SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / qualification	Computer Science / Engineer
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Numerical Methods***			Subject code	**24**
2.2 Course responsible / lecturer	Prof. univ. dr. Ivan Dumitru-Mircea - mircea.ivan@math.utcluj.ro				
2.3 Teachers in charge of seminars / Laboratory / project	Prof. univ. dr. Roșca Daniela - daniela.rosca@math.utcluj.ro Conf. univ. dr. Birou Marius - marius.birou@math.utcul.ro Drd. Pușcaș Roxana - Roxana.puscas@math.utcluj.ro				

2.4 Year of study	II	2.5 Semester	4	2.6 Type of assessment (E - exam, C - colloquium, V – verification)	E
2.7 Subject category	Formative category: DF – fundamental, DS – speciality, DC – complementary				DF
	Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice)				DOB

3. Estimated total time

3.1 Number of hours per week	4	3.2	lectures	2	3.3	applications	2
3.4 Total hours in the teaching plan	128	3.5	lectures	28	3.6	applications	28

Individual study	
Manual, lecture material and notes, bibliography	20
Supplementary study in the library, online, and in the field	4
Preparation for seminars/laboratory works, homework, reports, portfolios, essays	15
Tutoring	-
Exams and tests	5
Other activities	-

3.7 Total hours of individual study	44
3.8 Total hours per semester	100
3.9 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	Fundamental knowledge of calculus (limits, continuity, differentiation, integration, series). Basic concepts of linear algebra (vectors, matrices, systems of linear equations, determinants, eigenvalues and eigenvectors). Elements of mathematical analysis and functions of one variable. Basic programming skills and familiarity with a computational environment.
4.2 Competence	Ability to perform analytical reasoning and solve mathematical problems. Basic skills in manipulating algebraic expressions and matrices. Ability to interpret mathematical models and translate problems into computational form. Familiarity with algorithmic thinking and structured problem solving. Capacity to use computational tools for basic numerical calculations.

5. Requirements (where appropriate)

5.1 For the course	Blackboard, beamer, computer, graphic tablet
5.2 For the applications	Blackboard, beamer, computer, graphic tablet

6. Specific competences

6.1 Professional competences	**C1 –** Operating with basic Mathematical, Engineering, and Computer Science concepts • Understanding and application of error theory in numerical computations, including floating-point arithmetic, absolute and relative errors. • Analysis of conditioning, stability, and sensitivity of numerical problems using norms and condition numbers. • Application of direct and iterative methods for solving linear systems (LU and Cholesky factorizations with pivoting, Jacobi, Gauss–Seidel, relaxation methods). • Numerical solution of nonlinear equations and systems using classical iterative methods (bisection, Newton, secant, fixed-point, Chebyshev). • Construction and application of interpolation and approximation methods (Lagrange, Newton divided differences, Hermite, splines, least squares, orthogonal and polynomial approximations). • Application of numerical integration techniques (trapezoidal rule, Simpson, Newton–Cotes, Gaussian quadrature, Romberg and Richardson methods). • Numerical solution of ordinary differential equations using Euler and Runge–Kutta methods.
6.2 Cross competences	• Development of logical, analytical, and algorithmic thinking in solving numerical problems. • Ability to work independently in designing and implementing numerical algorithms. • Critical evaluation of numerical results, including error analysis and interpretation of approximation accuracy. • Responsible use of computational tools, with awareness of numerical stability and limitations of algorithms. • Effective communication of mathematical and computational results in written and oral form. • Teamwork skills in solving complex computational problems and collaborative implementation of algorithms. • Development of the ability to transfer numerical methods to interdisciplinary applications in science and engineering.

7. Expected Learning Outcomes

Knowledge	The student/graduate identifies and describes basic concepts, principles and methods in mathematics, physics, chemistry, technical drawing, economics and computer science.
Skills	The student/graduate operates with basic concepts, principles and methods from mathematics, physics, chemistry, technical drawing, economics and computer science. The student/graduate solves problems in mathematics, physics and chemistry with applicability in engineering and validates the solution obtained. The student/graduate performs engineering and economic calculations of medium complexity and associates them with graphical representations or specific computer-aided design. The student/graduate describes physico-chemical and economic phenomena and processes.
Responsibilities and autonomy	The student/graduate applies the values of ethics and deontology of the engineering profession. The student/graduate practices logical reasoning, evaluation and self-evaluation in decision-making. The student/graduate communicates effectively about engineering activities with a wide range of audiences. The student/graduate is engaged in lifelong learning to acquire and implement knowledge, as needed, using appropriate learning strategies. The student/graduate promotes dialogue, cooperation, respect for others and interculturality. The student/graduate works effectively as a team member or leader.

8. Discipline objectives (as results from the *key competencies gained*)

8.1 General objective	Development of fundamental competencies in numerical analysis through the acquisition and application of numerical methods for solving

	mathematical problems arising in science and engineering, including linear and nonlinear systems, interpolation and approximation, numerical integration, and differential equations, with emphasis on accuracy, stability, and computational efficiency.
8.2 Specific objectives	• Understanding and applying concepts from error theory, including floating-point arithmetic, absolute and relative errors, and error propagation. • Analyzing conditioning and numerical stability of problems using norms and condition numbers. • Applying numerical methods for solving linear systems (• Applying iterative methods for linear systems (Jacobi, Gauss–Seidel, relaxation methods) and analyzing their convergence. • Solving nonlinear equations using classical numerical methods (bisection, fixed-point iteration, Newton, secant, false position, Chebyshev methods). • Solving systems of nonlinear equations using Newton-type methods. • Constructing and applying interpolation methods (Lagrange, Newton divided differences, Hermite interpolation, finite differences, scattered data interpolation). • Applying spline interpolation techniques, including B-splines. • Using numerical integration methods (trapezoidal rule, Simpson's rule, Newton–Cotes formulas, Gaussian quadrature, Romberg integration, Richardson extrapolation). • Applying approximation methods (least squares, orthogonal polynomials, Padé approximation, trigonometric approximation, Bernstein polynomials, Bézier curves). • Applying numerical methods for solving ordinary differential equations (Euler, Taylor series, Runge–Kutta methods). • Developing the ability to select appropriate numerical methods based on problem type, accuracy requirements, and computational constraints.

9. Contents

<table>
<tr><th>9.1 Lecture (syllabus)</th><th>Teaching methods</th><th>Notes</th></tr>
<tr><td>Elements of Error Theory. Floating Point Arithmetic. Absolute and Relative Errors.</td><td rowspan="7">Exposition of theoretical concepts with illustrative examples.

Mathematical demonstrations and deductive reasoning.

Problem-based approach and case studies.

Interactive discussions and guided questioning.

Use of visual aids and computational demonstrations.</td><td>2 hrs</td></tr>
<tr><td>Numerical Methods in Linear Algebra. Special Types of Matrices. Norms of Vectors and Matrices. Eigenvalues and Eigenvectors. Error Estimation, Condition Number of a matrix.
Matrix Equations. Pivoting Elimination. Improved Solutions of Matrix Equations. Partitioning Methods for Matrix Inversion. LU Factorization. Doolittle's Factorization. Cholesky's Factorization Method.
Iterative Techniques for Solving Linear Systems. Jacobi Iterative Method. Gauss-Seidel Iterative Method. Relaxation Methods.</td><td>6 hrs</td></tr>
<tr><td>Numerical Methods for Solving Nonlinear Equations: Successive Approximations, Bisection, Tangent (Newton), Secant and False Position, Chebyshev.
Numerical Solutions of Nonlinear Systems of Equations: Newton's Method.</td><td>4 hrs</td></tr>
<tr><td>Elements of Interpolation Theory. Lagrange Interpolation. Divided Difference. Mean Value Properties in Lagrange Interpolation. Approximation by Interpolation. Hermite Interpolating Polynomial. Finite Differences. Scattered Data Interpolation. Shepard's Method.
Splines. B-splines.</td><td>6 hrs</td></tr>
<tr><td>Elements of Numerical Integration. Richardson's Extrapolation. Numerical Quadrature. Error Bounds in the Quadrature Methods. Trapezoidal Rule. Richardson's Deferred Approach to the Limit.
Romberg Integration. Newton-Cotes Formulas. Simpson's Rule. Gaussian Quadrature.</td><td>4 hrs</td></tr>
<tr><td>Elements of Approximation Theory. Discrete Least Squares Approximation. Orthogonal Polynomials and Least Squares Approximation. Padé Approximation. Trigonometric Polynomial Approximation. Bernstein Polynomial. Bézier Curves. METAFONT.</td><td>4 hrs</td></tr>
</table>

