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	**Doctoral School in Mathematics and Computer Science**
1.4 Field of study	**Mathematics**
1.5 Study cycle	**Doctoral studies**
1.6 Study programme	**TRAINING PROGRAM BASED ON ADVANCED ACADEMIC STUDIES**

2. Information regarding the discipline

2.1 Name of the discipline	**Introduction in Homological Algebra**						
2.2 Course coordinator	**Prof. Dr. Simion Breaz**						
2.3 Seminar coordinator	**Prof. Dr. Simion Breaz**						
2.4. Year of study	**1**	2.5 Semester	**1**	2.6. Type of evaluation	**E**	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	36	Of which: 3.5 course	24	3.6 seminar/laboratory	12
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					75
Additional documentation (in libraries, on electronic platforms, field documentation)					55
Preparation for seminars/labs, homework, papers, portfolios and essays					56
Tutorship					20
Evaluations					8
Other activities:					

3.7 Total individual study hours	214
3.8 Total hours per semester	250
3.9 Number of ECTS credits	10

4. Prerequisites (if necessary)

4.1. curriculum	
4.2. competencies	

5. Conditions (if necessary)

5.1. for the course	
5.2. for the seminar /lab activities	

6. Specific competencies acquired

Professional competencies	Knowledge, understanding and use of main concepts and results in Homological Algebra (complexes, homology and cohomology, derived functors) Ability to use fundamental theoretical concepts and in various fields of mathematics fields of mathematics (Algebra, Topology, Banach Spaces, Fixed Point Theory)	
Transversal competencies	Ability to inform themselves, to work independently or in a team; Ability to approach complex problems and to use information from various specific fields; Ability to identify and use advanced techniques and methods in order to realize a specific research.	

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

7.1 General objective of the discipline	Knowledge, understanding and use of main concepts and results in Homological Algebra Ability to use concepts and fundamental results in some specific fields of mathematics (module theory, topological spaces, Banach spaces)	
7.2 Specific objective of the discipline	Understanding the basic concepts about categories, complexes, resolutions, sheaves. Ability to use specific derived functors (Ext, Tor, Pext) in concrete situations.	

8. Content

8.1 Course	Teaching methods	Remarks
1. Preliminaries	Lectures, didactical demonstration, conversation.	
2. Modules	Lectures, didactical demonstration, conversation.	
3. Categories	Lectures, didactical demonstration, conversation.	
4. Limits and colimits	Lectures, didactical demonstration, conversation.	
5. Functors	Lectures, didactical demonstration, conversation.	

6. Injective and projective modules	Lectures, didactical demonstration, conversation.	
7. Flat modules	Lectures, didactical demonstration, conversation.	
8. Complexes	Lectures, didactical demonstration, conversation.	
9. Homology functors	Lectures, didactical demonstration, conversation.	
10. Derived functors	Lectures, didactical demonstration, conversation.	
11. Ext and Tor	Lectures, didactical demonstration, conversation.	
12. Sheaves	Lectures, didactical demonstration, conversation.	
Bibliography 1. I. Moerdijk: Notes on Homological Algebra, course notes, www.math.ru.nl/topology/Notes%20on%20Homological%20Algebra.pdf 2. J.J. Rotman: An Introduction to Homological Algebra, Springer, 2009		
8.2 Seminar / laboratory	Teaching methods	Remarks
1. The fundamental group	problematization, exercises, problem solving,	
2. Modules	problematization, exercises, problem solving,	
3. Example of Categories	problematization, exercises, problem solving,	
4. Categories of Banach spaces	problematization, exercises, problem solving,	

5. The additive category of Banach spaces	problematization, exercises, problem solving,	
6. The category of Abelian groups	problematization, exercises, problem solving,	
7. Flat modules	problematization, exercises, problem solving,	
8. Directed limits	problematization, exercises, problem solving,	
9. Inverse limits	problematization, exercises, problem solving,	
10. Functors	problematization, exercises, problem solving,	
11. Ext and Tor	problematization, exercises, problem solving,	
12. Ext and Tor for abelian groups	problematization, exercises, problem solving,	

Bibliography

1. S. Breaz, G. Calugareanu, G. Modoi, D. Valcan: Exercices in Abelian Group Theory, Kluwer 2003.
2. J. Cigler, V. Losert, P. Michor: Banach Modules and Functors on Cateories of Banach Specaes, Marcel Dekker, 1979.
3. A. Hatcher: Algebraic Topology, Cambridge University Press, 2001, http://www.math.cornell.edu/~hatcher/AT/AT.pdf
4. C. Schochet: A Pext primer: Pure extensions and $\lim^1$ for infinite abelian groups, NYJM Monographs, 2003, http://nyjm.albany.edu/m/2003/1v.pdf

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 content is in accordance with the curricula of many important universities where pure mathematics plays important places in their research.

This discipline is useful since it realizes connections between various mathematical domains, and it is well known that the methods of homological algebra were used during the time to solve important problems in mathematics. The methods and tools presented here are often used in specifical PhD research activities.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Concepts and basic results	Final exam	50%
	Standard examples		
10.5 Seminar/lab activities	Ability to use the concepts in order to solve problems	Final exam and a midterm test.	25%+25%
10.6 Minimum performance standards			
At least grade 5 from 10.			

Date	Signature of course coordinator	Signature of seminar coordinator
30.06.2021	Prof. Dr. Simion Breaz	Prof. Dr. Simion Breaz

Date of approval

07.07.2021

Signature of the head of doctoral school

Prof. dr. Gabriela Czibula