SYLLABUS

MATHEMATICAL OPTIMIZATION

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	Computer Science
1.4. Field of study	Artificial Intelligence
1.5. Study cycle	Bachelor
1.6. Study programme/Qualification	Artificial Intelligence
1.7. Form of education	

2. Information regarding the discipline

2.1. Name of the discipline	**Optimization Techniques**					Discipline code	**MLE0103**
2.2. Course coordinator					Lect. dr. Anca GRAD		
2.3. Seminar coordinator					Lect. dr. Anca GRAD		
2.4. Year of study	3	2.5. Semester	6	2.6. Type of evaluation	E	2.7. Discipline regime	optional

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 (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					21
Additional documentation (in libraries, on electronic platforms, field documentation)					10
Preparation for seminars/labs, homework, papers, portfolios and essays					10
Tutorship					10
Evaluations					13
3.7. Total individual study hours	**64**				
3.8. Total hours per semester	**100**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

4.1. curriculum	- Linear Algebra - Calculus 1 and 2
4.2. competencies	Mathematical thinking, modelling, logical reasoning

5. Conditions (if necessary)

5.1. for the course	Lecture hall with large board and beamer
5.2. for the seminar /lab activities	Seminar hall with large board

6.1. Specific competencies acquired [1]

Professional/essential competencies	• C4.1. Defining basic concepts, theory and mathematical models • C4.2 Interpretation of mathematical models • C4.3 Identifying the appropriate models and methods for solving real-life problems • C4.5 Embedding formal models in applications from various a
Transversal competencies	CT1 Application of efficient and rigorous working rules, manifest responsible attitudes towards the scientific and didactic field, respecting the professional and ethical principles. CT3 Use of efficient methods and techniques for learning, information, research and development of abilities for knowledge acquiring, for adapting to the needs of dynamic society and for communication in Romanian as well as in a widely used foreign language

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 optimal solutions of problems, convex sets and functions, polyhedral sets and optimization algorithms
Skills	The student is able to: - build 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, based on the ideas and tools already acquired, in order to expand his knowledge. - independently extend the mathematical ideas and arguments already acquired, to a mathematical topic that has not been studied previously.

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

7.1 General objective of the discipline	• Acquiring knowledge about classical optimization notions and solving algorithms
7.2 Specific objective of the discipline	• Presentation of the basic notions and concepts of convex analysis • Linear optimization • Duality • Newton Method, Gradient Descent

[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. General statement of an optimization problem. The objective function, constraint set and optimality notions.	Lecture, discussion, didactic proofs	
2. Convex sets and extreme points	Lecture, discussion, didactic proofs	
3. Convex functions. Local and global extreme points	Lecture, discussion, didactic proofs	
4. Level sets. Optimality conditions for convex optimization problems.	Lecture, discussion, didactic proofs	
5. Linear optimization problems.	Lecture, discussion, didactic proofs	
6. Duality for linear optimization problems.	Lecture, discussion, didactic proofs	
7. The primal simplex algorithm	Lecture, discussion, didactic proofs	
8. The dual simplex algorithm	Lecture, discussion, didactic proofs	
9. Nonlinear optimization	Lecture, discussion, didactic proofs	
10. The Newton algorithm	Lecture, discussion, didactic proofs, numerical simulations	
11. Gradient Descent	Lecture, discussion, didactic proofs, numerical simulations	
12. Dual Gradient	Lecture, discussion, didactic proofs, numerical simulations	

Bibliography

1. BOYD, S., VANDENBERGHE, L., Convex Optimization, Cambridge University Press, 2004.
2. BRECKNER, B.E., POPOVICI, N., Convexity and Optimization. An Introduction, EFES, Cluj-Napoca, 2006.
3. BRECKNER, W.W., Cercetare operaţională, Universitatea Babeş-Bolyai, Cluj-Napoca, 1981.
4. POPOVICI, N., Optimizare vectorială, Casa Cărţii de Ştiinţă, Cluj-Napoca, 2005.
5. MORDUKHOVICH, B.S., NAM, N.M., An easy path to convex analysis and applications, Morgan & Claypool Publishers, Milton Keynes, 2014.
6. VANDERBEI, R., Linear Programming. Foundations and Extensions, Springer, Bost

8.2 Seminar / laboratory	**Teaching methods**	**Remarks**
1. Special classes of convex sets.	Discussions, problematisation, self-tanking, team-work	
2. Convex functions.	Discussions, problematisation, self-tanking, team-work	
3. Linear optimization problems. The graphical approach	Discussions, problematisation, self-thinking, team-work	
4. Primal and dual simplex algorithm	Discussions, problematisation, self-thinking, team-work	
5. Nonlinear optimization algorithms	Discussions, problematisation, self-thinking, team-work	
6. Nonlinear optimization algorithms	Discussions, problematisation, self-thinking, team-work	

Bibliography

1. BOYD, S., VANDENBERGHE, L., Convex Optimization, Cambridge University Press, 2004.
2. BRECKNER, B.E., POPOVICI, N., Convexity and Optimization. An Introduction, EFES, Cluj-Napoca, 2006.
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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 course can be encountered in the syllabus of every respected university in land or abroad. It represents a basic part not only for mathematics teachers but also for researchers..

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	knowledge of the basic notions and results	Final written exam	60%
	knowledge of the proofs for the main theoretical results		
10.5 Seminar/laboratory	Homework including problems based on the theory presented at the lecture. Application of the theoretical results to practical problems	Continuous during the lecture or the seminar	40%
10.6 Minimum standard of performance			
• The definitions, the statement of the theoretical results and straight-forward applications Idenfitication and proper selection of the solving methods for various practical problems			

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

	General label for Sustainable Development							
								

[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.*”.

Date: 11.04.2025	Signature of course coordinator Lect. dr. Anca Grad	Signature of seminar coordinator Lect. dr. Anca Grad .....

Date of approval: 25.04.2025	Signature of the head of department Prof. dr. Andrei Mărcuș