

# MATH0114 Mathematics for Machine Learning and Artificial Intelligence

|                                 |   |
|---------------------------------|---|
| <i>Year:</i>                    | 2024–2025   |
| <i>Code:</i>                    | MATH0114  |
| <i>Level:</i>                   | 6 (UG)  |
| <i>Normal student group(s):</i> | UG: Year 3 Mathematics degrees                          |
| <i>Value:</i>                   | 15 credits (= 7.5 ECTS credits)                         |
| <i>Term:</i>                    | 2   |
| <i>Assessment:</i>              | 90% examination, 10% coursework                         |
| <i>Normal Pre-requisites:</i>   | MATH0003/4/5/6/11 and MATH0014: MATH0057 is recommended |
| <i>Lecturer:</i>                | Dr Alejandro Dias and Dr Luca Grieco                    |

## *Course Description and Objectives*

This module will introduce the student to the theoretical foundations behind some of the most widespread methods used in Machine Learning and Artificial Intelligence. We will dive deeply into the mathematical foundations of three learning paradigms, embodied in one flagship method within each one: (i) Linear regression for supervised learning, (ii) principal component analysis for unsupervised learning, and (iii) backpropagation for deep learning. Additionally, we will study the mathematics behind diffusion models, currently one of the most notable generative AI methods to produce images from text. Besides the theoretical aspects of these techniques, students will be exposed to practical implementation of machine learning algorithms through practical examples shown during lectures. Online tutorials on the coding (in Python) of the studied methods will be provided.

## *Recommended Texts*

The bibliographic resources are available online for free. Some of the main books are:

- Mathematics for Machine Learning (<https://mml-book.github.io/book/mml-book.pdf>)
- An Introduction to Statistical Learning (<https://www.statlearning.com/>)

Additionally, very recently published academic papers will be used, for instance <https://arxiv.org/abs/2006.11239>

## *Detailed Syllabus*

- Definitions of Machine Learning and AI
- Types of Machine Learning
- The Bias-Variance Trade-off
- Supervised Learning: Linear Regression as Maximum a Posteriori Estimation
- Unsupervised Learning: Principal Component Analysis
- Deep Learning: Basic Definitions
- Deep Learning: The Backpropagation Algorithm
- Generative AI: How does Stable Diffusion work?