# Mathematical methods for economics

## Prof. Gianandrea Ubiali; Prof.ssa Ornella Dallavalle

***COURSE AIMS and intended learning outcomes***

The course has two objectives: to present several fundamental mathematical tools for dealing with economic and financial problems, and to help students to acquire a precise and essential language. The course will emphasize how to develop a view toward critically re-examining mathematical concepts which students will find in their academic pursuits, and how to stimulate the capacity to use mathematical methods, tools and models in a wide array of applications. The course will cover basic topics in differential and integral calculus, optimization, linear algebra and financial mathematics; these concepts will provide an effective tool for analysing economic and business phenomena.

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 described in the program in order to solve problems and exercises;
2. be able to understand the translation of a real-world situation into a mathematical model;
3. be able to deal with complex problems by using mathematical tools;
4. have learned a rigorous and essential language that allows them to communicate the knowledge clearly and effectively;
5. have developed good learning skills that allow them to continue their plan of studies.

***COURSE CONTENT***

The course is divided in four parts:

*Elements of Linear Algebra*. The vector space Rn. Linear combinations, linearly dependent and independent vectors. Matrices and their operations. Determinants. Inverse matrices. The rank of a matrix. Homogeneous and non-homogeneous linear systems of m equations in n variables. The Rouché-Capelli theorem, and the Cramer theorem.

*The functions of a real variable.* Real numbers R. Elements of topology within R. Domain. The concepts of maximum, minimum, infimum, and supremum. Bounded functions, monotonic functions, function composition, and invertible functions. Concave and convex functions.

Limits and relative theorems. Operations on limits and indeterminate forms. Continuous functions and relative theorems. Horizontal, vertical, and oblique asymptotes.

The difference quotient and the derivative. Differentiable functions. Operations on derivatives. Derivatives of function compositions. Differential calculus theorems. Taylor’s formula. The absolute and relative extrema of a function. The inflection point. The necessary and/or sufficient conditions of existence of relative extrema. Concavity/convexity.

Antiderivatives and indefinite integrals. Riemann’s integrals in a limited interval [a,b] and relative theorems. Some of the methods of integration.

*The functions of two real variables*. The Euclidean space R2. Elements of topology within R2. Domain. Level curves. The absolute and relative extrema of a function. Saddle points. Continuity. First and second order partial derivatives, gradients, and the Hessian matrix. Homogeneous functions, concave and convex functions. Taylor’s formula. Unconstrained optimization: the first-order necessary condition and the second-order sufficient condition. Constrained optimization: a) equality constraints: the level curve method, the substitution method, the method of Lagrange multipliers (the first-order necessary condition and the second-order sufficient condition, the interpretation of Lagrange multipliers); b) inequality constraints: the level curve method.

*Concepts of financial mathematics.* Financial concepts of present and future values. Concepts of simple interest and compound interest. Annuities: definition, classification and valuation.

N.B. More detailed information on the aforementioned topics will be provided during lectures.

***READING LIST***

1. A. Torriero - M. Scovenna - L. Scaglianti, *Manuale di matematica. Metodi e applicazioni,* Ristampa aggiornata, Cedam 2015.
2. F. Brega-G. Messineo, *Esercizi di Matematica Generale,* Giappichelli, 2013 - 2019 (5 volumes; further information will be made available on Blackboard).
3. M. Scovenna - R. Grassi, *Esercizi di matematica. Esercitazioni e temi d’esame,* Cedam 2013 - Quinta ristampa 2019.
4. M. Bianchi-L. Scaglianti, *Precorso di Matematica,* Nozioni di base, Cedam, 2010.

Further teaching material will be made available on *Blackboard.*

***TEACHING METHOD***

Frontal lectures, practical classes, and preliminary courses (further information will be made available on Blackboard).

***ASSESSMENT METHOD AND CRITERIA***

The final assessment will consist in:

a *preliminary test* (fulfilment of the additive training obligation), aimed to check the basic knowledge of the subject. Only the students who pass this test, will be admitted to the following exam; the year-1 students who gave a correct answer to at least 8 questions in the Mathematics Session of the admission test for the Faculty of Economics will be allowed to skip the preliminary test. Once they have passed the preliminary test (Test OFA), students will not have to repeat it again;

a *written exam*, based on open-ended and closed-ended theoretical questions and practical exercises on the whole content of the course.

Alternatively, students will have the possibility to replace the written exam with two *interim tests* - the first one will take place during the course, while the second one in January 2023 - which are open to all students (including the ones of the previous academic years).

Further information on the final assessment will be made available on *Blackboard*.

***NOTES AND PREREQUISITES***

Preliminary notions

*Number sets. Elementary algebra. Powers, logarithms, exponentials. Equations and inequalities (polynomial and fractional), irrational, logarithmic and exponential. Systems of equations and inequalities. Plane analytical geometry. Basic notions of gonometry.*

These preliminary notions are included in the course programme, and they are fundamental to pass the preliminary test. They will be explained during the preliminary courses organised during the academic year (test OFA). Further information will be made available on Blackboard.

The first OFA course will take place during the week that precedes the beginning of the course, while the preliminary test will be held during the first week of classes. Although the preliminary course is mainly addressed to the students who need to prepare for the preliminary test, the attendance is highly recommended to all the students of the first year (this will help them get a better understanding of these fundamental notions).

In case the current Covid-19 health emergency does not allow frontal teaching, remote teaching will be carried out following procedures that will be promptly notified to students.