UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY	**THREE-YEAR BACHELOR PROGRAMME IN MATHEMATICS**
ACADEMIC YEAR	**2023-2024**
ACADEMIC SUBJECT	**NUMERICAL CALCULUS 1**

General information	
Programme year	Third
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	Luciano Lopez (instructor of record)	Giuseppe Vacca
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Telephone	+39 080 544 2678	+39 080 544 2645
Department and office	Department of Mathematics room 15 second floor	Department of Mathematics room 12 second floor
Virtual meeting room		
Web page	https://www.dm.uniba.it/it/members/lopez	https://www.dm.uniba.it/it/members/vacca
Office hours	Monday and Wednesday 11:00-13:00	by appointment to be arranged via email

Work schedule				
	Total	Lectures	Hands-on learning (recitations/laboratories)	Self-study
Hours	175	40	15+20	100
ECTS credits	7	5	1+1	

Learning objectives	
	Learning of some classical methods in numerical analysis and gathering of the knowledge needed to address the solution of mathematical problems through the use of computers.

Course prerequisites	
	Classical real analysis in one and several variables, elements of linear algebra, machine arithmetic and Matlab programming.

Syllabus	
Course contents	1. **Programming:** The programming environment will be Matlab. It is required to implement the algorithms related to the methods studied within the class, with special attention to comparison and experiments that shed some light on the properties of those methods. 2. **Rootfinding numerical methods:** Conditioning of the problem.

	Method of bisections. Order of convergence, asymptotic convergence rate. Newton's method and its variations. Secant method. General theory of one step iterations. Attractive fixed points and their basin of attraction. Error estimation and stop criteria. Stability issues. Multiple zeros. Higher order methods. Efficiency index. 3. **Elements of the theory of matrices:** Matrix norms. Eigenvalues and eigenvectors. Spectral radius. Gram-Schmidt orthogonalization process. Similarity and diagonalizability. Unitary, normal, Hermitian (or symmetric), positive definite matrices. Diagonally dominant matrices. Jordan's and Schur's canonical forms. 4. **Numerical solution of linear systems:** Direct methods: Conditioning of the problem, Gauss pivoting with partial/complete pivoting. Applications to a family of systems. Computational cost. Application to inverse computations. Elementary matrices, LU factorization. Stability of LU factorization. Gauss method through elementary matrices. Stability of LU factorization for diagonally dominant matrices. LU factorization for tridiagonal matrices. Cholesky's method. Householder and Givens elementary matrices, QR factorization. Iterative refinement for the solution of linear systems. Iterative methods: General theory, Methods of Jacoby and Gauss-Seidel. Convergence and stability for diagonal dominant matrices. Stop criteria. Spectral radius to estimate asymptotic error reduction rate. Comparison between Jacoby and Gauss-Seidel methods. Relaxation methods: convergence and matrix interpretation. 5. **Eigenvalue computation:** Eigenvalue localization, I and II Gerschgorin theorems. Conditioning of the problem of eigenvalue computation. Powers method and inverse powers method. QR factorization and transformation of a matrix into upper Hessenberg form. QR method for eigenvalue computation: implementation details and convergence. QR method with shift. 6. **Least Squares fitting-polynomial:** Rectangular systems. Existence of solutions.
Reference books	1. Bini D., Capovani M., Menchi O., Metodi numerici per l'algebra lineare. Zanichelli 2. Atkinson K.E., An introduction to Numerical Analysis - 2nd Ed. John Wiley & Sons 3. Golub G.H., Van Loan C.F., Matrix Computation - 3rd Ed. The Johns Hopkins University Press
Additional course materials	Notes, algorithms and problems shared as electronic documents.
Repository	

Expected learning outcomes	
Knowledge and understanding	• Basic techniques of classical numerical analysis; • fundamental algorithms of numerical analysis and their implementation in Matlab.
Applying knowledge and understanding	• Ability to solve on a computer math problems of theoretical and practical interest.

Soft skills	*Making judgements*: • Enriching student's skills in deductive reasoning; • Learning new mathematical proof techniques; • Validating or confuting a thesis through numerical experiments.
	Communication skills: The oral exam presses the student to improve his skills in expressive language.
	Learning skills: Students are encouraged to consult textbooks and solve the assignments in order to improve their knowledge.

Teaching methods	
	Main teaching tools will be lectures and laboratories. Problems will also be assigned, aimed at deepening (as well as evaluating) the knowledge of students.

Assessment	
Assessment methods	
Evaluation criteria	• *Knowledge and understanding*: Knowledge and understanding of the results explained during lectures and laboratories; • *Applying knowledge and understanding*: Matlab programming skills; • *Making judgement*: Being able to extend the results learned in lectures and laboratories; • *Communication skills*: Being able to verbally communicate knowledge; • *Learning skills*: Ability to improve knowledge through consultation of textbooks.
Grading policy	A final grade is given on a 30-point scale, and is based on the outcome of oral exam and Matlab programming assignments.

Further information	