



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Instrumentation and Control / Electronics and Instrumentation

Subject Code : BE05000081

Subject Name : Machine Learning for Industrial Automation

WEF Academic Year:	2024 -2025
Semester:	5
Category of the Course:	Professional Elective Course -02

Prerequisite:	Basic Proficiency in a Programming language, preferably Python , and basics of algorithms. Core Engineering and Automation Basics
Rationale:	The Machine Learning syllabus in Industrial Automation is aligned with Industry 4.0 and Smart Manufacturing concepts, where intelligent and data-driven systems are widely used in modern industries. It helps students understand applications such as predictive maintenance, fault detection, quality control, and process optimization. The course also enables effective handling and analysis of manufacturing data generated through sensors and automated systems. This knowledge enhances students' ability to develop smart industrial solutions and meet current industry requirements.

Course Outcome:

Sr. No	Course Outcomes	Marks% weightage
CO-1	Analyze and prepare data for machine learning models.	25
CO-2	Implement probability-based models and supervised learning algorithms.	20
CO-3	Design solutions using unsupervised and reinforcement learning techniques.	25
CO-4	Construct basic Artificial Neural Networks and compare advanced learning algorithms.	20
CO-5	Develop end-to-end machine learning pipelines and evaluate Generative AI applications.	10

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	TW/SL	TH		Theory		Tutorial/Practical			
						ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200



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* *Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.*

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	Introduction to Machine Learning: What is Human Learning?, Types of Human Learning, What is Machine Learning?, Types of Machine Learning, Need for Machine Learning, Application of Machine Learning, Languages and Tools in Machine Learning, Issues in Machine Learning, Problems not to be solved using Machine Learning	2	4
2	Basic of Matrix Operations, Probability and Bayesian Concept Learning: Matrix Operations: Addition, Multiplication, Subtraction, Division, transpose, and inverse, Types of Matrices Probability: Importance of Statistical tools in Machine Learning; Concept of Probability - Frequentist and Bayesian Interpretation; Random Variable - Discrete and Continuous; Common Discrete Distributions - Bernoulli, Binomial, Multinomial and Multinoulli and Poisson's distribution; Common Continuous Distributions - Uniform, Gaussian (Normal) and Laplace Distribution; Multiple Random Variables - Bivariate random variables, Joint distribution functions, joint probability mass functions, joint probability density functions, conditional distributions and covariance and correlation, central limit theorem; Sampling distributions - Sampling with and without replacement, mean and variance of sample; hypothesis Testing and Monte Carlo Approximation Bayesian Concept Learning: Importance; Bayes' theorem - Prior, Posterior and Likelihood; Bayes' Theorem and Concept Learning - Brute-force Bayesian algorithm, concept of consistent learners, bayes optimal classifier, applications of naive bayes classifier, handling continuous numeric features in naive bayes classifier; Bayesian belief Network - Independence and conditional independence, its use in machine learning.	4	9
3	Preparing to Model: Machine Learning Activities; Basic types of data in Machine Learning; Exploring structure of Data - Exploring numerical data, plotting and exploring numerical data, exploring categorical data, exploring relationship between variables; Data Quality and Remediation; Data Pre-Processing - Dimensionality Reduction and Feature Subset Selection.	2	4
4	Modelling and Evaluation: Selecting a Model - Predictive or descriptive; Training a model (for	2	4



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	supervised learning) - Holdout Method, k-fold cross validation method, bootstrap sampling, lazy vs eager learner; Model Representation and Interpretability - underfitting, overfitting and bias variance tradeoff; Evaluating Performance of a model - Supervised learning (Classification and Regression) and Unsupervised learning (Clustering); Improving performance of a model.		
5	Basics of Feature Engineering: What is a feature and feature engineering?; Feature Transformation - Construction and Extraction; Feature Subset Selection - Issues in high dimensional data, key drivers of feature selection - feature relevance and redundancy, measures of feature relevance and redundancy, Overall feature selection process, feature selection approaches	2	4
6	Supervised Learning Regression: Examples of Regression; Common Regression Algorithms: Simple Linear Regression, Multiple Linear Regression, Assumptions in Regression Analysis, Problems in Regression Analysis, Improving accuracy of Linear Regression Model, Logically weighted Linear Regression, Polynomial Regression Model, Logistic Regression, Multiclass Logistic Regression, Maximum Likelihood Estimation. Classification: Introduction and example of supervised learning, classification model, classification learning steps, Common classification algorithms - k-Nearest Neighbour(kNN), Decision Tree, Random Forest Model, Support Vector Machine.	7	16
7	Unsupervised Learning: Application of unsupervised learning; Clustering - Clustering as a machine learning task, different types of clustering techniques, partitioning methods, K-Medoids: a representative object based technique, Hierarchical Clustering, Density based methods - DBSCAN; Finding pattern using association rule - Definition of common terms, Association rule, Apriori algorithm for association rule learning, build the apriori principle rules	7	16
8	Reinforcement Learning: What is Reinforcement Learning?; Elements of Reinforcement Learning - Agent, Environment, State, Policy, Reward, Value function, Model, Introduction to Farama Foundations "The Frozen Lake RL Environment; Principles; Reinforced Learning Algorithm - Dynamic Programming, Monte Carlo Methods, Temporal Difference Learning (TD); Sample Python Implementation of Q-Learning, Applications of RL	4	9
9	Basics of Neural Network: Understanding the Biological Neuron; Exploring Artificial Neuron; Types	4	9



