Academic subject: Mathematical Analysis no. 3				
Degree Class: L-35 (Scienze Matematiche).		**Degree Course:** Mathematics	**Academic Year:** 2018/2019	
		Kind of class: mandatory	**Year:** 2	**Period:** 1
			ECTS: 8 divided into **ECTS lessons: 5** **ECTS exe/lab/tutor: 3**	

Time management, hours, in–class study hours, out–of–class study hours

lesson: 40 exe/lab/tutor: 30 in–class study: 70 out–of–class study: 130

Language:	**Compulsory Attendance:**		
Italian	no		
Subject Teacher: Francesco Altomare	**Tel:** +39 080 5442672 **e–mail:** francesco.altomare@uniba.it	**Office:** Department of Mathematics Room 6 , Floor 3°	**Office days and hours:** Monday, 10:00 – 12:00 Tuesday, 10:30 – 12:30

Prerequisites:
Mathematical knowledge which usually is acquired during the first two years of a degree of L–35 class. Especially: classical mathematical analysis of one variable, differential calculus, integral calculus, linear algebra.

Educational objectives:
To acquire further language and techniques of classical mathematical analysis, especially elementary theory of metric spaces and normed spaces, functions of several variables, sequences and series of functions.

Expected learning outcomes (according to Dublin Descriptors)

Knowledge and understanding:
To acquire fundamental concepts in the classical mathematical analysis. To acquire basic mathematical proof techniques.

Applying knowledge and understanding:
The acquired theoretical knowledge is useful in great part of mathematics and its applications.

Making judgements:
Ability to analyze the consistency of the logical arguments used in a proof. Problem solving skills should be supported by the capacity in evaluating the consistency of the found solution with the theoretical knowledge.

Communication:
Students should acquire the mathematical language and formalism necessary to read and comprehend textbooks, to explain the acquired knowledge, and to describe, analyze and solve problems.

Lifelong learning skills:
Acquiring suitable learning methods, supported by text consultation and by solving the exercises and questions periodically suggested throughout the course.

Course program

1. THE LINEAR SPACE IR^n, n≥1, NORMED SPACES, METRIC SPACES.

The linear space IR^n, n≥1, and its dual. The natural basis of IR^n. Linear functionals on IR^n. Young, Hölder and Minkowski inequalities. The Minkowski norms $θτθ_p$, $1 \le p \le +\infty$.
Normed spaces. Normed subspaces. Equivalent norms. Bounded subsets of normed spaces. Bounded mappings into normed spaces.

Metric spaces. Distances induced by norms. Metric subspaces. Products of metric spaces. Equivalent distances.

The topology of metric spaces. Open subsets, closed subsets. Closure, derived, boundary and interior of subsets of metric spaces.
Limits in metric spaces and in normed spaces. Limit of mappings into IR^n. Convergent sequences in metric spaces. Continuity in metric spaces. Continuous mappings into IR^n. Continuous linear mappings on normed spaces. Automatic continuity of linear mappings on IR^n. Differentiable mappings into normed spaces. The mean value theorem.
Compact metric spaces. Compact subsets of a metric space. Compact subsets of IR^n. The (generalized) Weierstrass theorem in metric spaces. Uniformly continuous mappings. Lipschitz-continuous mappings. The (generalized) Cantor theorem in metric spaces.

2. DIFFERENTIAL CALCULUS FOR FUNCTIONS OF SEVERAL VARIABLES.

Partial derivatives for functions of several variables. High order partial derivatives. The Schwarz theorem.

Partial derivatives for functions into IR^n. Gradients. Differentiability. The differentiability criterion. The Fréchet derivatives. Differentiability for functions into IR^n and the Jacobi matrix. Directional derivatives. The chain rule for differentiable functions.

Connected metric spaces. Convex subsets of normed spaces. Path-connectedness. The mean value theorem for functions of several variables. Functions with vanishing gradient. Taylor formulas.

Local extrema. Eigenvalues and quadratic forms. The Hessian matrix of functions and (local) extrema.

3. IMPLICIT FUNCTIONS AND DINI'S THEOREM

Introduction to the implicit function problems. Dini's implicit function theorem for functions of two variables.
Constrained local maxima and minima. Lagrange multipliers.

4. SEQUENCES AND SERIES OF FUNCTIONS

Pointwise and uniformly convergent sequences of functions. Cauchy criterion. Dini's Theorem. A theorem about the inversion of limits. Termwise integration and differentiation for sequences of functions.

Series of functions. Pointwise, absolutely, uniformly, equiabsolutely and totally convergent series of functions.
Cauchy criterion. Termwise integration and differentiation of functions series.
Power series. Power series obtained by integration or derivation and their convergence radii. Abel theorem. Cauchy-Hadamard criterion and D'Alembert criterion.
Analytic functions. The binomial series, the geometric series, the exponential series, the fundamental trigonometric series and some related noteworthy series. Applications to the calculus of integrals.

Teaching methods:
Lectures and exercise sessions.

Auxiliary teaching:

Assessment methods:
Written and oral exam

Bibliography:
[1] N. FUSCO - P. MARCELLINI – C. SBORDONE, Analisi Matematica due, Liguori Editore, Napoli, 1996.

[2] P. MARCELLINI – C. SBORDONE, Esercitazioni di Matematica, 2° Volume, Parte I e Parte II, Liguori Editore, Napoli, 1989.

[3] G. ZWIRNER, Esercizi di Analisi Matematica, Parte seconda, Edizioni Cedam, Padova, 1977.