COURSE DESCRIPTION
Numerical Calculus
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 Computer Science**
1.4 Field	**Computer Science**
1.5 Level of study	**Bachelor**
1.6 Degree programme / Qualification	**Computer Science**
1.7 Form of education	**Full-Time**

2. Course-related data

2.1 Course title	**Numerical Calculus**			Course code	**MLE0028**
2.2 Course coordinator	**Prof. Sanda Micula, PhD. Habil.**				
2.3 Seminar coordinator	**Prof. Sanda Micula, PhD. Habil.**				
2.4. Year of study	**3**	2.5 Semester	**6**	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	**4**	of which: 3.2 course	**2**	3.3 seminar/laboratory/project	**2 lab**
3.4 Total hours in the curriculum	**48**	of which: 3.5 course	**24**	3.6 seminar/laboratory	**24**
Time allocation for individual study (IS) and self-taught activities (ST)					hours
Learning from textbooks, course materials, bibliography, and notes (IS)					40
Additional research in the library, on subject-specific electronic platforms, and on-site					15
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					35
Tutoring (professional guidance)					12
Examinations					25
Other activities					
3.7 Total hours of individual study (IS) and self-taught activities (ST)					**127**
3.8 Total hours per semester					**175**
3.9 Number of credits					**7**

4. Prerequisites (where applicable)

4.1. curriculum-related	• Mathematical Analysis • Algebra
4.2. skills-related	• Logical thinking • Average logical programming skills

5. Specific conditions (where applicable)

5.1. course-related	• Lecture room with large blackboard and video projector
5.2. seminar/laboratory-related	• Laboratory with Matlab installed

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

Professional competencies	
Competency code	**Competency**
PC5	define technical requirements
PC7	design information system
PC8	create process diagram
Transversal competencies	
Competency code	**Competency**
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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**
PC5	The student/graduate selects, explains and specifies the mathematical foundations applied in computer science, including formal logic, algebra, probability and statistics.	The student/graduate develops interdisciplinary solutions by integrating mathematics with related fields and collaborating effectively with specialist teams.
PC7, PC8	The student/graduate names, gives examples, concludes, specifies, recognizes and critically argues the methods of designing and managing complex IT projects using modern strategies.	The student/graduate develops a collaborative environment and takes responsibility for the successful delivery of projects on time and according to requirements. The student/graduate organizes technical teams and manages the life cycle of software projects.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. Acquire basic knowledge and concepts of Numerical Analysis, with main focus on applications
2. Be able to implement numerical algorithms in order to solve practical problems.
Specific academic skills
1. Ability to apply numerical algorithms to solve practical and real-life problems.
2. Ability to use approximation and numerical features of various mathematical software

[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. 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.

8. Contents

8.1 Course	Teaching and learning methods	Remarks[3]
1. **Preliminaries.** Taylor polynomials. Errors, sources, propagation. Stability and conditioning of a problem. Divided and finite differences.	Interactive exposure, description, explanation, conversation, didactical demonstration	
2. **Solution of systems of linear algebraic equations.** Direct methods. Gaussian elimination. Backward and forward substitution. Factorization (LU, LUP, QR, Cholesky) methods. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
3. Iterative methods. Jacobi and Gauss-Seidel methods. SOR method. Conditioning of a linear system. Ill-conditioned matrices.	Interactive exposure, description, explanation, conversation, didactical demonstration	
4. **Approximation of functions.** Polynomial interpolation. Lagrange interpolation, Lagrange fundamental polynomials. Error in Lagrange interpolation. Optimal choice of nodes. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
5. Efficient computation of interpolation polynomials. Barycentric formula. Newton's divided and finite differences interpolation. Aitken's algorithm. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
6. Hermite interpolation. Interpolation with double nodes. General case. Error in Hermite interpolation. Special cases.	Interactive exposure, description, explanation, conversation, didactical demonstration	
7. Birkhoff interpolation. Birkhoff fundamental polynomials. Peano's theorem and the error in Birkhoff interpolation. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
8. Spline interpolation. Linear and cubic splines. Properties. Least squares approximation. Orthogonal polynomials.	Interactive exposure, description, explanation, conversation, didactical demonstration	
9. **Numerical differentiation and integration.** Numerical differentiation formulas. Examples. Interpolatory and Newton-Cotes quadratures. Composite rectangle, trapezoidal and Simpson's rules. Examples. Adaptive quadratures.	Interactive exposure, description, explanation, conversation, didactical demonstration	
10. Richardson extrapolation. Iterated quadratures. Romberg's method. Gaussian quadratures. Families of orthogonal polynomials. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
11. **Rootfinding for nonlinear equations.** Iterative methods. Order of convergence. Bisection, secant and Newton's methods. Comparison between Newton's and secant methods. Aitken extrapolation. One-point iteration methods, successive approximations. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	
12. Newton's method for multiple roots. Newton's method for nonlinear systems. Examples.	Interactive exposure, description, explanation, conversation, didactical demonstration	

