# COURSE DESCRIPTION

Calculus 1(Calculus on R)

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 | **Calculus 1 (Calculus on R)** | | | Course code | **MLE0001** |
| 2.2. Course coordinator | Lect. dr. Grad Anca | | | | |
| 2.3. Seminar coordinator | Lect. dr. Grad Anca | | | | |
| 2.4. Year of study | 1 | 2.5. Semester | 1 | 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 | **5** | of which: 3.2. course | **3** | 3.3. seminar/ laboratory/ project | **2** |
| 3.4. Total of hours in the curriculum | 70 | of which: 3.5. course | 42 | 3.6. seminar/ laboratory | **28** |
| **Time allocation for individual study (IS) and self-taught activities (ST)** | | | | | **hours** |
| Learning from textbooks, course materials, bibliography, and notes (IS) | | | | | 25 |
| Additional research in the library, on subject-specific electronic platforms, and on-site | | | | | 10 |
| Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays | | | | | 25 |
| Tutoring (professional guidance) | | | | | 10 |
| Examinations | | | | | 10 |
| Other activities | | | | | 0 |
| **3.7. Total hours of individual study (IS) and self-taught activities (ST)** | | | | **80** | |
| **3.8. Total hours per semester** | | | | **150** | |
| **3.9. Number of credits** | | | | **6** | |

**4. Prerequisites** (where applicable)

| | | |
|---|---|---|
| 4.1. curriculum-related | High-school calculus | |
| 4.2 skills-related | Mathematical thinking, logical thinking | |

**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**

| **Knowledge and comprehension** |
|---|
| 1.The student:<br>- has acquired the specific skills of mathematics-related disciplines necessary for completing assignments.<br>- knows fundamental notions related to the topology of real numbers as well as to strings, series, differentiable functions and Riemann integrable functions, as well as methods for applying them in areas of science related to mathematics and computer science. |
| 2. The student is able to:<br>- build clear and well-supported mathematical arguments to explain mathematical problems, topics and ideas in writing.<br>- prove theorems using mathematical language in theoretical courses and will be able to present these results both orally and 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.** The system of real numbers (upper and lower bound of a set; minimum and maximum of a set; infimum and supremum of a set; the infimum principle, the supremum principle and its consequences; the sets of natural numbers, the set integer numbers, the set of rational numbers, and the set of irrational numbers; the extended set of real numbers). Topology of the real axis (neighbourhoods, open sets, interior set, exterior set, boundary set, closure, accumulation points) | Lecture, discussion, didactic proofs | [1] pp. 125-157<br>or<br>[4] pp. 80-97 |

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

| | | |
|---|---|---|
| **2.** Sequences of real numbers (existence of the limit for monotone sequences; applications: the irrational number e ) | Lecture, discussion, didactic proofs | [4] pp. 159-195, 259-263 |
| **3. F**undamental sequences. Series of real numbers (convergence/divergence criteria for series: Cauchy's general criterion, Cauchy's condensation criterion, comparison criteria, the root criterion, Kummer's, D'Alembert's and Raabe-Duhamel's criteria) | Lecture, discussion, didactic proofs | [4] pp. 313-346 |
| **4.** Series of real numbers; comparison criteria. | Lecture, discussion, didactic proofs | [4] pp. 367-396 |
| **5.** Series of real numbers (Abel-Dirichlet criterion; absolutely convergent series; the Leibniz criterion for alternant series; convolutive product of series). | Lecture, discussion, didactic proofs | [2], pp. 193 – 204<br>pp. 232 – 244<br>[6], pp. 290 – 298<br>pp. 348 – 353 |
| **6.** Limits of real-valued functions, characterization theorems. Continuous functions, characterization theorems. | Lecture, discussion, didactic proofs | [4] pp. |
| **7.** Differential calculus. Mean theorems | Lecture, discussion, didactic proofs | [1] pp. 195-232<br>or<br>[4] pp. 409-420, 459-472, 486-507 |
| **8.** Higher order derivatives; Taylor's theorem and applications. | Lecture, discussion, didactic proofs | [1] pp. 233-263<br>or<br>[4] pag. 579-594 |
| **9.** Sequences of functions (convergence and uniform convergence; properties of the sum function). | Lecture, discussion, didactic proofs | [4], pp. 427 – 441 |
| **10.** Series of functions (convergence and uniform convergence; properties of the sum function). | Lecture, discussion, didactic proofs | [4], pp. 361 – 365 |
| **11.** Power series. Taylor's theorem | Lecture, discussion, didactic proofs | [4],pp. 441 – 445 |
| **12.** The Riemann integral (definition, characterizations of inerrability; properties of the Riemann integral) | Lecture, discussion, didactic proofs | [4], pp. 365 – 384 |
| **13** Primitives, the Leibniz-Newton formula. | Lecture, discussion, didactic proofs | [1] pp. 314-388 |
| **14.** Improper integrals | Lecture, discussions, didactic proofs | [8] pag. 379-391 |

