# Mathematical Methods and Probability

## Proff. Carlo A. De Bernardi, Alfredo Marzocchi, 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 three parts.

*First part (Enrico Miglierina – 20 hours)*. Linear Algebra.

Brief review of definitions and basic operations of vectors matrices. Trace, determinant and inverse of square matrices. Eigenvalues and Eigenvectors. Definite, semi-definite and indefinite matrices (including Cholesky Decomposition). Quadratic Forms and the associated matrix.

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

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

*Third part (Alfredo Marzocchi – 20 hours).* Events and probability. Random variable: discrete and continuous. Expectation, variance, and conditional expectation. Main univariate probability distributions. The change-of-variable formula. Random vectors and multivariate distributions. Expectation vector, variance-covariance matrix, correlation matrix. Multivariate normal and Multinomial distributions. Convergence of random variables, law of large numbers, central limit theorem.

***READING LIST[[1]](#footnote-1)***

Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong *-Mathematics for Machine Learning,* Cambridge University Press, 2020

***TEACHING METHOD***

Lectures in presence, exercise groups.

***ASSESSMENT METHOD AND CRITERIA***

Written exam concerning both theoretical and practical questions During the course it will be possible to attend partial tests concerning the parts of the program.

***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

***Office hours:*** by appointment by contacting the teachers via e-mail:

Carlo Alberto De Bernardi: carloalberto.debernardi@unicatt.it

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IMPORTANT REMARK:

If the health situation related to the Covid-19 pandemic should not allow face-to-face teaching, distance teaching will be guaranteed in ways that will be communicated to students in the due time.

1. I testi indicati nella bibliografia sono acquistabili presso le librerie di Ateneo; è possibile acquistarli anche presso altri rivenditori. [↑](#footnote-ref-1)