UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Advanced Numerical Methods for Partial Differential Equations

2223-1-F4001Q104

Aims

In line with the educational objectives of the Master Degree in Mathematics, the course aims at providing knowledge on some important advanced aspects of the finite element method, building a strong theoretical basis but also a good critical sense for applications. It will also build the skills needed to understand, analyse and compare the different methods, in addition to implementing and using them in the computer.

Contents

This course is about the approximation of problems in partial differential equations through the finite element method, and can be considered a second and more advanced stage of the course "Approximation of Partial Differential Equations". In particular, the course will treat important topics such as time dependent problems and problems in mixed form, that play a key role in many applications (such as fluidodynamics). Part of the course will be in the computer lab (MATLAB).

Detailed program

Brief review of the fundamental notions of the finite element method and main results for standard elliptic problems. The (non-stationary) heat diffusion problem, discretization in time and space, theoretical analysis of the method, implementation in MATLAB. A posteriori error analysis in the stationary case, theoretical analysis, implementation, adaptive algorithm. Problems in mixed form, Stokes as a model problem, discretization and difficulties, general theory of mixed methods, implementation. Diffusion in mixed form, theoretical analysis, implementation. Possible additional topics, such as the Navier-Stokes problem, will be treated at the end of the course.

Prerequisites

Basic notions of functional analysis are needed. It is moreover required to have followed the course "Numerical Methods for Partial Differential Equations". The course will have a strong theoretical component.

Teaching form

Standard blackboard lessons and computer practice labs.

Textbook and teaching resource

- D. Braess, “Finite Elements: theory, fast solvers, and applications in solid mechanics”, Cambridge University Press (alternative: P.Ciarlet “The finite element method for elliptic problems” oppure S.Brenner e R.Scott, “The mathematical theory of finite element methods”)
- D. Boffi, F. Brezzi, M. Fortin, “Mixed finite element methods and applications”, Springer
- V. Thomee, “Galerkin Finite Element Methods for Parabolic Problems”, Springer

Semester

First semester.

Assessment method

The exam is an oral examination, and is divided into two parts. In the first part, the student presents a matlab laboratory project, that the student choses among some projects proposed by the teacher at the end of the course. The students can work in groups of 1-3 members for the development of the project (is thus allowed to work individually or as a team, but the discussion will be anyway personal). The second part of the examination is an evaluation of the critical and operational knowledge of the definitions, results and proofs presented during the course. There relative weight of the two parts, project and theory, is roughly 40% and 60%, respectively.

Office hours

Email appointment.

Sustainable Development Goals