

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY	THREE-YEAR BACHELOR PROGRAMME IN MATHEMATICS
ACADEMIC YEAR	2023-2024
ACADEMIC SUBJECT	MATHEMATICAL COMPUTING LABORATORY

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, MAT/02, MAT/03, MAT/05
Language	Italian
Mode of attendance	Not mandatory

Lecturers		
Name and surname	Pierluigi Amodio (instructor of record, group A)	Felice Iavernaro (instructor of record, group B)
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Virtual meeting room		
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Office hours		

Work schedule				
	Total	Lectures	Hands-on learning (recitations/laboratories)	Self-study
Hours	175	40	30	105
ECTS credits	7	5	2	

Learning objectives	
	Acquiring some knowledge about the main properties and issues related to the use of finite arithmetic as opposed to real arithmetic. Acquiring the basic tools to operate in Matlab and Sage environments, with special attention to structured programming.

Course prerequisites	
	The notions provided by the course “Computer Science”, classical analysis of one and several variables, fundamental linear algebra.

Syllabus	
Course contents	<ol style="list-style-type: none"> INTRODUCTION TO SCIENTIFIC COMPUTING AND ERROR ANALYSIS. Mathematical models and numerical methods, errors sources, the process of the numerical approach to solve problems, computational environments, some languages for the scientific computing, problem solving environments: MATLAB, SAGE. Representing real numbers in a computer, IEEE standard, single and double precision. Truncating and

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	<p>rounding techniques. Absolute and relative errors. Machine precision. Floating-point operations. Errors propagations. Conditioning of a problem. Stability of an algorithm. Computational complexity.</p> <p>2. MATLAB. Introduction to Matlab, the language, script and function files. Built-in functions in Matlab. The workspace. Introduction to graphics in one and two dimensions. Some Matlab examples about rounding errors. Handle vectors and matrices in Matlab. Basic operations involving vector and matrices. Implementation of some numerical algorithms in Matlab: approximation of derivatives of functions by means of divided difference formulae, using the Taylor polynomial to approximate transcendent functions, Laplace formula, Cramer rule and related computational cost. Examples on unstable algorithms.</p> <p>3. SAGE. Programming basics, graphs of functions, derivation, integration, linear and nonlinear equations. Sequences, discrete dynamical systems, linear and nonlinear difference equations applied to biology, medicine, finance. Logistic equation and bifurcation diagram. Hints on the solution of differential equations. Iterated functions systems, fractals.</p> <p>Elementary operations in vector spaces. Generating random vectors and matrices. Orthogonal matrices, group actions, visualization of orbits generated by the standard action of the groups $O(3)$ e $O(2)$ on \mathbb{R}^3. Linear transformations and solution of some classical problems in linear algebra. Explicit construction of affinities or isometries. Classification of planar isometries: examples of a procedure that splits an isometry in axial symmetries and of a procedure that classifies a given isometry. Examples on the computation of the group of symmetries of a finite set of points. Construction of projectivities. Visualization of the five non-degenerate quadrics of the Euclidean space.</p> <p>Euclidean algorithm, extended Euclidean algorithm, Bezout coefficients, algorithms to find the first n prime numbers, algorithms for the prime factorization of a natural number.</p>
Reference books	<ul style="list-style-type: none"> • Handout on machine arithmetic, available at the url https://elearning-mat.hosting.uniba.it • Handouts supplied during the course lectures. • Uri M. Ascher and Chen Greif, A First Course on Numerical Methods, SIAM, 2011.
Additional course materials	Handouts, notes and Matlab codes will be made available through an e-learning platform. Log-in information will be provided at the course starting days
Repository	https://elearning-mat.hosting.uniba.it

Expected learning outcomes	
Knowledge and understanding	Understanding and being able to explain issues related to the use of a computer for solving elementary mathematical problems.
Applying knowledge and	Acquiring skills in programming, testing numerical algorithms and

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understanding	consistently interpreting computer results.
Soft skills	<i>Making judgements</i> : Being able to provide rigorous definitions and analysis of the principal aspects of finite arithmetic.
	<i>Communication skills</i> : Being able to communicate with computers ☺
	<i>Learning skills</i> : Capability of studying and solving, both numerically and symbolically, problems similar, but not necessarily equivalent, to those faced during the teaching activities.

Teaching methods	
	Lectures and exercise sessions. Exercise sessions in the Computer Centre.

Assessment	
Assessment methods	The exam consists in solving two exercises, in Matlab and Sage, on a computer and an oral test which includes a discussion of the Matlab codes prepared during the course lectures.
Evaluation criteria	<ul style="list-style-type: none"> • <i>Knowledge and understanding</i>: <ul style="list-style-type: none"> ○ Identification of the main differences between real and machine arithmetic. ○ Ability to compare methods that solve the same problem, in terms of stability and computational efficiency. • <i>Applying knowledge and understanding</i>: <ul style="list-style-type: none"> ○ Discussion of the codes and examples performed; correct interpretation of the results obtained. • <i>Making judgement</i>: <ul style="list-style-type: none"> ○ Collection and processing of data, encoding of the algorithm and interpretation of the results obtained. • <i>Communication skills</i>: <ul style="list-style-type: none"> ○ Clarity, also in terms of formalism, in the description and coding of the numerical methods, as well as ability to effectively present the numerical tests carried out. • <i>Learning skills</i>: <ul style="list-style-type: none"> ○ Numerical implementation and discussion of more elaborate problems than those presented during the lectures.
Grading policy	<p>The achievement of eligibility takes into account the judgment achieved by the student in three partial tests:</p> <ul style="list-style-type: none"> ○ Matlab test: correct implementation on the computer of the algorithm administered during the exam. ○ Sage test: correct implementation on the computer and discussion of the problem proposed during the preparation of the exam. <p>Theoretical test: theoretical discussion on machine arithmetic and error analysis.</p>

Further information	