COURSE DESCRIPTION

Differential equations: a dynamical systems approach

Academic year 2026/2027

1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University
1.2. Faculty	Faculty of Mathematics and Computer Science
1.3. Doctoral School	Doctoral School in Mathematics and Computer Science
1.4. Field of study	Mathematics
1.5. Level of study	Doctoral studies

2. Course-related data

2.1. Course title	Differential equations: a dynamical systems approach			Course code	MDE8174
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	1	2.6. Type of assessment	Exam
2.7. Course status	Optional			2.8. Course type	Specialisation subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**	of which: 3.2. course	**2**	3.3. seminar/ laboratory/ project	**1**
3.4. Total of hours in the curriculum	36	of which: 3.5. course	24	3.6. seminar/ laboratory	**12**
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					80
Additional research in the library, on subject-specific electronic platforms, and on-site					40
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					50
Tutoring (professional guidance)					22
Examinations					22
Other activities					0
3.7. Total hours of individual study (IS) and self-taught activities (ST)				**214**	
3.8. Total hours per semester				**250**	
3.9. Number of credits				**10**	

4. Prerequisites (where applicable)

4.1. curriculum-related	Linear algebra, mathematical analysis, differential equations
4.2 skills-related	Logical deduction, abstract thinking, critical thinking, ability to operate with mathematical notions and properties

5. Specific conditions (where applicable)

5.1. course-related	
5.2. seminar/laboratory-related	

6. Subject-specific learning outcomes

Knowledge
1. Knows the basic notions, like fundamental matrix solution, matrix exponential, orbit, invariant set, first integral, data dependence, stable solution.
2. Knows the properties of hyperbolic linear systems, their invariant spaces, of the first integrals, the fundamental theorems in the theory of differential equations and the main stability theorems.
3. Knows the main techniques used in the proofs, like using integral equations or the Gronwall lemma.
4. Knows to deduce the relations between the notions and to prove the results studied.
Skills
1. Based on the eigenvalues and eigenvectors of the matrix system, the student is able to find the matrix exponential, to estimate its norm when restricted to the stable/or unstable space, to establish the asymptotic behaviour of the solutions.
2. The student is able to apply the fundamental theorems for nonlinear systems.
3. The student is able to apply the stability theorems.
Responsibility and autonomy
1. The student is able to develop a specific subject by reading the bibliography.
2. The student works alone to extend his knowledge.
3. The student identify new research directions.

7. Contents

7.1. Course	**Teaching and learning methods**	**Remarks[1]**
Linear differential systems. Fundamental results	Explanation, conversation, demonstration	
Linear differential systems with constant coefficients: the exponential matrix, the asymptotic behaviour of the solutions, stable, unstable, center spaces.	Explanation, conversation, demonstration	
The fundamental theorems for nonlinear systems: the existence and uniqueness theorem; maximal interval of existence; continuity and differentiability with respect to parameters	Explanation, conversation, demonstration	
Stability of equilibria of nonlinear autonomous systems by linearization and by the Lyapunov functions method	Explanation, conversation, demonstration	
Stability of nonautonomous linear differential systems. Fundamental results	Explanation, conversation, demonstration	
Stability of periodic linear differential systems. Floquet theory	Explanation, conversation, demonstration	
The existence of periodic solutions of linear periodic systems	Explanation, conversation, demonstration	
Stability of periodic solutions of periodic nonlinear systems	Explanation, conversation, demonstration	

Bibliography

1. A. Buică, Periodic solutions for nonlinear systems, Cluj University Press, 2006.
2. C. Chicone, Ordinary differential equations with applications, Springer, 2006.
3. E.A. Coddington, N. Levinson, Theory of ordinary differential equations, 1959.
4. P. Hartman, Ordinary differential equations, SIAM, 2002.
5. L. Perko, Differential equations and dynamical systems, Springer, 2001.
6. M. Viana, J.M Espinar, Differential equations: a dynamical systems approach to theory and practice, American Mathematical Society, 2021.

[1] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

7.2. Seminar/ laboratory	Teaching and learning methods	Remarks
Various problems and exercises on the theme of the same week lecture.	Conversation, explanation	

Bibliography

1. A. Buică, Periodic solutions for nonlinear systems, Cluj University Press, 2006.
2. C. Chicone, Ordinary differential equations with applications, Springer, 2006.
3. E.A. Coddington, N. Levinson, Theory of ordinary differential equations, 1959.
4. P. Hartman, Ordinary differential equations, SIAM, 2002.
5. L. Perko, Differential equations and dynamical systems, Springer, 2001.
6. M. Viana, J.M Espinar, Differential equations: a dynamical systems approach to theory and practice, American Mathematical Society, 2021.

8. Evaluation

Type of activity	8.1 Evaluation criteria[2]	8.2 Evaluation methods[3]	8.3 Percentage in the final grade
8.4. Course	To know the notions and their properties by examples or counterexamples. To be able to prove the main theoretical results.	Oral exam	40
	To develop a specific subject by reading the bibliography.	Report with oral presentation	20
8.5. Seminar/ laboratory	Solving problems skills	Tests and oral presentation	30
8.6 Minimum standard for passing			
At least 20 (/40) at the oral exam and at least 20 (/30) at the seminar evaluation.			

9. SDG labels (Sustainable Development Goals)[4]

		Sustainable Development Generic Label

[2] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[3] Both final evaluation methods and ongoing evaluation strategies should be established.

[4] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*

								
○	○	○	○	○	○	○	○	○
								No label applies
○	○	○	○	○	○	○	○	○

Date of entry:
16/02/2026

Signature of course coordinator

Conf. dr. Adriana Buică

Signature of seminar coordinator

Conf. dr. Adriana Buică

Date of approval in the department:

Signature of the head of department

Prof. dr. Andrei Mărcuș