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	Mathematics
1.4 Field of study	Automation. Applied Informatics and Intelligent Systems
1.5 Cycle of study	Bachelor of Science
1.6 Program of study/Qualification	Automation and Applied Informatics (English)
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Numerical Methods***				Discipline code	16.00
2.2 Course responsible/lecturer	Lect. dr. Flavius-Olimpiu PATRULESCU					
2.3 Teachers in charge of applications	Lect. dr. Liana TIMBOS Drd. Ana-Maria Pastiu					
2.4 Year of study	2	2.5 Semester	1	2.6 Assessment *(E/C/V)*		C
2.7 Type of subject	*DF – fundamental, DS – specialty, DC – complementary*					DF
	DOB – compulsory, DOP – elective, DFA – optional					DOB

3. Estimated total time

3.1 Number of hours per week	4	of which:	Course	2	Seminar	0	Laboratory	2	Project	0
3.2 Number of hours per semester	56	of which:	course	28	Seminar	0	Laboratory	28	Project	0

3.3 Individual study	
(a) Manual, lecture material and notes, bibliography	30
(b) Supplementary study in the library, online and in the field	9
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	30
(d) Tutoring	0
(e) Exams and tests	3
(f) Other activities:	0

3.4 Total hours of individual study (sum of (3.3(a)…3.3(f)))	72
3.5 Total hours per semester (3.2+3.4)	128
3.6 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	Basic knowledge of Differential and Integral Calculus. Basic concepts of linear algebra. Basic programming skills and familiarity with a computational environment.
4.2 Competence	Competence in elementary Differential and Integral Calculus: derivatives, integrals, series. 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

Professional competences	**C1 –** Operating with basic Mathematical, Engineering and Computer Science concepts (5 credits) • Recognizing and describing concepts that are specific to the fields of calculability, complexity, programming paradigms, and modeling computational and communication systems • Building models for various components of computing systems • Providing a theoretical background for the characteristics of the designed systems

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	• Understanding of fundamental concepts in numerical analysis, including floating-point arithmetic, absolute and relative errors, and error propagation. • Knowledge of conditioning, stability, and sensitivity of numerical problems, including matrix norms and condition numbers. • Understanding of direct and iterative methods for solving linear systems (Gaussian elimination, LU and Cholesky factorizations, Jacobi, Gauss–Seidel and SOR methods). • Knowledge of numerical methods for nonlinear equations and systems (bisection, Newton, secant, fixed-point, Chebyshev methods). • Understanding of interpolation and approximation techniques (Lagrange, Newton divided differences, Hermite interpolation, splines, least squares, orthogonal polynomials). • Knowledge of numerical integration methods (trapezoidal rule, Simpson's rule, Newton–Cotes formulas, Gaussian quadrature, Romberg integration). • Understanding of numerical methods for ordinary differential equations (Euler and Runge–Kutta methods).
Skills	• Application of numerical methods for solving linear and nonlinear equations and systems. • Construction and evaluation of interpolation and approximation models for discrete and continuous data. • Implementation of numerical integration techniques and estimation of associated errors. • Application of numerical methods for solving ordinary differential equations. • Selection of appropriate numerical algorithms depending on problem structure and required accuracy. • Computation and interpretation of numerical errors and conditioning indicators in applied problems. • Practical implementation of algorithms in computational environments.
Responsibilities and autonomy	• Independent selection and application of appropriate numerical methods for problem solving. • Critical evaluation of numerical results, including awareness of approximation errors and algorithmic limitations. • Responsible use of computational tools with attention to numerical stability and accuracy. • Ability to work autonomously in designing and implementing numerical algorithms. • Capacity to integrate numerical methods into interdisciplinary problem-solving contexts

8. Course objectives

General objective	A presentation of the concepts, notions, methods and fundamental techniques used in numerical calculus.
Specific objectives	Use of numerical calculus to solve problems in engineering.

