School of Artificial Intelligence

CURRICULUM / SYLLABUS FOR
MASTER OF TECHNOLOGY IN

ARTIFICIAL INTELLIGENCE

BATCH 2025-27

Special Features:

1. **Efficient Learning and Times Group Support:** The proposed program offers a state-of-the-art curriculum which is tailored to the needs of industries. Additionally, This program is backed by Times Group, which provides students with high-quality education and real-world opportunities.

2. **Environment of Coding & Competitions:** Bennett provides an environment that engages students in coding as well as national/international competitions that enhance the creativity and teamwork skills necessary for future jobs.

3. **Multi-disciplinary Approach:** We incorporate AI into healthcare, agriculture, defence, law, media, marketing, and finance. It will help learners understand how AI can be used in different areas, preparing them for various professions.

4. **Sourcing Knowledge from Global Experts:** International Specialists will assist students through lectures and workshops. By doing so, they get a wider understanding of what AI is all about while being on par with current technological developments.

5. **Industry Experience:** This includes working with renowned industry experts, allowing students to gain practical experience via projects, internships, etc., hence learning and boosting their employability chances.

6. **Opportunities to Study Abroad**: Bennett collaborates with reputed international universities (QS ranking<300). The exchange programs we offer enable students to learn about AI abroad; such exposure enlightens students about various cultures.

7. **Cutting-Edge Research Labs:** Bennett University has state-of-the-art AI/ML research labs. Students can use advanced equipment (DGX, High-end workstations) for their research.

8. **Focus on Ethics:** We teach students about the ethical side of AI, like privacy, legal aspects and fairness. They need to think about these things as they will develop new technologies.

9. **Support for Entrepreneurs**: We have an incubator where students can work on AI startups and convert their ideas into startups. They will get help with things like funding and intellectual property. It's a great way for them to turn their ideas into reality.

10. **Using AI for Social Good:** Bennett University encourage students to use AI to help people and society through startups and projects. Bennett University encourages students through seed funding and by providing them with the needed infrastructure.

11. **International Events:** Bennett University hosts national/international conferences and workshops where experts from all over the world (Researchers, Academicians, Scientists, Industry experts etc.) come to share their knowledge. It's a great opportunity for students to learn from experts who are the best in their field.

M.Tech in Artificial Intelligence & Machine Learning (AI & ML) with specialization in Computer Vision, Natural Language Processing, Signal Processing, & Robotics

Program Overview:

AI is the effort to create intelligent machines with capabilities similar to humans, including sensing, comprehension, and action. The significant challenges in AI are imbuing computers attributes such as knowledge, thinking, problem-solving, perception, learning and planning. This field is quickly changing and affecting economies and societies across the globe. With the increased demand for AI applications arises the need to prepare a future workforce adept at confronting the various challenges of the field. The M.Tech program at the School of Artificial Intelligence will prepare a vibrant community of students & researchers passionate about leveraging artificial intelligence to revolutionise our world. Through state-of-the-art facilities, dynamic research prospects, robust industry collaborations, advanced curriculum, and hands-on learning experiences, we empower our students with the knowledge, expertise, and ethical grounding essential for thriving in today's dynamic landscape. With a diverse range of core-elective combinations available, students can get specialisation in natural language processing, computer vision, signal processing, & robotics.

Objectives:

The M.Tech program in Artificial Intelligence and Machine Learning will help students learn about AI technologies and their usage in the real world. The program combines theoretical knowledge with hands-on experience, preparing graduates for impactful careers in various industries and research domains. Postgraduates will be well-equipped for careers in both industry and academia. They will have the flexibility to delve into various domains such as Defence, Fintech, Healthcare, Agriculture/Food Processing, Education, Retail/Customer Engagement, Human and Robot Interaction/Intelligent Automation, Smart City development, and Aid for Differently Abled/Accessibility Technology.

Expected Postgraduate Attributes:

After completion of the program, students will acquire the following skills:

1. Grasp fundamental concepts and gain hands-on knowledge about the state-of-the-art cutting-edge AI methodologies.
2. Design, develop, and deploy machine learning-based applications utilising both structured and unstructured data (e.g., speech, text, images/videos).
3. Understand and evaluate the reliability, dependability, and trustworthiness of AI-based systems.
4. Design and construct real-world AI systems for intricate planning, decision-making, and learning, addressing application-specific challenges and providing thoughtful reasoning.
5. Design and develop AI applications tailored for resource-constrained environments.
6. Adhere to evolving ethics and privacy laws in diverse domains and territories.

7. Plan and manage technical projects effectively.

Learning Outcomes:

1. Master the essentials of Artificial Intelligence, including Machine Learning, Inference Engines, Speech, Vision, Natural Language Understanding, Robotics, and Human-Computer Interaction.
2. Integrate knowledge of human cognition, AI, Machine Learning, and data engineering to design comprehensive systems.
3. Apply hands-on expertise with cutting-edge AI tools for practical problem-solving.
4. Develop real-time and resilient AI-based systems tailored to specific software, hardware, and data requirements.
5. Execute projects utilising intelligent cognitive solutions provided by AI algorithms, gaining insights into stakeholder management, risk modelling, intelligent resource scheduling, and managing project constraints through intelligent use of data models.

Vision of the University:

To be a global leader in education, research, and innovation, empowering higher learning ecosystem

Mission of the University:

- Empower all the members of the Bennett ecosystem and provide thought leadership, focus on nation building and prepare our graduates to move with the Times.
- Cultivate international partnerships and collaborations with academic institutions, industry, and government organizations and provide a rigorous and innovative education that equips students with the knowledge, skills, and ethical values required to excel in their careers.
- Foster a culture of lifelong learning, adaptability, and critical thinking, ensuring graduates are prepared to tackle emerging challenges in all academic fields.
- Drive interdisciplinary research and innovation, pushing the boundaries of human knowledge, addressing pressing global issues and solving real world problems.
- Enhance a collaborative environment that encourages faculty and students to engage in research, innovation, and entrepreneurship, creating a lasting impact on society.
- Promote diversity, equity, and inclusion, ensuring that all individuals, regardless of background, feel welcomed, respected, and empowered.
- Prepare students to become global citizens, capable of addressing global challenges and contributing to the well-being of communities worldwide.
- Provide a globally connected career services networking with graduate employers and alumni.
- Foster a strong sense of ethical responsibility in our graduates, emphasizing the importance of ethical conduct, sustainability, and social impact in professional practice.

- Commit to ongoing assessment and improvement of our programs and invest in modern infrastructure and advanced technology to support teaching, research, and innovation adapting to the evolving needs of students, industries, and society.

