## SYLLABUS

### 1. Information regarding the programme

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| 1.1 Higher education institution | Babes-Bolyai University |
| 1.2 Faculty | Faculty of Mathematics and Computer Science |
| 1.3 Department | Department of Mathematics |
| 1.4 Field of study | Computer Science |
| 1.5 Study cycle | Bachelor |
| 1.6 Study programme / Qualification | Computer Science |

### 2. Information regarding the discipline

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| 2.1 Name of the discipline | **Dynamical Systems** | | | | | | |
| 2.2 Course coordinator | Conf. dr. Adriana Buică | | | | | | |
| 2.3 Seminar coordinator | Conf. dr. Adriana Buică | | | | | | |
| 2.4. Year of study | **1** | 2.5 Semester | **2** | 2.6. Type of evaluation | **E** | 2.7 Type of discipline | **DC** |

### 3. Total estimated time (hours/semester of didactic activities)

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|---|---|---|---|---|---|
| 3.1 Hours per week | 4 | Of which: 3.2 course | 2 | 3.3 seminar/laboratory | 2 |
| 3.4 Total hours in the curriculum | 56 | Of which: 3.5 course | 28 | 3.6 seminar/laboratory | 28 |

| Time allotment: | hours |
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| Learning using manual, course support, bibliography, course notes | 14 |
| Additional documentation (in libraries, on electronic platforms, field documentation) | 8 |
| Preparation for seminars/labs, homework, papers, portfolios and essays | 14 |
| Tutorship | 28 |
| Evaluations | 6 |
| Other activities: .................. | - |

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| 3.7 Total individual study hours | 70 |
| 3.8 Total hours per semester | 126 |
| 3.9 Number of ECTS credits | 5 |

### 4. Prerequisites (if necessary)

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| 4.1. curriculum | Mathematical Analysis, Linear Algebra, Basics of Geometry, Basics of Physics |
| 4.2. competencies | Derivation and integration, Taylor expansion, properties of real functions, eigenvalues, the Kernel of a linear map, the main quadratic curves, the Newton's second law of movement |

### 5. Conditions (if necessary)

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| 5.1. for the course | Classroom with blackboard |

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| 5.2. for the seminar /lab activities | Computers for the laboratory activity |

**6. Specific competencies acquired**

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| **Professional competencies** | • C4.5 The incorporation of formal models in specific applications from different domains |
| **Transversal competencies** | • CT1 To apply the rules of organized and efficient work, of responsible attitudes toward the didactic-scientific domain, for the creative valorization of their own potential, respecting the principles and the norms of the professional ethic.<br>• CT3 To use some efficient methods and techniques to learn, to inform themselves, to do research and to develop the abilities for the valorization of their knowledges, to adapt to a dynamical society, and to communicate. |

**7. Objectives of the discipline** (outcome of the acquired competencies)

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| 7.1 General objective of the discipline | • Introduction to the basic problems of dynamical systems theory as well as the discussion of some related formal models |
| 7.2 Specific objective of the discipline | • To understand the concepts of equilibrium point, orbit, periodic orbit, stability, chaos and to operate with them at least in some simple situations. |

**8. Content**

| 8.1 Course | Teaching methods | Remarks |
|---|---|---|
| 1. Introduction to differential equations (notions, initial conditions, boundary conditions, examples, fundamental problems) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 2. Linear differential equations (existence and uniqueness theorem, fundamental theorems) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 3. Linear differential equations with constant coefficients. | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 4. Linear differential equations. Applications (Newton's law of cooling, Pendulum equation, Harmonic oscillations) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |

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| 5. The dynamical system generated by a differential equation (main notions and first examples) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 6. Phase portraits of scalar equations. | • | |
| 7. Stability of equilibria (definition, examples, stability of linear systems, the linearization method). The nonlinear pendulum equation. | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 8. Phase portraits of planar systems. | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 9. Numerical methods for ordinary differential equations (Euler and Runge-Kutta numerical formulas) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 10. Linear recurrences (difference equations) with constant coefficients (fundamental theorems, Fibonacci sequence) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 11. Linear systems of difference equations (convergent matrix, complex notation) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 12. Nonlinear scalar discrete dynamical systems (notions, examples, stability of a fixed point) | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 13. The logistic map. Euler numerical formula revisited. | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |
| 14. Higher dimensional discrete dynamical systems (notions, examples, stability of the fixed points). | • Interactive exposure<br>• Explanation<br>• Conversation<br>• Didactical demonstration | |

