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 — NUMERICAL ANALYSIS

General information	
Programme year	Second
Term	First semester (September 25, 2023 – December 22, 2023)
European Credit Transfer and Accumulation System credits (ECTS)	7
SSD	MAT/08 – Numerical Analysis
Language	Italian
Mode of attendance	Not mandatory

Lecturers	
Name and surname	Roberto Garrappa
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Department and office	Department of Mathematics, room 7 third floor
Virtual meeting room	
Web page	https://www.dm.uniba.it/it/members/garrappa
Office hours	Monday 15:00-17:00. In other days as well, by appointment via email

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

Learning objectives	
	Learning advanced methods for numerically solving ordinary and partial differential equations and related problems.

Course prerequisites	
	Knowledge of Numerical Computing skills acquired through courses of "Numerical Calculus 1" and "Numerical Calculus 2$, and Matlab programming skills.

Syllabus	
Course contents	1. Numerical solution of initial value problems for ordinary differential equations. Multistep methods: consistency, convergence and 0-stabilty, stability, roots conditions. Adams methods and BDFs: development, properties, and implementation issues. Predictor-Corrector methods. 2. Numerical solution of partial differential equations. Poisson and Laplace equations. Finite difference methods: 5- and 9-points stencils. Ordering of variables. Dirichlet and Neumann boundary conditions. Consistency, convergence, and boundedness of inverse of the discretization matrix and its ill-conditioning. Evolutionary problems: explicit scheme and stability. The

	method of Lines: consistency, stability and convergence. Crank-Nicolson method. Advection equations. Mid-point, leapfrong and Lax-Friederisch method. Variational formulation and finite element methods. 3. Numerical methods for solving large systems of linear equations. Splitting methods. Krylov subspace methods. Arnoldi and Lanczos algorithms. FOM, MinRes, GMRes and GC. Restart and convergence. 4. Numerical experiences in Matalb
Reference books	• J.D. Lambert, Numerical Methods for Ordinary Differential Systems: the Initial Value Problem, John Wiley & Sons, 1991 • E. Hairer, S.P. Norsett and G. Wanner, Solving ODEs I, Springer 2008 • Endre Suli and David Mayers, An introduction to Numerical Analysis, Cambride 2003 • Randy LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady State and Time Dependent Problems. SIAM, 2007 • Yousef Saad, Iterative Methods for Sparse Linear Systems, SIAM, 2013
Additional course materials	In the teaching platform (moodle) there will be given information about the chapter of interest for each textbook.
Repository	

Expected learning outcomes	
Knowledge and understanding	Knowledge of basic techniques for developing numerical methods for solving different problems (mainly of differential type) and for studying their properties. Ability of selecting choosing the most suitable methods with respect to physical and mathematical features of the problem.
Applying knowledge and understanding	Ability of developing numerical methods also for problems not specifically studied during the lectures. Ability to optimize algorithms with respect to the available computational resources. Ability to test codes and correctly interpreter the obtained results.
Soft skills	*Making judgements*: Ability of selecting the most suitable methods with respect to the selected problem and to the available resources.
	Communication skills: Ability to describe in a correct way both the problem and the procedure using for its solution.
	Learning skills: Ability to solve other problems than those explicitly introduced during the course.

Teaching methods	
	Frontal lessons and computer laboratory.

Assessment	
Assessment methods	Oral exams: the student must show the knowledge of the main techniques for the development of numerical methods and for studying their properties. The student must also couple the study of theoretical topics with numerical experiences to be presented and discussed during the exam.
Evaluation criteria	• *Knowledge and understanding:* knowledge of the way by which numerical methods are devised and studied. • *Applying knowledge and understanding*: ability to apply known methods to different problems. • *Making judgement*: ability to evaluate the performance of the

	methods. • *Communication skills*: ability to describe in a correct way both the development of the numerical methods and their properties; ability of presenting in an efficient way the results of the numerical experiments.
Grading policy	The maximum mark for this exam is 30 and the minimum is 18. The mark is attributed on the basis of the above criteria.

Further information	
	Attendance of lectures in not mandatory but it is strongly suggested.