PEO1: Expertise in Core Domains

Graduates will establish themselves as competent professionals in Artificial Intelligence, leveraging advanced knowledge in mathematics, natural sciences, engineering fundamentals, and specialized AI techniques to address and solve complex, real-world challenges across diverse industries.

PEO2: Innovation and Problem Solving

Graduates will demonstrate the ability to critically analyze, design, and develop innovative AI-driven solutions while addressing societal, cultural, environmental, and economic concerns, ensuring their relevance and sustainability.

PEO3: Leadership and Teamwork

Graduates will excel as leaders and team members in multidisciplinary settings, contributing effectively to the development, management, and execution of complex projects while adhering to ethical practices and professional responsibilities.

PEO4: Lifelong Learning and Growth

Graduates will pursue lifelong learning, staying abreast of emerging technologies and trends in Artificial Intelligence, and continue their professional development through advanced studies, certifications, and contributions to research and innovation.

PEO5: Societal Impact and Sustainability

Graduates will apply their knowledge of AI to assess and address societal needs, promote sustainable development, and make a positive impact through responsible innovation, ethical considerations, and community engagement.

PEO to Mission Statement Mapping:

PEOs	**Mission Statements**									
	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
PEO1	3	3	2	3	2	2	1	2	3	3
PEO2	3	3	3	3	3	2	1	2	3	3
PEO3	3	2	2	3	3	3	2	3	3	3
PEO4	2	3	3	3	2	2	1	2	3	3
PEO5	3	3	3	3	3	3	3	2	3	3

(3 = High, 2 = Medium, 1 = Low)

Program Outcomes (POs)

1. Advanced Engineering Knowledge: Apply advanced knowledge of mathematics, science, engineering fundamentals, and specialized AI concepts to solve complex and interdisciplinary real-world problems.

2. Problem Identification and Analysis: Identify, analyze, and formulate complex problems by applying modern AI methodologies and critically evaluating research literature to derive evidence-based conclusions.

3. Design and Innovation of Solutions: Design and implement innovative AI-based solutions, systems, and processes that address specified real-world challenges, with consideration for public health, safety, society, and the environment.

4. Advanced Research and Experimentation: Conduct in-depth research using modern research methodologies, experimental design, data analysis, and result interpretation to provide actionable insights and solutions.

5. AI Tools and Technology Integration: Develop and apply state-of-the-art AI tools, frameworks, and techniques, while understanding their limitations and potential to address advanced engineering and societal challenges.

6. Societal and Ethical Responsibility: Assess and address the societal, legal, and ethical implications of AI systems, applying informed judgment to ensure responsible and beneficial use of AI technologies.

7. Sustainability and Impact Awareness: Evaluate the environmental and social impact of AI solutions and advocate for sustainable, inclusive, and equitable technological advancements.

8. Professional Ethics: Demonstrate a strong commitment to ethical principles, responsible AI development, and adherence to professional standards in AI research and applications.

9. Collaborative and Multidisciplinary Approach: Function effectively as an independent researcher, collaborative team member, or leader in multidisciplinary projects, leveraging AI knowledge to achieve common objectives.

10. Effective Communication: Communicate complex AI concepts, experimental findings, and technical solutions effectively through research papers, reports, presentations, and discussions with both technical and non-technical audiences.

11. Leadership and Project Management: Apply advanced project management principles and AI engineering practices to lead and execute projects effectively in diverse environments, ensuring timely delivery and resource optimization.

12. Continuous Learning and Adaptability: Recognize the importance of lifelong learning, keeping abreast of emerging AI trends, technologies, and research through self-directed study and professional development.

Program-Specific Learning Outcomes (PSOs)

By the end of the M.Tech in Artificial Intelligence program, students should have the following knowledge, skills, and attitudes:

1. **Advanced Competency Development:**
   Demonstrate mastery in applying theoretical and practical knowledge of Artificial Intelligence, independently and collaboratively, to solve complex, real-world challenges. Exhibit strong leadership, effective communication, and decision-making skills through multidisciplinary projects and research.
2. **Domain-Specific Expertise:**
   Apply advanced AI techniques and research methodologies to analyze, design, and implement innovative solutions tailored to specific industrial, academic, or entrepreneurial settings. Develop AI-driven systems addressing complex problems across specialized domains, contributing to technological advancements.
3. **Cross-Disciplinary Innovation:**
   Utilize interdisciplinary knowledge to drive AI applications in emerging fields such as Computer Vision, Natural language processing, Signal Processing and Robotics. Promote sustainable and responsible AI development while addressing societal and global challenges.

POs / PSOs	PEO1	PEO2	PEO3	PEO4	PEO5
PO1. Advanced Engineering Knowledge	3	2	1	2	2
PO2. Problem Identification and Analysis	3	3	2	2	2
PO3. Design and Innovation of Solutions	2	3	2	2	3
PO4. Advanced Research and Experimentation	3	3	2	2	2
PO5. AI Tools and Technology Integration	3	2	2	3	2
PO6. Societal and Ethical Responsibility	2	2	2	2	3
PO7. Sustainability and Impact Awareness	2	2	1	2	3
PO8. Professional Ethics	1	2	3	2	3
PO9. Collaborative and Multidisciplinary Approach	2	2	3	2	2
PO10. Effective Communication	1	2	3	2	2
PO11. Leadership and Project Management	1	2	3	2	2
PO12. Continuous Learning and Adaptability	1	1	2	3	2
PSO1. Advanced Competency Development	3	2	3	2	2
PSO2. Domain-Specific Expertise	3	3	2	2	2
PSO3. Cross-Disciplinary Innovation	2	2	2	2	3

(3 = High, 2 = Medium, 1 = Low)

Course Structure/Curriculum for

M.Tech. in AI Program

Semester-I

S. No	Course Code	Course Title	Pre-Requisites	L	T	P	Credits	Category*
1	ABAI5001L	Mathematics for Computing	Linear Algebra & Engg. Maths	3	1	0	4	Program core
2	ABAI5003L	Programming for AI	Python	2	0	2	3	Program core
3	ABAI5005L	Advanced Machine Learning	Linear Algebra, Probability & Statistics	3	1	2	5	Program core
4	ABAI5007L	Advanced Signal Theory	Probability & Statistics	3	1	2	5	Program core
5	ABAI5009L	Research Methodology & Ethics in AI		3	0	0	3	Program core
	Total Credits in Semester - I						20	

