# . – Numerical Analysis

## Prof. Maurizio Paolini

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

To teach the basics of numerical analysis, by tackling the following types of problem from a numerical point of view: solution of nonlinear equations, linear systems, approximation of functions of one variable, least squares, quadrature formulas, and Cauchy problem.

At the end of the course, students will be able to identify the important aspects for the approximate resolution, using automatic calculation tools, of a wide class of problems deriving from mathematical modelling; they will also become more sensitive towards critical aspects of the problems to be faced, including ill-conditioned data, numerical instability, computational cost, etc.

***COURSE CONTENT***

- Error theory: Absolute/relative error, conditioning of mathematical problems, error propagation, floating point representation, and stability of algorithms.

- Linear systems: Triangular systems, Gaussian elimination, pivotal strategies, LU decomposition, Cholesky decomposition, Jacobi, Gauss-Seidel and SOR iterative methods, residual correction method, and stopping test.

- Nonlinear equations: Bisection, secant and Newton's methods, order of convergence, and stopping test. Horner scheme for polynomials. Sturm successions.

- Function approximation: Lagrange polynomial, existence and uniqueness theorem; divided differences and Newton form of the interpolation polynomial; Chebyshev nodes; error formula.

- Least squares in the discrete setting, least squares in the continuum setting, families of orthogonal polynomials;

- Quadrature formulas: Interpolatory formulas, Newton-Cotes formulas, Gauss formulas;

- Cauchy problem: Euler method, error analysis of the Euler method, Runge-Kutta methods, theory of multistep methods, predictor-corrector, relative stability.

***READING LIST***

V. Comincioli, *Analisi Numerica. Metodi Modelli Applicazioni,* McGraw Hill Libri Italia, Milan, 1990.

A. Quarteroni, *Elementi di Calcolo Numerico,* Progetto Leonardo, Bologna, 1994.

G. Naldi - L. Pareschi - G. Russo, *Introduzione al Calcolo Scientifico,* McGraw-Hill, Milan, 2001.

***ASSESSMENT METHOD AND CRITERIA***

An oral exam. The exam aims to ascertain students’ assimilation of course concepts through a discussion on some of the topics on the syllabus, focussing particularly on students’ ability to identify aspects of problems to be solved that are particularly relevant from a numerical point of view. Assessment will take into account accuracy of presentations, their logical and methodological rigour and presentation efficacy, and personal reworking of the subject matter.

***NOTES AND PREREQUISITES***

Students must possess the basics for understanding the concept of "mathematical problem", either of the algebraic type or within the context of ordinary differential equations learned in Mathematical Analysis courses.

Interested students may contact the lecturer and the tutor by email for more information.

*Further information can be found on the lecturer's webpage at http://docenti.unicatt.it/web/searchByName.do?language=ENG or on the Faculty notice board.*