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	of Activation Functions - Identity, Threshold/Step, ReLU, Sigmoid and Hyperbolic Tangent functions; Architectures of Neural Networks - Single layer feed forward network, Multilayer feed forward layer, Competitive Network and Recurrent Network; Learning process in ANN - Number of layers, Direction of Signal Flow, Number of nodes in layers, Weight of interconnection between neurons; Early implementations of ANN - McCulloch Pitts Model, Rosenblatt's perceptron, ADALINE Network Model; Back Propagation, Deep Learning		
10	Generative AI and LLMs: Introduction to NLP; Generative Models - Foundational architectures; LLMs: Few Popular LLMs, Challenges and Risks with LLMs, Hallucinations; How is ChatGPT Trained?; Applications of Generative AI; Prompt Engineering - Types of Prompts, Applications, Integrating LLMs into Python using Langchain, Pair Programming powered by Prompt Engineering, Best Practices in Prompt Engineering.	5	11
11	Case Studies and Implementations: Detection of Iris Flower Species, Handwritten Digit Detection Sentiment based clustering of Text Data, Predictive Maintenance: Trends, Challenges, and Future Directions	6	14
Total		45	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	30	20	20	10	10

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of *Machine Learning* directly contributes to

SDG 4	Quality Education
SDG 8	Decent Work and Economic Growth



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SDG 9	Industry, Innovation and Infrastructure
SDG 12	Responsible Consumption and Production

Reference Book:

1. Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, “Machine Learning” 2nd Edition, Pearson Publication
2. Anuradha Srinivasaraghavan and Vincy Joseph, “Machine Learning”, 1st Edition, Wiley Publication
3. Christos Tsallis, Panagiotis Papageorgas, Dimitrios Piromalis and Radu Adrian Munteanu, “Application-Wise Review of Machine Learning-Based Predictive Maintenance: Trends, Challenges, and Future Directions”, *MDPI Applied Sciences Journal*, 2024.

List of Experiments:

1. To learn the basics of Python.
2. To implement linear regression using least square method/normal equation with single variable
3. To implement linear regression using least square method/normal equation with multiple variable
4. Implementation of gradient descent algorithm for single variable using MATLAB Software
5. Implementation of gradient descent algorithm for multiple variables using MATLAB Software
6. Implementation of logistic regression for binary classification
7. Implementation of Single layer ANN
8. Implementation of Normal Equation using MATLAB Software
9. To study neural network as sine wave function approximator
10. To study Neural Network based controller design.
11. Write a program using SVM on IRIS dataset and carry out classification.
12. To implement K-Means clustering on Iris dataset to group flowers based on features.
13. To apply dimensionality reduction on a digit dataset.

List of Open Source Software

1. Anaconda (Jupyter)
2. Google Colab



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3. Python
4. R Language

List of learning website/ resources:

1. NPTEL / SWAYAM (<https://nptel.ac.in/>)
2. Virtual Labs by IITs (<https://vlab.co.in/>)
3. DTE Common Lab manual

Activities suggested under self-learning:

Sr. No.	PBL Category	Name of the activity	No. of hours per activity	Evaluation Criteria
1.	Industry / Research Laboratory Visit	Industry/Research laboratory visit	Visit=5h, Report preparation = 5h Total = 10h	Based on the report submitted. Report should contain observations and calculations Based on industry/lab data.
2.	Video Based Learning	Technical Video based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5h Report preparation=5h Total= 10h	Report/presentation based on the video learning outcomes.
3.		Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment At the end of course. Based on the certificate produced.
4.		Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation =5h Total= 10h	Based on quiz/report submitted
5.	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical Based assignment is	5 assignments of 2h each. Total= 10h	Based on the assignment submitted.



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		preferable.		
6.		Problem solving/Coding using C, C++, Python, SCILAB, MATLAB,MS-EXCEL or any Other relevant software	5 small coding-based assignments of 2h each. Total = 10h	Based on the coding solution submitted.
7	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding, Total= 10h	Based on the depth of the Solution submitted.
8	Research Paper Review / Analysis	Discussion on research paper Based on relevant subject	5 research paper =20 h	Summarize research paper and Evaluation critical parameters
9.	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration=6h	Based on poster/chart Preparation and presentation skills
10	Micro Project	Working/non-working model on technical topics	Working=12h Non-working=8 h	Based on inter department/external evaluation
11		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
12	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration=1h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5h Report	Based on in-depth study, technical depth, data collected, fact



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			preparation=5h Total= 10h	finding, etc.
14.	Other	Patent Search and Innovation Gap Identification	10h(Search + Report)	Based on number of relevant patents analyzed and Identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject *Machine Learning for Industrial Automation* incorporates;

- Mini Project – 10 Marks
- Seminar activities -- 10 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
