SYLLABUS

Automated theorem proving with Lean

University year 2025-2026

1. Information regarding the programme

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

2. Information regarding the discipline

2.1. Name of the discipline	**Theorem proving in Lean**					Discipline code	**MLE0104**
2.2. Course coordinator	Lect. dr. Iulian Simion						
2.3. Seminar coordinator	Lect. dr. Iulian Simion						
2.4. Year of study	**3**	2.5. Semester	**5**	2.6. Type of evaluation	**VP**	2.7. Discipline regime	**Optional**

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

3.1. Hours per week	**4**	of which: 3.2 course	**2**	3.3 seminar/laboratory	**2**
3.4. Total hours in the curriculum	**56**	of which: 3.5 course	**28**	3.6 seminar/laborator	**28**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					10
Additional documentation (in libraries, on electronic platforms, field documentation)					15
Preparation for seminars/labs, homework, papers, portfolios and essays					16
Tutorship					16
Evaluations					12
Other activities:					
3.7. Total individual study hours	**69**				
3.8. Total hours per semester	**125**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

4.1. curriculum	A first course in algebra and programming.
4.2. competencies	Competencies of using the above mentioned courses.

5. Conditions (if necessary)

5.1. for the course	blackboard and chalk or whiteboard and whiteboard marker, video projector
5.2. for the seminar /lab activities	blackboard and chalk or whiteboard and whiteboard marker, video projector

6.1. Specific competencies acquired [1]

[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.

Professional/essential competencies	• C1.1 Identifying specific concepts, describing specific theories and using domain specific language. • C2.3 Applying suitable analytical methods to specific problems and contexts. • C3.1 Describing the concepts, theories, and models used in the field of application. • C3.2 Identifying and explaining fundamental informatics models appropriate for the field of application. • C3.3 Utilizing models and tools to effectively solve specific problems in the field of application.
Transversal competencies	• CT1. Applying the principles of rigorous and efficient work while demonstrating a responsible attitude toward science and education, in compliance with ethical and professional standards. • CT3 Using effective methods and techniques for learning, research, and developing the ability to apply knowledge, while fostering adaptability to the demands of a dynamic society and communication skills in Romanian or an international language.

6.2. Learning outcomes

Knowledge	The student knows: - The specific language, methods, and algorithms required to solve specific problems. - How to derive mathematical proofs for specific statements and formulas. - How to use the tools in the Lean4 ecosystem.
Skills	The student is able to: - Apply appropriate methods and algorithms to solve specific problems. - Derive mathematical proofs for specific statements and formulas. - Use the tools in the Lean4 ecosystem.
Responsibility and autonomy:	The student is capable of working independently to: - Expand acquired knowledge. - Critically engage with the relevant literature.

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

7.1 General objective of the discipline	• Knowledge, understanding, and use of basic concepts in the formalization of mathematical statements and assisted proof.
7.2 Specific objective of the discipline	• Usage of the Lean4 ecosystem, including Mathlib, LeanBlueprint, GitHub, Zulip, etc.

8. Content

8.1 Course	**Teaching methods**	**Remarks**
Week 1. Introduction • An overview of interactive theorem provers • Recent Lean projects • The Lean 4 System and the Lean Community	Exposition, proofs, examples	
Weeks 2-3. Basics • Equalities and inequalities • Theorems and lemmas • Logical operators	Exposition, proofs, examples	
Weeks 4-5. Dependent types • Judgments and contexts • Inference rules • Inductive types • Natural numbers	Exposition, proofs, examples	
Weeks 6-7. Functional-Logical Programming • Inductive types	Exposition, proofs, examples	

• Induction and recursion • Type Classes • Cases Tactic		
Week 8. Induction and recursion	Exposition, proofs, examples	
Week 9. Number theory	Exposition, proofs, examples	
Week 10. Lean Blueprints • Installation and interaction • LaTeX	Exposition, proofs, examples	
Week 11. Tactics in Lean	Exposition, proofs, examples	
Week 12-14. Formalization - selected topics • Functions • Sets • Relations • Groups	Exposition, proofs, examples	
Bibliography [1] Jeremy Avigad, Patrick Massot - Mathematics in Lean, 2020 [2] Heather Macbeth - The Mechanics of Proof, 2024 [3] Jeremy Avigad, Leonardo de Moura, Soonho Kong and Sebastian Ullrich, with contributions from the Lean Community - Theorem Proving in Lean 4, 2024 [4] Anne Baanen, Alexander Bentkamp, Jasmin Blanchette, Johannes Hölzl, Jannis Limperg - The Hitchhiker's Guide to Logical Verification, 2023 [5] Egbert Rijke - Introduction to Homotopy Type Theory, 2023 [6] The Univalent Foundations Program (2013). Homotopy Type Theory: Univalent Foundations of Mathematics		
8.2 Seminar / laboratory	**Teaching methods**	**Remarks**
Week 1. Introduction • An overview of interactive theorem provers • Recent Lean projects • The Lean 4 System and the Lean Community	Dialog, problem solving	
Weeks 2-3. Basics • Equalities and inequalities • Theorems and lemmas • Logical operators	Dialog, problem solving	
Weeks 4-5. Dependent types • Judgments and contexts • Inference rules • Inductive types • Natural numbers	Dialog, problem solving	
Weeks 6-7. Functional-Logical Programming • Inductive types • Induction and recursion • Type Classes • Cases Tactic	Dialog, problem solving	
Week 8. Induction and recursion	Dialog, problem solving	
Week 9. Number theory	Dialog, problem solving	
Week 10. Lean Blueprints • Installation and interaction • LaTeX	Dialog, problem solving	
Week 11. Tactics in Lean	Dialog, problem solving	
Week 12-14. Formalization - selected topics • Functions • Sets • Relations • Groups	Dialog, problem solving	
Bibliography [1] Jeremy Avigad, Patrick Massot - Mathematics in Lean, 2020 [2] Heather Macbeth - The Mechanics of Proof, 2024 [3] Jeremy Avigad, Leonardo de Moura, Soonho Kong and Sebastian Ullrich, with contributions from the Lean Community - Theorem Proving in Lean 4, 2024		

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

- Lean is a collective effort for the digitization and formalization of mathematics.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	Critical grasp of the learned material, ability to use what was learned	Two written partial exams at the middle and at the end of the semester	20% and 20% respectively
10.5 Seminar/laboratory	Ability to solve relevant problems	Individual verification	60%
10.6 Minimum standard of performance			
• 75% attendance at the Seminar and at least grade 5 for the final grade.			

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

	General label for Sustainable Development							
								

Date:
11.04.2025

Signature of course coordinator

Lect. dr. Iulian Simion

Signature of seminar coordinator

Lect. dr. Iulian Simion

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuș

[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*.”.