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	Multi-valued Analysis and Applications						
2.2 Course coordinator	Prof.dr. Petruşel Adrian						
2.3 Seminar coordinator	Prof.dr. Petruşel Adrian						
2.4. Year of study	**II**	2.5 Semester	3	2.6. Type of evaluation	VP	2.7 Type of discipline	optional

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	• Nonlinear Applied Analysis MME3024
4.2. competencies	• 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 some concepts and ideas from economics, biology 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 multi-valued analysis and fixed point theory for multi-valued operators and its applications to differential and integral inclusions
7.2 Specific objective of the discipline	• basic concepts and tools of metric spaces and Hausdorff-Pompeiu metric theory • main concepts concerning multi-valued operator theory • main concepts and results of metric fixed point theory, coincidence point theory and coupled fixed point theory for multi-valued operators • applications of the fixed point theory for multi-valued operators to differential and integral inclusions

8. Content

8.1 Course	Teaching methods	Remarks
1. Functionals on the family of all subsets of a metric space: gap functional, excess functional, Hausdorff-Pompeiu functional, diameter functional	**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. Hausdorff-Pompeiu functional: basic properties	the same as before	
3. Continuity notions for multi-valued operators	the same as before	

4. Fixed point theorems for multi-valued operators: the multi-valued contraction principle	the same as before	
5. Generalizations of Nadler's Contraction Principle	the same as before	
6. Weakly Picard operator theory. Examples	the same as before	
7. Qualitative properties of the fixed point set	the same as before	
8. Coincidence point theory for multi-valued operators	the same as before	
9. Coupled fixed point theorems for multi-valued operators	the same as before	
10. Applications of the multi-valued analysis	the same as before	
11. Open problems in the theory of multi-valued operators	the same as before	

Bibliography

1. J.-P. Aubin, H. Frankowska, Set-Valued Analysis, Birkhauser, Basel, 1990.

2. S. Hu, N.S. Papageorgiou, Handbook of Multivalued Analysis, Vol. I and II, Kluwer Acad. Publ., Dordrecht, 1997 and 1999.

3. I.A. Rus, A. Petruşel, G. Petruşel, Fixed Point Theory, Presa Universitara Clujeana, 2008.

4. A. Granas, J. Dugundji, Fixed Point Theory, Springer, 2003.

5. A. Petruşel, Gh. Mot, G. Petruşel, 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 gap functional, excess functional, Hausdorff-Pompeiu functional, diameter functional	**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 Hausdorff-Pompeiu functional	the same as before	
3. Examples and exercises concerning Hausdorff-Pompeiu functional (II)	the same as before	
4. Examples and exercises concerning continuity notions for multi-valued operators	the same as before	
5. Examples and exercises concerning continuity notions for multi-valued operators	the same as before	
6. Examples and exercises concerning the multi-valued contraction principle	the same as before	
7. Examples and exercises concerning generalizations 8. Of the multi-valued contraction principle	the same as before	
9. Examples and exercises concerning weakly Picard operators	the same as before	
10. Examples and exercises concerning coincidence point theorems	the same as before	
11. Examples and exercises concerning coupled fixed point theorems	the same as before	

12. Examples and exercises concerning applications of the fixed point theory for multi-valued operators	the same as before	
13. Examples and exercises concerning applications of the fixed point theory for multi-valued operators (II)	the same as before	

Bibliography

1. K. Deimling, Multivalued Differential Equations, W. de Gruyter, Basel, 1992.

2. L. Gorniewicz, Topological Fixed Point Theory of Multivalued Mappings, Kluwer Acad. Publ., Dordrecht, 1999.

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. Petruşel, G. Petruşel, Fixed Point Theory, Presa Univesritara 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 multi-valued analysis theory in metric spaces;
2. the understanding of the main concepts and approaches in the analysis of multi-valued operators;
3. the understanding of the fixed point theory for multi-valued operators;
4. to apply fixed point theory for multi-valued operators to integral and differential inclusions;

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 Report	20%
	There are valid the official rules of the faculty concerning the attendance of students to teaching activities.		
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
May 4, 2020	Professor Adrian Petrusel, Ph.D.	

Date of approval	Signature of the head of department
May 6, 2020	Professor Octavian Agratini, Ph.D.