SYLLABUS

Nonlinear Applied Analysis

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

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 manual, 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	• 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. Specific competencies acquired [1]

Professional/essential Competencies	- Ability to understand and manipulate concepts, results and advanced mathematical theories. - Ability to model and analyze from the mathematical point of view real processes from other sciences, economics, and engineering. - Ability to use the scientific language and to write scientific reports and papers. - Acquiring specific methods of nonlinear analysis theory (mainly from fixed point theory) and its applications
Transversal competencies	- Ability to inform themselves, to work independently or in a team in order to realize studies and to solve complex problems. - Ability for continuous self-perfecting and study. - Ability to use advanced and complementary knowledge in order to obtain a PhD in Pure Mathematics and Applied Mathematics.

6.2. Learning outcomes

Knowledge	The student knows: the basic concepts and results in the metric and topological fixed point theory for single-valued operators and its applications to differential and integral equations
Skills	The student is able to: - construct clear and well-supported mathematical arguments to explain mathematical problems, topics and ideas in writing. - - demonstrate theorems using mathematical language in theoretical courses and will be able to present these results both orally and in writing.
Responsibility and autonomy:	The student has the ability to: - explore independently certain mathematical contents, relying on the ideas and tools already acquired, to expand their knowledge. - to work independently and to extend already acquired mathematical ideas and arguments to a mathematical topic that has not been previously studied.

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

7.1 General objective of the discipline	• to present the basic concepts and results in the metric and topological fixed point theory for single-valued operators and its applications to differential and integral equations
7.2 Specific objective of the discipline	To understand and and use creatively: • the basic concepts and tools of metric and normed spaces • the main concepts and results of metric and topological fixed point theory • applications of the fixed point theory to nonlinear functional analysis, differential and integarl equations theory

[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. Content

8.1 Course	**Teaching methods**	**Remarks**
Metric spaces, normed spaces, complete metric spaces, Banach spaces, examples	**Expositions**: description, explanation, class lectures, dialog-based lectures, lectures with demonstrations, introductive lectures, synthesis lectures. **Conversations**: debate, dialog, introductive conversations, conversations for knowledge consolidation, conversations to systematize and synthesize knowledge **Use of problems**: use of problem questions, problems and problem situations.	
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;	**Conversations**: debate, dialog, introductive conversations, conversations for knowledge consolidation, conversations to	

	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

- 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:
  - 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			
• 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)[2]

	General label for Sustainable Development							
								

Date:
11.04.2025

Signature of course coordinator

Prof.dr. Adrian Petrusel

Signature of seminar coordinator

Prof.dr. Adrian Petrusel

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuş

[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.*”.