Semester-II

S. No	Course Code	Course Title	Pre-Requisites	L	T	P	Credits	Category*
1	ABAI5002L	Advanced Deep Learning	Machine Learning	3	1	2	5	Program core
2	ABAI5004L	Image Processing & Computer Vision	-	3	1	2	5	Program core
3	ABAI5006L	Natural Language Processing & Generative AI	Linear Algebra, Probability & Statistics	3	0	2	4	Program core
4	ABAI5008L	Reinforcement Learning & Robotics		3	0	2	4	Program core
5	ABAI5010L	Research Seminars & Writing Skills		2	0	0	2	Program core
	Total Credits in Semester – II						20	

Semester -III

S. No	Course Code	Course Title	Pre-Requisites	L	T	P	Total Credits	Category*
1	ABAI6098J	Academic/Industry Project with Dissertation-1		0	0	40	20	Research Project
OR								
1		Program Elective-I		3	0	2	4	Program Elective
2		Program Elective-II		3	0	2	4	Program Elective
3		Program Elective-III		3	0	2	4	Program Elective
4		Specialization Elective-I		3	0	2	4	Specialization Elective
5		Specialization Elective-II		3	0	2	4	Specialization Elective
	Total Credits in Semester- III			40			20	

Semester -IV

S. No	Course Code	Course Title	Pre-Requisites	L	T	P	Total Credits	Category*
1	ABAI6099J	Academic/Industry Project with Dissertation-1 (Specialization Domain)		0	0	40	20	Research Project
OR								
1		Program Elective-IV		3	0	2	4	Program Elective
2		Program Elective-V		3	0	2	4	Program Elective
3		Program Elective-VI		3	0	2	4	Program Elective
4		Specialization Elective-III		3	0	2	4	Specialization Elective
5		Specialization Elective-IV		3	0	2	4	Specialization Elective
	Total Credits in Semester-IV			80			20	

Program Elective Courses

S. No	Course Code	Course Title	L	T	P	Credits
1	ABAI5051L	Advanced Computational Biology and AI for Genomics	3	1	2	5
2	ABAI5053L	AI-Driven Optimization and Decision Science	3	1	2	5
3	ABAI5055L	Advanced Multi-Agent AI and Game Theory	3	1	2	5
4	ABAI5057L	Enterprise AI and Open-Source AI Development	3	1	2	5
5	ABAI5052L	Human-Like AI and Cognitive Architectures	3	1	2	5
6	ABAI5054L	AI for Next-Generation Networks and Cybersecurity	3	1	2	5
7	ABAI5056L	AI for Cloud Computing and Edge Intelligence	3	1	2	5
8	ABAI5058L	AI for Social Media Analytics and Misinformation Detection	3	1	2	5

Specialization Electives for M.Tech. in AI Program

Signal Processing Specialisation

S. No	Course Code	Course Title	L	T	P	Credits
1	ABAI5061L	Advanced Signal Processing	3	1	2	5
2	ABAI5063L	Adaptive Signal Processing	3	1	2	5
3	ABAI5065L	AI for Bio-Medical Signal processing	3	1	2	5
4	ABAI5067L	Audio and Video Processing	3	1	2	5
5	ABAI5062L	Deep Learning for Image and Video Processing	3	1	2	5

6	ABAI5064L	Deep Learning for Signal Processing	3	1	2	5
7	ABAI5066L	Compressive Sensing	3	1	2	5
8	ABAI5068L	Statistical Signal Processing	3	1	2	5

Computer Vision Specialisation

S. No	**Course Code**	**Course Title**	L	T	P	Credits
1	ABAI5071L	AI for Multi-Media	3	1	2	5
2	ABAI5073L	AI for Vision Applications	3	1	2	5
3	ABAI5075L	Augmented Reality (AR) and Virtual Reality (VR)	3	1	2	5
4	ABAI5077L	Deep Learning for Computer Vision	3	1	2	5
5	ABAI5072L	Medical Image Analysis	3	1	2	5
6	ABAI5074L	Robotics and Computer Vision	3	1	2	5
7	ABAI5076L	3D Computer Vision	3	1	2	5
8	ABAI5078L	Deep Generative AI for Vision	3	1	2	5

NLP Specialisation

S. No	**Course Code**	**Course Title**	L	T	P	Credits
1	ABAI5081L	Foundation of Large language models	3	1	2	5
2	ABAI5083L	Foundation of NLU	3	1	2	5
3	ABAI5085L	Information retrieval and text processing	3	1	2	5
4	ABAI5087L	Knowledge representation and reasoning	3	1	2	5
5	ABAI5082L	Advanced LLM Techniques and Application	3	1	2	5
6	ABAI5084L	Advanced NLU Techniques	3	1	2	5
7	ABAI5086L	Foundation of Large language models	3	1	2	5
8	ABAI5088L	Foundation of NLU	3	1	2	5

Robotics Specialisation

S. No	Course Code	Course Title	L	T	P	Credits
1		Deep learning for Robotics	3	1	2	5
2		Bio-Inspired Robotics and Assistive Robotics	3	1	2	5
3		Selected topics for Robotics	3	1	2	5
4		Probability Robotics	3	1	2	5
5		Mechatronics, Microcontroller, and robot operation systems	3	1	2	5
6		Robot Kinematics, Dynamics, Control, and Mechatronics	3	1	2	5
7		Robotics and Computer Vision	3	1	2	5
8		3D Computer Vision	3	1	2	5

Name of Program	M. Tech in Artificial Intelligence				
ABAI5001L	**Mathematics for Computing**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**1**	**0**	**4**
Pre-requisites/Exposure	**Linear Algebra, Engineering Mathematics**				

Course Outcomes (COs):

On completion of this course, the students will be able to:

- CO1: Analyze and apply key concepts from discrete mathematics and graph theory for data structures, algorithm design, and computing problem solving.
- CO2: Apply concepts of probability, statistics, and stochastic processes to model uncertainty in AI systems and develop data-driven solutions.
- CO3: Employ optimization and numerical methods for solving real-world computational problems involving machine learning, signal processing, and operations research.

CO-PO/PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	0	2	2	1	1	3	2	2
CO2	3	3	2	3	2	2	2	1	1	1	1	2	3	3	2
CO3	3	3	3	3	3	2	2	1	2	1	2	2	3	3	3

- **(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)**

Course Contents

Module 1: Linear Algebra and Vector Calculus 15 Hours

Vectors and Matrices, Basic operations: addition, multiplication, transpose, inverse, Special matrices: Identity, Orthogonal, Symmetric, Diagonal, Rank, Nullity, Span, Basis, Dimension, Systems of Linear Equations, Gaussian Elimination, Eigenvalues and Eigenvectors, Singular Value Decomposition (SVD), Vector Spaces and Projections, Dot product, Inner product, Orthogonal projections, Matrix Factorizations, LU decomposition, PCA introduction via eigen decomposition, Vector Calculus Basics, Gradient, Jacobian, Hessian.

