

**School on Numerical Methods**  
**IMCA, 1- 10 July 2015**  
**Numerical Methods for Partial Differential Equations**

Lecturer: E. Carlini  
Dip. Matematica, Sapienza Università di Roma

**Elliptic linear problems**

Recall of boundary problems for second order linear equations: classical solutions, maximum principle, variational formulation in Sobolev spaces. Finite difference schemes for Poisson equation, discrete maximum principle and convergence analysis. The Galerkin method for the approximation of variational problems. Lagrange finite elements. Interpolation theory in Sobolev spaces, convergence theorems and error estimates for the finite element approximation method, computational aspects and comparison with the finite difference approach. Numerical analysis of elliptic problems with a dominant transport (or reaction) term and their resolution with finite difference or finite element techniques. Up-wind type schemes and artificial diffusion. Some notes on stabilization methods for finite element schemes in advection-diffusion problems.

**Parabolic linear problems**

Recall of classical results and variational formulation for linear parabolic problems. Finite difference schemes for the heat equation, consistency error and stability estimate. A semi-discretization approach based on finite elements in space and finite differences in time (theta method), stability and convergence theorems, remarks on implementation.

**Nonlinear problems: Hamilton-Jacobi equations**

Recall of essential results of existence and uniqueness for viscosity solutions. Finite difference and Semi-Lagrangian schemes. Consistency, stability and convergence analysis

Computer sections will be organized by the use of Free Fem.

**References**

1. A. Quarteroni, *Modellistica numerica per problemi differenziali*, Springer, 2000
2. J.C. Strickwerda, *Finite Difference Schemes and PDE*, Wadsworth & Brooks/Cole, Pacific Gr., 1989
3. A. Quarteroni - A. Valli, *Numerical Approximation of Partial Differential Equations*, Springer, 1994