9. Contents

9.1 Lecture	No. hours	Teaching methods	Notes
Elements of Error Theory. Floating Point Arithmetic. Absolute and Relative Errors.	2h	Explanation	
Numerical Methods in Linear Algebra. Special Types of Matrices. Norms of Vectors and Matrices. Eigenvalues and Eigenvectors. Error Estimation.	4h	Demonstration	

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.		Collaboration Interactive activities	
Numerical Methods for Solving Nonlinear Equations. Method of Successive Approximation, The Bisection Method, The Newton-Raphson Method, The Secant Method, False Position Method, The Halley Method. **Numerical Solutions of Nonlinear Systems of Equations.** Newton's Method, Steepest Descent Method.	4h		
Elements of Interpolation Theory. Lagrange Interpolation. Divided Difference. Mean Value Properties in Lagrange Interpolation. Approximation by Interpolation. Hermite Interpolating Polynomial. Finite Differences. Interpolation of Multivariable Functions. Scattered Data Interpolation. Splines. B-splines.	5h		
Elements of Numerical Integration. Richardson's Extrapolation. Numerical Quadrature. Error Bounds in the Quadrature Methods. Trapezoidal Rule. Romberg Integration. Newton-Cotes Formulas. Simpson's Rule. Gaussian Quadrature.	4h		
Elements of Approximation Theory. Discrete Least Squares Approximation. Orthogonal Polynomials and Least Squares Approximation. Rational Function Approximation. Padé Approximation. Trigonometric Polynomial Approximation. Fast Fourier Transform. Bernstein Polynomial. Bézier Curves.	4h		
Integration of Ordinary Differential Equations. The Euler Method. The Taylor Series Method. The Runge-Kutta Method. The Adams Method. **Integration of Partial Differential Equations** The Finite Difference Method. The Finite Element Method.	5h		

Bibliography

M.L. Overton, Numerical Computing with IEEE Floating Point Arithmetic. SIAM, Philadelphia, 2001.
R. Burden, D. Faires, A. Burden, Numerical Analysis, Tenth Edition. Cengage Learning, Boston, 2014.
G. Dahlquist, A. Bjorck, Numerical Methods in Scientific Computing, Volume I. SIAM, Philadelphia, 2008.
J. W. Demmel, Applied Numerical Linear Algebra. SIAM, Philadelphia, 1997.
A. Quarteroni, R. Sacco, F. Saleri, Numerical Mathemtics. Springer-Verlag, New-York, 2000.

9.2 Applications (seminar/laboratory/project/practical work)	No. hours	Teaching methods	Notes
The applications follow the topics of the courses.	28	Individual work is supported by instructor feedback. Collaborative work for solving complex tasks.	

Bibliography

D.J. Higham, N.J. Higham, MATLAB Guide, Third Edition. SIAM, Philadelphia, 2017.
C.B. Moler, Numerical Computing with MATLAB, Revised Preprint. SIAM Philadelphia, 2004.
A. Quarteroni, F. Saleri, P. Gervasio, Scientific Computing with MATLAB and Octave, Fourth Edition. Springer-Verlag, Berlin Heidelberg, 2014.

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

Collaboration with engineers to identify and solve problems raised by the market.

11. Evaluation

Activity type	11.1 Assessment criteria	1.2 Assessment methods	11.3 Weight in the final grade
11.4 Course	Abilities of understanding and using creatively the concepts and proofs	Written examination (theoretical questions and problem solving)	70%
11.5 seminar/laboratory/project/ practical work	Abilities to solve problems and applying algorithms	Observation of student activity and participation during lab sessions. Final laboratory test.	30%
11.6 Minimum performance standard Ability to present coherently a theoretical subject and to solve problems with practical content. Conditions for participation in the final examination: maximum 4 (from 14) lab absences.			

Date of filling in:		Title, First name, NAME	Signature
	Course	Lect. dr. Flavius-Olimpiu PATRULESCU	
10.07.2026	Applications	Lect. dr. Liana TIMBOS	
		Drd. Anamaria PASTIU	

Date of approval by the Department Board	Head of Departament of Automation, Prof.univ.dr. Honoriu Valean
Date of approval by the Faculty Council	Dean, Prof.dr.ing. Vlad MUREȘAN