Bibliography:


1. D. Andrica, D.I. Duca, I. Purdea, I. Pop: Matematica de baza, Editura Studium, Cluj-Napoca, 2004
2. W.W. Breckner: Analiza matematica. Topologia spatiului R^n, Universitatea din Cluj-Napoca, Cluj -Napoca, 1985
3. S. Cobzas: Analiza matematica (Calcul diferential), Presa Universitara Clujeana, Cluj-Napoca, 1997
4. D.I. Duca: Analiza matematica (vol. I), Casa Cartii de Stiinta, Cluj-Napoca, 2013
5. D.I. Duca, E. Duca: Exercitii si probleme de analiza matematica (vol. I), Editura Casa Cartii de Stiinta, Cluj-Napoca, 2007
6. D.I. Duca, E. Duca: Exercitii si probleme de analiza matematica (vol II), Editura Casa Cartii de Stiinta, Cluj -Napoca, 2009
7. M. Megan: Bazele Analizei matematice, vol. 1,2,3, Editura Eurobit, 1997, 1997, 1998
8. Gh. Siretchi: Calcul diferential si integral, vol. I si II, Editura Stiintifica si Enciclopedica, Bucuresti,1985
9. V.A. Zorich: Mathematical Analysis, Springer, Berlin, 2004


| **8.2. Seminar/ laboratory** | **Teaching and learning methods** | **Remarks** |
|---|---|---|

