# Mathematical Methods and Probability

## Prof. Carlo Alberto De Bernardi; Prof. Giulia Giantesio; Prof. Enrico Miglierina

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The aim of the course is to provide a toolbox of mathematical and probabilistic methods to deal with the problems that often arise in statistics and data sciences.

At the end of the course students should:

1. have acquired the knowledge and understanding of the main parts of the program and be able to apply the mathematical methods and techniques described in the program in order to solve problems and exercises.;
2. have learned a rigorous and essential language that allows them to communicate the knowledge clearly and effectively;
3. be able to recognize links between the topics developed in the course and other issues addressed in the context of their study plan.

***COURSE CONTENT***

The course is divided into four parts.

Probability 1*. (Giulia Giantesio – 10 hours).* Events and probability. Random variables: discrete and continuous. Expectation, variance. Main univariate probability distributions. The change-of-variable formula.

Linear Algebra. *(Enrico Miglierina – 20 hours)* Brief review of definitions and basic operations of vectors and matrices. Trace, determinant and inverse of square matrices. Eigenvalues and Eigenvectors. Definite, semi-definite and indefinite matrices. Quadratic Forms and the associated matrix.

Calculus. *(Carlo A. De Bernardi – 20 hours).*

Improper integrals. n as normed space. Differential calculus for functions of several variables. Taylor approximation. Unconstrained optimization. Constrained optimization (Lagrange multipliers). Double integral.

Probability 2*. (Giulia Giantesio – 10 hours)* Random vectors and multivariate distributions. Expectation vector, variance-covariance matrix, correlation matrix. Convergence of random variables, law of large numbers, central limit theorem.

***READING LIST***

* Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong *-Mathematics for Machine Learning,* Cambridge University Press, 2020.
* L. Peccati, S. Salsa, and A. Squellati, Mathematics for Economics and Business, Bocconi University Press, Milan, 2016.

***TEACHING METHOD***

Lectures in presence, exercise groups, tutoring hours.

***ASSESSMENT METHOD AND CRITERIA***

Written exam concerning both theoretical and practical questions. The exam includes both multiple choice questions and open exercises. Detailed rules about the exam will be available on Blackboard.

***NOTES AND PREREQUISITES***

Prerequisites:

The student is assumed to know differential calculus in R and some basic notions of linear algebra (vectors and matrices, linear systems).

Announcements and additional material will be available on Blackboard

Some tutoring meetings, announced on Blackboard, will be organized in the second part of the course.

*Office hours*

Prof. Carlo Alberto De Bernardi: by appointment to be fixed by e-mail ([carloalberto.debernardi@unicatt.it](mailto:carloalberto.debernardi@unicatt.it)). The office hours are held in room 211b, second floor, building Via Necchi 9

Prof. Giulia Giantesio: by appointment to be fixed by e-mail ([giulia.giantesio@unicatt.it](mailto:giulia.giantesio@unicatt.it)). The office hours can be held in building Buonarroti or online via Teams.

Prof. Enrico Miglierina: by appointment to be fixed by e-mail ([enrico.miglierina@unicatt.it](mailto:enrico.miglierina@unicatt.it)). The office hours are held in room 207, second floor, building Via Necchi 9