

Branch Name:	M.Sc. (Artificial Intelligence & Data Science)
Program Code:	ET214
Course Title:	AI Fundamentals
Course Code:	1ET2140101
Pre-requisite Course:	Basic Linear Algebra & Probability

Course Objectives:

1. To develop strong mathematical foundations required for Artificial Intelligence and Machine Learning algorithms.
2. To apply linear algebra techniques for data representation, transformation, and dimensionality reduction.
3. To utilize probability, statistics, and calculus concepts to model uncertainty and learning behavior in AI systems.
4. To understand and implement optimization methods used in training machine learning and deep learning models.
5. To integrate advanced mathematical concepts such as information theory and numerical methods in intelligent model design.

Teaching and Examination Scheme:

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
Lecture (L)	Tutorial (T)	Practical (P)	Credit	Theory (Marks)		Practical (Marks)		Total (Marks)
				University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	
03	01	00	04	50	50	00	00	100

Course Contents:

Unit No	Topic	Total Hours	Weightage (%)
1	Mathematical Foundations for Artificial Intelligence: Role of Mathematics in Artificial Intelligence, Importance of Mathematics in AI, functions and relations, linear & nonlinear functions, mathematical modeling, vector representation of data, feature engineering, vector spaces, distance measures (Euclidean, Manhattan, Cosine Similarity), mathematical foundations of AI	06	15
2	Linear Algebra for Artificial Intelligence: Vectors, matrices, matrix operations, systems of linear equations, determinants, eigenvalues, eigenvectors, orthogonality, linear transformations, matrix decomposition (LU, QR, SVD), Principal Component Analysis (PCA), low-rank approximation, applications in feature extraction, embeddings and dimensionality reduction.	10	25
3	Calculus for Machine Learning and Deep Learning: Limits, continuity, differentiation, partial derivatives, gradients, chain rule, Jacobian, Hessian, computational graphs, automatic differentiation, backpropagation, multivariable optimization, mathematical foundations of neural network learning.	08	20
4	Optimization Techniques for Intelligent Systems: Convex optimization, objective and loss functions, gradient descent, stochastic and mini-batch gradient descent, Momentum, RMSProp, Adam optimizer, learning rate scheduling, constrained optimization, Lagrange multipliers, regularization (L1/L2), optimization challenges in deep learning.	08	15

5	Advanced Mathematical Concepts for Modern AI: Information theory (Entropy, Cross-Entropy, KL Divergence), numerical methods, numerical stability, high-dimensional vector spaces, representation learning, embeddings, similarity search, Mathematical Foundations of Self-Attention and Transformers, foundations of Generative AI and Large Language Models (LLMs).	10	25
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Text Books:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong – Mathematics for Machine Learning, Cambridge University Press.
2. Gilbert Strang – Linear Algebra and Learning from Data, Wellesley-Cambridge Press.
3. Kevin P. Murphy – Machine Learning: A Probabilistic Perspective, MIT Press.

Reference Books:

1. Boyd & Vandenberghe – *Convex Optimization*, Cambridge University Press.
2. Christopher Bishop – *Pattern Recognition and Machine Learning*, Springer.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville – *Deep Learning*, MIT Press.
4. Steven Boyd – *Introduction to Applied Linear Algebra*, Cambridge University Press.

LIST OF EXPERIMENTS / TUTORIAL BASED PRACTICALS

- o Matrix computations and eigenvalue analysis using Python
- o Implementation of linear regression using least squares
- o Probability distribution visualization and sampling
- o Gradient descent optimization demo
- o PCA for dimensionality reduction on real dataset
- o Bayesian inference and classification example

Course Learning Outcomes (CLO):

CO	Course Outcome	Bloom's Level
CO1	Explain mathematical foundations, vector spaces, linear algebra, and matrix operations used in Artificial Intelligence and Data Science.	L2 – Understand
CO2	Apply calculus, optimization techniques, and numerical methods to formulate and solve AI and Machine Learning problems.	L3 – Apply
CO3	Analyze matrix decomposition, dimensionality reduction, embeddings, and representation learning techniques for intelligent systems.	L4 – Analyze
CO4	Evaluate optimization algorithms, automatic differentiation, and information-theoretic measures for developing efficient Deep Learning models.	L5 – Evaluate
CO5	Design mathematically sound AI solutions using modern concepts such as Transformers, Large Language Models (LLMs), vector embeddings, and Generative AI foundations.	L6 – Create

Mapping of CLO with PO and PSO

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO1	H	M	–	–	M	–	–	–	–	L	–	M	M	L	H	L
CLO2	H	H	M	M	H	–	–	–	–	L	–	M	H	H	H	M
CLO3	M	H	M	H	M	–	–	–	–	M	–	M	H	M	H	M
CLO4	M	M	H	H	H	–	–	–	–	M	M	M	H	H	H	M
CLO5	M	H	H	H	H	M	L	M	M	H	H	H	H	H	H	H

H:High, M:Medium, L:Low