SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş Bolyai University of 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	**Master of Advanced Mathematics**

2. Information regarding the discipline

2.1 Name of the discipline	**Nonlinear partial differential equations**						
2.2 Course coordinator	**Prof.PhD. Radu Precup**						
2.3 Seminar coordinator	**Prof.PhD. Radu Precup**						
2.4. Year of study	**1**	2.5 Semester	**2**	2.6. Type of evaluation	**E**	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 sem
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					41
Additional documentation (in libraries, on electronic platforms, field documentation)					43
Preparation for seminars/labs, homework, papers, portfolios and essays					40
Tutorship					18
Evaluations					16
Other activities:					-

3.7 Total individual study hours	158
3.8 Total hours per semester	200
3.9 Number of ECTS credits	8

4. Prerequisites (if necessary)

4.1. curriculum	•
4.2. competencies	•

5. Conditions (if necessary)

5.1. for the course	• Partial differential equations; Functional analysis
5.2. for the seminar /lab activities	• Partial differential equations; Functional analysis

6. Specific competencies acquired

Professional competencies	• Use of the theory of linear partial differential equations and of the basic principles of functional analysis for the investigation of nonlinear boundary value problems • Ability to apply abstract principles of nonlinear analysis to elliptic boundary value problems
Transversal competencies	• Understand the role of partial differential equations in mathematical modelling of real phenomena

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

7.1 General objective of the discipline	• Acquire knowledge about some main techniques of investigation of nonlinear boundary value problems
7.2 Specific objective of the discipline	• Rewrite boundary value problems as operator equations • Apply general fixed point principles to the operator equations associated to boundary value problems • Apply basic variational methods to elliptic equations • Compare different methods by analysing the sufficient conditions and the conclusions of the theorems

8. Content

8.1 Course	Teaching methods	Remarks
1. Summary basic notions and results from the theory of linear partial differential equations	Exposure: description, explanation, dialogue, examples	
2. Sobolev spaces: definition, properties	Exposure: description, explanation, dialogue, examples	
3. Operator formulation of semilinear elliptic boundary value problems	Exposure: description, explanation, dialogue, examples	
4. The Nemytskii superposition operator. Properties; Elliptic problems with Lipschitz nonlinearities	Exposure: description, explanation, examples, proof, dialogue	
5. Elliptic problems with nonlinearities having a growth at most linear. Application of Schauder's fixed point theorem	Exposure: description, explanation, examples, proof	
6. The Leray-Schauder continuation principle. Method of „a priori" bounds	Exposure: description, explanation, examples, proof, dialogue	
7. Comparison of different existence results by analysing their hypotheses and conclusions	Exposure: explanation, examples, dialogue	
8. Supersolutions, subsolutions, monotone iterations	Exposure: description, explanation, examples	
9. Variational methods. The Frechet derivative.	Exposure: description,	

	explanation, examples, proofs	
10. Variational structure of elliptic boundary value problems	Exposure: description, explanation, examples	
11. Ekeland's variational principle	Exposure: description, explanation, examples, discussion of case studies	
12. The Palais-Smale compactness condition	Exposure: description, explanation, examples	
13. Schechter's critical point theorem in a ball	Exposure: description, explanation, proofs, examples	
14. Applications to elliptic problems	Exposure: description, examples, dialogue	

Bibliography

1. R. Precup, Linear and Semilinear Partial Differential Equations, De Gruyter, Berlin, 2012.
2. R. Precup, Methods in Nonlinear Integral Equations, Kluwer, 2002.
3. H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, New York, 2011
4. M. Struwe, Variational Methods, Springer, 1990.

8.2 Seminar	Teaching methods	Remarks
1. Exemplification of some basic notions and results from the theory of linear partial differential equations	Exercise, dialogue, team work	
2. Sobolev spaces	Exercise, dialogue, team work	
3. Operator formulation of boundary value problems. Case of ordinary differential equations; The Nemytskii superposition operator. Examples	Exercise, explanation, dialogue, team work	
4. Examples of elliptic problems with Lipschitz nonlinearities	Exercise, explanation, dialogue, team work	
5. Examples of elliptic problems with nonlinearities having a growth at most linear	Exercise, explanation, dialogue, team work	
6. Applications of the homotopy principle to two-point boundary value problems	Exercise, explanation, dialogue, team work	
7. Comparison of different existence results in case of two-point boundary value problems	Exercise, explanation, dialogue, team work	
8. Applications of super and subsolutions method	Exercise, explanation, dialogue, team work	
9. Examples of cones	Exercise, explanation, dialogue	
10. The Frechet derivative. Examples	Exercise, explanation, dialogue, team work	
11. Ekeland's variational principle. Consequences and applications	Exercise, explanation, dialogue, team work	
12. The Palais-Smale condition. Case of one-dimensional problems	Exercise, explanation, dialogue	
13. Schechter's critical point theorem. Applications	Exercise, explanation, dialogue, team work	
14. Case of systems without a variational structure	Exercise, explanation, dialogue, team work	

Bibliography
5. R. Precup, Linear and Semilinear Partial Differential Equations, De Gruyter, Berlin, 2012.
6. R. Precup, Methods in Nonlinear Integral Equations, Kluwer, 2002.
7. H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, New York, 2011.
8. M. Struwe, Variational Methods, Springer, 1990.

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 contents of the course correspond to current research themes in nonlinear boundary value problems and make connexion to mathematical models from physics, biology, medicine etc.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course		Written exam Continuous observations	60% 10%
10.5 Seminar/lab activities		-Practical examination -continuous observations	20% 10%
10.6 Minimum performance standards			
➢ At least grade 5 (from a scale of 1 to 10) at both written exam and seminar practical examination			

Date	Signature of course coordinator	Signature of seminar coordinator
May 10, 2022	Prof.PhD. Radu Precup	Prof.PhD. Radu Precup
Date of approval		Signature of the head of department
May 18, 2022		Prof.PhD. Octavian Agratini