Academic subject: Numerical Analysis				
Degree Class: LM-40 – Matematica		**Degree Course:** Mathematics	**Academic Year:** 2017/2018	
		Kind of class: Mandatory/optional	**Year:**	**Period:**
			ECTS: 7 divided into **ECTS lessons: 6.5** **ECTS exe/lab/tutor: 0.5**	

Time management, hours, in–class study hours, out–of–class study hours
lesson: 52 exe/lab/tutor: 8 in–class study: 60 out–of–class study:115

Language: Italian	**Compulsory Attendance:** no		
Subject Teacher: Francesca Mazzia	**Tel: 0805442702** **e–mail: francesca.mazzia@uniba.it**	**Office:** Department of Mathematics Room 7, Floor 4	**Office days and hours:** **monday 11:30-13:30, wednesday11:30-13:30.** Other days and times by appointment.

Prerequisites: Mathematical knowledge which usually is acquired during the years of a degree of L–35 class. Especially: Numerical calculus, linear algebra and programming.

Educational objectives:
Acquiring knowledge of numerical methods for the solution of differential equations and large linear systems.

Expected learning outcomes (according to Dublin Descriptors)

Knowledge and understanding:
- Learn the techniques for the numerical programming of numerical methods for the solution of differential equations and large linear systems by means of iterative methods.

Applying knowledge and understanding:
- Acquiring the ability to solve differential equations using optimized algorithms with good stability problems.
- Acquiring the ability to programming, testing interpreting the results correctly.
- Acquiring the ability to solve mathematical problems using problem solving environment.

Making judgements:
Acquiring ability to find the most suitable numerical method for the solution of a differential problem.

Communication:
Acquiring ability to rigorously define the mathematical problem studied in the course and to expose its numerical methods, outlining its fundamental properties

Lifelong learning skills:
Ability to study and solve problems similar but not necessarily the same as those dealt with during lessons.

Course program

1. Numerical solution of differential equations, initial value problems: linear multi-step methods, Adams methods, BDF methods, MEBDF methods; Consistency, convergence and 0-stability; root conditions. Absolute and relative stability; A.stability; stiff problems, error estimation and step-variation strategies. Solution of test problems in R and/or Matlab.

2. Numerical solution of boundary value diffrential equations: Dicotomy and conditioning, finite difference schemes for first order and second order problems, collocation methods, mono implicit Runge-Kutta methods, boundary value linear multistep method, deferred correction, estrapolation techniques, error estimation and mesh selection. Solution of test problems in R and/or Matlab.

3. Numerical solution of partial differential equations: advection-diffusion equations (heat equation, advection equation, Laplace equation), finite difference methods, CFL condition. Semidiscretization methods, the method of lines. Staggered mesh and finite volume methods. Boundary conditions, Crank-Nicholson method, Stability and convergence for the semidiscretized problem e for the total discretization. Note on Fourier analysis and eigenvalue analysis. Variational formulation and finite element method for one dimensional problems. Solution of test problems in R and/or Matlab.

4. Iterative method for the solution of sparse linear system: the gradient descend method, method on Krylov subspaces, the Lanczos tridiagonalization process. Convergence theorem. Optimized Lanczos algorithm, the conjugate gradient method and the Hestenes-Stiefeld formulation. Preconditioned Conjugate Gradient method. Notes on the construction of preconditioners for symmetric and positve definite matrices, incomplete Cholesky factorization.
sparse inverse preconditioners; splitting. Notes on iterative methods foe nonsymmetric matrices:
GMRES,BICG,CGS,BICGstab,QMR.

Teaching methods:

Lectures and exercises on the implementation of numerical schemes.

Auxiliary teaching:

The suggested books are completed by slides, didactic material of the teacher.

Assessment methods: Oral exam.

Bibliography:

Uri M. Asher, Numerical methods for evolutionary differential equations, SIAM 2008, ISBN 9780898716528
K. Soetaert, J. Cash, Jeff, F. Mazzia, Solving Differential Equations in R, Springer, 2012, ISBN 978-3-642-28070-2.
G. Golub, C. Van Loan, Matrix Computation, Johns Hopkins University Press; fourth edition, 2012, ISBN-13: 978-1421407944
Uri M. Ascher , Robert M. M. Mattheij and Robert D. Russell, Numerical Solution of Boundary Value Problems for Ordinary Differential Equations, SIAM 1995,