Module 2: Probability, Statistics, and Information Theory **15 Hours**

Probability Theory, Random Variables: Discrete and Continuous, Probability Distributions: Bernoulli, Binomial, Normal, Poisson, Exponential, Conditional Probability, Bayes' Rule, Expectation, Variance, Covariance, Correlation, Law of Large Numbers, Central Limit Theorem, Maximum Likelihood Estimation (MLE), MAP Estimation, Information Theory Basics, Entropy, Cross-Entropy, KL Divergence, Mutual Information

Module 3: Optimization and Graph Theory **15 Hours**

Optimization: Convex Functions and Sets, Convex Optimization Problems, Gradient Descent and its Variants (SGD, Momentum, RMSProp, Adam), Constrained Optimization: Lagrange Multipliers (conceptual), Numerical Stability, Overflow, Underflow, Conditioning of Problems

Graph Theory Basics, Graphs, Trees, Directed and Undirected Graphs, Graph Search Algorithms (BFS, DFS - intuition only), Applications in Neural Networks (Computational Graphs).

Textbooks:

- Rosen, Kenneth H. *Discrete Mathematics and Its Applications*. 7th ed. New York: McGraw-Hill Education, 2012.
- Ross, Sheldon M. *Introduction to Probability Models*. 11th ed. Amsterdam: Academic Press, 2014.
- Nocedal, Jorge, and Stephen J. Wright. *Numerical Optimization*. 2nd ed. New York: Springer, 2006.
- Linear Algebra and Its Applications by Gilbert Strang, 6th edition, MIT Press.

Reference Books:

- Grimaldi, Ralph P. *Discrete and Combinatorial Mathematics: An Applied Introduction*. 5th ed. Boston: Pearson, 2003.
- Papoulis, Athanasios, and S. Unnikrishna Pillai. *Probability, Random Variables and Stochastic Processes*. 4th ed. New York: McGraw-Hill, 2002.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5003L	**Programming for AI**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**2**	**0**	**2**	**3**
Pre-requisites/Exposure	**Basic Programming**				

Course Outcomes (COs):

On completion of this course, the students will be able to:

- CO1: Apply Python programming concepts to develop and preprocess AI models and datasets effectively.
- CO2: Utilize scientific computing libraries like NumPy, Pandas, TensorFlow & PyTorch to solve AI-related problems.
- CO3: Develop and deploy basic AI applications using APIs and version control practices for real-world scenarios.

CO-PO/PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1	1	2	1	1	2	3	3	2
CO2	3	3	3	3	3	2	2	2	2	2	2	2	3	3	3
CO3	2	2	3	2	3	3	2	3	3	3	3	3	2	2	3

(Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant)

Course Contents:

Module 1: Python Foundations for AI 10 Hours

Python Essentials: Variables, Data types, Control Structures, Functions, Lambda expressions, Decorators, List Comprehensions, Generators, Iterators, Object-Oriented Programming (OOP): Classes, Inheritance, Polymorphism (basic needed for AI model design), File Handling (CSV, JSON, Pickle), Data handling using Pandas (Reading, Writing, Manipulating), Visualization: Matplotlib, Seaborn basics, Environment Setup: Virtual environments (.venv, conda), docker, Jupyter Notebook, Google Colab

Module 2: Scientific Computing and AI Libraries **10 Hours**

Numerical Computing with NumPy:Arrays, Broadcasting, Vectorization, Basic Matrix operations, Scientific Computation with SciPy, Optimization, Linear Algebra, Statistics modules, Data Processing: Data Cleaning, Feature Scaling, Handling missing data, Encoding categories, Introduction to Tensor Libraries, PyTorch / TensorFlow basics, Tensors vs Arrays, Autograd (automatic differentiation), Project Structure, Organizing AI codebases (folder structures, modularization)

Module 3: Essential Tools, APIs, and Deployment **10 Hours**

Version Control: Introduction to Git & GitHub, Collaborating on codebases, Introduction to OpenCV, Introduction to Cloud Deployment, Running notebooks on Google Colab, Mini-Project Development: Complete end-to-end project: Data Preprocessing, Model, API, Demo, Mini project: Anomaly prediction, Image classifier, Simple AI model deployment (local + cloud demo), GitHub repo creation and versioning

Laboratory Experiments / Practical Exercises:

1. **Write Basic Python Scripts**
    - Develop simple Python programs using loops, functions, file handling, and exception handling for data processing.
2. **Perform Matrix Operations using NumPy**
    - Implement matrix addition, multiplication, transpose, inversion, and eigenvalue computation.
3. **Load and Analyze Data using Pandas**
    - Import a CSV dataset, handle missing values, filter data, and compute basic statistics (mean, median, mode).
4. **Visualize Data with Matplotlib and Seaborn**
    - Create different types of plots: line plot, bar chart, scatter plot, histogram, and heatmap.
5. **Implement a Simple Linear Regression Model**
    - Train a linear regression model using Scikit-Learn on a real dataset (e.g., housing price prediction).
6. **Train a Logistic Regression Classifier**
    - Develop and evaluate a logistic regression model for binary classification tasks (e.g., Titanic survival prediction).
7. **Practice Tensor Operations using PyTorch or TensorFlow**
    - Perform basic tensor manipulations: creation, reshaping, slicing, and simple arithmetic operations.
8. **Use Git and GitHub for Version Control**
    - Initialize a Git repository, commit changes, manage branches, and push code to GitHub.
9. **Deploy a Mini AI Project on Google Colab**

- Complete a small end-to-end project: data preprocessing ➔ model training ➔ evaluation ➔ deployment demo on Colab.

Text Books:

1. Géron, Aurélien. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems.* 2nd ed. Sebastopol: O'Reilly Media, 2019.
2. Raschka, Sebastian, and Mirjalili, Vahid. *Python Machine Learning: Machine Learning and Deep Learning with Python, Scikit-learn, and TensorFlow 2.* 3rd ed. Birmingham: Packt Publishing, 2019.

Reference Books:

1. Goodfellow, Ian, Bengio, Yoshua, and Courville, Aaron. *Deep Learning*. Cambridge: MIT Press, 2016.
2. Russell, Stuart, and Norvig, Peter. *Artificial Intelligence: A Modern Approach.* 4th ed. Hoboken: Pearson, 2021.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5005L	**Advanced Machine Learning**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**1**	**2**	**5**
Pre-requisites/Exposure	**-**				

Course Outcomes (COs):

On completion of this course, the students will be able to:

- CO1: Analyze and apply advanced machine learning algorithms including ensemble methods, probabilistic models, and optimization techniques to complex real-world data.
- CO2: Analyze, tune, and optimize machine learning models for higher performance and explainability.
- CO3: Develop innovative solutions applying modern trends like ensemble learning, meta-learning, and self-supervised learning.

