SYLLABUS

1. Information regarding the programme

1.1 I Higher education institution	BABES-BOLYAI UNIVERSITY
1.2 Faculty	MATHEMATICS AND COMPUTER SCIENCE
1.3 Departamentul	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	RINGS, MODULES AND REPRESENTATIONS						
2.2 Course coordinator	Conf. Dr. George Ciprian Modoi						
2.3 Seminar coordinator	Conf. Dr. George Ciprian Modoi						
2.4 Year of study	2	2.5 Semester	4	2.6. Type of evaluation	E	2.7 Type of discipline	DS

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	3.2 Of which: course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	36	Of which: course	24	3.6 seminar/laboratory	12
Learning using manual, course support, bibliography, course notes					45
Additional documentation (in libraries, on electronic platforms, field documentation)					45
Preparation for seminars/labs, homework, papers, portfolios and essays					45
Tutorship					34
Evaluations					20
Other activities:					
3.7 Total individual study hours					189
3.8 Total hours per semester					225
3.9 Number of ECTS credits					9

4. Prerequisites (if necessary)

4.1 curriculum	Category Theory (MME3123); Group Theory and Applications (MME3103); Homological Algebra (MME3112)
4.2 competencies	Linear algebra, basics about rings, modules, categories, functors.

5. Conditions (if necessary)

5.1 for the course	N/A
5.2 for the seminar /lab activities	N/A

6. Specific competencies acquired

Professional competencies	• Understanding and use of main concepts and results concerning rings, modules and quiver representations • Ability to use fundamental theoretical concepts and to apply them in various fields of mathematics fields of mathematics (Algebra, Geometry etc.) • Ability to use scientific language and to write scientific reports and papers
Transversal competencies	• Ability to inform themselves, to work independently or in a team; • Ability to identify and use advanced techniques and methods in order to realize a specific research. • Ability for continuous self-perfecting and study.

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

7.1 General objective of the discipline	• To get advanced knowledge on rings, modules and quiver representations. • To built the ability to use fundamental theoretical concepts and to apply them in various fields of mathematics
7.2 Specific objective of the discipline	• To construct some specific examples of rings, algebras and modules using the mechanism of quiver representations. • To use the language of categories and functors in this particular case of the theory of modules and quiver representations.

8. Content

8.1 Course	Teaching methods	Remarks
1. Quivers and their representations	Lectures, didactical demonstration, conversation	
2. Rings, algebras and modules	Lectures, didactical demonstration, conversation	
3. Quiver representations vs modules; path algebras	Lectures, didactical demonstration, conversation	
4. Kernels, cokernels, exact sequences	Lectures, didactical demonstration, conversation	
5. Hom functors	Lectures, didactical demonstration, conversation	
6. Simples, projectives and injectives	Lectures, didactical demonstration, conversation	
7. Projective resolutions and injective	Lectures, didactical demonstration,	

coresolutions	conversation	
8. Duality and Nakayama functor	Lectures, didactical demonstration, conversation	
9. Admissible ideals and quotients of path algebras	Lectures, didactical demonstration, conversation	
10. Homological dimensions	Lectures, didactical demonstration, conversation	
11. Morita theory	Lectures, didactical demonstration, conversation	
12. Tilted algebras	Lectures, didactical demonstration, conversation	

Bibliography

1. 1. F.W. Anderson, K.R. Fuller, *Rings and Categories of Modules*, Springer, 1992.
2. H. Derksen, J. Weyman – *An Introduction to Quiver Representations*, Graduate Studies in Mathematics 184, American Mathematical Society, 2017.
3. R. Schiffler – *Quiver Representations*, CMS Books in Mathematcs, Springer, 2014.
4. S. Mac Lane – *Categories for the Working Mathematician*, Graduate Text in Mathematics, Second Edition, Springer Verlag, 1998.

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Examples of quiver representations	problematization, exercises, problem solving	
2. Universal properties; categorical (re)formulations of kernels, cokernels, sums, products etc.	problematization, exercises, problem solving	
3. Example of modules over path algebras	problematization, exercises, problem solving	
4. Examples of simple, projective and injective objects	problematization, exercises, problem solving	
5. Computing some homological dimensions	problematization, exercises, problem solving	
6. Examples of Morita equivalent rings and algebras	problematization, exercises, problem solving	

Bibliography

1. S. Breaz, G. Calugareanu, G. Modoi, C. Pelea, D. Valcan: *Exercices in Abelian Group Theory*, Kluwer 2003.
2. H. Derksen, J. Weyman – *An Introduction to Quiver Representations*, Graduate Studies in Mathematics 184, American Mathematical Society, 2017.
3. T.Y. Lam, *Exercises in classical ring theory*, Springer, 2003.
4. R. Schiffler – *Quiver Representations*, CMS Books in Mathematcs, Springer, 2014.

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 of this discipline is in accordance with the curricula of many important universities.

The mechanism of quiver representations is a relatively simple and intuitive method to construct examples of rings and modules satisfying various abstract properies, provinding a useful requisite for anyone which is interested in algebra, geometry and connex subiects of mathematics.

The methods and tools presented here are often used in specifical PhD research activities.

10. Evaluare

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	20%
	Examples	Final exam	20%
10.5 Seminar / lab activities	Ability to use the concepts in order to solve standard problems	Final exam	20%
	Ability to solve advanced problems	Homeworks	40%
10.6 Minimum performance standards			
At least grade 5 out 10.			

Date	Signature of course coordinator	Signature of seminar coordinator
29.04.2024	Conf. Dr. George Ciprian Modoi	Conf. Dr. George Ciprian Modoi

Date of approval	Signature of the head of department
.....	Prof. Dr. Andrei Marcus