SYLLABUS

1. Information regarding the programme

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

2. Information regarding the discipline

2.1 Name of the discipline	Nonlinear Applied Analysis						
2.2 Course coordinator	Prof.dr. Petrusel Adrian						
2.3 Seminar coordinator	Prof.dr. Petrusel Adrian						
2.4. Year of study	**I**	2.5 Semester	2	2.6. Type of evaluation	C	2.7 Type of discipline	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/laboratory	14

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	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 MLR0009
4.2. competencies	• Mathematical Analysis (I-III), Functional Analysis

5. Conditions (if necessary)

5.1. for the course	• Video projector
5.2. for the seminar /lab activities	• Video projector

6. Specific competencies acquired

Professional 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.

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	• basic concepts and tools of metric and normed spaces • main concepts and results of metric and topological fixed point theory • main concepts and results in the (weakly) Picard operator theory • applications of the fixed point theory to nonlinear functional analysis, differential and integarl equations theory

8. Content

8.1 Course	Teaching methods	Remarks
1. 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.	
2. Contraction principle and basic applications	the same as before	
3. Generalizations of the Contraction Principle (Kannan, Reich-Rus, Ciric)	the same as before	
4. Generalizations of the Contraction Principle (local	the same as before	

fixed point theorems, Maia's theorem)		
5. Graphic Contraction Principle and Caristi-Browder fixed point theorems	the same as before	
6. Picard and weakly Picard operator theory (WPO). Basic notions and examples	the same as before	
7. Characterization theorem for WPO. Abstract Gronwall lemma and comparison theorems	the same as before	
8. Applications of WPO theory for integral and differential equations	the same as before	
9. KKM Lemma and consequences (I)	the same as before	
10. KKM Lemma and consequences (II)	the same as before	
11. Ky Fan approximation lemma and applications	the same as before	
12-14 Schauder's theorems and applications to integral and differential equations	the same as before	

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
1. 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	
2. Examples and exercises concerning Contraction Principle and its applications (I)	the same as before	
3. Examples and exercises concerning Contraction Principle and its applications (II)	the same as before	
4. Examples and exercises concerning some generalizations of the Contraction Principle (I)	the same as before	
5. Examples and exercises concerning some generalizations of the Contraction Principle (II)	the same as before	
6. Examples and exercises concerning Picard and weakly Picard operator theory	the same as before	
7. Examples and exercises concerning some applications to integral and differential equations via WPO theory (I)	the same as before	
8. Examples and exercises concerning some applications to integral and differential equations via WPO theory (II)	the same as before	

9. Examples and exercises concerning some applications to integral and differential equations via WPO theory (III)	the same as before	
10. Examples and exercises concerning KKM operators	the same as before	
11. Examples and exercises concerning Schauder's theorems	the same as before	
12. Examples and exercises concerning some applications of Schauder's theorem to integral and differential equations	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:

1. the understanding of the main concepts in nonlinear analysis theory in metric and normed spaces;
2. to apply fixed point theory for singlevalued operators to integral and differential equations theory;
3. applications of the Picard and WPO theory to integral and differential equations theory;

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

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the 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/lab activities	Ability to apply concepts and results acquired in the course in nonlinear analysis theory	Written and Oral Reports	20%
	Ability to use some software programs		
10.6 Minimum performance standards			
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.

Date	Signature of course coordinator	Signature of seminar coordinator
April 22, 2019	Professor Adrian Petrusel, Ph.D.	

Date of approval	Signature of the head of department
May 6, 2019	Professor Octavian Agratini, Ph.D.