

## COURSE DESCRIPTION

### *Mathematical Analysis*

Academic year 2026-2027

#### 1. Programme-related data

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

#### 2. Course-related data

2.1. Course title	<b>Mathematical Analysis</b>	Course code	<b>MLE0002</b>		
2.2. Course coordinator	Lect. PhD. Mihai Nechita				
2.3. Seminar coordinator	Lect. PhD. Mihai Nechita				
2.4. Year of study		2.5. Semester		2.6. Type of assessment	Exam
2.7. Course status	Compulsory	2.8. Course type	Complementary subject		

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

3.1. Number of hours per week	<b>4</b>	of which: 3.2. course	<b>2</b>	3.3. seminar/ laboratory/ project	<b>2</b>
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	<b>28</b>
<b>Time allocation for individual study (IS) and self-taught activities (ST)</b>					<b>hours</b>
Learning from textbooks, course materials, bibliography, and notes (IS)					28
Additional research in the library, on subject-specific electronic platforms, and on-site					8
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					42
Tutoring (professional guidance)					10
Examinations					6
Other activities					-
<b>3.7. Total hours of individual study (IS) and self-taught activities (ST)</b>				<b>94</b>	
<b>3.8. Total hours per semester</b>				<b>150</b>	
<b>3.9. Number of credits</b>				<b>6</b>	

#### 4. Prerequisites (where applicable)

4.1. curriculum-related	Basic knowledge of high school calculus
4.2. skills-related	Computing limits (sequences and functions), derivatives, antiderivatives

#### 5. Specific conditions (where applicable)

5.1. course-related	Lecture room with whiteboard/blackboard and projector
5.2. seminar/laboratory-related	Classroom with whiteboard/blackboard

#### 6.1. Competencies resulting from the completion of the degree programme (*as referred to in the curriculum*)<sup>1</sup>

<sup>1</sup> 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.

<b>Professional competencies</b>	
<b>Competency code</b>	<b>Competency</b>
<b>PC1</b>	Create software
<b>PC10</b>	Use software libraries
<b>Transversal competencies</b>	
<b>Competency code</b>	<b>Competency</b>
<b>TC1</b>	Work independently
<b>TC2</b>	Solve problems
<b>TC3</b>	Think analytically

## 6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)<sup>2</sup>

<b>Learning outcomes targeted by the subject</b>		
<b>Competency code</b>	<b>Knowledge and comprehension</b>	<b>Specific academic skills</b>
<b>PC5</b>	The student/graduate selects, explains and specifies the mathematical foundations applied in computer science	The student/graduate applies, evaluates, and proposes mathematical methods for modeling, simulating and solving computer science problems.
<b>TC1</b>	The student/graduate has the knowledge necessary to understand and solve complex problems, and to plan and organize advanced processes in various fields.	The graduate is able to identify complex problems and examine related issues to develop solving options and implement solutions. The graduate has the ability to apply general rules to specific problems and produce relevant solutions. The graduate is able to combine diverse information to formulate solutions and generate ideas for developing new products and applications.

## 7. Subject-specific learning outcomes

<b>Knowledge and comprehension</b>
1. The student will be able to define and explain fundamental concepts of mathematical analysis, including the properties of real numbers, the convergence of sequences and series, and the study of functions of a single real variable.
2. The student will understand the theoretical foundations of multivariable calculus, including partial derivatives, the gradient, the Hessian matrix, and multiple integrals, as well as their application in optimization problems.
<b>Specific academic skills</b>
1. The student will be able to calculate limits, derivatives, and integrals, and analyze the convergence of sequences and series using appropriate tests.
2. The student will be able to find local extrema for multivariable functions by analyzing the gradient and the Hessian matrix, and will be able to solve constrained optimization problems using the method of Lagrange multipliers.
3. The student will be able to define and calculate multiple integrals.
4. The student will be able to use the fundamentals of mathematical analysis in applications related to optimization, statistics, machine learning, and data science.

## 8. Contents

<sup>2</sup> 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.

<b>8.1. Course</b>	<b>Teaching and learning methods</b>	<b>Remarks<sup>3</sup></b>
1. Real numbers: basic concepts	Exposition, proofs, examples	
2. Sequences of real numbers	Exposition, proofs, examples	
3. Series of real numbers (I)	Exposition, proofs, examples	
4. Series of real numbers (II). Power series	Exposition, proofs, examples	
5. Functions of one variable: limits, continuity, differentiability	Exposition, proofs, examples	
6. Higher order derivatives. Taylor series	Exposition, proofs, examples	
7. Riemann integrals. Improper integrals	Exposition, proofs, examples	
8. The n-dimensional Euclidean space	Exposition, proofs, examples	
9. Functions of several variables: limits and continuity	Exposition, proofs, examples	
10. Partial derivatives and differentiability. Gradient descent	Exposition, proofs, examples	
11. Higher order derivatives. Hessian matrix. Local extrema	Exposition, proofs, examples	
12. Optimization with constraints. Lagrange multipliers	Exposition, proofs, examples	
13. Double integrals. Change of variables	Exposition, proofs, examples	
14. Triple integrals. Change of variables	Exposition, proofs, examples	
Bibliography [1] M. Nechita, Lecture notes for mathematical analysis, 2025. [2] W. Rudin, Principles of Mathematical Analysis 3rd ed, McGraw-Hill, 1976. [3] T. Tao, Analysis I, Springer, 2016. [4] J.E. Marsden, A. Tromba, Vector Calculus 6th ed, W.H. Freeman and Company, 2012. [5] M. Oberguggenberger, A. Ostermann, Analysis for Computer Scientists, Springer, 2018. [6] G. Strang, Linear Algebra and Learning from Data, Wellesley Cambridge Press, 2019. [7] Ș. Cobzaș, Analiză matematică - Calcul Diferențial, Presa Universitară Clujeană, 2019.		
<b>8.2. Seminar/ laboratory</b>	<b>Teaching and learning methods</b>	<b>Remarks</b>
1. Real numbers	Problem solving, discussions, proofs	
2. Sequences of real numbers	Problem solving, discussions, proofs	
3. Series of real numbers (I)	Problem solving, discussions, proofs	
4. Series of real numbers (II). Power series	Problem solving, discussions, proofs	
5. Functions of one variable: limits, continuity, differentiability	Problem solving, discussions, proofs	
6. Higher order derivatives. Taylor series	Problem solving, discussions, proofs	
7. Riemann integrals. Improper integrals	Problem solving, discussions, proofs	
8. The n-dimensional Euclidean space	Problem solving, discussions, proofs	
9. Functions of several variables: limits and continuity	Problem solving, discussions, proofs	
10. Partial derivatives and differentiability. Gradient descent	Problem solving, discussions, proofs	
11. Higher order derivatives. Hessian matrix. Local extrema	Problem solving, discussions, proofs	
12. Optimization with constraints. Lagrange multipliers	Problem solving, discussions, proofs	


















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

13. Double integrals. Change of variables	Problem solving, discussions, proofs	
14. Triple integrals. Change of variables	Problem solving, discussions, proofs	
Bibliography		
[1] W.J. Kaczor, M.T. Nowak, Problems in Mathematical Analysis, AMS, 2000, 2001, 2003.		
[2] P.D. Lax, M.S. Terrell, Calculus with Applications, Springer, 2014.		
[3] J.E. Marsden, A. Tromba, Vector Calculus 6th ed, W.H. Freeman and Company, 2012		
[4] M. Nechita, Lecture notes for mathematical analysis, 2025.		

## 9. Evaluation

Type of activity	9.1 Evaluation criteria <sup>4</sup>	9.2 Evaluation methods <sup>5</sup>	9.3 Percentage in the final grade
9.4. Course	Knowledge of fundamental theoretical results	Exam	50%
	Problem solving	Midterm Exam	30%
9.5. Seminar/ laboratory	Knowledge of fundamental theoretical results	Seminar Activity	10%
	Problem solving	Homework	10%
9.6 Minimum standard for passing			
<ul style="list-style-type: none"> <li>Attending at least 75% of the seminars.</li> <li>Final grade greater or equal to 5.</li> </ul>			

## 10. SDG labels (Sustainable Development Goals)<sup>6</sup>

 Sustainable Development Generic Label								
								
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
								No label applies
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<sup>4</sup> 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.

<sup>5</sup> Both final evaluation methods and ongoing evaluation strategies should be established.

<sup>6</sup> 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."

Date of entry:  
30.04.2026

Signature of course coordinator

Lect. PhD Mihai Nechita

Signature of seminar coordinator

Lect. PhD Mihai Nechita

Date of approval in the department:  
30.04.2026

Signature of the head of department

Prof. PhD Andrei Mărcuș