Artificial Intelligence in Environmental Systems

COURSE CODE:	ENE-311
COURSE NAME:	Artificial Intelligence in Environmental Systems
CREDIT HOURS:	Theory = 2 Practical = 1 Total = 3
CONTACT HOURS:	Theory = 32 Practical = 48 Total = 80
PREREQUISITE:	MATH-121 Linear Algebra and Ordinary Differential Equations
MODE OF TEACHING:	Two hours of lecture per week Three hours of lab work per week

COURSE DESCRIPTION:

This course provides a broad introduction to machine learning, data mining, and statistical pattern recognition, covering supervised learning (including parametric and non-parametric algorithms, support vector machines, kernels, and neural networks), unsupervised learning (such as clustering, dimensionality reduction, recommender systems, and deep learning), best practices in machine learning (including bias/variance theory and the innovation process in machine learning and AI), as well as reinforcement learning and deep learning.

COURSE OBJECTIVES:

The objectives of the course are: -

1. To familiarize students with the use of ML and AI techniques for environmental data analysis to forecast predictions.
2. To inculcate in students course knowledge for optimization and decision support relevant to environmental challenges.
3. To use real world data for monitoring of environmental compartments by employing ML and AI tools.

RELEVANT PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the PLOs:

1	Engineering Knowledge:	☐	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐

3	Design/Development of Solutions:	☑	9	Individual and Teamwork:	☐
4	Investigation:	☑	10	Communication:	☐
5	Modern Tool Usage:	☑	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will demonstrate competency by being able to:

No.	CLO	Domain	Taxonomy level	PLO
1.	Describe different types of learning algorithms	Cognitive	2	2
2.	Apply the variety of learning algorithms to data for solution development.	Cognitive	3	3
3.	Develop solutions by using modern machine learning tools / models to solve practical problems.	Psychomotor	3	5

Open-Ended Lab

4.	Analysis and investigation of the problem and develop solution to the problem.	Psychomotor	3	4

PRACTICAL APPLICATIONS/ EMPLOYMENT PROSPECTS:

1. Graduates can work in national and international educational institutions creating environmental educational programs under the umbrella of data science, data mining, multivariate statistical analysis, machine learning, deep learning, and artificial intelligence.
2. Students can help the government, national and international organizations, and international universities to solve environmental problems in disciplinary, interdisciplinary, and cross-disciplinary domains.
3. Machine learning and Artificial Intelligence is a continuously growing field which is penetrating in every discipline of arts, science, and engineering. It is capturing the job market nationally as well as internationally. The students will

be able to work for various national and international organizations and find ML and AI as their career path.

TOPICS COVERED WITH THEIR CONTRIBUTION TO PLOs:

Theory:

Week #	Topic
Week 1-2	Introduction to AI, Its Scope, and Environmental Applications
Week 2-3	Decision Tree Learning and the Environmental Species Identification
Week 4-5	Linear Regression: One Variable
Week 6-8	Linear Regression: Multiple Variables Pollution Level Prediction
Week 9	**Mid Semester Exam**
Week 10-11	Logistic Regression in Air Quality Indexing
Week 12-13	Artificial Neural Networks for Climate Modeling and Environmental Impact Assessment
Week 14-15	Support Vector Machines for Bacterial and Viral Disease Classification
Week 16	Clustering of Pollutants for Identification of Pollution Hot Spots
Week 17	Dimensionality Reduction in Pollution Source Apportionment
Week 18	**End Semester Exam**

International Benchmarking:

Machine Learning and Artificial Intelligence courses are being offered in various international universities. The course contents of 4x universities are mapped with the proposed course in Table 1.

1. 6.034 – Artificial Intelligence

   Massachusetts Institute of Technology (MIT), USA

   QS Ranking: 1

   https://ocw.mit.edu/courses/6-034-artificial-intelligence-fall-2010/pages/readings/

2. CIS – Artificial Intelligence
   Pennsylvania University (PU), USA
   QS Ranking: 89
   https://artificial-intelligence-class.org/schedule.html#now
3. CS229 – Machine Learning
   Stanford University (SU), USA
   QS Ranking: 6
   https://cs229.stanford.edu/
4. CS4780/CS5780 – Machine Learning for Artificial Intelligent System
   Cornell University (CU), USA
   QS Ranking: 16
   https://courses.cis.cornell.edu/cs4780/2018fa/page18/index.html

Table 1. Mapping of proposed course contents with similar courses offered in international universities.

Week #	**Topics to be covered**	MIT, USA	PU, USA	SU, USA	CU, USA
Week 1-2	Introduction to AI, Its Scope, and Environmental Applications	✔	✔	✔	✔
Week 2-3	Decision Tree Learning and the Environmental Species Identification		✔	✔	
Week 4-5	Linear Regression: One Variable Statistical and Minimization of Sum of Squares Algorithms	✔		✔	✔
Week 5-7	Linear Regression: Multiple Variables Pollution Level Prediction	✔	✔	✔	✔
Week 8-9	Logistic Regression			✔	✔

Week 10-11	Artificial Neural Networks for Climate Modeling and Environmental Impact Assessment	✔	✔	✔	✔
Week 12-13	Support Vector Machines for Bacterial and Viral Disease Classification	✔	✔		✔
Week 13-14	Clustering			✔	
Week 15	Dimensionality Reduction in Pollution Source Apportionment			✔	
Week 16	Project Presentations			✔	

Practical:

No.	Topics
1	Python: Review
2	Numpy, Scipy, Pandas, and Scikit-learn
3	Decision Trees: Identification of Pollutants
4	Linear regression in one variable
5	Linear regression in multiple variables for pollutant level prediction
6	Logistic regression in air quality indexing
7	Support vector machine for identification of bacterial and viral disease
8	Artificial Neural Networks for environmental impact assessment
9	Convolutional Neural Networks for climate modeling and particulate matter

	prediction
10	Apply machine learning models to predict air quality and PM2.5 for air quality indexing and prediction of smog levels associated with air quality and PM2.5
11	Clustering for pollutant clusters in water bodies
12	Principal Component Analysis for reduction of soil parameters

TEXT AND MATERIAL:

Textbook (s)

1. Pattern Recognition and Machine Learning by Christopher M. Bishop. 2007, Springer
2. Machine Learning by Tom M. Mitchell, 1997, McGraw-Hill.
3. Artificial Intelligence: A Modern Approach, (3rdEdition) by Stuart Russell and Peter Norvig, Prentice Hall.

ASSESMENT SYSTEM:

Theoretical 67%

Assignments 10%

Quizzes 15%

Mid Exams 25%

Final Exams 50%

Lab 33%

Nature of Exam	**Duration**	**Frequency**	**Weightage (%age)**
Lab Work / Psychomotor Assessment / Lab Reports	3 Contact Hours	1 per week for each lab CH	50-70
Lab Project / Open-ended Lab Project / Assignment Quiz	-	1-2	10-20

Final Assessment / Mid Semester Assessment (Written, viva, hands-on programs, group tasks)	-	1	20-30