COURSE OUTLINE

Machine Learning

Bachelor of Science in Computer Science & Engineering | 4th Year, 2nd Semester | 3 Credits

1. Course Information

COURSE INFORMATION			
Course Title	Machine Learning	**Course Code**	CSE-4207
Credit Hours	3 Credits (3-0-0)	**Contact Hours**	45 Lecture Hours (3 hrs/week)
Year / Semester	4th Year, 2nd Semester	**Department**	Computer Science & Engineering
University	Comilla University, Bangladesh	**Program**	B.Sc. in CSE
Course Instructor	Dr. Mahmudul Hasan	**Designation**	Associate Professor, Dept. of CSE
Pre-requisites	Probability & Statistics, Linear Algebra, Python/Programming	**Exam Schedule**	As per University Academic Calendar

2. Instructor Profile

Dr. Mahmudul Hasan | Associate Professor, Dept. of CSE, Comilla University

Ph.D. in Computer Vision — Saitama University, Japan

Research Interests: Computer Vision, Machine Learning, Speech Signal Processing, Human-Computer Interaction, NLP, Data Mining

Senior Member, IEEE | Former Dean, Faculty of Engineering | Former Head, Dept. of CSE, Comilla University

Website: www.mhraju.com

3. Course Description

This course provides a rigorous and comprehensive introduction to the theory and practice of Machine Learning (ML). Students will explore the mathematical foundations, core algorithms, and real-world applications that underpin modern ML systems. Beginning with classical supervised and unsupervised methods, the course progresses through ensemble techniques, model evaluation strategies, and deep learning architectures including Convolutional and Recurrent Neural Networks. Advanced topics cover transfer learning, reinforcement learning basics, ethical considerations, and model deployment.

The course has a strong applied focus: students will implement algorithms using Python (scikit-learn, TensorFlow/Keras) and work on a semester-long mini project. On successful completion, students will be prepared to tackle industry-level ML problems and proceed to research in AI-related areas.

4. Course Learning Outcomes (CLOs)

Upon successful completion of this course, students will be able to:

CLO	Course Learning Outcome	Bloom's Level	PI Code
CLO-1	Understand core ML concepts, types, and the complete ML pipeline	Remember / Understand	PI-1
CLO-2	Apply mathematical tools and preprocessing techniques for ML problems	Apply	PI-2
CLO-3	Design and implement supervised learning models for classification and regression tasks	Apply / Analyze	PI-3
CLO-4	Evaluate and compare ML models using appropriate metrics and validation strategies	Evaluate	PI-3
CLO-5	Implement unsupervised learning algorithms for clustering and dimensionality reduction	Apply / Analyze	PI-4
CLO-6	Build neural network-based models for image and sequential data tasks	Apply / Create	PI-4
CLO-7	Discuss advanced ML topics including RL, ethics, fairness, and model deployment	Evaluate / Create	PI-5

5. Course Schedule & Module-wise Topics

The course spans 15 weeks with 3 contact hours per week (45 total hours). The schedule is structured across 8 modules as follows:

Module	Topic	Lectures	CLO	Teaching Methods
M1	**Introduction to Machine Learning**	3	CLO-1	Lecture, Discussion
	• What is Machine Learning? Types (Supervised, Unsupervised, Reinforcement)	1	CLO-1	Lecture
	• ML Pipeline: Data → Model → Evaluation → Deployment	1	CLO-1	Lecture
	• Applications of ML: Computer Vision, NLP, Speech, Healthcare, Finance	1	CLO-1	Lecture, Case Study
M2	**Mathematical Foundations & Data Preprocessing**	4	CLO-1,2	Lecture, Problem Solving
	• Linear Algebra Review: Vectors, Matrices, Eigenvalues	1	CLO-1	Lecture
	• Probability & Statistics: Distributions, Bayes Theorem, MLE	1	CLO-1	Lecture

	• Feature Engineering: Scaling, Encoding, Selection, Extraction	1	CLO-2	Lecture, Lab Demo
	• Handling Missing Data, Outliers, and Imbalanced Datasets	1	CLO-2	Lecture, Lab Demo
M3	**Regression & Classification**	8	CLO-2,3	Lecture, Problem Solving
	• Linear Regression: OLS, Gradient Descent, Polynomial Regression	2	CLO-2	Lecture, Derivation
	• Regularization: Ridge, Lasso, ElasticNet	1	CLO-2	Lecture
	• Logistic Regression: Binary & Multiclass, Softmax	2	CLO-3	Lecture, Problem Solving
	• Decision Trees: ID3, CART, Pruning Strategies	1	CLO-3	Lecture, Illustration
	• Naive Bayes Classifier: Gaussian, Multinomial, Bernoulli	1	CLO-3	Lecture
	• K-Nearest Neighbors (KNN) and Instance-based Learning	1	CLO-3	Lecture, Lab Demo
M4	**Ensemble Methods & Advanced Classifiers**	6	CLO-3,4	Lecture, Case Study
	• Bagging: Bootstrap Aggregation, Random Forests	2	CLO-3	Lecture, Lab Demo
	• Boosting: AdaBoost, Gradient Boosting, XGBoost, LightGBM	2	CLO-4	Lecture, Comparison
	• Support Vector Machines (SVM): Hard/Soft Margin, Kernel Trick	2	CLO-4	Lecture, Derivation
M5	**Model Evaluation & Selection**	4	CLO-4	Lecture, Problem Solving
	• Evaluation Metrics: Accuracy, Precision, Recall, F1, ROC-AUC	2	CLO-4	Lecture, Exercises
	• Cross-validation, Bias-Variance Tradeoff, Hyperparameter Tuning (Grid/Random Search)	2	CLO-4	Lecture, Lab Demo
M6	**Unsupervised Learning**	6	CLO-5	Lecture, Lab Demo
	• Clustering: K-Means, K-Medoids, Hierarchical Clustering	2	CLO-5	Lecture, Visualization
	• Density-based Clustering: DBSCAN, OPTICS	1	CLO-5	Lecture
	• Dimensionality Reduction: PCA, LDA, t-SNE, UMAP	2	CLO-5	Lecture, Lab Demo
	• Association Rule Mining: Apriori, FP-Growth	1	CLO-5	Lecture
M7	**Neural Networks & Deep Learning Fundamentals**	8	CLO-5,6	Lecture, Lab Demo

	• Perceptron, MLP, Activation Functions, Forward Propagation	2	CLO-5	Lecture
	• Backpropagation, Gradient Descent Variants (SGD, Adam, RMSProp)	2	CLO-5	Lecture, Derivation
	• Convolutional Neural Networks (CNN) for Image Recognition	2	CLO-6	Lecture, Lab Demo
	• Recurrent Neural Networks (RNN), LSTM for Sequential Data	2	CLO-6	Lecture, Lab Demo
M8	**Advanced Topics & Applications**	6	CLO-6,7	Lecture, Seminar
	• Transfer Learning & Pretrained Models (VGG, ResNet, BERT)	2	CLO-6	Lecture, Case Study
	• Reinforcement Learning: Q-Learning, Policy Gradient Basics	2	CLO-7	Lecture
	• ML Ethics, Fairness, Bias, Explainability (XAI, LIME, SHAP)	1	CLO-7	Discussion
	• ML Deployment: Pipelines, REST APIs, MLOps Basics	1	CLO-7	Lecture, Demo
	TOTAL LECTURE HOURS	**45**	**3 Credit Hours**	

6. Assessment & Grading

6.1 Assessment Breakdown

#	Assessment Component	Marks	Weight (%)	CLO Covered
1	Class Attendance & Participation	5	5%	CLO-1 to CLO-7
2	Assignments / Homework (4 Assignments)/Class Test	10	10%	CLO-1, CLO-2, CLO-3, CLO-5
3	Presentation/Mini Project	5	5%	CLO-4, CLO-5, CLO-6, CLO-7
4	Mid-term Examination	20	20%	CLO-1, CLO-2, CLO-3
5	Final Examination	60	60%	CLO-1 to CLO-7
	TOTAL	**100**	**100%**	**All CLOs**

