SYLLABUS

Dynamical Systems

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	Babeş-Bolyai University
1.2. Faculty	Mathematics and Computer Science
1.3. Department	Mathematics
1.4. Field of study	Computer Science
1.5. Study cycle	Bachelor
1.6. Study programme/Qualification	Computer Science (english)
1.7. Form of education	Full attendance

2. Information regarding the discipline

2.1. Name of the discipline	**Dynamical Systems**					Discipline code	**MLE0010**
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. Discipline regime	Compulsory

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

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/laborator	**28**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					35
Additional documentation (in libraries, on electronic platforms, field documentation)					8
Preparation for seminars/labs, homework, papers, portfolios and essays					14
Tutorship					4
Evaluations					6
Other activities:					2
3.7. Total individual study hours	**69**				
3.8. Total hours per semester	**125**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

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, quadratic curves, the Newton's second law of motion	

5. Conditions (if necessary)

5.1. for the course	Classroom with blackboard	
5.2. for the seminar /lab activities	Computers for the laboratory activity	

6. Specific competencies acquired [1]

Professional/essential competencies	• C4.5 The incorporation of formal models in specific applications from different domains
Transversal competencies	• CT1 The application of 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. • CT3 The use of 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)

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 dynamical systems (examples, notions, initial conditions, boundary conditions, examples, fundamental problems, physical models)	Exposition, proofs, examples	
2.Linear differential equations (existence and uniqueness theorem, fundamental theorems)	Exposition, proofs, examples	
3.Linear differential equations with constant coefficients.	Exposition, proofs, examples	
4.Linear differential equations. Applications (Newton's law of cooling, Pendulum equation, Harmonic oscillations)	Exposition, proofs, examples	
5.Scalar first order linear differential equations	Exposition, proofs, examples	
6.Linear differential systems	Exposition, proofs, examples	
7.The dynamical system generated by a differential equation (main notions and first examples). Phase portraits of scalar equations.	Exposition, proofs, examples	

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

8.Stability of equilibria (definition, examples, stability of linear systems, the linearization method). The nonlinear pendulum equation.	Exposition, proofs, examples	
9.Phase portraits of planar systems.	Exposition, proofs, examples	
10.Numerical methods for ordinary differential equations (Euler and Runge-Kutta numerical formulas)	Exposition, proofs, examples	
11.Linear recurrences (difference equations) with constant coefficients (fundamental theorems, Fibonacci sequence)	Exposition, proofs, examples	
12.Linear systems of difference equations (convergent matrix, complex notation)	Exposition, proofs, examples	
13.Nonlinear scalar discrete dynamical systems (notions, examples, stability of a fixed point)	Exposition, proofs, examples	
14.The logistic map. Euler numerical formula revisited.	Exposition, proofs, examples	

Bibliography

1. The webpage of the course http://www.math.ubbcluj.ro/~abuica/dynsys.htm
2. A. Buică, Lecture notes on Dynamical Systems uploaded in Teams
3. S.E. Elaydi, Discrete Chaos: with applications in science and engineering, CRC Press, 2008.
4. J. Hale, H. Kocak, Dynamics and Bifurcations, Springer, 1991.
5. M.W. Hirsch, S. Smale, R.L. Devaney, Differential Equations, Dynamical Systems and an Introduction to Chaos, Academic Press, 2004.
6. R.Precup, Ordinary Differential Equations, De Gruyter, 2017.

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…)	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 1. Introduction to Maple. Basic notions.	Examples, dialogue, explanations, critical thinking	
Seminar 2. Linear differential equations (the method of undetermined coefficients, the Lagrange method).	Examples, dialogue, explanations, proofs, critical thinking	
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	Examples, dialogue, explanations, critical thinking	
Seminar 3. Linear differential equations.	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 3. The use of Maple to find the general solution to Euler equations and to linear systems. Power series method.	Examples, dialogue, explanations, critical thinking	
Seminar 4. Phase portraits of scalar nonlinear dynamical systems and planar linear systems.	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 4. Orbits and direction fields of planar systems.	Examples, dialogue, explanations, critical thinking	
Seminar 5. Stability of linear systems and of equilibria of nonlinear systems.	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 5. First integrals of planar systems around equilibria of center type.	Examples, dialogue, explanations, critical thinking	
Seminar 6. Test. Introduction to linear recurrences.	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 6. Numerical methods. Nonlinear scalar maps.	Examples, dialogue, explanations, critical thinking	
Seminar 7. Linear recurrences. Nonlinear scalar maps.	Examples, dialogue, explanations, proofs, critical thinking	
Laboratory 7. Test.	Evaluation	

Bibliography

1. The webpage of the course http://www.math.ubbcluj.ro/~abuica/dynsys.htm
2. A. Buică, Problems on Dynamical Systems uploaded in Teams
3. S. Lynch, Dynamical systems with applications using MAPLE, Birkhauser, 2001.

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

- 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

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	The evaluation of the knowledges and the competencies to apply them	Written exam	70%
10.5 Seminar/laboratory	Solving problems skills	One test	10%
	Interest and implication in each lab activity. One final test in the last lab.	Dialogue in each lab and one final test	20%
10.6 Minimum standard of performance			

- Presence at least at 6 labs and 5 seminars.
- To obtain at least 7 points at the lab test and at least 15 points at the written exam.
- The minimum passing grade is 5.

11. Labels ODD (Sustainable Development Goals)[2]

	General label for Sustainable Development							
								

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.".

Date:
11.04.2025

Signature of course coordinator

Conf. Dr. Adriana Buică

Signature of seminar coordinator

Conf. Dr. Adriana Buică

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuş