UNIVERSITÀ DI PAVIA

Anno Accademico 2022/2023

DYNAMICAL SYSTEMS: THEORY AND NUMERICAL METHODS

Enrollment year	2022/2023
Academic year	2022/2023
Regulations	DM270
Academic discipline	MAT/08 (NUMERICAL ANALYSIS)
Department	DEPARTMENT OF MATHEMATICS "FELICE CASORATI"
Course	MATHEMATICS
Curriculum	PERCORSO COMUNE
Year of study	1°
Period	1st semester (29/09/2022 - 13/01/2023)
ECTS	6
Lesson hours	56 lesson hours
Language	Italian
Activity type	WRITTEN TEST
Teacher	PAVARINO LUCA FRANCO (titolare) - 6 ECTS
Prerequisites	Differential and integral calculus for function of many variables, vector calculus, matrices. MATLAB programming
Learning outcomes	The course is divided in two parts. DYNAMICAL SYSTEMS: theory and numerical methods (6CFU) and FINITE ELEMENT METHOD AND APPLICATIONS (3CFU). The first part of the course introduces the main concepts related to qualitative and quantitative study of solutions of ordinary differential systems providing the main analytical and numerical methods for the investigation of the dynamics of mathematical models and the critical interpretation of the numerical results.
Course contents	DYNAMICAL SYSTEMS: theory and numerical methods - Basic notion of linear algebra and analysis. Vector spaces, matrices, eigenvalues, eigenvectors.

	- Linear differential equations, differential and integral calculus, vector Taylor series. - Introduction to initial value problems for ordinary differential equations. Local and global solvability, continuous dependence on the initial data, parameters and right hand side perturbations. - Asymptotic Stability, Stability of solutions and of equilibrium points. Linear systems. Stability of the linear autonomous systems based on the spectral abscissa. Nonlinear system: linearization. Nonlinear system: Liapunov function. Two dimension linear system and global analysis of the phase plane. - Complements of numerical analysis for ordinary differential equations. Polynomial interpolation and remainder terms. Numerical integration: Newton-Cotes formulae and Gausian quadrature. Functional iteration for a system of nonlinear equations: explicit iteration scheme and Newton method. - Numerical methods for ordinary differential systems. - One step methods: consistency, zero-stability and convergence. - Runge-Kutta methods based on numerical quadratures, Runge-Kutta methods based on collocation methods. - Linear multistep methods: consistency, zero-stability and convergence. Adams Bashforth and Moulton methods, Predictor-Corrector methods, backwords differentiation formulae. - Estimators of the local discretization error and adative strategy of the time step. - Test problems and region of absolute stability. Stiff problems. - Introduction to bifurcation involving fixed points and limit cycles in biological systems. - Analysis and Simulation of dynamical systems, Lotka-Volterra model and extensions.
Teaching methods	Lectures + programming labs using MATLAB and xppaut
Reccomended or required readings	F. Verhulst. Nonlinear differential equations and dynamical systems. Springer-Verlag,Heidelberg, 2006. R. Mattheij, J. Molenaar. Ordinary differential equations in theory and practice. SIAM, Philadelphia, 2002. A. Quarteroni, R. Sacco, F. Saleri. Matematica Numerica. Springer 3ra ed., 2008. A.M. Stuart , A.R. Humphries. Dynamical Systems and Numerical Analysis. Cambridge University Press 1998.
Assessment methods	Dynamical system: Written examination with possible oral exam with discussion and interpretation of the models and simulations developed in the course.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile