INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

INTRODUCTION TO MACHINE LEARNING AND DEEP LEARNING								
III Semester: ST								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
BSTE27	Elective	3	0	0	3	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Probability and Statistics								

I. COURSE OVERVIEW:

This course introduces the concepts of machine learning and data analytics with applications in civil engineering. It covers supervised and unsupervised learning algorithms, neural networks, big data tools, and visualization platforms. Students will learn to apply machine learning techniques for tasks such as structural health monitoring, soil classification, traffic state prediction, and construction data management. Emphasis is placed on real-world applications, use of big data frameworks, and practical implementation through modern AI/ML libraries and visualization tools.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Foundations in machine learning and data analytics concepts relevant to civil engineering.
II. Big data processing frameworks and tools for handling large-scale civil engineering datasets.
III. Visualization techniques to interpret and communicate engineering data insights.
IV. The ML/DL algorithms for solving real-world civil engineering problems through projects.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1 Explain the fundamentals of machine learning and data analytics and their importance in modern civil engineering.
CO 2 Apply supervised and unsupervised machine learning algorithms to solve classification and clustering problems in civil engineering.
CO 3 Implement neural network architectures (CNN, RNN, LSTM, GANs) for image-based and time-series applications in structural, geotechnical, and transportation engineering.
CO 4 Utilize big data processing tools (Hadoop, Spark, Pig, Hive) for analyzing large-scale civil engineering datasets.
CO 5 Develop effective data visualization and interpretation using tools such as Tableau, Power BI, and deep learning frameworks.
CO 6 Analyze real-world case studies and projects to identify suitable ML/DA methods for solving civil engineering challenges.

IV. COURSE CONTENT:

MODULE –I: INTRODUCTION (9)
Introduction to machine learning and data analytics in civil engineering: fundamentals, tools, history necessities, machine learning in modern civil engineering; recapitulation of linear regression, logistic regression

MODULE -II: APPLIED LEARNING MODELS (9)
supervised algorithms such as k-nearest neighbor, support vector machines, neural networks fundamentals and backpropagation, applications to structural damage detection, soil classification, etc.; unsupervised clustering algorithms such as hierarchical clustering, k-means and DBSCAN, applications on transportation mode inference, level of service of roads.

MODULE -III: DEEP LEARNING (9)
Introduction and fundamentals of convolutional neural network, image classification and object detection, applications to camera-based classification and object detection related to structural health monitoring, vehicle detection, etc.

Recurrent neural networks, long-short term memory, applications to traffic state prediction (speed/volume), soil strength prediction, rainfall-runoff modelling, etc.; variational autoencoder, generative adversarial networks, applications to sensor data generation and imputation such as traffic sensors, fault diagnostics in structural health monitoring.

MODULE -IV: BIG DATA (9)
Map reduce fundamentals (key-value), interface, algorithms (matrix multiplication, sorting, etc.), relevant tools such as apache pig, hive, spark fundamentals, spark streaming, applications to large-scale traffic trajectory data analysis, building information modelling in construction industry, etc.

MODULE -V: DATA VISUALIZATION TOOLS (9)
large-scale data visualization using Tableau, Power BI; deep learning tools such as keras, pytorch. Students will carry out a project applying the tools/algorithms covered in the course on a topic of their choice of interest.

V. TEXTBOOKS:

1. Ethem Alpaydin, "*Introduction to Machine Learning*", MIT Press, 4th Edition, 2020.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "*Deep Learning*" MIT Press, 2016.
3. Jure Leskovec, Anand Rajaraman, Jeffrey Ullman, "*Mining of Massive Datasets*", Cambridge University Press, 3rd Edition, 2020.
4. Christopher M. Bishop, "*Pattern Recognition and Machine Learning*", Springer, 2006.

VI. REFERENCE BOOKS:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "*The Elements of Statistical Learning*", Springer, 2nd Edition, 2017.
2. Andreas C. Müller, Sarah Guido, "*Introduction to Machine Learning with Python*", O'Reilly, 2017.
3. Aurélien Géron, "*Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*", O'Reilly, 3rd Edition, 2022.
4. Foster Provost, Tom Fawcett, "*Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking*", O'Reilly, 2013.

VII. ELECTRONICS RESOURCES:

1. https://nptel.ac.in/courses/106106139
2. https://nptel.ac.in/courses/106106184
3. https://nptel.ac.in/courses/106106179
4. Scikit-learn: https://scikit-learn.org – Python ML library.

VIII. MATERIAL ONLINE:

1. Course Outline Description
2. Tutorial Question Bank
3. Assignments
4. Model Question Paper – I
5. Model Question Paper - II
6. Lecture Notes
7. Early Lecture Readiness Videos
8. Power point presentation