



UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Mathematics I

2526-1-E2703Q001

Aims

1. Knowledge and understanding

Students will acquire a solid understanding of the basic concepts and foundational techniques of differential and integral calculus for real-valued functions of one real variable. They will be able to comprehend both the theoretical meaning and practical applications of the studied mathematical tools.

2. Applying knowledge and understanding

Students will be able to apply the acquired calculus techniques to solve exercises and problems, both under the instructor's guidance and independently. They will be able to correctly use theoretical tools to address practical problems typically encountered in the chemical sciences.

3. Making judgements

The course promotes the ability to critically and independently reflect on the fundamental mathematical concepts. Students will be able to assess the correctness of solutions, identify conceptual errors, and propose alternative strategies for problem solving.

4. Communication skills

Students will develop the ability to clearly, rigorously, and coherently present both the theoretical concepts learned and the solutions to exercises and problems, using appropriate mathematical language and logical reasoning.

5. Learning skills

The course aims to provide the foundations for long-term and self-directed learning in mathematics, fostering the ability to approach new content and techniques independently, also in preparation for future courses and scientific applications.

Contents

Real and complex numbers, operations and their properties. Elementary functions, properties and their graphs. Numerical sequences, limits of sequences, forms of indecision. Comparison of infinities. Numerical series, convergence tests. Absolute convergence. Function limits. Continuity. The derivative. Theorems of differential calculus. The Taylor's theorem. Primitive functions and indefinite integral. The Riemann Integral. Generalized integrals.

Detailed program

Real numbers. Natural numbers \mathbb{N} , and the ring of relative integers \mathbb{Z} . Induction principle. The field \mathbb{Q} of rational numbers. Properties and their inadequacy: the equation $x^2 = 2$ has no solution in \mathbb{Q} . The real numbers field \mathbb{R} . Decimal representation. The real axes, ordering. Intervals. Neighbourhood. Absolute value. Bounded sets in \mathbb{R} . Maximum and minimum. Supremum and infimum, completeness. Roots, powers and logarithms.

Real functions of a real variable. Definition. Domain and range. Graph of a function. Elementary functions: powers, exponentials, logarithmic functions. The sequence as a function whose domain is the set \mathbb{N} . Bounded function. Maximum, minimum, superior, inferior of a function. Properties of a real function: injectivity, increasing, decreasing, monotone, convex, concave, even, odd. Extremal points, absolute extremals and relative extremals. Understanding the properties of the given definitions by reading the graph. Composite function, inverse function. Periodic functions, trigonometric functions and their inverse. Solving the inequalities by inversion of injective and monotonic functions.

Complex numbers. The field \mathbb{C} of complex numbers: algebraic form, operations, equality. Representation in the complex plane. Polar coordinates, modulo and argument, trigonometric form, exponential form. De Moivre's formula. Formula of the n -th roots of a complex number w (solutions in \mathbb{C} of the equation $z^n = w$). The fundamental theorem of algebra.

Limits. Limits of sequence, of functions. Properties: uniqueness of the limit, permanence of the sign, existence of the limit for monotonic functions. Comparison test. The ratio test. Operations with limits, indecision forms. The limit e . Notable limits. Symbol of asymptotic Landau. Order of an infinitesimal / infinite, compared to a sample.

Numerical series. Sequence of partial sums. Convergent, divergent, irregular series. Geometric series, Mengoli series, harmonic series. Necessary condition of convergence. Series with positive terms: their regularity and convergence tests: comparison, asymptotic comparison, root and ratio tests. Series with alternating signs and Leibniz test. Simple and absolute convergence.

Continuity. Continuous function at a point, on a set. Classification of discontinuities. Operations between continuous functions, continuity of composite function. Properties of continuous functions in a closed and bounded interval: Weierstrass theorem, existence of zeros, Darboux (or intermediate values). Continuity and monotony. Continuity of the inverse function.

Differential calculus. The derivative and its geometric interpretation. Equivalence between derivability and differentiability for functions of a variable. Equation of the tangent line. Points of non-derivability. Continuity and derivability. Calculation rules for derivatives. Stationary points. Theorems of the differential calculus: Fermat, Rolle, Lagrange and its corollaries, examples and counterexamples. The theorems of De l'Hôpital. Higher order derivatives. Polynomial approximation: Taylor formula, Peano remainder and Lagrange remainder. Convexity and inflection points. Use of the derivatives of higher order to establish the nature of a stationary point. Asymptotes. Study of the graph of a function. Primitive functions and indefinite integral. Elementary methods for the search for a primitive. Integration by parts, by substitution (change of variable). Integration of rational functions.

The Riemann integral. Definition and its properties. The integral average theorem. Integral function, integration and differentiation. The fundamental theorem of calculus. Generalized integrals, definitions and examples.

Prerequisites

Sets operations, union, intersection; membership and inclusion. Operations and comparison between real numbers, sorting. Properties of powers. Second-degree equations. Binomial expansion. Polynomials, division between polynomials, root of a polynomial, Ruffini's rule. Factoring. First and second degree inequations, rational inequalities. Cartesian coordinates. The line, the parabola, the circle. Degrees and radians. Elements of trigonometry. Systems of first degree equations.

Teaching form

48 hours of in-person, lecture-based teaching

24 hours of in-person, lecture-based exercises classes

Course delivered in Italian

Textbook and teaching resource

Suggested textbook

- Marco Bramanti, Carlo D. Pagani, Sandro Salsa *Analisi matematica 1*. Zanichelli 2008.

Lecture Notes available online

- A. Albanese, A. Leaci, D. Pallara, [Appunti del Corso di Analisi Matematica 1](#)
- L. De Michele, [Appunti di Analisi Matematica 1](#)

Further material

During the course, on the E-Learning platform, the following will be made available: lecture notes; numerous exercise sheets to be completed both under the supervision of the teacher and independently; other materials on specific topics.

Semester

First Semester

Assessment method

Written examination with optional oral colloquium.

The goal of the evaluation is to ascertain a correct assimilation of concepts and techniques studied during lessons and exercises sessions. There will be a partial examination (optional) that, if passed, will permit to skip part of the final exam and its score will contribute to the final score.

Written exam

The written exam consists of two part:

- Exercises. The student has to solve exercises similar to those solved in the classroom and/or assigned during the lectures by applying specific computational techniques.
- Theoretical questions. The student is required to state definitions and theorems from the lectures or to illustrate basic concepts and examples taken from the lectures.

The exam is passed if it scores at least 18 points over 30.

Oral exam (optional)

It consists of a discussion that, starting from the exercises of the written exam, can touch different topics of the course.

Partial exam (optional)

During the semester there will be one partial written exam consisting in four exercises on the topics presented up to that moment (no theoretical questions).

The partial exam is optional but recommended due to (at least) three reasons:

1. If passed, it allows the students to skip part of the final written examination. The score attributed to the exam will be the average of the scores obtained in the partial and in the final exam.
2. It is useful to verify the student own state of learning
3. If failed, or if the student decides to not use it, it does not affect the score of the final written examination.

Office hours

Office hours is by appointment

Sustainable Development Goals

QUALITY EDUCATION
