# Mathematics

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

The priority objective of the course is to develop the aptitude to critically examine the mathematical concepts encountered by the student in his didactic-training path and to stimulate the ability to use methods, tools and mathematical models, in the framework of disciplines with an economic, statistical and financial content that the student will deal with in the following. The course aims to provide the basics of linear algebra, differential and integral calculus and optimization that constitute an effective tool for analyzing economic and business phenomena. Lessons of a more theoretical nature will be integrated by exercises carried out in the classroom and by indications to guide students in solving autonomously the exercises.

At the end of the course the students

- will have acquired the knowledge and understanding of the main parts of the program and will be able to apply the mathematical methods described in the program to solving problems and exercises;

- will be able to translate real-world situations, especially in the economic, financial and social fields, into the symbols and formalism of mathematics;

- will be able to deal with complex problems through the logical and formal tools made available by mathematics;

- will have acquired a rigorous and essential language that allows them to communicate the acquired knowledge clearly and effectively;

- will have developed good learning skills that allow them to undertake with greater autonomy advanced studies.

***COURSE CONTENT***

The course is divided in three parts:

*Elements of linear algebra*. The linear space Rn. Linear combinations and linear independence of vectors. Matrices and corresponding operations. Determinant. Inverse matrix. Matrix rank. Systems of linear equations. Rouchè-Capelli theorem, Cramer’s rule.

*Real functions of one variable.* Domain. Maximum, minimum, upper and lower bounds. Bounded functions, monotonic functions, composition of functions, inverse function. Convex functions.

Limits and related theorems. Operations on limits and indeterminate forms. Continuity of functions and related theorems. Asymptotes.

Incremental ratio and derivative. Differentiable functions. Rules of differentiation. Derivative of composite and inverse functions. Fundamental theorems of differential calculus. Taylor formula. Global and local maxima and minima, inflection points. Necessary and/or sufficient conditions for the existence of maxima and minima. Concavity, convexity.

The indefinite integral. The Riemann (definite) integral and related theorems. Some techniques of integration.

*Real functions of two real variables.* The Euclidean space R2. Domain. Level sets. Global and local maxima and minima. Saddle points. Continuity. Partial derivatives. Hessian. Concave, convex and homogeneous functions. Taylor Formula. Unconstrained optimization: first and second order conditions. Constrained optimization via the level set approach. The Lagrange multiplier method, interpretation of the Lagrange multiplier.

***READING LIST***

1. M. Bianchi--G. Messineo-E. Miglierina-S. Vassallo, *Note di Matematica*, Giappichelli, 2022
2. Torriero-M. Scovenna-L. Scaglianti, *Manuale di Matematica, Metodi e applicazioni*, Cedam, 2013.
3. F. Brega-G. Messineo, *Esercizi di Matematica Generale*, Giappichelli, 2013 - 2019 (5 volums, more details on the e-learning platform *Blackboard.*).
4. M. Scovenna-R.Grassi, *Esercizi di Matematica, Esercitazioni e temi d’esame*, Cedam, quarta ristampa 2018.
5. 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.

***ASSESSMENT METHOD AND CRITERIA***

The exam aims to assess reasoning skills and analytical rigor on the topics covered by the course, as well as the ability to understand mathematical language. Knowledge assessment takes place in writing and includes:

a. a *preliminary test* (or OFA test) on the computer aimed at ascertaining the possession of basic knowledge. Passing the test is an indispensable condition for taking the subsequent written test; 1st year students who, in the admission test to the Faculty of Economics, have correctly answered at least 7 questions from the Mathematics Section are exempt from the preliminary test. The preliminary test consists of 12 multiple-choice questions from one point each without penalty. To pass it, one needs to answer at least 7 questions correctly.

b. a *written test* divided into two modules with the same structure on the two parts of the exam relating to the first and last six weeks of the course, both lasting 1 hour and to be taken one after the other in the same session. Each single test, with an overall score of 16 points, is based on multiple-choice questions, both theoretical and numerical, for an overall score of 10 points and exercises in open form for an overall score of 6 points. Each multiple-choice question is awarded full points for a correct answer and no score or penalty is awarded for missing answers. In the open exercises, the procedure to obtain the solution is also evaluated; in this case the full score is assigned when the solution is correct, adequately motivated by the procedure necessary to obtain it, while in the case of incomplete or partially correct answers a score lower than the complete one will be assigned. The final grade is given by the sum of the scores obtained in the two tests. The exam is passed if the final grade is greater than or equal to 18 and if at least 4 points have been obtained in the part of the closed form answers in each of the two tests.

With the multiple-choice questions the knowledge of the fundamental notions and the student's ability to treat, understand and apply the mathematical tools learned are tested.

The open exercise evaluates the ability to tackle a more structured problem by exposing in a sequentially correct manner the logical steps necessary to arrive at the solution.

The actual achievement of the expected learning outcomes will be verified taking into account the following evaluation parameters: (i) understanding of the nature of the mathematical problem and ability to solve it; (ii) rigorous, clear and unambiguous exposition.

c. The written test referred to in point b. can also be replaced by two *partial tests* that contribute equally to the determination of the final grade - intermediate test during the week of suspension of lessons of the first semester and completion test in the exam session of January-February 2022 - in which all students can participate. Detailed indications regarding the methods of the aforementioned tests will be available on Blackboard.

***NOTES AND PREREQUISITES***

*Preliminary notions.*

Natural, integer, rational and real numbers.  Basic elements of logic and set theory. Elementary algebra.  Powers, logarithmic and exponential functions. Equations and inequalities (polynomial, fractional, irrational, logarithmic and exponential). Systems of equations and inequalities. Plane analytical geometry. Basic notions of trigonometry.

The prerequisites are an integral part of the exam program and are essential knowledge for passing the preliminary test. The prerequisites are the contents of OFA Mathematics Courses. Students who have received an Additional Training Obligation (OFA), for the recovery of the OFA must accrue the attendance of at least 70% of the lessons of one of the OFA courses and pass the preliminary test. Once passed, the test does not need to be repeated. The schedule of the courses and the dates in which it will be possible to take the preliminary test will be communicated on Blackboard.

To review the introductory topics, the TEOREMA online course is also available (https://elearning.teorema.cineca.it/).

*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.*