

SYLLABUS

Nonlinear Applied Analysis

University year 2026-2027

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	Mathematics
1.5. Study cycle	Master
1.6. Study programme/Qualification	Advanced Mathematics/Master
1.7. Form of education	with frequency

2. Information regarding the discipline

2.1. Name of the discipline	Nonlinear Applied Analysis				Discipline code	MME3024	
2.2. Course coordinator	Prof.dr. Adrian Petrusel						
2.3. Seminar coordinator	Prof.dr. Adrian Petrusel						
2.4. Year of study	1	2.5. Semester	2	2.6. Type of evaluation	V	2.7. Discipline regime	compulsory

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

3.1. Hours per week	3	of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4. Total hours in the curriculum	42	of which: 3.5 course	28	3.6 seminar/laborator	14
Time allotment for individual study (ID) and self-study activities (SA)					hours
Learning using textbooks, course support, bibliography, course notes (SA)					32
Additional documentation (in libraries, on electronic platforms, field documentation)					23
Preparation for seminars/labs, homework, papers, portfolios and essays					32
Tutorship					21
Evaluations					8
Other activities:					17
3.7. Total individual study hours	133				
3.8. Total hours per semester	175				
3.9. Number of ECTS credits	7				

4. Prerequisites (if necessary)

4.1. curriculum	Differential Equations, Mathematical Analysis (I-III), Topology
4.2. competencies	<ul style="list-style-type: none"> • operation with abstract concepts • the ability to make logical deductions • the ability to solve mathematical problems based on the learned concepts

5. Conditions (if necessary)

5.1. for the course	Black board, Video projector
5.2. for the seminar /lab activities	Black board, Video projector

6.1. Competencies resulting from the completion of the degree programme (as referred to in the curriculum)¹

Professional competencies	
Competency code	Competency
CP3	perform analytical mathematical calculations
CP1	develop problem-solving strategies
CP6	disseminate results among the scientific community
Transversal competencies	
Competency code	Competency
CT3	work independently
CT6	think analytically

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)²

Learning outcomes targeted by the subject		
Competency code	Knowledge and comprehension	Specific academic skills
CP3	5. The graduate formulates observations and differentiates notions, properties and assertions from advanced disciplines of mathematics through examples and counterexamples.	5. The graduate verifies, on particular cases or by constructing examples or counterexamples, the validity of mathematical statements. The graduate translates a practical situation into mathematical language, solves the problem obtained and interprets the results obtained.
CP1	1. The graduate analyses the hypotheses and conclusions from mathematical assertions and links them within the demonstration.	1. The graduate demonstrates the acquisition and use of effective research methods and techniques.
CP7, CT3	3. The graduate compares and distinguishes related notions and their properties from advanced mathematics disciplines in the curriculum.	3. The graduate is able to identify and formulate significant problems which form the basis for further research.
CT6	4. The graduate critically studies the specialized literature, including by using international databases, identifying fundamental concepts.	4. The graduate applies appropriate techniques for solving advanced problems.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. The student/graduate has acquired the knowledge specific to the discipline studied necessary for solving problems.
2. The student/graduate knows fundamental notions of algebra as well as methods of applying them in fields of science related to mathematics and computer science.
Specific academic skills
1. The student/graduate is able to construct clear and well-supported mathematical arguments to explain mathematical problems, topics, and ideas in writing.
2. The student/graduate is able to prove theorems using mathematical language in theoretical courses and will be able to present these results both orally and in writing.

