Course guide
295457 - 295TM114 - Data Science in Mechanical Engineering

Last modified: 03/03/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics.

Degree: MASTER'S DEGREE IN MECHANICAL TECHNOLOGIES (Syllabus 2024). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: MARIO MIGUEL VALERO PÉREZ - JOAN CALAFELL SANDIUMENGE

Others: Segon quadrimestre:
JOAN CALAFELL SANDIUMENGE - Grup: T1
JAN MATEU ARMENGOL - Grup: T1
MARIO MIGUEL VALERO PÉREZ - Grup: T1

PRIOR SKILLS

IMPORTANT: Programming knowledge. Ability to independently create and execute small functions and scripts, preferably in Python.
Knowledge of basic statistics concepts.
No prior experience in data science is required.

LEARNING RESULTS

Knowledges:
K.08. Identify data analysis tools to characterise, synthesise, explain and predict the behaviour of physical systems in the field of mechanical engineering.
K.05. Identify emerging technologies, both in the mechanical domain and in the field of new information and communication technologies, that can be applied to mechanical engineering projects.
K.07. Define appropriate analytical, experimental and/or computational models to study relevant problems in mechanical engineering.

Skills:
S.02. Correctly apply the analytical, computational and/or experimental techniques best suited to the analysis of a case or project in the mechanical field.
S.08. Integrate knowledge from different areas of the mechanical field in the design and development of projects, systems and engineering solutions.
S.04. Incorporate sustainability and energy efficiency criteria into the design, planning, execution and operation phases of engineering projects.
S.05. Critically examine the results of the analysis of a process or product, taking into account the limitations of the techniques used.
S.07. Design flexible production/operation systems to improve the performance of industrial processes.
S.03. Use advanced numerical simulation and virtual prototyping techniques to solve complex mechanical problems.
S.06. Efficiently manage information collected during analytical, numerical and/or experimental studies and automate its analysis to facilitate knowledge extraction.

Competences:
C.03. Manage the acquisition, structuring, analysis and visualisation of data and information in the mechanical field and critically evaluate the results of this process.
C.02. Work as part of a multidisciplinary team, whether as a team member or in a leadership role, to contribute to the development of projects with pragmatism and a sense of responsibility, undertaking commitments with due regard to the resources available.
C.05. Propose advanced scientific and technological solutions to complex industrial challenges in the field of mechanical engineering.

TEACHING METHODOLOGY

The teaching methodology of the course Data Science in Mechanical Engineering is based on a balanced combination of theoretical lectures and in-person practical sessions, with the aim of ensuring both the assimilation of conceptual foundations and the development of applied competencies. The theoretical classes introduce the basic principles of data science, analysis methods, and relevant algorithms in the context of mechanical engineering, while the practical sessions are carried out through interactive scripts developed in Google Colab environments. This approach allows students to engage in guided experimentation with real data, implement computational models, and interpret the results, fostering active learning, autonomy in problem-solving, and effective integration of theory and practice.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of this course, the student will be able to:
1. Manage and visualize large datasets.
2. Implement data science workflows in a scalable fashion.
3. Design, implement, and evaluate the performance of advanced data analysis techniques, data-driven models or machine and deep learning schemes.
4. Select the most adequate methodologies to resolve data-related mechanical engineering problems.
5. Design, implement, and evaluate the performance of data science workflows in mechanical engineering frameworks.
6. Explain and discuss data science solutions, both orally and in writing.

STUDY LOAD

Type	Hours	Percentage
Hours large group	21,0	14.00
Self study	108,0	72.00
Hours small group	21,0	14.00

Total learning time: 150 h

CONTENTS

Topic 1: Basics of Data Science

Description:
Recap of basic statistics.
Optimization techniques.
Basics of software development.
Code and data management.
Scientific data visualization.
Cloud computing.
Distributed and Parallel systems for big data.

Specific objectives:
Understand and apply basic statistics concepts used in data science.
Implement a variety of multiparametric optimization techniques.
Process data at scale.
Create reproducible and maintainable data workflows.

Related activities:
Short exercises on statistics, optimization, and other relevant mathematical tools.
Implement a simple data workflow.

Full-or-part-time: 7h 30m
Theory classes: 1h 30m
Laboratory classes: 1h 30m
Self study : 4h 30m

Topic 2: Data-Driven Modeling

Description:
Uncertainty quantification.
Model verification and model validation.
Bayesian inference.
Data assimilation (dynamic assimilation, gap filling, data-fusion).
Dynamical systems.
Reduced order models.
Intelligent control through learning and optimization.

Specific objectives:
Apply uncertainty propagation on basic mathematical operations.
Understand the underlying concepts of reduced order models and their implementation.
Build surrogate models from large databases and perform cross-validation.
Understand global sensitivity models and their implementation.
Implement Bayesian calibration algorithms.

Related activities:
Build a full Uncertainty Quantification workflow from a real-world application.

Full-or-part-time: 30h
Theory classes: 6h
Laboratory classes: 6h
Self study : 18h

Topic 3: Data analysis and Technological applications

Description:
Detection of anomalies (e.g. predictive maintenance).
Pattern recognition.
Image processing and computer vision.
Dimensionality reduction.
Regression.
Clustering and classification.

Specific objectives:
Obtain a general overview of the possibilities that data science techniques offer in various technological applications, emphasizing mechanical engineering.

Full-or-part-time: 30h
Theory classes: 6h
Laboratory classes: 6h
Self study : 18h

Topic 4: Machine Learning. Deep Learning fundamentals

Description:
Deep learning in the context of Machine Learning.
Supervised vs. Unsupervised Learning.
Regression vs. Classification problems. Metrics.
Perceptron: single neuron model and activation functions.
Loss Function, Backpropagation, and Optimization.
Multilayer Perceptron.
Convolutional Neural Networks, Pooling Layers.
Neural Network training process. Regularization techniques.

Specific objectives:
Understand and apply fundamental concepts in deep learning (neural networks) development.
Implement basic neural networks for classification and regression problems.
Training basic models for classification and regression problems.

Related activities:
Complete missing but essential parts of a basic PyTorch code defining a neural network and its training functions.
Training a model following training guidelines including hyperparameter tuning and application of regularization techniques.

Full-or-part-time: 37h 30m
Theory classes: 7h 30m
Laboratory classes: 7h 30m
Self study : 22h 30m

GRADING SYSTEM

The student's competencies and skills will be evaluated through continuous evaluation using the following methodology:
1. Evaluation of the theoretical content of the first part of the course through a midterm exam (25%).
2. Evaluation of the theoretical content of the entire course through a final exam (30%).
3. Evaluation of the laboratory sessions corresponding to Data-driven Modeling (15%).
4. Evaluation of the laboratory sessions corresponding to Machine Learning (15%).
5. Evaluation of the laboratory sessions corresponding to Data Analysis and Technological Applications (15%).