SYLLABUS

1. Information regarding the programme

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 of study	**Computer Science**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Computer Science**

2. Information regarding the discipline

2.1 Name of the discipline	**Numerical Calculus**						
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 evaluation	**E**	2.7 Type of discipline	**DF Compulsory**

2.8 Course Code	**MLE0028**	

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	48	Of which: 3.5 course	24	3.6 seminar/laboratory	24
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					40
Additional documentation (in libraries, on electronic platforms, field documentation)					15
Preparation for seminars/labs, homework, papers, portfolios and essays					35
Tutorship					12
Evaluations					25
Other activities:					-

3.7 Total individual study hours	127
3.8 Total hours per semester	175
3.9 Number of ECTS credits	7

4. Prerequisites (if necessary)

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

5. Conditions (if necessary)

5.1. for the course	• Lecture room with large blackboard and video projector
5.2. for the seminar /lab activities	• Laboratory with Matlab installed

6. Specific competencies acquired

Professional competencies	C3.3 Use of computer science and mathematical models and tools for solving specific problems in the application field C3.4 Data and model analysis 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 areas
Transversal competencies	CT1 Ability to conform to the requirements of organized and efficient work, to develop a responsible approach towards the academic and scientific fields, in order to make the most of one's own creative potential, while obeying the rules and principles of professional ethic CT3 Using efficient methods and techniques for learning, information, research and developing capabilities for using knowledge, for adapting to a dynamic society and for communicating in Romanian and in a worldwide spoken language

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

7.1 General objective of the discipline	• Acquire basic knowledge and concepts of Numerical Analysis, with main focus on applications • Be able to implement numerical algorithms in order to solve practical problems.
7.2 Specific objective of the discipline	• Become familiar and be able to work with various numerical algorithms and models • Gain the ability to apply numerical algorithms to solve practical and real-life problems. • Ability to use approximation and numerical features of various mathematical software

8. Content

8.1 Course	**Teaching methods**	**Remarks**
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.	Interactive exposure, description, explanation, conversation, didactical demonstration	
10. Adaptive quadratures. 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.

8.2 Laboratory	**Teaching methods**	**Remarks**
1. Taylor polynomials. Errors.	Interactive exposure, explanation, conversation, individual and group work	
2. Newton's divided and finite differences.	Interactive exposure, explanation, conversation, individual and group work	
3. Linear algebraic systems. Gaussian elimination. Factorizations. Backward and forward substitution.	Interactive exposure, explanation, conversation, individual and group work	
4. Linear algebraic systems. Iterative methods. Jacobi, Gauss-Seidel, SOR methods.	Interactive exposure, explanation, conversation, individual and group work	

5. Lagrange interpolation. Lagrange fundamental polynomials. Barycentric formula.	Interactive exposure, explanation, conversation, individual and group work	
6. Lagrange interpolation. Newton's form. Aitken's algorithm.	Interactive exposure, explanation, conversation, individual and group work	
7. Hermite interpolation with double nodes.	Interactive exposure, explanation, conversation, individual and group work	
8. Cubic spline interpolation.	Interactive exposure, explanation, conversation, individual and group work	
9. Least squares approximation.	Interactive exposure, explanation, conversation, individual and group work	
10. Newton-Cotes quadratures. Adaptive quadratures. Romberg's method.	Interactive exposure, explanation, conversation, individual and group work	
11. 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.
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4. R. Trîmbitaş, Numerical Analysis in Matlab, Cluj University Press, 2008.

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 course follows the ACM and IEEE Curriculum Recommendations for Computer Science majors;
- The course exists in the studying program of all major universities in Romania and abroad;
- The knowledge and skills acquired in this course give students a foundation for launching a career in scientific research;
- The problem solving abilities acquired in this course are useful in any career path students may choose.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- acquire the basic principles and notions in Numerical Analysis; - apply correctly the course concepts on various applications - problem solving	**Written exam**	70%

10.6 Lab activities	- be able to implement course concepts and algorithms - apply numerical algorithms to solve practical and real-life problems	- participation in discussing and solving problems throughout the semester	30%
10.7 Minimum performance standards			
➢ A grade of 5 or above (on a scale from 1 to 10) on **each** of the activities mentioned above (written exam, lab evaluation)			

Date	Signature of course coordinator	Signature of seminar coordinator
26.04.2023	Prof. Sanda Micula, PhD. Habil.	Prof. Sanda Micula, PhD. Habil.

Date of approval	Signature of the head of department
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