| | | |
|---|---|---|
| **1.** The set of real numbers. Topology of the set of real numbers. | Discussions, problematisation, self-tanking, team-work | [5] 1.2-1.4; 1.7-1.10; 1.12-1.16; 2.2; 2.4-2.6; 2. 8-2.9; 2.11-2.32 |
| **2. .** Real number sequences; convergence of the monotone sequences. | Discussions, problematisation, self-tanking, team-work | [5] 3.24; 3.26; 3.33; 3.39; 3. 43; 3.47; 3.54; 3.59; 3.67-3.73; 3.85; 3.90; 3.95; 3.99-3.108 |
| **3.** Fundamental sequences. Series of real numbers. | Discussions, problematisation, self-thinking, team-work | List of problems edited by the lecturer |
| **4.** Series of real numbers. | Discussions, problematisation, self-thinking, team-work | List of problems edited by the lecturer |
| **5.** Limits of functions. Continuous functions | Discussions, problematisation, self-thinking, team-work | [5] 4.2-4.3; 4.7; 4.12; 4.16; 4.18; 4.22; 4.24-4.26; 4.41; 4.45; 4.47; 4.50; 4.56; 4.73-4.75; 4.79; 4.80; 4.84; 4.94 5.2; 5.8; 5.11; 5.15-5.19; 5.22; 5.26; 5.29; 5.31; 5.35; 5.40; 5.41 |
| **6.** Limits of real-valued functions, characterization theorems. Continuous functions, characterization theorems. | Discussions, problematisation, self-thinking, team-work | [3] 6.2; 6.14-6.17; 6.21; 6.26-6.32; 6.92-6.95; 7.10; 7.12-7.17; 7.24-7.36; 7.48; 7.52; 7.57-7.63 |
| **7.** Differential calculus. Mean theorems | Discussions, problematisation, self-thinking, team-work | [3] 6.68-6.90; 6.169-6.187 |
| **8.** Higher order derivatives; Taylor's theorem and applications. | Discussions, problematisation, self-thinking, team-work | [4] 1.2; 1.14; 1.20; 1.22; 1.32; 1.39-1.40; 1.65-1.66; 1.126; 2.6-2.42; 2.46-2.51; 2.60; 2.68; 2.72-2.74; 2.78; 2.82-2.89; 2.130-2.131; 2.139; 2.147; 2.171; 2.224; 2.262; 2.303; 2.307; 2.314 |
| **9.** Sequences of functions (convergence and uniform convergence; properties of the sum function). | Discussions, problematisation, self-thinking, team-work | [1] pp. 339-352 |
| **10.** Series of functions (convergence and uniform convergence; properties of the sum function).<br>Power series. Taylor's theorem | Discussions, problematisation, self-thinking, team-work | List of problems edited by the lecturer |
| **11.** Power series. | Discussions, problematisation, self-thinking, team-work | List of problems edited by the lecturer |
| **12.** The Riemann integral (definition, characterizations of inerrability; properties of the Riemann integral) | Discussions, problematisation, self-thinking, team-work | [1] pag. 277-313 |
| **13.** Primitives, the Leibniz-Newton formula. | Discussions, problematisation, self-thinking, team-work | [1] pag. 314-338 |
| **14.** Improper integrals | Discussions, problematisation, self-thinking, team-work | [8] pag. 379-391 |

Bibliography


1. D. Andrica, D.I. Duca, I. Purdea, I. Pop: Matematica de baza, Editura Studium, Cluj-Napoca, 2004
2. W.W. Breckner: Analiza matematica. Topologia spatiului R^n, Universitatea din Cluj-Napoca, Cluj -Napoca, 1985
3. S. Cobzas: Analiza matematica (Calcul diferential), Presa Universitara Clujeana, Cluj-Napoca, 1997
4. D.I. Duca: Analiza matematica (vol. I), Casa Cartii de Stiinta, Cluj-Napoca, 2013
5. D.I. Duca, E. Duca: Exercitii si probleme de analiza matematica (vol. I), Editura Casa Cartii de Stiinta, Cluj-Napoca, 2007

6. D.I. Duca, E. Duca: Exercitii si probleme de analiza matematica (vol II), Editura Casa Cartii de Stiinta, Cluj -Napoca, 2009
7. M. Megan: Bazele Analizei matematice, vol. 1,2,3, Editura Eurobit, 1997, 1997, 1998
8. Gh. Siretchi: Calcul diferential si integral, vol. I si II, Editura Stiintifica si Enciclopedica, Bucuresti,1985
9. V.A. Zorich: Mathematical Analysis, Springer, Berlin, 2004

**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 | | |
| 9.5. Seminar/ laboratory | Homework including problems based on the theory presented at the lecture | Continuous evaluation during the seminar | 20% |
| | application of the theoretical results to practical problems | quizzes during the lecture or the seminar | 20% |
| 9.6 Minimum standard for passing | | | |
| - Minimum 7% out of 20% from the Continuous evaluation during the seminary<br>- Minimum 20% out of 60% from the final written exam | | | |

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

| | | |
|---|---|---|
|  | ○ | Sustainable Development Generic Label |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | x |
|  |  |  |  |  |  |  |  | No label applies |
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

[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.

[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."*

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