COURSE DESCRIPTION

Group Theory and Applications

Academic year 2026-2027

1. Programme-related data

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

2. Course-related data

2.1. Course title	**Group Theory and Applications**			Course code	**MME3103**
2.2. Course coordinator	Prof. dr. Andrei Mărcuş				
2.3. Seminar coordinator	Prof. dr. Andrei Mărcuş				
2.4. Year of study	I	2.5. Semester	2	2.6. Type of assessment	Exam
2.7. Course status	Compulsory			2.8. Course type	Core subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**	of which: 3.2. course	**2**	3.3. seminar/ laboratory/ project	**1**
3.4. Total of hours in the curriculum	42	of which: 3.5. course	28	3.6. seminar/ laboratory	**14**
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					**ore**
Additional research in the library, on subject-specific electronic platforms, and on-site					**36**
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					**36**
Tutoring (professional guidance)					**36**
Examinations					**20**
Other activities					
3.7. Total hours of individual study (IS) and self-taught activities (ST)				**158**	
3.8. Total hours per semester				**200**	
3.9. Number of credits				**8**	

4. Prerequisites (where applicable)

4.1. curriculum-related	Deep knowledge of bachelor level algebra, especially of the following subjects: - algebraic structures - linear algebra
4.2 skills-related	- 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. Specific conditions (where applicable)

5.1. course-related	**blackboard, projector**
5.2. seminar/laboratory-related	**blackboard**

6.1. Competencies resulting from the completion of the degree programme *(as referred to in the curriculum)*[1]

Professional competencies	
Competency code	**Competency**
CP3	perform analytical mathematical calculations
CP1	develop problem-solving strategies
CP6	disseminate results among the scientific community
Transversal competencies	
Competency code	**Competency**
CT3	work independently
CT6	think analytically

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)[2]

Learning outcomes targeted by the subject		
Competency code	**Knowledge and comprehension**	**Specific academic skills**
CP3	5. The graduate formulates observations and differentiates notions, properties and assertions from advanced disciplines of mathematics through examples and counterexamples.	5. The graduate verifies, on particular cases or by constructing examples or counterexamples, the validity of mathematical statements. The graduate translates a practical situation into mathematical language, solves the problem obtained and interprets the results obtained.
CP1	1. The graduate analyses the hypotheses and conclusions from mathematical assertions and links them within the demonstration.	1. The graduate demonstrates the acquisition and use of effective research methods and techniques.
CP7, CT3	3. The graduate compares and distinguishes related notions and their properties from advanced mathematics disciplines in the curriculum.	3. The graduate is able to identify and formulate significant problems which form the basis for further research.
CT6	4. The graduate critically studies the specialized literature, including by using international databases, identifying fundamental concepts.	4. The graduate applies appropriate techniques for solving advanced problems.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. The student/graduate has acquired the knowledge specific to the discipline studied necessary for solving problems.
2. The student/graduate knows fundamental notions of algebra as well as methods of applying them in fields of science related to mathematics and computer science.
Specific academic skills
1. The student/graduate is able to construct clear and well-supported mathematical arguments to explain mathematical problems, topics, and ideas in writing.

[1] The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

[2] The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

2. The student/graduate is able to prove theorems using mathematical language in theoretical courses and will be able to present these results both orally and in writing.

8. Contents

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

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 and learning 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	

[3] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

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. Evaluation

Activity type	9.1 Evaluation criteria	9.2 Evaluation methods	9.3 Percentage of final grade
9.4 Course	- know the basic principles of the field. - apply the new concepts.	written exam	75%
9.5 Seminar/laboratory	- problem solving	- homeworks	25%
9.6 Minimum standard of performance			
• to aquire 5 points to pass the exam.			

10. SDG labels (Sustainable Development Goals)[4]

	○	Sustainable Development Generic Label
								
○	○	○	○	○	○	○	○	X
								No label applies
○	○	○	○	○	○	○	○	○

Date of entry:
11.04.2025

Signature of course coordinator

Prof. dr. Andrei Mărcuș

Signature of seminar coordinator

Prof. dr. Andrei Mărcuș

Date of approval in the department:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuș

[4] 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."*