Faculty of Fundamental Problems of Technology

COURSE CARD

Name in polish: Algebra numerycznaName in english: Numerical algebraField of study: Computer Science

Specialty (if applicable)

Undergraduate degree and form of : masters, stationary

	Lectures	Exercides	Laboratory	Project	Seminar
Number of classes held in schools (ZZU)	30	30			
The total number of hours of student work-	90	90			
load (CNPS)					
Assesment	pass				
For a group of courses final course mark	X				
Number of ECTS credits	3	3			
including the number of points correspond-		3			
ing to the classes of practical (P)					
including the number of points correspond-	3	3			
ing occupations requiring direct contact					
(BK)					

PREREQUISITES FOR KNOWLEDGE, SKILLS AND OTHER POWERS

Pass the course Scientific Computing. Learning Octave or Matlab.

COURSE OBJECTIVES

- C1 Learning basic algorithms of numerical linear algebra
- C2 Achievement of practical competence in applications and implementation of basic algorithms of numerical linear algebra

COURSE LEARNING OUTCOMES

The scope of the student's knowledge:

- W1 Student knows QR and SVD decompositions, orthogonal transformations and their applications.
- **W2** Student knows parallel algorithm for systems of linear equations with banded matrices and ijk variants of Gauss elimination and Cholesky decomposition.
- W3 Student knows methods for solving linear least squares problem and their properties. Student knows Savitzky-Golay method.
- **W4** Student knows bisection, QR method and power method for algebraic eigenvalue problem, matrix sign function and matrix equations of Sylvester and Lyapunov.

The student skills:

- **U1** Student is able to apply orthogonal transformations.
- **U2** Student is able to apply BLAS and parallel algorithms for solving systems of linear equations and comparing their costs.
- **U3** Student is able to choose suitable method for solving linear least squares problem and to investigate its conditioning.
- **U4** Student is able to implement algorithms for computing eigenvalues and eigenvectors of matrices, and for solving matrix equation of Sylvester by means of matrix sign function.

The student's social competence:

K1 Student understands role of numerical algorithms of algebra in computer science and technique.

COURSE CONTENT

	Type of classes - lectures	
Wy1 BLAS, BLACS and libraries of algorithms of numerical linear algebra		2h
Wy2 ijk forms of realization of Gauss elimination and Cholesky decomposition		2h
Wy3	Orthogonal transformations, QR and SVD decompositions of matrix	2h
Wy4	Applications of decompositions of matrix	2h
Wy5	Parallel algorithms for solving systems of linear equations	2h
Wy6	Linear least squares problem with matrix of full column rank	2h
Wy7	Linear least squares problem with deficient rank matrix	2h
Wy8	Savitzky-Golay algorithm for filtering noise data	2h
Wy9	Bisection for computing eigenvalues of symmetric tridiagonal matrix	2h
Wy10	QR method for computing eigenvalues	2h
Wy11	Algorithms for computing dominant eigenvalues of large matrices	2h
Wy12	Applications of theorem of Perron-Frobenius and algorithms for computing eigenvalues and	2h
	eigenvectors in PageRank method	
Wy13	Matrix equations of Sylvester and Lyapunov, and matrix sign function and its applications	2h
Wy14	Algorithms for computing SVD and applications of SVD to classification of handwritten	2h
	digits.	
Wy15	Final test	2h

	Type of classes - exercises	
Ćw1	Introduction to numerical linear algebra, LU decomposition.	2h
Ćw2	Selected problems of linear algebra. BLAS.	2h
Ćw3	Applications of BLAS to implementation of ijk forms of Gauss elimination and Cholesky	2h
	decomposition	
Ćw4	Householder transformations and rotations of Jacobi, and their applications	2h
Ćw5	Algorithms for computing QR decomposition and applications of QR and SVD decomposi-	2h
	tions	
Ćw6	Parallel algorithms for solving systems of linear equations and their complexity in compari-	2h
	son to complexity of Gauss elimination	
Ćw7	Solving and investigation of conditioning of linear least squares problem with full rank matrix	2h
Ćw8	Algorithms for linear least squares problem with deficient rank matrix	2h
Ćw9	Test	2h
Ćw10	Transformation of symmetric matrix to tridiagonal form and implementation of bisection for	2h
	computing eigenvalues of tridiagonal symmetric matrix	
Ćw11	QR method - properties and shifts	2h
Ćw12	Power method - convergence and deflation	2h
Ćw13	Computer home works - presentation of reports	2h
Ćw14	Properties of matrix equations and matrix sign function	2h
Ćw15	Computer home works - presentation of reports	2h

Applied learning tools

- 1. Traditional lecture
- 2. Solving tasks and problems
- 3. Solving programming tasks
- 4. Consultation
- 5. Self-study students

EVALUATION OF THE EFFECTS OF EDUCATION ACHIEVEMENTS					
Value	Number of training effect	Way to evaluate the effect of educa-			
		tion			
F1	W1-W4, K1-K1	final test			
F2	U1-U4, K1-K1	test, report, activity of student dur-			
		ing exercises			
P=30%*F1+70%*F2					

BASIC AND ADDITIONAL READING

- 1. A. Kiełbasiński, H. Schwetlick, Numeryczna algebra liniowa, WNT 1993.
- 2. D. Kincaid, W. Cheney, Analiza numeryczna, WNT 2005.
- 3. P. Krzyżanowski, Obliczenia inżynierskie i naukowe. Szybkie, skuteczne, efektowne, PWN 2011.
- 4. J. Stoer, R. Burlisch, Wstęp do analizy numerycznej, t.1 i t.2, PWN 1987.
- 5. L. Elden, Matrix Methods in Data Mining and Pattern Recognition, SIAM 2007.
- 6. C.B. Moler, Numerical Computing with MATLAB, SIAM 2004.
- 7. T.L Freeman, C. Phillips, Parallel Numerical Algorithms, Prentice Hall 1992.

SUPERVISOR OF COURSE

dr hab. Krystyna Ziętak

RELATIONSHIP MATRIX EFFECTS OF EDUCATION FOR THE COURSE Numerical algebra WITH EFFECTS OF EDUCATION ON THE DIRECTION OF COMPUTER SCIENCE

Course train-	Reference to the effect of the learning out-	Objectives of	The con-	Number of
ing effect	comes defined for the field of study and	the course**	tents of the	teaching
	specialization (if applicable)		course**	tools**
W1	K2_W02 K2_W04	C1	Wy1-Wy15	1 4 5
W2	K2_W02 K2_W04	C1	Wy1-Wy15	1 4 5
W3	K2_W02 K2_W04	C1	Wy1-Wy15	1 4 5
W4	K2_W02 K2_W04	C1	Wy1-Wy15	1 4 5
U1	K2_U09 K2_U10 K2_U11	C2	Ćw1-Ćw15	2 3 4 5
U2	K2_U09 K2_U10 K2_U11	C2	Ćw1-Ćw15	2 3 4 5
U3	K2_U09 K2_U10 K2_U11	C2	Ćw1-Ćw15	2 3 4 5
U4	K2_U09 K2_U10 K2_U11	C2	Ćw1-Ćw15	2 3 4 5
K1	K2_K01 K2_K13 K2_K14	C1 C2	Wy1-Wy15	1 2 3 4 5
			Ćw1-Ćw15	