**NUMERICAL METHODS**

Bergamaschi Luca / Franceschini Andrea

**Program:**

**Iterative methods for large linear and nonlinear systems.**

Sparse matrices. Preliminaries on iterative methods. The method of the steepest descent. The Conjugate Gradient method. Convergence theory. Acceleration of iterative methods by preconditioning. Krylov subspace methods. The GMRES method. Practical implementations.

Iterative solution of large systems of nonlinear equations: The Newton method and its variants. Local convergence, hints to global convergence. Inexact Newton methods. Quasi-Newton methods.

**Introduction to Finite Elements for elliptic and parabolic equations.**

Remarks of functional analysis. Second order partial differential equations (PDEs): elliptic, parabolic, and hyperbolic equations. Boundary and initial conditions. Variational methods: Galerkin methods and weak formulations. Time integration for parabolic PDEs. Finite elements: 1D Lagrangian elements, extensions to 2D and 3D, triangular finite elements. Finite element solution of Poisson's equation and diffusion equation.

**References:**


1. Y. Saad: Iterative methods for sparse linear systems, SIAM, 2003
2. C.T. Kelley. *Iterative methods for linear and nonlinear equations, SIAM, 1987*
3. A. Quarteroni: *Numerical models for differential problems*, Springer (2014).
4. O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu: *The finite element method: its basis and fundamentals*, Butterworth-Heinemann 2005).


**Examination and grading:**

Implementation of a finite element code - which makes use of an iterative solver - in the preferred coding language to solve a problem. The problem can be proposed by the student or provided by the teacher. The final grading is based on a relation describing the code.

**Course details:**

The course will be offered in-person (online attendance allowed).