MODULE DESCRIPTION

Module title	Module code
Numerical Analysis	

Lecturer(s)	Department where the module is delivered
Coordinator: assoc. prof. dr. Olga Štikonienė **Other lecturers:**	Department of Differential Equations and Numerical Mathematics Faculty of Mathematics and Informatics Vilnius University

Cycle	Type of the module
First	Optional

Mode of delivery	Semester or period when the module is delivered	Language of instruction
Face-to-face	Autumn semester Third or Fourth year of study	Lithuanian

Prerequisites
Prerequisites: Mathematics for Software Engineering I and II

Number of credits allocated	Student‘s workload	Contact hours	Self-study hours
5	130	68	62

Purpose of the module: programme competences to be developed
Purpose of the module – give basic skills in numerical solution of differential equations and related mathematical problems. It is also aimed to develop communication skills in subject-related situations. ***Generic competences:*** • Communication and collaboration *(GK1).* ***Specific competences:*** • Knowledge and skills of underlying conceptual basis *(SK4).*

Learning outcomes of the module: students will be able to	Teaching and learning methods	Assessment methods
Define and illustrate main concepts related to Numerical Analysis.	Lecture Practicals with computer Individual reading	Exam (written) Presentation of laboratory work (orally with computer)
Formulate and prove main propositions related to Numerical Analysis.		
Apply propositions of Numerical Analysis to solve standard problems analytically and/or using computer software.		
Formulate practical problems in mathematical language.		
Solve and analyze mathematical models, give conclusions based on mathematical models and justify them logically.		

Content: breakdown of the topics	**Contact hours**							**Self-study work: time and assignments**	
	Lectures	Tutorials	Seminars	Practice	Laboratory work (LW)	*Tutorial during LW*	**Contact hours**	**Self-study hours**	**Assignments**
1. Computer arithmetic and algorithms	2						**2**	2	Individual reading Problem solving 6 laboratory works
2. **Direct methods for solving linear systems**. Gauss method. Pivoting technique. Complexity of Gauss method. Tridiagonal systems (Thomas algorithm). Cholesky decomposition method.	3				4	*1*	**8**	10	
3. **Data approximation**. Interpolation of functions. Linear and quadratic interpolation. Finite difference quotient formulas and finite difference tables. Newton’s interpolating polynomial. Spline interpolation. Linear, quadratic and cubic splines. Least squares method.	6				6	*1*	**12**	10	
4. **Solution of nonlinear equations**. Contraction mapping and its properties. Vector norm, matrix norm. Norm of symmetric matrix. Some inequalities for symmetric matrices. Bisection method. Separation of roots. Fixed point method. Newton’s method. Method of secants. Solution of nonlinear systems.	3				6	*1*	**10**	8	
5. **Iterative methods for linear systems**. Jacobi, Gauss-Seidel, relaxation methods. Implicit stationary iterative methods. Classification of iterative methods. Sufficient condition for convergence of stationary methods. Optimal value of iterative parameter. Condition number. Variational methods: steepest descent, conjugate gradient methods.	4				6	*1*	**10**	10	
6. **Numerical integration and ordinary differential equations (ODE)**. Rectangular formula, trapezoidal formula, Simpson’s formula. Methods for estimation of error. Runge’s rule. Adaptive methods of numerical integration. Gaussian quadrature. Main concepts of ODE. Euler methods. Runge-Kutta methods. Truncation error, convergence, consistency and stability.	6				6	*1*	**10**	8	
7. **Eigenvalue problem**. Eigenvalues and eigenvectors of matrices. Complete system of vectors. Gram-Schmidt algorithm. Recursive formula for values of characteristic polynomial of tridiagonal systems. Muller’s method. Sturm chain and Gershgorin theorem. Power method. Inverse iterations method. Hausholder transformation.	6				4	*1*	**10**	10	
8. **Function optimization methods**. Golden section search. Newton’s method. Minimization of functions of several variables. Simplex method. Gradient methods.	2						**2**	4	
Exam (written)		2					**4**		2 hours for tutorial before exam, 2 hours for exam.

Total	**32**	**2**			**32**	*6*	**68**	62	

Assessment strategy	**Weight %**	**Deadline**	**Assessment criteria**
Practicals with computer	50	During the semester	In the laboratory work problems are being solved (with the programs like Maple). During the laboratory work in the computer class students have to demonstrate and explain their solution. Maximum number of points is given for full and correct solution; some points are given for partial solutions. Then average number of points is computed and normalized to 10, where 10 corresponds to the average number of points (laboratory works) of the best student. These points constitute 50% of the final marks.
Exam (written)	50	Exam session	All questions are worth the same number of points. Maximal number of points is given if the student answered the question: the student has given correct definitions, has given correct statements and their proofs. Some points are given for partial answers. Then average number of points is computed and normalized to 10, where 10 correspond to the average number of points of the best student. These points constitute 50% of the final mark

Author	**Publishing year**	**Title**	**Number or volume**	**Publisher or URL**
Required reading				
V.Būda, R.Čiegis	1997	Computational mathematics (in Lithuanian)		Vilnius: TEV
O. Štikonienė		Numerical Analysis. Lecture notes (in Lithuanian)		http://www.mif.vu.lt/~olgas/SM.html
Recommended reading				
A.Quarteroni, F.Saleri and P. Gervasio	2010	Scientific Computing with MATLAB and Octave		Springer
J.H.Mathews, K.D.Fink	2004	Numerical methods Using MATLAB		Prentice Hall http://math.fullerton.edu/mathews/numerical.html
B.Kvedaras, M.Sapagovas	1974	Numerical Analysis (in Lithuanian)		Vilnius: Mintis
R.Čiegis	2003	Numerical methods for differential equations (in Lithuanian)		Vilnius: Technika
A.Quarteroni, R.Sacco, F.Saleri	2000	Numerical Mathematics		Springer
V.Būda, M.Sapagovas	1998	Numerical methods. Algorithms, problems, projects (in Lithuanian)		Vilnius: Technika
K. Plukas	2001	Numerical methods and algorithms (in Lithuanian)		Kaunas: N. lankas