Academic subject: Numerical Calculus 1				
Degree Class: L-35 – Scienze Matematiche		**Degree Course:** Mathematics	**Academic Year:** 2020/2021	
		Kind of class: Mandatory	**Year:** 3	**Period:** 1
			ECTS: 7 divided into **ECTS lessons:** 5 **ECTS exe/lab/tutor:** 2	
Time management, hours, in–class study hours, out–of–class study hours lesson: 40 exe/lab/tutor: 30 in–class study: 70 out–of–class study: 105				
Language: Italian	**Compulsory Attendance:** no			
Subject Teacher: Luciano Lopez	**Tel:** +39 080 5442678 **e–mail:** luciano.lopez@uniba.it	**Office:** Department of Mathematics Room 15, II Floor	**Office days and hours:** Wed 11:00-13:00	
Prerequisites: Classical real analysis in one and several variables, elements of linear algebra, machine arithmetic and Matlab programming.				
Educational 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.				
Expected learning outcomes (according to Dublin Descriptors)	**Knowledge and understanding:** The class presents some techniques which are classical in numerical analysis. Attention is given to theoretical analysis of the algorithms as well as to their implementation in Matlab's programming language. **Applying knowledge and understanding:** The class allows the student to develop the ability to numerically solve mathematical problems, of theoretical as well as practical interest, through the use of a computer. **Making judgements:** The class helps with improving logical deductions skills of students, who will learn new proof techniques. Moreover, the class teaches the students how to validate or confute an argument through numerical experiments, before trying to use rigorous arguments. **Communication:** The instructors promote the use of text books which are classical within the field, written in english or italian language. The exam is made of an oral exposition on the subjects covered in the class and on individual projects of algorithmic nature to be done in Matlab. All of this helps in improving the communication skills of the students. **Lifelong learning skills:** The class provides the students with abilities that will help them in their course of study (with numerical/applied subjects, as well as other subjects) and in is future work career.			

Course program

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.

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.

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.

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.

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.

Teaching methods:
Lectures and exercise/laboratory sessions, in presence or online on MS Teams

Auxiliary teaching:
Notes, algorithms and problems shared as electronic documents

Assessment methods:
Oral examination.

Bibliography:

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

4. Isaacson E., Heller H.B., *Analysis of numerical methods*. Dover