General information		Academic year 2022-2023
Academic subject	**Mathematical Analysis 1**	
Degree programme	Mathematics	
Programme year	First	
Term	First semester (October 3, 2022 – January 20, 2023)	
European Credit Transfer and Accumulation System credits (ECTS)	8	
Language	Italian	
Attendance	Not compulsory	

Lecturers		
Name and surname	Silvia Cingolani (instructor of record)	Gabriele Mancini
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Department and office	Department of Mathematics, room 11 second floor	Department of Mathematics, room 30 second floor
Virtual meeting room	Microsoft Teams code: p8nkwze	Microsoft Teams code: p8nkwze
Web page	https://www.dm.uniba.it/members/cingolani	https://www.dm.uniba.it/members/mancini
Office hours	Wednesday 15:30-17:30 and by appointment via email	Monday 14:30-16:30 and by appointment via email

Syllabus	
Learning objectives	Basic notions about set theory and logic.
Course prerequisites	Acquiring main notions and concepts of Mathematical Analysis 1, in particular concerning generalities on real functions, sequences and limits of real functions.
Course contents	**Real Numbers.** Set theory preliminaries. Inclusion, union, intersection, complement set and Cartesian product. Ordered sets. Real numbers. Axioms. Real line. Completeness of R. Absolute value and Euclidean distance. Upper bound, lower bound, minimum, maximum, infimum, supremum and their properties. Theorem of existence of the supremum (infimum) in R. Characterization of the infimum and the supremum. Intervals in R and characterizations. Inductive sets. The set of natural numbers N as the intersection of all the inductive subsets of R. Inductive Principle. Generalized Inductive Principle. Bernouilli Inequality. The sum and the product in N. Theorem on the discreteness of N. Theorem on the unboundedness of N. Archimedean Property of R. Principle of the minimal integer in N. The set of integers Z, the set of rational numbers Q and their structures. Density of Q in R. Incommensurability of the diagonal of the unit square. Incompleteness of Q. Elements of combinatorics and Newton's binomial. Theorem of existence of the nth root. Density theorem of irrationals in R. Rational and real powers and properties. General properties on functions. Injective, surjective, bijective functions. Composition of functions. Invertible functions and their inverses. Cardinality of a set. Equipotent sets. Finite sets and infinite sets. Countable sets. Properties on the cardinality of the union, intersection and product sets. Cardinality of the set of subsets of a finite set. Cantor's theorem on the cardinality of infinite sets. R is uncountable. Continuous power. Topology in R. Internal, external

	and boundary points of a subset of R. Boundary of a set. Open and closed sets of R. Isolated points. The extended real line. Points of adherence and points of accumulation of a subset of R. Complex numbers. Principle of identity of complex numbers. Complex Powers and n-th Roots. **Numerical sequences.** Numerical sequences. Upper and lower bounded sequences. Supremum and infimum of numerical sequences. Limits of sequences. Theorem on the uniqueness of limits. Regular sequences and their limits. Operations with regular sequences and their limits. Every convergent sequence is bounded. Inequalities for sequences and for their limits. Comparison theorems for sequences. Theorem on the limit of a monotonic sequence. Neper number. Subsequences and their limits. Upper and lower limit of a sequence and their properties. Limit points of a sequence. Theorem about the upper limit and the lower limit of a sequence. Bolzano-Weierstrass theorem about bounded numerical sequences. Compact sets of R and their properties. Cauchy sequences. Cauchy criterion for the convergence of sequences. Ratio test for limits of sequences. Cesaro criteria (arithmetic/geometric mean, n-th root). Sequences defined by recurrence. **Limits of functions.** Real functions. Bounded functions. Monotone functions. Even functions, odd functions, periodic functions. Elementary functions and graphs. Rational, irrational, transcendental inequalities. Limits of functions and first theorems on limits. Relations between limits of functions and limits of sequences. Left and right limits. Limits of monotonic functions. Theorem on locally boundedness of convergent functions. Theorem on inequalities between functions and their limits, applications. Comparison theorems for limits. Limits of elementary functions. Operations between limits. Theorem on the limit of the composition of two functions. Upper limit and lower limit of a function. Cauchy criterion for convergence. Infinite and infinitesimals. Negligible terms. Asymptotes of a function. **Continuous functions (I).** Continuous functions and their elementary properties. Continuity and sequential continuity. Theorems on the continuous functions. The continuity of the composition of continuous functions. Discontinuity points and their classification. Bolzano theorem. The intermediate value theorem. Any continuous function maps intervals into intervals. Existence of the n-th root. Continuity of the inverse function for a continuous function defined on an interval, or on a bounded closed set. Weierstrass theorem. Upper semicontinuous functions and lower semicontinuous functions. Generalized Weierstrass theorem.
Reference books	E. Acerbi, G. Buttazzo, Primo corso di Analisi Matematica, Pitagora Editore E. Giusti, Analisi Matematica 1, Bollati Boringhieri Editore P. Marcellini, C. Sbordone, Analisi Matematica uno, Liguori Editore E. Giusti, Esercitazioni e complementi di Analisi Matematica 1, Bollati Boringhieri Editore P. Marcellini, C. Sbordone, Esercitazioni di Analisi Matematica, Vol 1, (Parte 1, Parte 2), Liguori Editore
Additional course materials	Didactic material available at platform Microsoft Teams.

Work schedule				
	Total	Lectures	Hands-on learning (recitations+tutoring)	Self-study
Hours	200	40	30 + 25	105

ECTS credits	8	5	3	

Teaching methods	
	Lectures and exercise sessions.

Expected learning outcomes	
Knowledge and understanding	Acquiring fundamental concepts and results of Mathematical Analysis 1. Acquiring main tools and proof techniques.
Applying knowledge and understanding	The acquired theoretical knowledge is the essential background for understanding and using the techniques necessary in the mathematical applications.
Making judgement	Ability to analyze the consistency of the logical arguments used in a proof, problem solving skills and ability to choose suitable mathematical tools consistent with the theoretical knowledge.
Communication skills	Acquiring mathematical language and formalism necessary to read and understand textbooks, to explain the acquired knowledge, and to describe, analyze and solve problems.
Learning skills	Acquiring suitable learning methods, supported by consultation of texts and by solving exercises and problems related to the contents of the course.

Assessment and feedback	
Assessment methods	Written exam and subsequent oral exam.
Evaluation criteria	• *Knowledge and understanding*: mastering and deep understanding of the main theoretical course contents; • *Applying knowledge and understanding*: ability to apply the theoretical knowledge acquired to the study of numerical sequences and real functions; ability to solve complex equations; • *Making judgements*: approaching notions in a critical way and ability to choose the methods of Mathematical Analysis useful for solving the exercises; • *Communication skills*: mastering the language of the Mathematical Analysis; • *Learning skills*: organizing knowledge and autonomous learning.
Grading policy	The exam consists of a written test and a subsequent oral test. Passing the written test requires the student to be able to correctly perform the proposed exercises or at least part of them. During the oral exam the student must show mastery of the language, methodological rigor and have acquired the basic notions and concepts of the course. The final grade is awarded out of thirty and the exam is passed if the final grade is greater than or equal to 18/30.

Additional information	
	Attendance is strongly recommended. As part of the Mathematical Analysis 1 course, there is a 25-hour tutoring that will be held in the classroom by Prof. Elvira Mirenghi (elvira.mirenghi@uniba.it, telefono +39 080 5442675, stanza 29 secondo piano, Dipartimento di Matematica). Attendace of the tutoring lectures is strongly recommended and recordered in the classroom.