# SECOND SEMESTER 2022-2023 COURSE HANDOUT (PART-II)

**Date: 16/01/2023**

In addition to Part-I (General Handout for all courses appended to the timetable), this portion gives further specific details regarding the course.

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| **Course Code** | **:** | **ME F321** |
| **Name of the Course** | **:** | **Data Mining in Mechanical Sciences** |
| **Instructor-In-Charge** | **:** | **Dr. Kundan Kumar Singh** |

**Scope and Objective of the Course:** The primary focus of this course is on application of data mining methods in mechanical sciences and engineering. Following are the detailed objectives of this course:

* Understanding the fundamental of data mining.
* Building mathematical foundation for data mining.
* Knowledge of data capturing to minimize the information losses.
* Understanding of patterns in data, data classification and clustering.
* Knowledge of application of identified patterns in data in fields like in-process monitoring, machine monitoring, defect analysis, machine and maintenance scheduling etc.
* Understanding of different prediction methods based on the data processing.
* Understand the difference between artificial intelligence, machine learning and deep learning.
* Knowledge of which data mining methods should be used for what type of data.
* Understanding the concept of big data in manufacturing and how to handle it.

# Text Books

1. Bhatia, P., 2019. Data mining and data warehousing: principles and practical techniques. Cmbridge University Press.
2. Zaki, M.J. and Meira Jr, W., 2020. Data Mining and Machine Learning: Fundamental Concepts and Algorithms. Cambridge University Press

# Reference Books

1. Kantardzic, Mehmed. Data mining: concepts, models, methods, and algorithms. John Wiley & Sons, 2011.
2. Hand, David J. "Data mining: statistics and more?" The American Statistician 52, no. 2, 1998.
3. Maimon, Oded Z., and Lior Rokach. Data mining with decision trees: theory and applications. Vol. 81. World scientific, 2014.

# Course Contents

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| **Lecture No.** | **Learning Objectives** | **Topic to be covered** | **Chapter in the**  **text book** |
| 1-2 | Understanding the objectives of data mining | Why data analysis? Importance of data analysis, Data analysis to data mining, Definition of data mining,  Objectives of data mining, Analogy of data mining with concept of mechanical science, Steps in data mining/Data mining process, Concept of data  warehouses, Why data mining fails? | Class notes and  [3]-1 |
| 3-4 | Measuring the data and changing the form of raw data (Data preprocessing) | Data measurement (Sampling method) Structure/ representation of data Temporal and spatial data  Different types of data; Numeric and categorical data Dimensionality of data., Mean, variance, data normalization  methods, data smoothing methods. | Class notes and  [4]-2 |
| 5-6 | Statistical analysis and outlier detection | Point estimation, central limit theory, Regression methods, logistical regression, Density and proximity based outlier detection, clustering based method. | Class notes and  [5]-8, [4]-6 |
| 7-10 | Feature identification/extracti on methods | Supervised and unsupervised feature, Architecture for feature subset selection, Principle component analysis for feature selection, relief algorithm, ranking score,  entropy method, Chimerge technique for feature discretization | Class notes and  [5]-13, [4]-6 |
| 11-15 | Different clustering algorithms and its applications | Objective of clustering, methods for similarity measure, Agglomerative hierarchical clustering, partitional and incremental clustering, DBSCAN  algorithm, clustering validity. | Class notes and  [3]-9, [4]-9 |
| 16-22 | Different classification algorithms and its application | General approach for classification problem, accuracy and error rate, Decision tree, design of decision tree, algorithm for decision tree, K nearest neighbors. | Class notes and  [4]-10, [4]-4 |

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| 23-26 | Prediction from data; machine learning methods | Learning machine, types of learning methods; supervised and unsupervised learning, statistical learning theory, Support vector machine algorithm, Neural networks; ANN, RNN etc. Deep  learning methods. | Class notes and  [3]-6,7 |
| 27-28 | Case studies | Different case studies for application of machine learning in mechanical system, design and manufacturing. | Class notes, Journal papers |

**List of Experiments\***

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| **Week** | **Experiment No.** | **Experiment details** |
| 1 | E1 | Basics of python, installing python and setting up python  environment; how python works? |
| 2 | E2 | Getting started with python programming; running code, input,  processing and output, running a script |
| 3 | E3 | Data loading and preprocessing with pandas, data processing  with NumPy, Creating NumPy arrays |
| 4 | E4 | Writing control loop, programming for if and if-elase  statements, Design and functions |
| 5 | E5 | Binary classification and multilabel classification, linear  regression, logistical regression |
| 6 | E6 | The data pipeline, principle component analysis Kernel PCA,  outlier detection binary classification |
| 7 | E7 | Feature selection, univariant selection, recursive elimination |
| 8 | E8 | K-nearest neighbors, Clustering using python DBSCAN in  python |
| 9 | E9 | Programming for decision tree and entropy analysis, different  examples |
| 10 | E10 | SVM for classification, SVM for regression, tuning SVM |
| 11 | E11 | Neural network programming |
| 12 | E12 | ANN and deep learning using Keras, different case studies  using Keras. |

\*All experiments will be conducted using Python.

# Evaluation Scheme and Schedule

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage(%)** | **Date & Time** | **Nature of**  **Component** |
| Mid Sem. Test | 90 Min. | 20 | 18/03 4.00 - 5.30PM | Close Book |
| Quiz | – | 10 | To be announced in class | Close Book |
| Project/case study | – | 15 | – | Open Book |
| Laboratory | - | 20 | To be announced. | Open Book |
| Comprehension  examination | 3 Hrs. | 35 | 20/05 AN | Close Book |

1. **Chamber Consultation Hour:** To be announced in the class
2. **Notices concerning the course:** All notices concerning the course will be displayed on the CMS notice board.
3. **Make-up Policy:** Make-up will be permitted only in genuine cases with prior permission.

# NOTE: The border cases in final grading will be decided based on mainly classroom attendance and attentiveness in the classroom.

**Academic Honesty and Integrity Policy:**

Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Instructor-In-Charge ME F321**