| General information | |
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| Academic subject | **Calcolo Numerico 1, Numerical Calculus 1** |
| Degree course | Corso di Laurea in Matematica |
| Academic Year | 3 |
| European Credit Transfer and Accumulation System (ECTS) | 7 |
| Language | Italiano |
| Academic calendar (starting and ending date) | September 27 – Decembre 23 2021 |
| Attendance | Optional |

| Professor/ Lecturer | |
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| Name and Surname | Luciano Lopez |
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| Telephone | +39 080 5442678 |
| Department and address | Department of Mathematics, 2nd floor, room 15 |
| Virtual headquarters | MS Teams, team's code: ic3pnim |
| Tutoring (time and day) | Wed 11:00AM-1:00PM |

| Syllabus | |
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| **Learning Objectives** | **Educational objectives:**<br>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. |
| **Contents** | 1. **Programming:** The programming environment will be used is 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.<br><br>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. Aitken's acceleration technique.<br><br>3. **Elements of the theory of matrices:** Matrix norms. Eigenvalues and eigenvectors. Spectral radius. Gram-Schmidt orthogonalzation process. Similarity and diagonalizability. Unitary, normal, hermitian (or symmetric), positive definite matrices. Diagonally dominant matrices. Jordan's and Schur's canonical form. |

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| | **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 giveng elementary matrices, Qt 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.<br><br>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. |
| **Books and bibliography** | **1.** Bini D., Capovani M., Menchi O., *Metodi numerici per l'algebra lineare*. Zanichelli<br><br>**2.** Atkinson K.E., *An introduction to Numerical Analysis - 2nd Ed.*. John Wiley & Sons<br><br>**3.** Golub G.H., Van Loan C.F., *Matrix Computation - 3rd Ed.*. The Johns Hopkins University Press |
| **Additional materials** | **Auxiliary teaching:**<br>Notes, algorithms and problems shared as electronic documents |

| **Work schedule** | | | |
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| Total | Lectures | Hands on (Laboratory, working groups, seminars, field trips) | Out-of-class study hours/ Self-study hours |
| **Hours** | | | |
| 70 | 40 | 30 | 105 |
| **ECTS** | | | |
| 7 | 5 | 2 | |
| **Teaching strategy** | | | |
| | Main teaching tools will be lectures and laboratories. Problems will also be assigned, aimed at deepening (as well as evaluating) the knowledge of students. The course will not be administered in e-learning mode. | | |
| **Expected learning** | | | |

| **outcomes** | |
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| **Knowledge and understanding on:** | ○ Basic techniques of classical numerical analysis<br>○ Fundamental algorithms of numerical analysis and their implementation in Matlab |
| **Applying knowledge and understanding on:** | ○ Ability to solve on a computer math problems of theoretical and practical interest |
| **Soft skills** | • Making informed judgments and choices<br>○ Enriching student's skills in deductive reasoning<br>○ Learning new mathematical proof techniques<br>○ Validating or confuting a thesis through numerical experiments<br>• Communicating knowledge and understanding<br>○ The oral exam presses the student to improve his skills in expressive language<br>• Capacities to continue learning<br>○ Students are encouraged to consult textbooks and solve the assignments in ortde to improve their knowledge |

| **Assessment and feedback** | |
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| Methods of assessment | Oral exam and evaluation of programming problems to be solved in Matlab |
| Evaluation criteria | • Knowledge and understanding<br>○ Knowledge and understanding of the results explained during lectures and laboratories<br>• Applying knowledge and understanding<br>○ Matlab programming skills<br>• Autonomy of judgment<br>○ Being able to extend the results learned in lectures and laboratories<br>• Communicating knowledge and understanding<br>○ Being able to verbally communicate knowledge<br>• Capacities to continue learning<br>○ Ability to improve knowledge through consultation of textbooks |
| Criteria for assessment and attribution of the final mark | |
| **Additional information** | |
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