage I is intended to provide students with an opportunity to identify, analyze, and initiate research/development work in the field of Artificial Intelligence and Machine Learning. The selected project should preferably address real-world societal problems, industrial challenges, research issues, or applications aligned with Sustainable Development Goals (SDGs) and national initiatives such as Digital India, Smart India, Startup India, Make in India, and Atmanirbhar Bharat.

Students are expected to conduct an extensive literature survey by referring research papers, reputed journals, conference proceedings, patents, technical reports, and online research resources. As a part of the literature survey, students shall study at least 20–30 research articles from reputed IEEE, Springer, Elsevier, ACM, Scopus, SCI, or WoS indexed journals/conferences.

The project may be carried out individually and should demonstrate innovation, research contribution, technical implementation, and practical applicability using suitable AI/ML/DL techniques and tools.

During Stage I, students shall:

- Identify problem statement and objectives
- Conduct literature survey and research gap analysis
- Study existing systems and methodologies
- Collect datasets/resources/tools required
- Design system architecture and methodology
- Develop initial prototype/model
- Prepare implementation plan and project timeline
- Present progress seminars and periodic reviews



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Students are encouraged to publish research papers, develop prototypes/products, file patents, participate in hackathons/innovation activities, or extend the work towards startup and incubation initiatives wherever applicable.

Proper technical documentation, ethical practices, plagiarism-free work, and standard citation/referencing methods shall be strictly followed throughout the project work.

The work carried out in Project Stage I shall be continued, implemented, validated, and extended in M.Tech Project – Stage II.



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M. Tech. Project-Stage-II

Semester	:	IV	Internal Assessment	:	140
Course Code	:	PAMRC40600	End Sem. Exam	:	210
Teaching Hours/Week (L:T:P)	:	0:0:28	Exam Duration (Hours)	:	2
Credits: 10					

PREREQUISITES

Successful completion of M.Tech Project– Stage I.

COURSE OUTCOMES

1. Develop and implement an AI/ML-based solution for real-world societal, industrial, or research problems.
2. Analyze and evaluate system performance using appropriate experimental methods and performance metrics.
3. Prepare technical dissertation/report and present research findings effectively through presentations and demonstrations.
4. Publish research work, file patents/IPR, or develop innovative solutions/products contributing towards research, entrepreneurship, and societal applications.

Guidelines

M.Tech Project – Stage II is the continuation and completion phase of Project Stage I. In this stage, students shall implement, test, evaluate, and finalize the proposed AI/ML-based system developed during Stage I. The selected project should preferably address real-world societal problems, industrial challenges, research issues, or applications aligned with Sustainable Development Goals (SDGs) and national initiatives such as Digital India, Smart India, Startup India, Make in India, and Atmanirbhar Bharat.

Students are expected to complete the implementation using suitable AI/ML/DL techniques, tools, frameworks, and datasets. The project should demonstrate innovation, research contribution, technical implementation, performance evaluation, and practical applicability.

During Stage II, students shall:

- Complete system implementation and experimentation
- Perform training, testing, validation, and performance evaluation
- Analyze and compare results with existing methodologies
- Optimize and improve system performance
- Validate the proposed system/model using suitable metrics
- Prepare dissertation/thesis report and technical documentation
- Present periodic progress reviews and final demonstration

Students shall prepare:



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- Final dissertation/report
- Source code and implementation details
- Experimental results and performance analysis
- Research paper/manuscript/report
- Patent/IPR draft or innovation disclosure document
- Final PPT presentation and demonstration

As a part of M.Tech Project – Stage II, students shall preferably publish/present their research work in reputed Scopus/WoS indexed journals/conferences and are encouraged to file patents, copyrights, design patents, software copyrights, or any other Intellectual Property Rights (IPR) based on the novelty and innovation of the developed work.