Bibliography

1. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons Inc., 1988.
2. K. E. Atkinson, W. Han, Elementary Numerical Analysis, Third Edition, John Wiley and Sons Inc., 2004.
3. S. Micula, R. Sobolu, M. Micula, Numerical Analysis with Maple (rom.), Academic Press, Cluj-Napoca, 2008.
4. R. Trîmbitaş, Numerical Analysis in Matlab, Cluj University Press, 2008.
5. W. Gautschi, Numerical Analysis, An Introduction, Birkhaeuser, Boston, 1997.
6. Gh. Coman, I. Chiorean, T. Cătinaş, Numerical Analysis, An Advanced Course, Cluj University Press, 2007.

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

8.2 **Laboratory**	**Teaching and learning methods**	**Remarks**
1. Review of Matlab.	Interactive exposure, explanation, conversation, individual and group work	
2. Taylor polynomials. Errors.	Interactive exposure, explanation, conversation, individual and group work	
3. Newton's divided and finite differences.	Interactive exposure, explanation, conversation, individual and group work	
4. Linear algebraic systems I. Gaussian elimination. Factorizations. Backward and forward substitution.	Interactive exposure, explanation, conversation, individual and group work	
5. Linear algebraic systems II. Iterative methods. Jacobi, Gauss-Seidel, SOR methods.	Interactive exposure, explanation, conversation, individual and group work	
6. Lagrange interpolation I. Lagrange fundamental polynomials. Barycentric formula.	Interactive exposure, explanation, conversation, individual and group work	
7. Lagrange interpolation II. Newton's form. Aitken's algorithm.	Interactive exposure, explanation, conversation, individual and group work	
8. Hermite interpolation with double nodes. Summary and review of polynomial interpolation.	Interactive exposure, explanation, conversation, individual and group work	
9. Cubic spline interpolation. Least squares approximation.	Interactive exposure, explanation, conversation, individual and group work	
10. Numerical Integration I. Newton-Cotes quadratures. Adaptive quadratures.	Interactive exposure, explanation, conversation, individual and group work	
11. Numerical Integration II. Romberg's method. Gaussian quadratures.	Interactive exposure, explanation, conversation, individual and group work	
12. Numerical methods for nonlinear equations.	Interactive exposure, explanation, conversation, individual and group work	

Bibliography

1. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons Inc., 1988.
2. K. E. Atkinson, W. Han, Elementary Numerical Analysis, Third Edition, John Wiley and Sons Inc., 2004.
3. S. Micula, R. Sobolu, M. Micula, Numerical Analysis with Maple (rom.), Academic Press, Cluj-Napoca, 2008.
4. R. Trîmbitaş, Numerical Analysis in Matlab, Cluj University Press, 2008.

9. Evaluation

Activity type	9.1 Evaluation criteria[4]	9.2 Evaluation methods[5]	9.3 Percentage of final grade
9.4 Course	- acquire the basic principles and notions in Numerical Analysis;	**Written exam**	**70%**

[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.

	- apply correctly the course concepts on various applications - problem solving		
9.5 Laboratory	- be able to implement course concepts and notions - apply numerical algorithms to solve practical and real-life problems	- participation in discussing and solving problems throughout the semester	**30%**
9.6 Minimum standard for passing			
A grade of 5 or above (on a scale from 1 to 10) on **each** of the activities mentioned above (written test, lab evaluation)			

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

	○	Sustainable Development Generic Label						
1 FĂRĂ SĂRĂCIE	2 FOAMETE „ZERO"	3 SĂNĂTATE ȘI BUNĂSTARE	4 EDUCAȚIE DE CALITATE	5 EGALITATE DE GEN	6 APĂ CURATĂ ȘI SANITAȚIE	7 ENERGIE CURATĂ ȘI LA PREȚURI ACCESIBILE	8 MUNCĂ DECENTĂ ȘI CREȘTERE ECONOMICĂ	9 INDUSTRIE, INOVAȚIE ȘI INFRASTRUCTURĂ
○	○	○	○	○	○	○	○	**X**
10 INEGALITĂȚI REDUSE	11 ORAȘE ȘI COMUNITĂȚI DURABILE	12 CONSUM ȘI PRODUCȚIE RESPONSABILE	13 ACȚIUNE CLIMATICĂ	14 VIAȚA ACVATICĂ	15 VIAȚA TERESTRĂ	16 PACE, JUSTIȚIE ȘI INSTITUȚII EFICIENTE	17 PARTENERIATE PENTRU REALIZAREA OBIECTIVELOR	No label applies
○	○	○	○	○	○	○	○	○

Date	Signature of course coordinator	Signature of seminar coordinator
9.04.2026	Prof. Sanda Micula, PhD. Habil.	Prof. Sanda Micula, PhD. Habil.

Date of approval

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."*