

## Machine Learning

<b>Level:</b>	Second cycle	<b>Semester:</b>	Fall
<b>Curricular Unit Code:</b>	200179	<b>Duration:</b>	S1
<b>Year:</b>	1	<b>Academic year:</b>	2025-26

### Total of hours

Total of Hours Spent	Contact Hours	Nr. of hours per week	ECTS
210	45 TP	3	7.5

T - Theoretical; TP - Theoretical and practical ; PL - Practical and Laboratorial; TC - Field Work; S - Seminar; E - Internship; OT - Tutorial Orientation; O - Other

### Responsible teaching staff

Roberto André Pereira Henriques

### Other teaching staff

Leon Debatin, Ricardo Miguel Costa Santos

### Office hours

Roberto Henriques - Fridays , 11:00-12:00 upon scheduling

Ricardo Santos - Wednesdays, 16:00-17:00 upon scheduling

Leon Debatin - Mondays, 11:00-12:00 upon scheduling

### General objectives

Machine learning is revolutionizing numerous areas by enabling computers to learn from data and make intelligent predictions and decisions. In this course, students will gain a strong foundation in the core concepts, applications, and tools for machine learning. Through theory and hands-on programming, they will develop skills to build and deploy machine-learning models for real-world tasks. The general Learning Objectives are:

- Understand the significant machine learning approaches, including supervised learning and unsupervised learning.
- Use Python to implement popular machine learning algorithms like linear regression, logistic regression, neural networks, support vector machines, decision trees, and k-means clustering.
- Evaluate and compare machine learning models using proper evaluation metrics and techniques like train/test splits, cross-validation, confusion matrices, and classification reports.
- Gain experience with the whole machine learning workflow, including data exploration, data cleaning and preprocessing, feature engineering, model optimization, and deployment.
- Apply machine learning to solve real-world problems through hands-on projects and assignments using datasets from domains like computer vision, natural language processing, and recommender systems.
- Develop proper techniques to avoid overfitting, handle missing data, and perform feature selection and dimensionality reduction.

By completing this course, students will gain valued machine-learning skills to drive innovations and technologies powered by artificial intelligence.

## Sustainable Development Goals (SDG)

**4** **QUALITY EDUCATION**



**16** **PEACE, JUSTICE AND STRONG INSTITUTIONS**



4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

16 - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

### Enrolment Requirements

NA

### Learning outcomes (knowledge, skills, and competences to be developed by the students), and their compatibility with the teaching modality

LO1. Understand fundamental concepts, algorithms, and techniques in machine learning, including supervised and unsupervised learning.

LO2. Gain proficiency in Python and machine learning libraries like Scikit-Learn, Pandas, and NumPy to implement workflows, covering data preprocessing, model training, evaluation, and prediction.

LO3. Apply machine learning algorithms, such as linear regression, logistic regression, decision trees, SVMs, and neural networks, to solve classification and regression problems.

LO4. Develop skills in data preparation for machine learning, including cleaning, feature engineering, selection, scaling, and dimensionality reduction, transforming raw data for ML algorithms.

LO5. Evaluate machine learning models with suitable metrics, visualize performance, and optimize through grid search, cross-validation, and hyperparameter tuning, avoiding overfitting and underfitting.

## Programmatic Contents

LU1 Introduction to machine learning fundamentals:

- a. Overview of machine learning and key terminology
- b. Categories of machine learning: supervised, unsupervised, reinforcement
- c. Applications and examples of machine learning

LU2 Data Preprocessing and feature selection:

- a. Data preprocessing techniques: cleaning, transformations, feature engineering
- b. Types of feature selection

LU3 Model Selection and Evaluation:

- a. Train/test splits, cross-validation
- b. Classification evaluation metrics and techniques
- c. Regression evaluation metrics and techniques
- d. Overfitting and underfitting

LU4 Introduction Supervised Learning Algorithms:

- a. Linear and Logistic regression
- b. Probability-based learning
- c. Similarity-based learning
- d. Regression and classification trees
- e. Ensemble classifiers
- f. Neural networks
- g. Support Vector Machines

LU5 Machine Learning Projects:

- a. End-to-end machine learning project walkthrough
- b. Deploying machine learning models to applications

## Curricular unit Planning

Week	Type	Week	Topic	Details	Type
1	T	8-Sep-25	Introduction to machine learning. Motivation & Applications of Machine Learning. Supervised Learning, Unsupervised Learning, Reinforcement Learning	RH	Lecture
	TP		No practical class		
2	T	15-Sep-25	Machine Learning Tribes	RH	Lecture
	TP		No practical class		
3	T	22-Sep-25	Feature selection	RH	Lecture
	TP		The concept of Supervised and Unsupervised Learning applied to the real world The steps of a ML Project Group Project Presentation	RS	Python demo & Exercise
4	T	29-Sep-25	Model selection and evaluation	RH	Lecture
	TP		Data transformation, feature engineering and feature selection in Python	LD	Coding demos & hands-on labs
5	T	6-Oct-25	Linear and Logistic Regression	RH	Lecture
	TP		How to evaluate predictive models using different metrics in Python	LD	Coding demos & hands-on labs Practical Quizz
6	T	13-Oct-25	Probability based Learning	RH	Lecture
	TP		Linear and Logistic Regression in Python	LD	Coding demos & hands-on labs
7	T	20-Oct-25	Similarity based learning	RH	Lecture