6.2 Grading Scale

Grade	Letter	Grade	Letter	Grade	Letter	Letter	Grade
80–100	A+	65–69	B+	50–49	C+	Below 40	F
75–79	A	60–64	B	45–49	C		
70–74	A-	55–59	B-	40–44	D		

7. Tools, Software & Laboratory

Programming Language & Libraries

- Python 3.x — Primary programming language
- NumPy, Pandas — Data manipulation and numerical computing
- Matplotlib, Seaborn — Data visualization
- Scikit-learn — Classical ML algorithms and evaluation
- TensorFlow / Keras — Deep learning model development
- Jupyter Notebook / Google Colab — Interactive development environment

Datasets

- UCI Machine Learning Repository datasets
- Kaggle open datasets relevant to course topics
- Custom domain-specific datasets for the mini project

8. Textbooks & Reference Materials

#	Title & Authors	Publisher	Type
1	Pattern Recognition and Machine Learning — Christopher M. Bishop	Springer	Primary Text
2	Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow (3rd Ed.) — Aurélien Géron	O'Reilly	Primary Text
3	The Elements of Statistical Learning — Hastie, Tibshirani, Friedman	Springer	Reference
4	Deep Learning — Ian Goodfellow, Yoshua Bengio, Aaron Courville	MIT Press	Reference
5	Introduction to Machine Learning with Python — Mueller & Guido	O'Reilly	Supplementary

Additional reading materials, lecture slides, and tutorial notebooks will be provided through the course management system.

9. Course Policies

Attendance

Attendance is mandatory. Students must maintain at least 60% attendance to sit for the final examination as per Comilla University academic regulations. Each absence beyond the permissible limit may result in grade reduction.

Academic Integrity

All submitted work must be the student's own. Plagiarism, copying, or any form of academic dishonesty will result in a zero for the component and may lead to disciplinary action as per university policy. Proper citation is required for all referenced material.

Assignment Submission

Assignments must be submitted by the stated deadline. Late submissions will incur a penalty of 10% per day. Extensions may be granted for documented medical or emergency circumstances only.

Mini Project

Students will form groups of 2–3 and complete a semester-long ML project on a topic of their choice (subject to instructor approval). A project proposal is due in Week 6, interim report in Week 11, and final presentation and report in Week 15.

10. Weekly Teaching Plan

Week	Topics Covered	Module	Remarks
1	Introduction to ML, Types, Applications, ML Pipeline	M1	
2	Math Review: Linear Algebra & Probability; Feature Engineering	M2	
3	Data Preprocessing: Scaling, Encoding, Missing Data	M2	**Assignment 1 Out**
4	Linear Regression, Gradient Descent, Polynomial Regression	M3	
5	Regularization (Ridge, Lasso); Logistic Regression	M3	
6	Decision Trees, Naive Bayes, KNN	M3	**Project Proposal Due; Assignment 1 Due**
7	Bagging, Random Forests	M4	**Assignment 2 Out**
8	**Mid-term Examination**	—	**Mid-term Week**
9	Boosting: AdaBoost, Gradient Boosting, XGBoost	M4	
10	SVM: Hard/Soft Margin, Kernels; Model Evaluation Metrics	M4, M5	**Assignment 2 Due; Assignment 3 Out**
11	Cross-Validation, Bias-Variance Tradeoff, Hyperparameter Tuning	M5	**Interim Report Due**

12	K-Means, Hierarchical, DBSCAN Clustering; PCA, t-SNE	M6	**Assignment 3 Due**
13	Neural Networks: MLP, Backpropagation, Activation Functions	M7	**Assignment 4 Out**
14	CNN, RNN, LSTM; Transfer Learning	M7, M8	
15	RL Basics, ML Ethics, Fairness, XAI, MLOps; Project Presentations	M8	**Assignment 4 Due; Final Report Due**

Prepared by:
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