



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Numerical Linear Algebra

2122-1-F4001Q114

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#### Aims

Consistently with the educational objectives of the Master Degree in Mathematics, the course aims at providing the *knowledge* about the advanced iterative methods for solving linear systems. Skills to understand the computational difficulties typical in the resolution of large linear systems and skills to handle the techniques of analysis of the most innovative iterative methods will be provided, so that the student will acquire those *abilities* useful in facing the choice of a suitable solver in practical problems.

#### Contents

Advanced iterative methods proposed in literature are studied and their application to the solution of linear systems arising in the discretization of PDEs and IEs is considered.

#### Detailed program

- Krylov methods for symmetric and non-symmetric linear systems.
- Spectral analysis and preconditioning techniques.
- Geometrical and algebraic Multigrid methods.
- Singular value decomposition and its applications.
- Fast Transforms.
  
- Application to linear systems arising in the approximation of PDEs and IEs: (convection)-diffusion equations e Image deblurring.

## Prerequisites

Basic courses of the degree in Mathematics (Mathematical Analysis I and II, Linear Algebra, Introduction to Numerical Analysis) and Approximation of Differential Equation, even if not mandatory.

## Teaching form

Standard blackboard lessons and computer practice labs in Matlab (8 CFU).

## Textbook and teaching resource

- S. C. Brenner, L. R. Scott. *The mathematical theory of finite element methods. Third edition.* Texts in Applied Mathematics, 15. Springer, New York, 2008.
- G. H. Golub, C. F. Van Loan. *Matrix computations. Third edition.* Johns Hopkins Studies in the Mathematical Sciences. Johns Hopkins University Press, Baltimore, MD, 1996.
- A. Greenbaum. *Iterative methods for solving linear systems.* Frontiers in Applied Mathematics, 17. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 1997.
- P. C. Hansen, J. G. Nagy, D. P. O'Leary, *Deblurring Images: Matrices, Spectra, and Filtering*, SIAM, 2006.
- Y. Saad. *Iterative methods for sparse linear systems. Second edition.* Society for Industrial and Applied Mathematics, Philadelphia, PA, 2003.
- U. Trottenberg, C. W. Oosterlee, A. Schüller. *Multigrid. With contributions by A. Brandt, P. Oswald and K. Stüben.* Academic Press, Inc., San Diego, CA, 2001.

## Semester

Second semester.

## Assessment method

Written individual project, chosen among two possible projects proposed at the end of the course and to be discussed during the oral examination, and oral examination.

The written project evaluates student's skills in solving problems by using theoretical tools and Matlab codes developed during the course. The original development of the project is encouraged according to personal curiosity and interests.

The oral examination consists in discussing the written project and in a second part where the knowledge and the ability to critically expose the studied arguments and computational techniques is evaluated in order to verify if the student has acquired the critical and operational knowledge of the definitions, methods and results presented during the course.

Mark is out of thirty. The student needs to reach at least 18/30 in both parts to pass the exam. the final mark is the average of the two partial marks. The project with at least 18/30 mark is still valid if the oral test is repeated.

There will be 5 exam sessions (in June, July, September, January, February).

### **Office hours**

By appointment.

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