	TP		Probability based Learning algorithms in Python	RS	Coding demos & hands-on labs
	T	27-Oct-25	<b>No class week for trimester courses exams</b>		
	TP				
<b>Handout: November 3th at 18:00h</b>					
8	T	3-Nov-25	Neural Networks I	RH	Lecture
	TP		Similarity based learning algorithms in Python	RS	Coding demos & hands-on labs Practical Quizz
9	T	10-Nov-25	Neural Networks II	RH	Lecture
	TP		Neural Networks in Python.	RS	Coding demos & hands-on labs
10	T	17-Nov-25	Regression and classification trees I	RH	Lecture
	TP		Neural Networks in Python. The concept of GridSearch.	RS	Coding demos & hands-on labs Practical Quizz
11	T	24-Nov-25	Regression and classification trees II	RH	Lecture
	TP		Regression Trees in Python	RS	Coding demos & hands-on labs
12	T	1-Dec-25	Ensemble classifiers I	RH	Lecture
	TP		Classification Trees in Python	RS	Coding demos & hands-on labs
13	T	8-Dec-25	Ensemble classifiers II	RH	Lecture
	TP		Ensemble classifiers in Python I	RS	Coding demos & hands-on labs
14	T	15-Dec-25	Support Vector Machines	RH	Lecture
	TP		Ensemble classifiers in Python II	RS	Coding demos & hands-on labs Practical Quizz
15	TP	Extra to be scheduled	SVM in Python	RS	Coding demos & hands-on labs
16	TP	Project Support	Project-Based Learning		
<b>Project Deadline: December 22nd at 18:00h</b>					

### Evidence that the curricular unit's content dovetails with the specified learning outcomes

The learning units (LU) cover the learning objectives (LO) as follows:

LU 1 addresses LO 1.

LU 2 addresses LO 4.

LU 3 addresses LO 5.

LU 4 addresses LO 3.

LU 5 addresses LO 2 and LO 5.

## Teaching methodologies

The course is based on theoretical and practical lessons. As presented in the curricular unit planning table, various effective teaching methodologies are applied:

- Lectures - covering theoretical concepts and algorithms. Use of slides and diagrams to convey key ideas.
- In-class coding demos - demonstrating programming examples and machine learning workflows on notebooks.
- Hands-on labs - providing structured labs to implement models and algorithms with clear instructions.
- Project-based learning - Assign sizable projects for students to work on applying multiple models and techniques end-to-end.

## Assessment

Regular (1st examination period)

- Exam (50%)
- Practical handout (10%)
- Final Project (40%)

Resit (2<sup>nd</sup> examination period)

- Exam (60%)
- Final Project (40%)

A minimum grade of 8.0 (in 20) for the exam

A minimum grade of 5.0 (in 20) for the projects

## Evidence that the teaching and assessment methodologies are appropriate for the learning outcomes

The lectures provide overviews of machine learning concepts, algorithms, and techniques, directly addressing LO1, LO2, LO3 and LO4 on fundamental machine learning knowledge for theoretical classes.

The hands-on labs, and in-class coding demos, give students practical experience with Python, ML libraries, and end-to-end workflows. This aligns with LO2 on gaining proficiency with ML coding tools and implementations.

Working through supervised learning algorithms in the demos and labs allows students to apply these techniques (LO3) on sample datasets and problems. Project-based learning also provides an opportunity to apply algorithms.

Data preprocessing and feature engineering are critical skills covered through demos and labs focused on these tasks. This supports the data preparation aspects of LO4.

Model evaluation methods and metrics are taught through lectures and reinforced by applying techniques like cross-validation and parameter tuning in the hands-on labs. This aligns with the model analysis parts of LO5.

Finally, team projects require applying multiple skills across the learning outcomes, providing a synthesis experience that ties together conceptual knowledge and practical abilities.

## Mandatory bibliography

- Pattern Recognition and Machine Learning, Christopher M. Bishop
- Machine Learning Yearning: technical strategy for AI engineers in the era of deep learning. Andrew NG
- Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies (The MIT Press), John D. Kelleher, Brian Mac Namee, Aoife D'arcy
- Mastering Machine Learning with Python in Six Steps. A Practical Implementation Guide to Predictive Data Analytics Using Python. Swamynathan, Manohar