UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY TWO-YEAR MASTER OF SCIENCE PROGRAMME IN MATHEMATICS

ACADEMIC YEAR 2023-2024

ACADEMIC SUBJECT DIFFERENTIAL EQUATIONS

General information	
Programme year	Second
Term	Second semester (February 26, 2024 – May 31, 2024)
European Credit Transfer and Accumulation System credits (ECTS)	7
SSD	MAT/05 – Mathematical Analysis
Language	Italian
Mode of attendance	Not mandatory

Lecturer	
Name and surname	Addolorata Salvatore
E-mail	addolorata.salvatore@uniba.it
Telephone	+39 080 544 2705
Department and office	Department of Mathematics, room 10 fourth floor
Virtual meeting room	Microsoft Teams codice rj2bqk2
Web page	https://www.dm.uniba.it/en/members/salvatore
Office hours	By appointment via e-mail

Work schedule	Total	Lectures	Hands-on learning (recitations)	Self-study
Hours	175	48	15	112
ECTS credits	7	6	1	

Learning objectives	
	Knowledge of theory and techniques of ordinary differential equations, especially local and global existence, uniqueness theorems, regularity and stability of the solutions, qualitative analysis of solutions, study of linear systems. Examples and applications accompany the theory.

Course prerequisites	
	Mathematical knowledge which usually is acquired during the first three years of a degree of L-35 class. Especially: classical mathematical analysis of one and several variables, general topology, linear algebra.

Syllabus	
Course contents	**Some Elementary Methods** Generalities on first order differential equations. Equivalence of differential equation of order n to vector equation of the first order. The linear equation of the first order. The equation with separable variables. Exact differential equations. The uniqueness problem: an example. Some Integral inequalities. Gronwall's Lemma. Bihari's Lemma. Generalities on Banach spaces. Banach fixed point Theorem. **Existence Theorems for Differential Equations**

	The first order equation. First order differential systems. Equations and systems of higher order. Cauchy problem. Local existence and uniqueness Theorem: proof of the result via the method of successive approximations and via Banach fixed point Theorem. Ascoli-Arzelà Theorem. Peano existence Theorem: proof via the polygonal method and via Schauder point fixed Theorem. Other uniqueness Theorems. **Some global problems for ordinary differential equations** Statement of the problem. Global uniqueness. Global existence and the behavior of saturated solutions. Dependence of solutions on initial values. Differential inequalities and the comparison method. A criterion of global existence. Qualitative analysis of solutions. Some special classes of differential systems and equations. **Linear systems** Generalities. Linear homogeneous systems. Linear nonhomogeneous systems. Linear equations of higher order. Autonomous systems. Linear systems and equations with constant coefficients. Linear homogeneous systems with periodic coefficients: Floquet theory. **Stability theory of ordinary differential systems** Definitions and examples. Stability of linear systems. Stability in the first approximations. Stability theorems by comparison method. Linear equations of second order. Ascoli's theorem. Bessel's equation. Perturbed linear systems. Poincaré-Lyapunov theorems. Lyapunov's direct method (*). Stability theorems: I e II Lyapunov's theorems (*), Parsidski's theorem. Instability theorem. Stability for autonomous systems. Applications to some models in Biology and Physics: logistic equation, a prey-predator model, a model of competition between two species, the pendulum equation, the Van der Pol's equation. Linear autonomous systems. Orbits near to an equilibrium point: node, focus, center.
Reference books	A. Ambrosetti, Appunti sulle equazioni differenziali ordinarie, Springer, Milano 2012. C. Corduneau, Principles of Differential and Integral Equations, Allyn and Bacon Inc., Boston 1971. M. Rama Mohana Rao, Ordinary Differential Equations Theory and Applications E. Arnold Ed., London 1980.
Additional course materials	
Repository	

Expected learning outcomes	
Knowledge and understanding	Knowledge of basic and advanced concepts in the field of Ordinary Differential Equations. Acquisition of the relavant demonstration techniques.
Applying knowledge and understanding	Ability to use the theoretical results to study particular differential equations.
Soft skills	*Making judgements*: Ability to apply the mathematical tools acquired during the course to study differential problems also coming from applied sciences.
	Communication skills: Knowledge of advanced mathematical language and formalism, necessary for consulting and understanding texts, displaying acquired knowledge, describing, analyzing and solving problems.
	Learning skills: Acquisition of an appropriate study method, also obtained thanks to the consultation of texts and the resolution of exercises and problems proposed during the course.

Teaching methods

	The mode of delivery of the teaching is frontal. Lessons and exercises are held in presence.

Assessment	
Assessment methods	The oral exam includes the solution of an exercise and an interview on the main topics covered in the course.
Evaluation criteria	• *Knowledge and understanding*: acquisition and mastery of the definitions and theoretical results presented in the course and of the related demonstration techniques. • *Applying knowledge and understanding*: ability to apply the acquired knowledge to the study of linear and non linear differential equations. • *Making judgement*: critical approach to concepts, ability to choose theoretical results and solution techniques for the study of a differential equation. • *Communication skills*: : mastery of the specific mathematical language, quality of exposition. • *Learning skills*: ability to organize knowledge, critical reasoning and possible independent study.
Grading policy	The student takes the oral test which is passed if the grade obtained is greater than or equal to 18/30. The student must show mastery of the language, methodological rigor and have acquired the fundamental notions and concepts of the course. Assessment is based on the achievement of the intended learning objectives. To achieve a high evaluation, the student must have developed independent judgment and adequate capacity for argumentation and exposition.

Further information	
	Attendance at lectures and tutorials is strongly recommended.