¹ The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

² The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

8. Content

8.1 Course	Teaching methods	Remarks
Metric spaces, normed spaces, complete metric spaces, Banach spaces, examples	<p>Expositions: description, explanation, class lectures, dialog-based lectures, lectures with demonstrations, introductory lectures, synthesis lectures.</p> <p>Conversations: debate, dialog, introductory conversations, conversations for knowledge consolidation, conversations to systematize and synthesize knowledge</p> <p>Use of problems: use of problem questions, problems and problem situations.</p>	
Contraction principle and basic applications	the same as before	
Generalizations of the Contraction Principle (Kannan, Edelstein-Nemitki)	the same as before	
Generalizations of the Contraction Principle (local fixed point theorems, Maia's theorem)	the same as before	
Graphic Contraction Principle and Caristi-Browder fixed point theorems	the same as before	
Picard and weakly Picard operator theory (WPO). Basic notions and examples	the same as before	
Characterization theorem for WPO. Abstract Gronwall lemma and comparison theorems	the same as before	
Applications of WPO theory for integral and differential equations	the same as before	
KKM Lemma and consequences (I)	the same as before	
KKM Lemma and consequences (II)	the same as before	
Ky Fan approximation lemma and applications	the same as before	
Schauder's theorems and applications to integral and differential equations (I)	the same as before	
Schauder's theorems and applications to integral and differential equations (II)	the same as before	
Research directions in fixed point theory	the same as before	
Bibliography Bibliography 1. R.P. Agarwal, D. O'Regan, An Introduction to Ordinary Differential Equations, Springer, 2008. 2. I.A. Rus, Principii si aplicatii ale teoriei punctului fix, Editura Dacia, 1979. 3. I.A. Rus, A. Petrusel, G. Petrusel, Fixed Point Theory, Presa Universitara Clujeana, 2008. 4. A. Granas, J. Dugundji, Fixed Point Theory, Springer, 2003. 5. A. Petrusel, Gh. Mot, G. Petrusel, Topics in Nonlinear Analysis and Applications to Mathematical Economics, House of the Book of Science, Cluj-Napoca, 2007.		
8.2 Seminar / laboratory	Teaching methods	Remarks
Examples and exercises concerning metrics and norms in different spaces. Equivalent norms;	<p>Conversations: debate, dialog, introductory conversations, conversations for knowledge consolidation, conversations to</p>	

	systematize and synthesize knowledge Use of problems: use of problem questions, problems and problem situations	
Examples and exercises concerning Contraction Principle and its applications (I)	the same as before	
Examples and exercises concerning Contraction Principle and its applications (II)	the same as before	
Examples and exercises concerning some generalizations of the Contraction Principle (I)	the same as before	
Examples and exercises concerning some generalizations of the Contraction Principle (II)	the same as before	
Examples and exercises concerning Picard and weakly Picard operator theory	the same as before	
Examples and exercises concerning some applications to integral and differential equations via WPO theory (I)	the same as before	
Examples and exercises concerning some applications to integral and differential equations via WPO theory (II)	the same as before	
Examples and exercises concerning some applications to integral and differential equations via WPO theory (III)	the same as before	
Examples and exercises concerning KKM operators	the same as before	
Examples and exercises concerning Schauder's theorems	the same as before	
Examples and exercises concerning some applications of Schauder's theorem to integral and differential equations	the same as before	
Written test (II)	the same as before	
Research directions in fixed point theory	the same as before	
Bibliography 1. R.P. Agarwal, D. O'Regan, An Introduction to Ordinary Differential Equations, Springer, 2008. 2. I.A. Rus, Ecuatii diferentiale, ecuatii integrale si sisteme dinamice, Transilvania Press, 1996 3. A. Petruşel, Operatorial Inclusions, House of the Book of Science Cluj-Napoca, 2003 4. A. Granas, J. Dugundji, Fixed Point Theory, Springer, 2003. 5. I.A. Rus, A. Petrusel, G. Petrusel, Fixed Point Theory, Presa Universitara Clujeana, 2008.		


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

<ul style="list-style-type: none"> • The syllabus of this course is focused on the multivalued operator theory, as a basis for a good research activity through the Doctoral School in Mathematics. Moreover, the course propose the following three important directions: <ul style="list-style-type: none"> - the understanding of the main concepts in nonlinear analysis theory in metric and normed spaces; - to apply fixed point theory for singlevalued operators to integral and differential equations theory; - applications of the Picard and WPO theory to integral and differential equations theory; - to understand some topological fixed point theorems and to use them in applications. • The content of this discipline is in accordance with the curricula of the most important universities in Romania and abroad, where nonlinear analysis plays an essential role. This discipline is useful in preparing future teachers and researchers in pure and applied mathematics, as well as those who use mathematical models and advanced methods of study in other areas.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	Knowledge of concepts and basic results	Middle term written test	40%
	Ability to justify by proofs theoretical results	Final written test	40%
10.5 Seminar/laboratory	Ability to apply concepts and results	Oral reports	10%
	Ability to prove new results in fixed point theory	Oral reports	10%
10.6 Minimum standard of performance			
<ul style="list-style-type: none"> • Successful passing of the exam is conditioned by the final grade that has to be at least 5. • All university official rules with respect to students attendance of academic activities, as well as to cheating and plagiarism, are valid and enforced. 			

11. Labels ODD (Sustainable Development Goals)³

General label for Sustainable Development								
								

Date:
11.04.2026

Signature of course coordinator

Prof.dr. Adrian Petrusel

Signature of seminar coordinator

Prof.dr. Adrian Petrusel

Date of approval:
25.04.2026

Signature of the head of department

Prof. dr. Andrei Mărcuș

³ 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.”.