Numerical methods for Integration of Ordinary/Partial Differential Equations: Euler, Taylor Series Method, Runge-Kutta.		2 hrs

Bibliography:
1. Mircea Ivan and Kálmán Pusztai. Numerical Methods with Mathematica. Mediamira, Cluj-Napoca, 2003. ISBN 973-9357-41-5.
2. Mircea Ivan and Kálmán Pusztai. Mathematics by Computer. Comprex Publishing House, Cluj-Napoca, 1992.
3. Ioan Gavrea & Mircea Ivan, ML. Numerical Methods, POSDRU/86/1.2/S/62485, 2013.

9.2 Applications - Seminars / Laboratory / Projects	Teaching methods	Notes
The applications follow the topics of the courses.	Individual work supported by instructor feedback. Collaborative work for solving complex tasks.	28 hrs

Bibliography:
1. Mircea Ivan and Kálmán Pusztai. Numerical Methods with Mathematica. Mediamira, Cluj-Napoca, 2003. ISBN 973-9357-41-5.

10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The course content is aligned with the current standards and expectations of the scientific and professional community in applied mathematics, computer science, and engineering. It reflects the need for solid knowledge of numerical methods used in modeling, simulation, and computational problem solving.
The topics covered—numerical linear algebra, nonlinear equations, interpolation and approximation, numerical integration, and differential equations—correspond to core competencies required in academic research and industry practice. Emphasis is placed on algorithmic thinking, numerical stability, error analysis, and efficient implementation, which are essential in real-world applications.
The inclusion of practical computational aspects ensures compatibility with the expectations of employers, who require the ability to implement and apply numerical methods using modern software tools. The course also supports the development of transferable skills such as problem solving, critical analysis, and adaptability to interdisciplinary contexts.
Through this approach, the course contributes to preparing graduates for professional roles in areas such as scientific computing, data analysis, engineering applications, and software development.

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Understanding of fundamental concepts and proofs in numerical methods and error analysis. Correctness and accuracy in solving numerical problems. Ability to select and apply appropriate numerical methods. Rigor of mathematical reasoning and correctness of computations.	Continuous assessment through quizzes. Written examination (theoretical questions and problem solving)	75%
Applications	Ability to solve problems and apply algorithms	Observation of student activity and participation during lab sessions. Final laboratory test.	25%
Minimum standard of performance**:** Ability to present a theoretical subject coherently and to solve problems with practical content. Conditions for participation in the final examination: maximum 4 (from 14) lab absences, according to the ECTS Regulations of UTCluj and Lab test >=5. Calculation of final mark: 25% final Lab test, 75% written examination. Conditions for passing: written examination >=5.			

Date of filling in: 27.04.2026	Responsible	Title, First name Last name	Signature
	Lectures	Prof.univ. dr. Dumitru-Mircea IVAN	
		Prof. Univ. Dr. Daniela ROȘCA	
	Applications	Prof.univ.dr. Daniela ROȘCA	
		Conf. univ. dr. Marius BIROU	
		Drd. Roxana PUȘCAS	

Date of approval by the Department Board	Head of Department of Mathematics, Prof.univ.dr. Dorian Popa
Date of approval by the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan