# Mathematics

## Prof. Michele Longo

***COURSE AIMS and INTENDED learning outcomes***

The course has the double aim of, firstly, introducing the students to basic mathematical tools for dealing with economic and financial problems, and, secondly, helping them to acquire a precise and essential language. In addition, the course aims to develop students' aptitude to critically examine the mathematical concepts encountered in their studies and to stimulate the ability to use mathematical tools and methods in economic, statistical and financial real-world situations. The course will cover basic topics in linear algebra, differential and integral calculus, and optimization; 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 use mathematical concepts and language to describe, analyze and solve economic, statistical and financial real-world situations;
3. be able to deal with complex problems by using mathematical tools and rigorous reasoning;
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 three parts:

**Real functions of one real variable**. *Preliminaries*. Natural, integer, rational and real numbers. Topology of the real line and plane. *Introductory concepts*: Domain. Maximum, minimum, upper and lower bounds. Bounded functions, monotonic functions, composition of functions, inverse function. *Limits and continuity*: Limits and related theorems. Operations on limits and indecision forms. Limit of the composite function. Infinitesimal and infinite. Asymptotes. Continuity of functions and related theorems. *Differential calculus*: Difference quotient and derivative. Differentiable functions. Geometric interpretation of the derivative and tangent line. Rules of differentiation. The chain rule for the derivative of composite functions. The derivative of the inverse function. Fundamental theorems of differential calculus. Necessary and/or sufficient conditions for the existence of maxima and minima. Concavity/convexity. Characterization of convex twice differentiable functions, points of inflexion. *Integral calculus*: The indefinite integral. The Riemann (definite) integral and related theorems. Some techniques of integration.

**Elements of linear algebra**. *The vector space Rn*: Subspace, linear combinations and linear independence. Basis and dimension. *Matrices*: Definitions of sum, scalar multiplication, transposition and their properties. Definition of matrix multiplication and its properties. Determinant. Inverse matrix. Matrix rank. *Systems of linear equations*: Basic definitions. Cramer’s rule. Rouchè-Capelli theorem.

**Real functions of two real variable**. *Introductory concepts*: Domain. Level sets. Continuity. Partial derivatives and gradient. Second derivative and *hessian* matrix. *Schwarz*’s theorem. *Unconstrained optimization*: Global and local maxima and minima. Saddle points. Necessary and/or sufficient conditions for the existence of maxima and minima. *Constrained optimization*: a) Equality constraints: The Lagrange multiplier method. Level set approach. Constraint substitution method. b) Inequality constraints: Level set approach.

***READING LIST***

1. A. Torriero-M. Scovenna-L. Scaglianti, *Manuale di Matematica,* *Metodi e applicazioni*, Cedam, 2013.
2. F. Brega-G. Messineo, *Esercizi di Matematica Generale,* Giappichelli, 2013 - 2019 (5 volumes).
3. M. Scovenna-R.Grassi, *Esercizi di Matematica,* *Esercitazioni e temi d’esame*, Cedam, quarta ristampa 2018.
4. M. Bianchi-L. Scaglianti, *Precorso di Matematica,* *Nozioni di base*, Cedam, 2010.

Online instructional material is available on the e-learning platform *Blackboard.*

***TEACHING METHOD***

Lectures, assignments, pre-course classes. An online pre-course TEOREMA is also accessible to the address [http://teorema.cilea.it](http://teorema.cilea.it/). Videos on some parts of the program are available on the e-learning platform *Blackboard.*

***ASSESSMENT METHOD AND CRITERIA***

The assessment is by a written and an oral test, both mandatory. The written test is divided into two parts: the first consists of multiple choice questions; the second consists of open-ended analytical questions. Candidates who passed the written exam can take the oral exam only on the established date. Students who do not pass the oral test or who do not take the oral exam must repeat the written exam.

Furthermore, two partial written tests are foreseen which, if passed, replace the written exam: the first partial test (intermediate test) take place during the week of suspension of first semester lessons and the second partial test (completion test) in the exam session of January-February 2023. All students, including those from previous years, can take part in the partial exams by registering according to the rules indicated during the course.

More detailed information about the assessment process will be provided during the first lecture and posted on the e-learning platform *Blackboard.*

***NOTES AND PREREQUISITES***

*Basic knowledge* (pre-course). Introduction to logic and basic set theory. Introduction to natural, integer, rational and real numbers. Power, n-root and absolute value of a real number. Elementary algebra.  Logarithmic and exponential functions. Equations and inequalities (polynomial, fractional, irrational, logarithmic and exponential). Systems of equations and inequalities. Plane analytical geometry. These topics will be reviewed during the pre-course class and are also in the videos. The attendance at the pre-course classes and the viewing of the videos are highly recommended.

The Blackboard IT platform will be used for the distribution of teaching material, the communication of grades, the publication of all communications relating to the course.

In the event that the health situation relating to the Covid-19 pandemic does not allow face-to-face teaching, distance learning will be guaranteed in ways that will be communicated to students in time.