General information	
Academic subject	NUMERICAL ANALYSIS
Degree course	
Academic Year	AA 2021-2022
European Credit Transfer and Accumulation System (ECTS)	
Language	ITALIAN
Academic calendar (starting and ending date)	I SEMESTER
Attendance	

Professor/ Lecturer	
Name and Surname	CINZIA ELIA
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Department and address	Dept. of Mathematics. University of Bari.
Virtual headquarters	
Tutoring (time and day)	By appointment via e-mail. Wed 3-5 pm.

Syllabus	
Learning Objectives	Theoretical and numerical study of techniques and algorithms for the simulation of real world problems.
Course prerequisites	Geometry: lines and curves in the plane Real analysis: functions, sequences, series, Fourier series. Matlab: use of Command Window for computations and graphics.

Contents	Linear algebra: basics. Matrices and vectors. Linear independence. Vector spaces. Subspaces. Bases. Laplace rule for determinant of a matrix and its computational cost. Solution of linear systems via Gaussian elimination. LU formalism. Statistics: linear regression and least squares. Trigonometric interpolation: Trigonometrc polynomial, Fourier series of a periodic function of period T, linear system with orthogonal matrix for determining the Fourier coefficients. Zeroes of functions: bisection method, Newton's method, secant method, fixed point iterations. Convergence theorems. Convergence speed: theoretical and numerical evaluation. Numerical solution of ODEs: Forward Euler method (FWE). Order of convergence, linear stability theory. Qualitative behaviour of FWE when applied to Hamiltonian problems (harmonic oscillator, non linear pendulum) Symplectic Euler. Applications: linear and non linear oscillators in mechanical, electrical and chemical systems: 1) harmonic oscillator with natural frequencies 1,2,3; 2)linear oscillator with friction; 3)harmonic oscillator with periodic external forcing in resonancace and non; 4) linear oscillator with friction and external forcing; 5) Duffing; 6) Brusselator as a model of a chemical autocatalytic reaction; 7) Van Der Pol non linear oscillator. Matlab: command window as a computation environment. Basics. Variables. Matlab's predefined functions and use of help. Matrices and vectors. For loop and function to compute the mean. While loop and convergence of sequences. Fibonacci sequence. If statement. Montecarlo method for approximating pi and integrals in 1d. Linear algebra: forward and backward substitution. Practical techniques to detect badly conditioned matrices. Functions for the numerical techniques studied in class and simulations.
Books and bibliography	Quarteroni, Saleri. Scientific computing with Matlab and Octave. 2006.
Additional materials	

Work schedule	

Total 77 hours	Lectures 32 hours	Hands on (Laboratory, working groups, seminars, field trips) 45 hours	Out-of-class study hours/ Self-study hours: 98 hours.
Hours			
ECTS			

Teaching strategy	
	In class lectures and practical lab sessions in Matlab
Expected learning outcomes	
Knowledge and understanding on:	○ Understanding of numerical techniques and algorithms for the resolution of a given problem. ○ Concept of well conditioned problem and stable algorithm.
Applying knowledge and understanding on:	○ Coding of the main algorithms studied during the theoretical lectures. ○ Create test problems for the codes.
Soft skills	• *Making informed judgments and choices* ○ Ability in choosing suitable numerical technique to simulate and/or solve a given problem; ○ Select and recognise the needed solution • *Communicating knowledge and understanding* ○ Ability in presenting and describing the problem that needs to be solved, the numerical techniques chosen, the suitable solution selected for the simulation. ○ Team working. • *Capacities to continue learning* ○ Ability in learning new techniques, derive corresponding algorithms, write appropriate codes, test them and use them in simulations.

Assessment and feedback	
Methods of assessment	Practical exam: write the code for a given algorithm, test it and use it in simulations. After passing the practical exam, the student will give an oral exam on the theoretical and numerical aspects of the numerical techniques and algorithms learned during lectures.

Evaluation criteria	• *Knowledge and understanding* ○ Given a problem, recognise a suitable technique to solve it. • *Applying knowledge and understanding* ○ Derive an algorithm and write a code to simulate the given problem. Interpret the obtained solution. • *Autonomy of judgment* ○ Given a problem, find a suitable numerical technique for its solution, implement it on a computer to run simulation. Interpret the obtained solution in function of the initial problem. • *Communicating knowledge and understanding* ○ Ability in presenting the problem, justify the choice of the numerical techniques, explain how to derive a stable algorithm and the corresponding code, interpret the simulations and explain how they give insights into understanding the initial problem. • *Capacities to continue learning* ○ Learn new techniques and derive new algorithms and corresponding codes.
Criteria for assessment and attribution of the final mark	During the exam the student is given a problem. In order to pass the exam he/she needs to find a suitable numerical technique to solve it m=among the techniques studied in class, he/she will have to write a code or use one of Matlab's functions to simulate the solutions and interpret the obtained solution in function of the initial problems. For a deeper level of understanding the student must give all the theoretical justifications for his/her choices.