Program	Type of studies (cycle)	Third cycle
	Name of the program	Doctoral Studies in Mathematical and Computer Science

Course

Course title	**Numerical Methods for Solving Linear and Nonlinear Eigenvalue Problems**

Course code	Semester	Course status	ECTS credits	Contact hours
AMAT625	II	Elective	10	30

Aims and intended learning outcomes	The main objective of the course is to familiarize students with the fundamental concepts, theories, and methods related to linear and nonlinear eigenvalue problems. Throughout the course, doctoral students develop the ability to determine and analyze eigenvalues and eigenvectors, understand their role in various mathematical models, and apply appropriate numerical methods to solve these problems. Particular emphasis is placed on practical applications in mathematics, physics, engineering, and computer science. This emphasis on applications is well justified, as the modeling of physical and engineering processes often leads to ordinary differential equations, systems of differential equations, and partial differential equations, which in turn give rise to eigenvalue problems. Eigenvalue problems represent one of the fundamental and most important topics in modern mathematics.

Course content/topics

- Linear Eigenvalue Problems
  Nonsymmetric Case
  Power Method (Mises Iteration); Inverse Iteration; Deflation ; Subspace Iteration QR Algorithm; Acceleration of the QR Algorithm Using Shifts; QZ Algorithm for the Generalized Eigenvalue Problem
  Symmetric Case
  QR Algorithm, Bisection (Based on Sylvester's Law of Inertia), Rayleigh Quotient Iteration, Divide-and-Conquer Method, Jacobi Method, Singular Value Decomposition (SVD), Generalized Symmetric Eigenvalue Problem
  Structured Matrices and Their Eigenvalue Problems
  Applications of Linear Eigenvalue Problems in Physics and Engineering
- Nonlinear Eigenvalue Problems
  Linearization
  Variational Characterization (Min–Max Principle)
  Sylvester's Law of Inertia for Nonlinear Eigenvalue Problems
  Arnoldi Method for Nonlinear Eigenvalue Problems
  Jacobi–Davidson-Type Projection Methods for Nonlinear Eigenvalue Problems
  Special Focus on Quadratic Eigenvalue Problems
  Applications of Nonlinear Eigenvalue Problems

LITERATURE

[1] B.N. Parlett: The Symmetric Eigenvalue Problem. SIAM, Classics in Applied Mathematics 20, Philadelphia, 1998

[2] Heinrich Voss Fundamentals of Numerical Mathematics, lecture notes, TUHH

[3] H. Voss Nonlinear Eigenvalue Problems Handbook of Linear Algebra. Chapman & Hall/CRC, FL,]

[4] F. Tisseur, K. Meerbergen The quadratic eigenvalue problem SIAM Review, 43 (2001), pp. 235-286

[5] Aleksandra Kostić, Heinrich Voss On Sylvester's law of inertia for nonlinear eigenvalue problems. ETNA 40, 82 – 93 (2013)

Grading

	Criterion	Points	Cut-off points
1.	Written assignment	20	10
2.	Project	30	20
3	Final exam	50	25
	Total	100	55