**Bibliography**


1. The webpage of the course http://www.math.ubbcluj.ro/~abuica/dynsys.htm
2. P. Blanchard, R.L. Devaney, G.R. Hall, Differential Equations, Brooks/Cole, Cengage Learning, 2012.
3. M.W. Hirsch, S. Smale, R.L. Devaney, Differential Equations, Dynamical Systems and an Introduction to Chaos, Academic Press, 2004.
4. R.Precup, Ecuatii diferentiale, Risoprint, Cluj-Napoca, 2011.

| 8.2 Seminar / laboratory | Teaching methods | Remarks |
|---|---|---|
| Seminar 1. Linear homogeneous differential equations with constant coefficients. General solutions and properties of solutions (periodicity, oscillations, boundedness…) | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 1. Introduction to Maple. Basic notions. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Seminar 2. Linear differential equations (the method of undetermined coefficients, the Lagrange method). | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 2. The use of Maple to find the general solution of linear differential equations, to solve initial and boundary value problems and to study the properties of solutions | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Seminar 3. Linear differential equations. Test. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 3. The use of Maple to find the general solution to Euler equations and to linear systems. Power series method. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Seminar 4. Phase portraits of scalar nonlinear dynamical systems and planar linear systems. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 4. Orbits and direction fields of planar systems. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Seminar 5. Stability of linear systems and of equilibria of nonlinear systems. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 5. First integrals of planar systems around equilibria of center type. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Seminar 6. Test. Introduction to linear recurrences. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 6. Numerical methods. | • Explanation<br>• Conversation | |

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| | • Didactical demonstration | |
| Seminar 7. Linear recurrences. Nonlinear scalar maps. | • Explanation<br>• Conversation<br>• Didactical demonstration | |
| Laboratory 7. Nonlinear scalar maps. Test. | • Examination | |

**Bibliography**

1. The webpage of the course http://www.math.ubbcluj.ro/~abuica/dynsys.htm
2. P. Blanchard, R.L. Devaney, G.R. Hall, Differential Equations, Brooks/Cole, Cengage Learning, 2012.
3. S. Lynch, Dynamical systems with applications using MAPLE, Birkhauser, 2001.
4. Gh. Micula, P. Pavel, Ecuatii diferentiale si integrale prin probleme si exercitii, Ed. Dacia, Cluj-Napoca,1989
5. R. Precup, Ecuatii diferentiale, Risoprint, Cluj-Napoca, 2011.

**9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program**

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| The content of this discipline is synchronized with the curriculum of most of the important universities from our country and from abroad where the applied mathematics plays an important role. |

**10. Evaluation**

| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Share in the grade (%) |
|---|---|---|---|
| 10.4 Course | • To know the notions and their properties by examples or counterexamples. To be able to apply the theoretical results in concrete problems. | Exam | 65% |
| | | | |
| 10.5 Seminar/lab activities | • Solving problems skills | Two tests | 20% |
| | • Interest and implication in each lab activity. One final test in the last lab. | Dialogue in each lab and one final test | 15% |
| | • | | |
| 10.6 Minimum performance standards | | | |
| • Presence at least at 90% from the lab activities, Presence at least at 75% from the seminar activities, at least 10% points from the lab activity, at least 15% points from the written final exam and the minimum passing grade is 5. | | | |

| Date | Signature of course coordinator | Signature of seminar coordinator |
|---|---|---|
| 22-04-2018 | Conf. dr. Adriana Buică | Conf. dr. Adriana Buică |

| Date of approval | Signature of the head of department |
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| 23-04-2018 | Prof. dr. Octavian Agratini |