SYLLABUS

Group Theory and Applications

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	**Babeş-Bolyai University**
1.2. Faculty	**Mathematics and Computer Science**
1.3. Department	**Mathematics**
1.4. Field of study	**Mathematics**
1.5. Study cycle	**Master**
1.6. Study programme/Qualification	**Advanced Mathematics**
1.7. Form of education	**Full-time**

2. Information regarding the discipline

2.1. Name of the discipline	**Group Theory and Applications**					Discipline code	**MME3103**
2.2. Course coordinator				Prof. dr. Andrei Mărcuş			
2.3. Seminar coordinator				Prof. dr. Andrei Mărcuş			
2.4. Year of study	1	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Discipline regime	**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**
3.4. Total hours in the curriculum	**42**	of which: 3.5 course	**28**	3.6 seminar/laborator	**14**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					**36**
Additional documentation (in libraries, on electronic platforms, field documentation)					**36**
Preparation for seminars/labs, homework, papers, portfolios and essays					**36**
Tutorship					**20**
Evaluations					**30**
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	Deep knowledge of bachelor level algebra, especially of the following subjects: - algebraic structures - linear algebra
4.2. competencies	- ability to perform symbolic calculations ability to operate with abstract concepts - ability to do logical deductions - ability to solve mathematics problems based on the aquired notions

5. Conditions (if necessary)

5.1. for the course	**blackboard, projector**
5.2. for the seminar /lab activities	**blackboard**

6.1. Specific competencies acquired [1]

Professional/essential competencies	• C1.1 Identifying the notions, describing the theories and using the specific language. • C2.3 Applying the adequate analytical theoretical methods to a given problem
Transversal competencies	• CT1. Applying some rules of precise and efficient work, showing a responsible attitude regarding the scientific domain and teaching training for an optimal and creative development of the personal potential in specific situations, respecting the deontological norms.

6.2. Learning outcomes

Knowledge	The student: - has acquired the specific skills of mathematics-related disciplines necessary for completing assignments. - knows fundamental notions related to logic and set theory as well as methods of applying them in fields of science related to mathematics and computer science.
Skills	The student is able to: - construct clear and well-supported mathematical arguments to explain mathematical problems, topics and ideas in writing. - prove theorems using mathematical language in theoretical courses and will be able to present these results both orally and in writing.
Responsibility and autonomy:	The student has the ability to - independently explore certain mathematical contents, drawing on previously acquired ideas and tools, in order to extend his/her knowledge. - independently extend previously acquired mathematical ideas and arguments to a mathematical topic that has not been previously studied.

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

7.1 General objective of the discipline	• Advanced knowledge on group theory. Ability to solve more difficult problems
7.2 Specific objective of the discipline	• students will operate with fundamental concepts of group theory • students will aquire knowlegde regarding the structure of groups from various important classes. • students solve problems, theoretical and practical, using instruments of modern algebra, regarding symmetry groups.

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

8. Content

8.1 Course	**Teaching methods**	**Remarks**
1. Revision: groups, subgroups, factor group, isomorphism theorems. Symmetry groups.	Explanation, dialogue, examples, proofs	
2. The symmetric group. Group actions on sets.	Explanation, dialogue, examples, proofs	
3. p-groups and Sylow theorems	Explanation, dialogue, examples, proofs	
4. Direct and semidirect products. Finitely generated abelian groups. Dihedral groups.	Explanation, dialogue, examples, proofs	
5. Group extensions. The Schur-Zassenhaus theorem.	Explanation, dialogue, examples, proofs	
6. Classification of groups of given order.	Explanation, dialogue, examples, proofs	
7. The general linear group.	Explanation, dialogue, examples, proofs	
8. Algebras, subalgebras, homomorphisms, ideals, factor algebras.	Explanation, dialogue, examples, proofs	
9. Examples. Group algebra.	Explanation, dialogue, examples, proofs	
10. Representations and modules. Simple modules (irreducible representations) and indecomposable modules.	Explanation, dialogue, examples, proofs	
11. Semisimple algebras and modules.	Explanation, dialogue, examples, proofs	
12. Representations of finite groups. Characters.	Explanation, dialogue, examples, proofs	
13. Orthogonality of characters.	Explanation, dialogue, examples, proofs	
14. The character table of a finite group.	Explanation, dialogue, examples, proofs	

Bibliography

1. J.L. Alperin and R.B. Bell. *Groups and representatons*. Springer-Verlag. 1995.
2. J.J. Rotman. *An introduction to the theory of groups*. Springer-Verlag. 1995.

8.2 Seminar / laboratory	**Teaching methods**	**Remarks**
1. Revision: groups, subgroups, factor group, isomorphism theorems. Symmetry groups.	dialogue, examples, proofs	
2. The symmetric group. Group actions on sets.	dialogue, examples, proofs	
3. p-groups and Sylow theorems	dialogue, examples, proofs	
4. Direct and semidirect products. Finitely generated abelian groups. Dihedral groups.	dialogue, examples, proofs	
5. Group extensions. The Schur-Zassenhaus theorem.	dialogue, examples, proofs	
6. Classification of groups of given order.	dialogue, examples, proofs	
7. The general linear group.	dialogue, examples, proofs	
8. Algebras, subalgebras, homomorphisms, ideals, factor algebras.	dialogue, examples, proofs	
9. Examples. Group algebra.	dialogue, examples, proofs	
10. Representations and modules. Simple modules (irreducible representations) and indecomposable modules.	dialogue, examples, proofs	
11. Semisimple algebras and modules.	dialogue, examples, proofs	
12. Representations of finite groups. Characters.	dialogue, examples, proofs	
13. Orthogonality of characters.	dialogue, examples, proofs	
14. The character table of a finite group.	dialogue, examples, proofs	

Bibliography

3. D.J.S. Robinson. *An introduction to the theory of groups*. 2nd Ed. Springer-Verlag. 1996.
4. B.E. Sagan. *The symmetric group*. Springer-Verlag. 2001.
5. D.S. Dummit and R.M. Foote. *Abstract Algebra*. 2nd edition. John Wiley & Sons, 1999.
6. J.A. Gallian. *Contemporary Abstract Algebra*. 7th Edition.

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

- Such a course exists in the curricula of all major universities in Romania and abroad;
- Groups are fundamental mathematical structures and have multiple applications in geometry, number theory, cryptography, chemistry and physics, as they measure symmetry.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	- know the basic principles of the field. - apply the new concepts.	written exam	75%
10.5 Seminar/laboratory	- problem solving	- homeworks	25%
10.6 Minimum standard of performance			
• to aquire 5 points to pass the exam.			

11. Labels ODD (Sustainable Development Goals)[2]

	General label for Sustainable Development							
								

Date:
11.04.2025

Signature of course coordinator

Prof. dr. Andrei Mărcuş

Signature of seminar coordinator

Prof. dr. Andrei Mărcuş

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuş

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable.*”.