Stampare su carta intestata del CdS

| General information | | |
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| Academic subject | Numerical Methods and Modelling | |
| Degree course | MATHEMATICS | |
| Academic Year | AA 2021-2022 | |
| European Credit Transfer and Accumulation System (ECTS) | LECTURES: 4; PRACTICAL: 3 | |
| Language | ITALIAN | |
| Academic calendar (starting and ending date) | As in the Math Department lectures calendar | |
| Attendance | | |

| Professor/ Lecturer | |
|---|---|
| Name and Surname | Luciano Lopez/ Cinzia Elia |
| E-mail | luciano.lopez@uniba.it/ cinzia.elia@uniba.it |
| Telephone | 080 5442655 / 080 544 2685 |
| Department and address | Math Department, University of Bari, Via Orabona 4, Bari |
| Virtual headquarters | |
| Tutoring (time and day) | Wednesday 11-13 or by appointment |

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| *Syllabus* | |
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| **Learning Objectives** | Acquiring methods and techniques of applied mathematics for the qualitative analysis and simulation of continuous and discrete models of evolution. |
| **Course prerequisites** | Basic knowledge of systems of ODEs, Linear Algebra and Numerical Analysis. Bases of programming in Matlab. All requirements are achieved in the Bachelor class L-35. |

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| **Contents** | **1. DISCRETE DYNAMICAL SYSTEMS**<br>First order difference equations and their solutions. Theory of linear difference equations od order k. Homogeneous difference equations. Computation of solutions. Characteristic polynomial: single roots and multiple roots. Operator p(E) and its properties. Computation of particular solutions. Equilibria of difference equations and their stability. Formal series. Variation of constants formula. Linear systems of difference equations. Stability of solutions of difference equations. Matrix functions and their properties. Asymptotic study of A^n and exp(tA). Discrete models: Cobweb simple and complex; Lesley model of population dynamic; Indian Natchez.<br><br>**2. CONTINUOUS DYNAMICAL SYSTEMS**<br>Autonomous linear systems of ODES: Principal matrix solution and its properties. Matrix exponential. Continuity of solutions with respect to the initial condition and concept of stability. Invariant subspaces: stable, unstable and central space. Examples: planar linear systems; node, saddle point, focus and center.<br>Autonomous nonlinear systems. Properties of the flow. Equilibria and concepts of asymptotic stability, stability and instability. Equilibria and linearizations. Lyapunov functions. Periodic orbits and limit cycles. Long time behavior of solutions. Continuous models: harmonic oscillator with damping and forcing. Duffing oscillator with damping and forcing. Nonlinear pendulum. Van der Pol. Lotka-Volterra, competing species, Darwin.<br><br>**3. RUNGE KUTTA METHODS**<br>Forward Euler (FWE): local and global error. Linear stability. FWE applied to the harmonic oscillator. Runge Kutta method of order 2. Local and global error. Linear stability and behavior of solutions of the harmonic oscillator. Spurious fixed points. Runge Kutta methods, general theory: consistency, convergence, local and global error, upper bounds. Verification of order of convergence in function of the discretization stepsize. Linear stability: stability function and region of absolute stability.<br><br>**4. PROGRAMMING**<br>Creation of Matlab functions for explicit Runge Kutta methods.<br>Geometrical and quantitive verification of order of convergence.<br>Creation of Matlab function to trace the absolute stability regione of the method.<br>Simulation of models of ODEs with particular emphasis on the qualitative behaviour of the numerical solutions. |

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| **Books and bibliography** | V. Lakshmikantham, D. Trigiante, Theory of difference equations: numerical methods and applications, Academic Press Inc, 1988.<br><br>D.G: Luemberger, Introduction to dynamic systems, J. Weley and Sons, 1979.<br><br>M. Braun, Differential Equations and Their Applications**:** An Introduction to Applied Mathematics: An Introduction to Applied Mathematics. Springer, 1983.<br><br>L. Perko, Differential Equations and Dynamicla Systems, Springer, 1991.<br><br>J.D. Lambert, Numerical Methods for Ordinary Differential Systems: The Initial Value Problem, Wiley and Sons |
| **Additional materials** | |

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| **Work schedule** | | | |
| Total | Lectures | Hands on (Laboratory, working groups, seminars, field trips) | Out-of-class study hours/ Self-study hours |
| **Hours** | | | |
| *175* | *40* | *32* | *103* |
| **ECTS** | | | |
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| **Teaching strategy** | In class and online lectures and lab session. | | |
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| **Expected learning outcomes** | | | |
| **Knowledge and understanding on:** | ○ Qualitative behaviour of continuous and discrete dynamical systems; | | |
| **Applying knowledge and understanding on:** | ○ Numerical simulation of continuous and discrete dynamical systems;<br>○ Qualitative behaviour of the numerical solutions; | | |

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| **Soft skills** | • *Making informed judgments and choices*<br>○ Predict the behaviour of a model described during the lectures and labs via qualitative and numerical analysis.<br>• *Communicating knowledge and understanding*<br>○ Use formal mathematical language to describe the qualitative and numerical analyses.<br>• *Capacities to continue learning*<br>○ Predict the behaviour of a real world model via qualitative and numerical analysis. |

| **Assessment and feedback** | |
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| Methods of assessment | |
| Evaluation criteria | • *Knowledge and understanding*<br>○ The student should be able to perform the qualitative analysis of a model introduced during the lectures.<br>• *Applying knowledge and understanding*<br>○ The student should be able to study numerically a model introduced during the lectures.<br>• *Autonomy of judgment*<br>○ The student should be able to predict the long term behaviour of a given model via qualitative and numerical analysis.<br>• *Communicating knowledge and understanding*<br>○ The student should be able to describe with proper terminology a given model and the behaviour of its solutions.<br>• *Capacities to continue learning*<br>○ The student should be able to apply qualitative and numerical analysis to any real world model. |
| Criteria for assessment and attribution of the final mark | The final grade is given out of 30 with a minimum passing grade of 18.<br>The practical exam consists in the numerical simulation of a given model.<br>Upon passing the practical exam, the student will be admitted to the oral exam. |
| **Additional information** | |
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