CO-PO/PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	1	2	2	1	2	3	3	2
CO2	3	3	2	3	3	2	2	2	2	2	2	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	2	3	3	3	3

- **(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)**

Course Contents:

Module 1: Ensemble Methods and Supervised Learning **15 Hours**

Classification, Regression, Neural Network, K-Nearest Neighbour, Ensemble Techniques: Bagging, Random Forests, Boosting (AdaBoost, XGBoost, LightGBM), SVM, Kernel tricks, Multi-class SVM, Model Evaluation, ROC-AUC, Precision-Recall, Cross-Validation (K-fold, Stratified), Hyperparameter Tuning, Grid Search, Random Search.

Module 2: Probabilistic & Unsupervised Learning **15 Hours**

Bayesian learning, Variational inference, Markov Chain Monte Carlo (MCMC), Probabilistic Graphical Models: Bayesian Networks, Markov Random Fields, Hidden Markov Models (HMMs), Bayesian Optimization, Clustering: K-Mean, DBSCAN, Gaussian Mixture Models (GMMs), Dimensionality Reduction: PCA, t-SNE.

Module 3: Optimization and Recent Trends in ML **15 Hours**

Optimization Techniques: Stochastic Gradient Descent (SGD) Variants: Adam, RMSProp, Momentum, Meta-Learning, Self-Supervised Learning, Contrastive Learning basics, Reinforcement Learning Algorithms, Ethical AI and bias mitigation techniques, Introduction to Fairness, Explainability, and Interpretability in ML.

Experiments:

1. Implement Neural Network for classification
2. Implement K-NN, Random Forest from Scratch or using Scikit-Learn
3. Train and Tune an XGBoost Model on a Real-world Dataset
4. Apply Kernel SVM for Non-linearly Separable Data
5. Perform Hyperparameter Tuning
6. Build a Naïve Bayes Classifier on Text Data
7. Apply HMMs for Basic Sequence Modeling (e.g., POS tagging, Weather prediction)
8. Cluster a Dataset using GMM and visualize latent components
9. Reduce Dimensionality of Image Data using PCA and t-SNE
10. Train a Classifier using Adam and Compare Performance with SGD
11. Analyze Model Fairness and Bias using FairLearn toolkit (basic demonstration)

Text Books:

- Bishop, Christopher M. *Pattern Recognition and Machine Learning*. 1st ed. New York: Springer, 2006.
- Goodfellow, Ian, Bengio, Yoshua, and Courville, Aaron. *Deep Learning*. Cambridge: MIT Press, 2016.
- Murphy, Kevin P. *Machine Learning: A Probabilistic Perspective*. 1st ed. Cambridge: MIT Press, 2012.

Reference Books:

- Hastie, Trevor, Tibshirani, Robert, and Friedman, Jerome. *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. 2nd ed. New York: Springer, 2009.

- Sutton, Richard S. and Barto, Andrew G. *Reinforcement Learning: An Introduction*. 2nd ed. Cambridge: MIT Press, 2018.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5007L	**Advanced Signal Theory**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**1**	**2**	**5**
Pre-requisites/Exposure	**Mathematics for Computing**				

Course Outcomes (COs):

On completion of this course, the students will be able to:

- CO1: Analyze and characterize complex signals and systems using advanced mathematical and transform techniques.
- CO2: Apply modern time-frequency methods and stochastic signal theory to model and interpret real-world signal behavior.
- CO3: Design and implement advanced signal processing algorithms for applications in communications, biomedical systems, and AI.

CO-PO/PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1	1	2	1	1	1	3	3	2
CO2	3	3	2	3	3	2	2	1	2	2	2	2	3	3	3
CO3	2	2	3	2	3	2	2	2	3	2	2	3	3	2	3

- **(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)**

Course Contents:

Module 1: Time-Frequency Analysis **15 Hours**

Continuous and Discrete-Time Signals and Systems, Convolution and its Applications, Correlation: Auto-correlation, Cross-correlation, Fourier Series and Fourier Transform, Time and Frequency domain properties, Laplace Transform and Z-Transform (overview), Sampling Theorem and Aliasing, Power and Energy Spectra, Linear Time-Invariant Systems (LTI), AR, MA, ARMA systems.

Module 2: Random Variables, and Random Processes **15 Hours**

Basics of Probability Theory, Conditional probability, Bayes' theorem, Random Variables, PDFs, PMFs, CDFs, Expected value, Moments, Variance, Joint Distributions, Joint PDF, conditional expectation, covariance, Random Processes, Stationarity (strict and wide sense),

Ergodicity, Autocorrelation, Cross-correlation Functions, Power Spectral Density (PSD), Moments and Cumulants in Signal Characterization

Module 3: Filtering, Detection and Estimation Theory **15 Hours**

Filtering concepts, Wiener Filtering, Introduction to Adaptive Filtering (LMS Algorithm), Hypothesis Testing, Binary Hypothesis Testing, Bayes Risk, Neyman-Pearson Criterion, Detection of Signals in Noise, Maximum Likelihood Estimation (MLE), Maximum a Posteriori Estimation (MAP), Minimum Mean Square Error (MMSE) Estimation, Cramér-Rao Bound (concepts), Introduction to Kalman Filtering (concept and demo).

Experiments:

1. Perform Convolution and Correlation of Discrete Signals in Python/MATLAB
2. Apply Fourier Transform to Analyze Frequency Components of a Signal
3. Design and Apply Low-pass, High-pass, and Band-pass Filters on Signals
4. Simulate Random Variables (Uniform, Gaussian) and Plot their PDFs and CDFs
5. Model a Random Process and Estimate its Autocorrelation and Power Spectral Density
6. Develop and Apply a Wiener Filter for Noise Reduction
7. Implement an Adaptive LMS Filter for Noise Cancellation
8. Demonstrate Signal Sampling, Reconstruction, and Aliasing Effects
9. Perform Binary Hypothesis Testing for Signal Detection
10. Estimate Parameters Using Maximum Likelihood Estimation (MLE) and Compare with MMSE

Textbooks:

1. Oppenheim, Alan V., and Ronald W. Schafer. *Discrete-Time Signal Processing*. 3rd ed. Upper Saddle River: Prentice Hall, 2009.
2. Hayes, Monson H. *Statistical Digital Signal Processing and Modeling*. 1st ed. New York: Wiley, 1996.
3. Vaidyanathan, P. P. *Multirate Systems and Filter Banks*. 1st ed. Upper Saddle River: Prentice Hall, 1993.

Reference Books:

1. Papoulis, Athanasios, and Unnikrishna Pillai. *Probability, Random Variables and Stochastic Processes*. 4th ed. New York: McGraw-Hill, 2002.
2. Cohen, Leon. *Time-Frequency Analysis*. 1st ed. Upper Saddle River: Prentice Hall, 1995.

3. Mallat, Stéphane. *A Wavelet Tour of Signal Processing*. 3rd ed. Oxford: Academic Press, 2008.
4. Proakis, John G., and Dimitris K. Manolakis. *Digital Signal Processing: Principles, Algorithms, and Applications*. 4th ed. Upper Saddle River: Prentice Hall, 2007.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5009L	**Research Methodology & Ethics in AI**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**2**	**0**	**0**	**2**
Pre-requisites/Exposure	**None**				

Course Outcomes (COs):

On completion of this course, the students will be able to:

- CO1: Formulate research problems and adopt suitable methodologies for AI research based on structured problem analysis and literature review.
- CO2: Apply appropriate data collection, hypothesis testing, evaluation, and reporting techniques for empirical AI research.
- CO3: Critically analyze and apply ethical principles and responsible AI guidelines in designing and evaluating AI-based solutions.

CO-PO/PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	2	1	2	2	2	2	2	3	3	2
CO2	2	3	3	3	2	1	1	1	2	2	2	2	3	2	2
CO3	1	2	2	2	2	3	3	3	2	2	2	3	2	2	3

(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)

Course Contents

Module I: Foundations of Research Methodology **15 Hours**

Meaning and objectives of research, AI-specific research paradigms, research process, research problem formulation, hypothesis development, variables and types, experimental design principles, literature survey techniques, types of research (qualitative, quantitative, exploratory, descriptive, empirical)

Module II: Research Process and Data Analytics **15 Hours**

Data collection methods in AI, data preprocessing, evaluation metrics for classification and regression, validation techniques, statistical inference and significance tests, model building and selection, reproducibility and replicability, research documentation, technical paper writing, visualization of results

Module III: Ethics, Integrity, and Responsible AI **15 Hours**

Ethical issues in AI, bias and fairness, transparency and explainability, privacy and surveillance, AI in society and policy implications, ethics in data collection and annotation, IEEE/ACM/UNESCO AI ethics frameworks, plagiarism, citation styles, intellectual property rights, responsible innovation, AI for social good

Text Books:

1. Kothari, C. R. Research Methodology: Methods and Techniques. 2nd ed. New Delhi: New Age International, 2004.
2. Floridi, Luciano. The Ethics of Artificial Intelligence. 1st ed. Oxford: Oxford University Press, 2022.

Reference Books:

1. Creswell, John W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th ed. Thousand Oaks: SAGE Publications, 2018.
2. Russell, Stuart, and Norvig, Peter. Artificial Intelligence: A Modern Approach. 4th ed. Boston: Pearson, 2021.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5002L	**Advanced Deep Learning**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**1**	**2**	**5**
Pre-requisites/Exposure	**Machine Learning**				

Course Outcomes (COs)

On completion of this course, the students will be able to:

- CO1: Demonstrate deep understanding of advanced architectures and learning strategies in deep neural networks for complex data-driven tasks.
- CO2: Apply state-of-the-art deep learning algorithms to solve real-world problems across domains like vision, language, and reinforcement learning.
- CO3: Critically evaluate, design, and deploy scalable and ethical deep learning models using modern tools and frameworks.

CO-PO/PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1	1	2	1	1	1	3	3	2
CO2	3	3	2	3	3	2	2	1	2	2	2	2	3	3	3
CO3	2	2	3	2	3	2	2	2	3	2	2	3	3	2	3

- **(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)**

Course Contents

Module I: Foundations and Architectures of Deep Learning 15 Hours

Neural networks, review of deep neural networks, vanishing and exploding gradients, advanced activation functions, deep feedforward and convolutional neural networks, residual and densely connected networks, recurrent neural networks and their variants, attention and self-attention mechanisms

Module II: Specialized Models and Optimization 15 Hours

Transformers and BERT, generative adversarial networks, variational autoencoders, deep reinforcement learning basics, loss functions for different tasks, regularization and dropout techniques, learning rate schedules, batch normalization, optimization algorithms like AdamW and RAdam, hyperparameter tuning strategies

Module III: Applications, Explainability and Deployment 15 Hours

Applications in image analysis, NLP, speech, and multimodal systems, model compression

and pruning, transfer learning and fine-tuning, interpretability and explainable AI (XAI), fairness and bias in deep learning, model deployment with TensorFlow Lite and ONNX, scalability on edge devices and cloud platforms

Laboratory Experiments (Python/TensorFlow/PyTorch)

1. Implement a deep convolutional neural network for CIFAR-10 classification
2. Design and train a ResNet and compare performance with a vanilla CNN
3. Implement and visualize LSTM for text classification
4. Fine-tune a pre-trained BERT model for sentiment analysis
5. Build and evaluate a GAN to generate synthetic images
6. Construct a variational autoencoder on MNIST and visualize latent space
7. Use Grad-CAM or SHAP for explaining CNN predictions
8. Hyperparameter tuning using Optuna or Keras Tuner
9. Deploy a deep learning model on a Flask web app using TensorFlow Serving
10. Prune and quantize a deep learning model and compare performance
11. Apply transfer learning on medical image dataset using EfficientNet
12. Train a DQN (Deep Q Network) on a custom game environment using OpenAI Gym

Text Books:

1. Goodfellow, Ian, Bengio, Yoshua, and Courville, Aaron. *Deep Learning*. 1st ed. Cambridge, MA: MIT Press, 2016.
2. Géron, Aurélien. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*. 3rd ed. Sebastopol, CA: O'Reilly Media, 2022.

Reference Books:

1. Chollet, François. *Deep Learning with Python*. 2nd ed. Shelter Island, NY: Manning Publications, 2021.
2. Raschka, Sebastian, and Mirjalili, Vahid. *Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2*. 3rd ed. Birmingham, UK: Packt Publishing, 2019.
3. Zhang, Lei, and Zheng, Yunqian. *Deep Learning for Computer Vision*. 1st ed. Amsterdam: Elsevier, 2020.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5004L	Image Processing & Computer Vision	L	T	P	C
Owning School/Department	School of Artificial Intelligence (SoAI)	3	1	2	5
Pre-requisites/Exposure	Advanced Signal Theory, Programming for AI				

Course Outcomes (COs)

On completion of this course, the students will be able to:

- CO1: Understand and apply fundamental and advanced techniques of digital image processing and computer vision for real-world visual data analysis.
- CO2: Design and implement image processing pipelines and computer vision applications using state-of-the-art algorithms and tools.
- CO3: Analyze and evaluate the performance of image-based AI models in tasks such as object detection, recognition, segmentation, and tracking.

