UNIVERSITÀ DI PAVIA

Anno Accademico 2016/2017

NUMERICAL METHODS IN ENGINEERING SCIENCES	
Enrollment year	2016/2017
Academic year	2016/2017
Regulations	DM270
Academic discipline	MAT/08 (NUMERICAL ANALYSIS)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	ELECTRICAL ENGINEERING
Curriculum	PERCORSO COMUNE
Year of study	1°
Period	1st semester (26/09/2016 - 13/01/2017)
ECTS	6
Lesson hours	45 lesson hours
Language	ENGLISH
Activity type	WRITTEN AND ORAL TEST
Teacher	MARINI LUISA DONATELLA (titolare) - 6 ECTS
Prerequisites	Differential and integral calculus for real functions; complex numbers; linear algebra; computer programming experience.
Learning outcomes	The aim of the course is to enable students to classify real-life problems and choose the best suited algorithms for solving them, in terms of costs/benefits and convergence properties. At the same time, the course is meant to make students well acquainted with the use of Matlab software and with the practical implementation of some algorithms.
Course contents	The course is divided in two parts, devoted essentially to the numerical approximation of boundary value problems for Partial Differential Equations (Pde's), and of initial value problems for Ordinary Differential Equations (Ode's). The basic common and necessary instruments to deal with both classes of problems are also developed.

NUMERICAL SOLUTION OF BOUNDARY VALUE PROBLEMS FOR PARTIAL DIFFERENTIAL EQUATIONS (PDE):

* Finite Difference method on a model problem in 1D. Consistency and Stability - Lax's Theorem for convergence of a numerical scheme.
*Finite Element method on a model problem in 1D: Variational formulation, continuous piecewise linear finite element approximation, stability and convergence; construction of the final system and comparison with finite differences.
*Finite Element method on a model problem in 2D: Variational Formulation, Continuous piecewise linear finite element discretization on triangular meshes; Explicit computation of the elementary stiffness matrix and right-hand side; Assembling and solution of the final system.
*Various examples of boundary value problems in 2D.

NUMERICAL SOLUTION OF INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS (ODE):

*One-step methods: Euler backward and forward, Crank-Nicolson, Heun; Stability and A-stability, consistency, convergence and order of convergence.
*Multistep Methods: general structure, consistency and stability conditions; Explicit and Implicit Adams methods.
*Runge-Kutta methods: consistency and stability conditions; example of construction of an explicit RK-method (Hints on predictor-corrector methods).
*Systems of Ordinary Differential Equations: stiff problems.

COMMON TOOLS:

*Solution of linear systems of equations: direct and iterative methods.
*Nonlinear equations: bisection and Newton's methods. Convergence, order of convergence, stopping criteria. Nonlinear systems of equations: Newton's method and variants.
*Lagrange interpolation: interpolation error, piecewise Lagrange interpolation, order of approximation in various norms.
*Least squares method for data fitting: linear regression and various examples.
*Interpolatory quadrature formulas in 1D: midpoint, trapezoidal, Simpson and error analysis. Gaussian formulae.Extension to dimension 2 on rectangular domains. Quadrature formulas on triangular domains: barycenter, vertex, and midpoint of the edges.

Teaching methods

Lectures (hours/year in lecture theatre): 45
Practical class (hours/year in lecture theatre): 0
Practicals / Workshops (hours/year in lecture theatre): 0

Reccomended or required readings

A. Quarteroni, R. Sacco, F. Saleri . Numerical Mathematics-2nd edition. Springer Series: Texts in Applied Mathematics, Vol. 37 (2007).

Assessment methods

The exam will be written. Each student will be offered a couple of questions on subjects developed in the classes and has one hour to

	answer. There are two typologies of exam: Basic exam: it consists in a couple of simple questions and/or exercises, intended to verify the capability of applying the numerical algorithms, without the need for a deep understanding. The maximum grade is 24/30. Advanced exam: it consists in a couple questions (more theoretical than in the basic exam), intended to verify comprehension of the subjects and not just a mere application of ready-to-use formulas. The answers must be articulated with a certain mathematical precision. The maximum grade is 30/30 cum laude.
Further information	Additional information can be found on my web page: http://arturo.imati.cnr.it/marini
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile