MASTER 'S PROGRAMME
APPLIED MATHEMATICS - IN ENGLISH

1ST YEAR OF STUDY, 1ST SEMESTER

COURSE TITLE	NUMERICAL METHODS IN LINEAR ALGEBRA AND MULTIDIMENSIONAL ANALYISIS
COURSE CODE	**MA1MNA**
COURSE TYPE	full attendance/tutorial
COURSE LEVEL	2nd cycle (master's degree)
YEAR OF STUDY, SEMESTER	1st year of study, 1st semester
NUMBER OF ECTS CREDITS	**7**
NUMBER OF HOURS PER WEEK	4 (2 lecture hours + 2 laboratory hours)
NAME OF LECTURE HOLDER	Dr. Vărvărucă Eugen
NAME OF SEMINAR HOLDER	Dr. Vărvărucă Eugen
PREREQUISITES	Curriculum: Linear Algebra, Functional Analysis, Mathematical Software Competencies: basic knowledge of Linear Algebra as well as familiarity with Differential and Integral Calculus are essential; basic knowledge of Computer Programming would be helpful Language: advanced level of English

A GENERAL AND COURSE-SPECIFIC COMPETENCES

General competences:

- ✓ Having a responsible attitude towards scientific research and teaching, being able to fully develop the personal potential in the professional career, respecting the principles of a rigorous and efficient work in order to fulfill complex tasks, respecting the ethical norms and principles in the professional activity
- ✓ Being able to make a selection of information resources and to use them efficiently, in order to develop the professional activity and adapt it to the demands of a dynamical society

Course-specific competences:

- ✓ Manipulating notions, methods and mathematical models, specific techniques and technologies in scientific calculus and applications in economy and informatics
- ✓ Data processing, analysis and interpretation using mathematical, statistical and informatics tools
- ✓ Being able to develop, test and validate algorithms; implementation in high level programming languages
- ✓ Being able to construct and apply mathematical models for analysing and simulating certain phenomena and processes
- ✓ Being able to develop, analyse and test computer systems and specific programming languages; being able to use them for solving problems in applied mathematics

B LEARNING OUTCOMES

- ✓ Familiarize students with the main algorithms in numerical linear algebra and for the numerical solution of nonlinear equations. Provide students with knowledge of advanced numerical methods that solve certain representative classes of computational problems with a high degree of complexity, problems that by their very nature cannot be solved using only pencil and paper
- ✓ Application of these general methods and techniques to solve specific problems, using a computer equipped with the MATLAB programming environment
- ✓ After successfully completing this course, the students will be able to:
  - ✧ know the practical motivation behind the problems investigated and to understand the associated mathematical models

	✧ to explain the theoretical foundations on which the algorithms presented in the course rely ✧ to prove the correctness of the algorithms ✧ to analyse the stability, accuracy and complexity of the algorithms used ✧ to adapt the general algorithms presented in the course to concrete examples and effectively get the numerical results ✧ to creatively use MATLAB functions, programming facilities and data representation tools
C	**LECTURE CONTENT**
	1. Introduction. Motivation. The MATLAB working environment. Computer representation of real numbers. Computational costs 2. Fundamentals of matrix analysis (vector norms and induced matrix norms, the condition number of a matrix, perturbation analysis for linear systems) 3. Direct methods for solving linear systems (Gaussian elimination, the role of pivoting, the LU factorization of matrices, the Cholesky factorization of SPD matrices) 4. Iterative methods for solving linear systems (general setting, Jacobi's method, Gauss-Seidel's method, sufficient conditions for convergence) 5. Numerical methods for finding eigenvalues and eigenvectors (general setting, the power method) 6. Numerical methods for solving nonlinear equations (Newton's method, fixed point algorithms, Banach's theorem, Ostrowski's theorem, other convergence results)
D	**RECOMMENDED READING FOR LECTURES**
	1. A. Quarteroni, F. Saleri, P. Gervasio, *Scientific Computing with MATLAB and Octave*, 3rd edn., Springer, 2003 2. A. Quarteroni, R. Sacco, F. Saleri, *Numerical Mathematics*, 2nd edn., Springer, 2007 3. Ph. Ciarlet, *Introduction to Numerical Linear Algebra and Optimisation*, CUP, 1989 4. B. Dumitrescu, C. Popeea, B. Jora, *Metode de Calcul Numeric Matriceal. Algoritmi Fundamentali,* Editura All, 1998 5. E. Isaacson, H. Keller, *Analysis of Numerical Methods*, Wiley,1966 6. D. Higham, N. Higham, *Matlab Guide*, 2nd edn., SIAM, 2005
E	**SEMINAR CONTENT**
	1. Introduction. Motivation. The MATLAB working environment. Computer representation of real numbers. Computational costs 2. Fundamentals of matrix analysis (vector norms and induced matrix norms, the condition number of a matrix, perturbation analysis for linear systems) 3. Direct methods for solving linear systems (Gaussian elimination, the role of pivoting, the LU factorization of matrices, the Cholesky factorization of SPD matrices) 4. Iterative methods for solving linear systems (general setting, Jacobi's method, Gauss-Seidel's method, sufficient conditions for convergence) 5. Numerical methods for finding eigenvalues and eigenvectors (general setting, the power method) 6. Numerical methods for solving nonlinear equations (Newton's method, fixed point algorithms, Banach's theorem, Ostrowski's theorem, other convergence results)
F	**RECOMMENDED READING FOR SEMINARS**
	1. A. Quarteroni, F. Saleri, P. Gervasio, *Scientific Computing with MATLAB and Octave*, 3rd edn., Springer, 2003 2. A. Quarteroni, R. Sacco, F. Saleri, *Numerical Mathematics*, 2nd edn., Springer, 2007 3. Ph. Ciarlet, *Introduction to Numerical Linear Algebra and Optimisation*, CUP, 1989 4. B. Dumitrescu, C. Popeea, B. Jora, *Metode de Calcul Numeric Matriceal. Algoritmi Fundamentali,* Editura All, 1998 5. E. Isaacson, H. Keller, *Analysis of Numerical Methods*, Wiley,1966 6. D. Higham, N. Higham, *Matlab Guide*, 2nd edn., SIAM, 2005
G	**EDUCATION STYLE**

LEARNING AND TEACHING METHODS	Lectures: lecture, dialogue, proof Seminars/laboratory: exercises, dialogue, PC simulations
ASSESSMENT METHODS	Course: weight in the final grade 50% (written/oral examination) Laboratory: weight in the final grade 50% (practical examination, computer-aided numerical resolution of problems)

	Minimal requirements: 1. Familiarity with the fundamental concepts and the main theoretical results. Knowledge of the theoretical foundations of the methods used to treat the classes of problems under investigation. Understanding of the issues related to the accuracy, stability and computational cost of the algorithms. 2. Ability to solve the simplest numerical problems by applying without modification the algorithms presented in the course. The ability to adapt the general algorithms introduced in the course in order to address concrete situations present in the exercises. A good knowledge of the relevant MATLAB functions. The ability to handle numerical errors in order to get accurate numerical solutions to the proposed problems. The ability to improve the code or to modify the presentation format of the data. 3. Understanding of the role played by the main MATLAB functions occurring in the algorithms used. 4. Minimum grade 5
LANGUAGE OF INSTRUCTION	English