CO-PO/PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	2	2	1	1	1	1	1	3	3	2
CO2	3	3	3	3	3	2	2	2	2	2	2	1	3	3	3
CO3	3	3	2	3	3	3	2	2	2	2	2	2	3	3	3

(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)

Course Contents

Module I: Foundations of Image Processing **15 Hours**

Image acquisition, Sampling and quantization, Histogram equalization, Spatial filtering, Frequency domain filtering, Edge detection, Morphological image processing, Color image processing, Image restoration and reconstruction

Module II: Features, Motion, and Recognition **15 Hours**

Feature extraction, SIFT and SURF, Image descriptors, Optical flow, Background subtraction, Object tracking, Pin hole camera, Camera calibration, Epipolar geometry, Stero vision, Structure from motion, Image stitching, Face recognition techniques

Module III: Deep Learning in Computer Vision **15 Hours**

Convolutional neural networks, Image classification with CNNs, Transfer learning, Object detection using YOLO and SSD, Semantic segmentation with U-Net and MedSAM,

Generative Adversarial Networks (GANs), 3D vision, Vision transformers, Applications in medical imaging and autonomous driving.

Laboratory Experiments (Python/TensorFlow/PyTorch)

1. Image filtering using spatial and frequency domain techniques
2. Histogram equalization and contrast enhancement
3. Edge detection using Sobel, Prewitt, and Canny
4. Morphological operations on binary images
5. Implementing corner detection (Harris and FAST)
6. Object tracking using optical flow
7. Stereo vision and depth estimation
8. Image segmentation using thresholding and clustering
9. Image classification using pre-trained CNNs
10. Object detection using YOLOv5
11. Semantic segmentation using U-Net
12. Face recognition using OpenCV and Dlib

Textbooks

1. Gonzalez, Rafael C., and Richard E. Woods. *Digital Image Processing*. 4th ed. New York: Pearson, 2018.
2. Szeliski, Richard. *Computer Vision: Algorithms and Applications*. 2nd ed. Cham: Springer, 2022.

Reference Books

1. Forsyth, David A., and Jean Ponce. *Computer Vision: A Modern Approach*. 2nd ed. Boston: Pearson, 2011.
2. Shapiro, Linda G., and George C. Stockman. *Computer Vision*. 1st ed. Upper Saddle River: Prentice Hall, 2001.
3. Prince, Simon J.D. *Computer Vision: Models, Learning, and Inference*. 1st ed. Cambridge: Cambridge University Press, 2012.
4. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. *Deep Learning*. 1st ed. Cambridge: MIT Press, 2016.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5006L	**Natural Language Processing & Generative AI**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**0**	**2**	**4**
Pre-requisites/Exposure	**Advanced Machine Learning, Programming for AI**				

Course Outcomes (COs)

On completion of this course, the students will be able to:

- CO1: Analyze and apply core Natural Language Processing techniques for linguistic data interpretation and transformation.
- CO2: Design and implement Generative AI models including Transformer-based architectures for diverse NLP applications.
- CO3: Evaluate the performance, ethical considerations, and societal implications of NLP and generative AI technologies.

CO-PO/PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1	1	1	2	2	1	3	3	3	2
CO2	3	3	3	3	3	3	1	1	1	2	2	2	3	3	3
CO3	2	3	3	3	3	3	3	3	2	2	2	2	2	2	3

(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)

Course Contents

Module I: Foundations of Natural Language Processing **15 Hours**

Text preprocessing, Language models and n-grams, POS tagging, Syntax and parsing, Word embeddings and semantic similarity, Named entity recognition, Coreference resolution, Morphological analysis, Vector semantics and lexical semantics, Introduction to deep learning for NLP

Module II: Features, Motion, and Recognition **15 Hours**

Recurrent Neural Networks, LSTM and GRU, Attention mechanisms, Transformer architecture, BERT and its variants, GPT models, Sequence-to-sequence models, Encoder-decoder frameworks, Pretraining and fine-tuning, Transfer learning in NLP

Module III: Generative AI Applications and Ethics in NLP **15 Hours**

Text summarization, Question answering systems, Conversational agents and Chatbots, Text-to-text and text-to-image generation, Prompt engineering, Generative Adversarial networks, Diffusion models, Multimodal language models, Bias, fairness and explainability in NLP, NLP for low-resource languages, Societal impact and AI ethics in language generation

Laboratory Experiments (Python/TensorFlow/PyTorch)

1. Text preprocessing using NLTK and spaCy
2. Implementing and evaluating n-gram language models
3. POS tagging and Named Entity Recognition using pre-trained models
4. Word2Vec and GloVe embedding visualization and comparison
5. Building a sentiment analysis model using LSTM
6. Fine-tuning BERT for a text classification task
7. Generating text with GPT-2 or GPT-3
8. Designing a chatbot using a transformer-based encoder-decoder model
9. Text summarization using HuggingFace transformers
10. Prompt engineering for text generation and completion tasks
11. Text-to-image generation using multimodal generative models
12. Evaluating model bias and applying mitigation techniques in NLP

Text Books

1. Jurafsky, Daniel, and James H. Martin. *Speech and Language Processing*. 3rd edition. Upper Saddle River, NJ: Prentice Hall, 2023.
2. Goldberg, Yoav. *Neural Network Methods for Natural Language Processing*. 1st edition. San Rafael, CA: Morgan & Claypool, 2017.
3. Vaswani, Ashish, and Others. *Attention Is All You Need*. 1st edition. Redmond, WA: Google Research, 2017.

Reference Books

1. Eisenstein, Jacob. *Introduction to Natural Language Processing*. 1st edition. Cambridge, MA: MIT Press, 2019.
2. Delip Rao and Brian McMahan. *Natural Language Processing with PyTorch*. 1st edition. Sebastopol, CA: O'Reilly Media, 2019.
3. Brown, Tom, and Others. *Language Models are Few-Shot Learners*. 1st edition. Redwood City, CA: OpenAI, 2020.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5008L	**Reinforcement Learning & Robotics**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**3**	**0**	**2**	**4**
Pre-requisites/Exposure	**Engineering Mathematics**				

Course Outcomes (COs)

On completion of this course, the students will be able to:

- CO1: Apply reinforcement learning algorithms to train intelligent agents for decision-making in dynamic and uncertain environments.
- CO2: Develop robotic systems integrating reinforcement learning techniques for navigation, control, and task automation.
- CO3: Analyze and optimize reinforcement learning policies in robotic applications using simulation and real-world implementations.

CO-PO/PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	2	1	2	1	1	1	3	3	2
CO2	3	3	3	3	3	2	2	1	2	2	2	1	3	3	3
CO3	3	3	3	3	3	2	2	2	3	2	2	2	3	3	3

(*Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant*)

Course Contents

Module I: Fundamentals of Reinforcement Learning 15 Hours

Markov decision processes, Bellman equations, dynamic programming, model-free learning, Monte Carlo methods, temporal difference learning, Q-learning, policy iteration, value iteration, actor-critic methods, exploration vs. exploitation, function approximation in RL

Module II: Reinforcement Learning in Robotics 15 Hours

Application of RL in robotic control, robot path planning using RL, deep reinforcement learning for robotics, policy gradient methods, reward engineering, inverse reinforcement learning, multi-agent reinforcement learning, imitation learning, safe RL for robotic systems, RL for robotic arm manipulation, locomotion and autonomous navigation

Module III: Advanced Topics and Real-World Implementations **15 Hours**

Sim-to-real transfer in RL, reinforcement learning with constraints, curriculum learning, hierarchical reinforcement learning, meta-learning in RL, real-time robotic applications using RL, reinforcement learning frameworks (OpenAI Gym, ROS, Mujoco, PyBullet), case studies of RL in industrial robotics, healthcare robotics, and autonomous vehicles

Laboratory Experiments (Python/TensorFlow/PyTorch)

1. Implementing Markov Decision Processes (MDP) and solving using dynamic programming.
2. Implementing Q-learning for simple grid-world navigation.
3. Training an RL agent using deep Q-networks (DQN) in OpenAI Gym.
4. Policy gradient implementation for robotic arm movement.
5. Applying RL for path planning in mobile robots.
6. Multi-agent reinforcement learning in robotic swarm systems.
7. Transfer learning using RL for real-world robotic deployment.
8. Training an autonomous drone using RL.
9. Implementing inverse reinforcement learning for human motion imitation.
10. Developing an RL-based robotic grasping system.
11. Implementing safe RL for robotic applications with constrained optimization.
12. Case study: Reinforcement learning for self-driving cars using CARLA simulator.

Text Books

1. Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction.* 2nd ed. Cambridge: MIT Press, 2018.
2. Kaelbling, Leslie Pack, Michael L. Littman, and Andrew W. Moore. *Reinforcement Learning: A Survey.* San Francisco: Morgan Kaufmann, 1996.
3. Peters, Jan. *Machine Learning for Robotics: Reinforcement Learning, Artificial Intelligence, and Neuroscience.* Berlin: Springer, 2020.
4. Szepesvári, Csaba. *Algorithms for Reinforcement Learning.* 1st ed. San Rafael: Morgan & Claypool, 2010.

Reference Books

1. Russell, Stuart, and Peter Norvig. *Artificial Intelligence: A Modern Approach.* 4th ed. Upper Saddle River: Pearson, 2020.
2. Lillicrap, Timothy, et al. *Continuous Control with Deep Reinforcement Learning.* arXiv preprint, 2015.
3. Arulkumaran, Kai, et al. *Deep Reinforcement Learning: A Brief Survey.* IEEE Signal Processing Magazine, 2017.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%

Name of Program	M. Tech in Artificial Intelligence				
ABAI5010L	**Research Seminars & Writing Skills**	**L**	**T**	**P**	**C**
Owning School/Department	**School of Artificial Intelligence (SoAI)**	**2**	**0**	**0**	**2**
Pre-requisites/Exposure	**None**				

Course Outcomes (COs)

On completion of this course, the students will be able to:

- CO1: Understand and apply the principles of academic writing, literature review, and research reporting for AI and multidisciplinary research.
- CO2: Develop and deliver effective technical presentations and seminars, synthesizing research information clearly and logically.
- CO3: Evaluate and critique research publications and technical reports, and adhere to professional and ethical standards in research dissemination.

CO-PO/PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	3	2	2	1	3	2	2	1	3	3	2	2
CO2	1	2	2	2	2	1	1	2	3	3	2	2	2	2	2
CO3	2	3	2	3	1	3	2	3	2	3	2	3	3	2	2

(Note: 3 = Highly Relevant, 2 = Moderately Relevant, 1 = Low Relevance, 0 = Not Relevant)

Course Contents

Module I: Fundamentals of Research Writing and Presentation 15 Hours

Scientific method and research process, Types of research papers, Structure of a research paper, Abstract and title writing, Introduction and related work, Materials and methods, Results and discussion, Conclusion and future work, Literature review techniques, Citation and referencing styles (APA, IEEE, etc.), Research ethics and plagiarism

Module II: Technical Writing and Communication Skills 15 Hours

Technical grammar and language usage, Common writing errors, Paragraph and sentence structure, Figures and tables, Writing conference and journal papers, Preparing posters and technical reports, Writing research proposals and funding applications, Review and rebuttal processes, Oral presentation techniques, Using LaTeX and other formatting tools

Module III: Seminar Delivery and Review Techniques **15 Hours**

Seminar organization and delivery, Effective use of slides and visual aids, Time management and Q&A handling, Peer review methods, Technical discussion facilitation, Critically analyzing research papers, Assessing novelty and originality, Evaluating contributions and limitations, Research impact and indexing, Preparing for thesis/dissertation defense

Text Books

1. Alley, Michael. *The Craft of Scientific Writing*. 4th ed. New York: Springer, 2018.
2. Day, Robert A., and Barbara Gastel. *How to Write and Publish a Scientific Paper*. 8th ed. Cambridge: Cambridge University Press, 2016.
3. Turabian, Kate L. *A Manual for Writers of Research Papers, Theses, and Dissertation*s. 9th ed. Chicago: University of Chicago Press, 2018.

Reference Books

1. Zinsser, William. On Writing Well: *The Classic Guide to Writing Nonfiction*. 30th Anniversary ed. New York: Harper Perennial, 2006.
2. Hart, Jack. A Writer's Coach*: The Complete Guide to Writing Strategies That Work.* 1st ed. New York: Anchor Books, 2006.
3. Pechenik, Jan A. *A Short Guide to Writing About Biology*. 9th ed. New York: Pearson, 2013.
4. Booth, Wayne C., Gregory G. Colomb, and Joseph M. Williams. *The Craft of Research.* 4th ed. Chicago: University of Chicago Press, 2016.

Assessment Scheme:

Components	Internal Assessment	Mid Term Exam	End Exam	Total
Weightage (%)	40	20	40	100%