SYLLABUS

Introduction to Homological Algebra

University year 2025-2026

1. Information regarding the programme

1.1 Higher education institution	Universitatea Babeş-Bolyai Cluj-Napoca
1.2 Faculty	Matematică şi Informatică
1.3 Doctoral School	Matematică şi Informatică
1.4 Field of study	Matematică
1.5 Level of study	Doctoral

2. Information regarding the discipline

2.1. Course title	**Introduction to Homological Algebra**			Course code	**MDE3134**
2.2. Course coordinator	**Prof. Simion Sorin Breaz**				
2.3. Seminar coordinator	**Prof. Simion Sorin Breaz**				
2.4. Year of study	1	2.5. Semester	1	2.6. Type of assessment	Exam
2.7. Course status	Optional			2.8. Course type	Core discipline

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/laborator	**12**
Time allotment for individual study (IS) and self-taught activities (SA)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					77
Additional research in the library, on subject-specific electronic platforms, and on-site					57
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					40
Tutorship					30
Examinations					10
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 (where applicable)

4.1. curriculum-related	
4.2 skills-related	

5. Specific conditions (where applicable)

5.1. course-related	
5.2. seminar/laboratory-related	

6. Subject-specific learning outcomes

Knowledge
1. CP1 Knows the advanced concepts, theories, and models in the field.
2. CP1 Identifies frontier literature in the field.
3. CP2 Knows methods and techniques for identifying and formulating problems.
4. CP3 Knows advanced research methods and techniques, both theoretical and experimental.
Skills
1. CP1 Applies knowledge in the field to the analysis of complex problems.
2. CP2 Employs innovative methodologies to address the identified problems.
3. CT1 Writes and presents scientific information coherently.
Responsibility and autonomy
1. CP1 .Works autonomously in investigating and expanding knowledge.
2. CP3 Makes autonomous decisions regarding the choice and adaptation of methods.
3. CT4 They take responsibility for their own contribution.

7. Contents

7.1 Course	**Teaching and learning 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	Lectures, didactical demonstration, conversation.	
12. Tor	Lectures, didactical demonstration, conversation.	
13. Ext for Abelian Groups	Lectures, didactical demonstration, conversation.	

14. Tensor and Tor for Abelian Groups	Lectures, didactical demonstration, conversation.	

Bibliography

1. I. Moerdijk: Notes on Homological Algebra, course notes, www.**math**.ru.nl/topology/**Notes**%20on%20**Homological**%20**Algebra**.pdf
2. J.J. Rotman: An Introduction to Homological Algebra, Springer, 2009
3. S.M. Osborne, Basic homological algebra. Graduate Texts in Mathematics. 196. New York, NY: Springer. x, 395 p. (2000).
4. B.L. Osofsky, Homological dimensions of modules. Conference Board of the Mathematical Sciences. Regional Conference Series in Mathematics. No. 12. Providence, R.I.: American Mathematical Society (AMS). VIII,89 p. (1973).

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Preliminaries	problematization, exercises, problem solving,	
2. Modules	problematization, exercises, problem solving,	
3. Categories	problematization, exercises, problem solving,	
4. Limits and colimits	problematization, exercises, problem solving,	
5. Functors	problematization, exercises, problem solving,	
6. Injective and projective modules	problematization, exercises, problem solving,	
7. Flat modules	problematization, exercises, problem solving,	
8. Complexes	problematization, exercises, problem solving,	
9. Homology functors	problematization, exercises, problem solving,	
10. Derived functors	problematization, exercises, problem solving,	
11. Ext	problematization, exercises, problem solving,	
12. Tor	problematization, exercises, problem solving,	
13. Ext for Abelian Groups	problematization, exercises, problem solving,	
14. Tensor 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

8. 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 activity during the semester.	25%+25%
10.6 Minimum performance standards			
At least 50% of the maximum score.			

9. SDG labels (Sustainable Development Goals)[1]

	○	Sustainable Development Generic Label

								
○	○	○	○	○	○	○	○	☑
								No label applies
○	○	○	○	○	○	○	○	○

Date:
11.02.2026

Signature of course coordinator

Prof. dr. Simion-Sorin Breaz

Signature of seminar coordinator

Prof. dr Simion-Sorin Breaz

Date of approval:

Signature of the head of department

[1] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*