COURSE DESCRIPTION

Optimization Techniques

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	**Bachelor**
1.6. Degree programme / Qualification	**Mathematics Computer Science (English)**
1.7. Form of education	**Full-time**

2. Course-related data

2.1. Course title	**Optimization Techniques**			MLE0005	
2.2. Course coordinator	Lect. dr. Grad Anca				
2.3. Seminar coordinator	Lect. dr. Grad Anca				
2.4. Year of study	3	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	36	of which: 3.5. course	24	3.6. seminar/ laboratory	**12**
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					21
Additional research in the library, on subject-specific electronic platforms, and on-site					10
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					10
Tutoring (professional guidance)					10
Examinations					13
Other activities [i.e.: two-way communication with the course coordinator/tutor]					0
3.7. Total hours of individual study (IS) and self-taught activities (ST)				**64**	
3.8. Total hours per semester				**100**	
3.9. Number of credits				**4**	

4. Prerequisites (where applicable)

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

5. Specific conditions (where applicable)

5.1. course-related	Lecture hall with large board and beamer
5.2. seminar/laboratory-related	Seminar hall with large board

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

[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.

Professional competencies	
Competency code	**Competency**
PC1	Develop problem-solving strategies
PC2	Perform analytical mathematical calculations
PC5	Synthesize information
PC6	Think abstractly
PC7	Communicate mathematical information
Transversal competencies	
Competency code	**Competency**
TC1	Interpret mathematical information
TC3	Work independently
TC4	Solve problems
TC5	Think analytically
TC6	Master the English language

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**
CP5, CP6, CP7	1. The student/graduate defines the fundamental concepts from the core disciplines of mathematics.	1. The student/graduate provides examples of how fundamental concepts and theoretical results are used in solving exercises and problems related to the topics covered in the curriculum disciplines.
CP1,CT4, CT5	2. The student/graduate compares and distinguishes related notions and their properties from the core disciplines of mathematics.	2. The student/graduate recognizes and analyses the necessary and/or sufficient conditions in the statements of mathematical assertions and specifies their role in the proof.
CP1, CT3	3. The student/graduate formulates observations and differentiates notions, properties, and assertions from the core disciplines of mathematics through examples and counterexamples.	3. The student/graduate identifies and describes the essential elements in the construction of proofs of mathematical assertions (lemmas, propositions, theorems), recognizes errors in reasoning, and corrects them.
CP5, CP6, CT1	4. The student/graduate defines the basic concepts from advanced mathematics disciplines in the curriculum.	4. The student/graduate answers questions and correctly and rigorously formulates the statements of mathematical assertions (lemmas, propositions, theorems) from the disciplines in the curriculum.
CP5, CT5	5. The student/graduate compares and distinguishes related notions and their properties from the advanced mathematics disciplines in the curriculum.	5. The student/graduate reproduces and analyzes the hypotheses and conclusions of mathematical assertions and discusses how these connect within the proof.

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.

CP5, CP7	9. The student/graduate formulates observations and differentiates notions, properties, and assertions from advanced mathematics disciplines through examples and counterexamples.	9. The student/graduate argues the role of elements found in the hypotheses of mathematical assertions, discusses how they articulate within the proof, and independently constructs correct proofs of mathematical assertions from major mathematical disciplines. The student/graduate translates a practical situation into mathematical language, solves the resulting problem, and interprets the obtained results.
CP2	11. The student/graduate indicates and recognizes the concepts involved in the requirements of exercises and problems formulated in the curriculum disciplines.	11. The student/graduate uses numerical methods and software packages to solve constructed mathematical models and interprets the obtained mathematical results from the perspective of the practical problem being modelled.

7. Subject-specific learning outcomes (referred to by each subject coordinator across the range of competencies and learning outcomes at the level of the degree programme)

Knowledge and comprehension
The student:
1. has acquired the specific skills of mathematics-related disciplines necessary for completing assignments.
2. knows fundamental notions related to optimal solutions of problems, convex sets and functions, polyhedral sets and optimization algorithms
3. can build clear and well-supported mathematical arguments to explain mathematical problems, topics and ideas in writing.
Specific academic skills
The student has the ability to:
1. independently explore certain mathematical contents, based on the ideas and tools already acquired, in order to expand his knowledge.
2. independently extend the mathematical ideas and arguments already acquired, to a mathematical topic that has not been studied previously.

8. Contents

8.1. Course	**Teaching and learning methods**	**Remarks[3]**
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	

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

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, Boston

8.2. Seminar/ laboratory	**Teaching and learning 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.
3. BRECKNER, W.W., Cercetare operaţională, Universitatea Babeş-Bolyai, Cluj-Napoca, 1981.
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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, Boston

9. Evaluation

Type of activity	9.1 Evaluation criteria[4]	9.2 Evaluation methods[5]	9.3 Percentage in the final grade
9.4. Course	knowledge of the basic notions and results	Final written exam	60%
	knowledge of the proofs for the main theoretical results		

[4] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[5] Both final evaluation methods and ongoing evaluation strategies should be established.

9.5. Seminar/ laboratory	Homework including problems based on the theory presented at the lecture. Application of the theoretical results to practical problems knowledge of the basic notions and results	Continuous during the lecture or the seminar	40%
9.6 Minimum standard for passing			
• The definitions, the statement of the theoretical results and straight-forward applications Idenfitication and proper selection of the solving methods for various practical problems			

10. SDG labels (Sustainable Development Goals)[6]

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

Date of entry:
06.04.2026

Signature of course coordinator

Lect. dr. Grad Anca

Signature of seminar coordinator

Lect. dr. Grad Anca

Date of approval in the department:
24.04.2026

Signature of the head of department

Prof. dr. Andrei Mărcuș

[6] 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."*