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	**Applied Mathematics**

2. Information regarding the discipline

2.1 Name of the discipline			**Topological methods for 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					24
Additional documentation (in libraries, on electronic platforms, field documentation)					22
Preparation for seminars/labs, homework, papers, portfolios and essays					20
Tutorship					8
Evaluations					16
Other activities:					-

3.7 Total individual study hours	90
3.8 Total hours per semester	132
3.9 Number of ECTS credits	8

4. Prerequisites (if necessary)

4.1. curriculum	• Data Structures and Algorithms
4.2. competencies	• Average programming skills in a high level programming language

5. Conditions (if necessary)

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

activities	

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 • 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. Operator formulation of semilinear elliptic boundary value problems	Exposure: description, explanation, dialogue, examples	
3. The Nemytskii superposition operator. Properties	Exposure: description, explanation, examples, proof, dialogue	
4. 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. Krasnoselskii type theorems in cones	Exposure: description,	

	explanation, examples, proofs	
10. Applications of the compression-expansion theorems	Exposure: description, explanation, examples	
11. Localization of the solutions of nonlinear elliptic problems. Multiplicity	Exposure: description, explanation, examples, discussion of case studies	
12. Vector methods for the studying systems of operator equations	Exposure: description, explanation, examples	
13. Applications of the Perov fixed point theorem to elliptic systems	Exposure: description, explanation, proofs, examples	
14. Combined applications of vector methods with other principles of nonlinear analysis	Exposure: description, examples, dialogue	

Bibliography

1. R. Precup, Lectii de ecuatii cu derivate partiale, Presa Universitara Clujeana, 2004.
2. R. Precup, Linear and Semilinear Partial Differential Equations, De Gruyter, Berlin, 2012.
3. R. Precup, Methods in Nonlinear Integral Equations, Kluwer, 2002.
4. H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, New York, 2011

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. Operator formulation of boundary value problems. Case of ordinary differential equations	Exercise, explanation, dialogue, team work	
3. 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. Applications of Krasnoselskii's theorems to two-point boundary value problems	Exercise, explanation, dialogue, team work	
11. Problem of multiplicity of solutions. Examples	Exercise, explanation, dialogue, team work	
12. Inverse-positive matrices. Examples	Exercise, explanation, dialogue	
13. Systems of equations depending upon one parameter	Exercise, explanation, dialogue, team work	
14. Vector method for two-point boundary value problems	Exercise, explanation, dialogue, team work	

Bibliography

5. R. Precup, Lectii de ecuatii cu derivate partiale, Presa Universitara Clujeana, 2004.
6. R. Precup, Linear and Semilinear Partial Differential Equations, De Gruyter, Berlin, 2012.
7. R. Precup, Methods in Nonlinear Integral Equations, Kluwer, 2002.
8. H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, New York, 2011

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 -continous 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
April 26, 2013	Prof.PhD. Radu Precup	Prof.PhD. Radu Precup
Date of approval		Signature of the head of department
April 30, 2013		Prof.PhD. Octavian Agratini