UNIVERSITA' DI PAVIA

**DOTTORATO DI RICERCA IN INGEGNERIA**
**ELETTRONICA, INFORMATICA ED ELETTRICA**

# Introduction to Inverse Problems in Electromagnetism

(14 Nov.–5 Dic. 2008, 10 hours –> 2 + 1 CFU)

**Instructor**
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**Description and goals of the course**
The course, which is mainly addressed to PhD students in engineering science, provides an introduction to the most common methods of automated optimal design used in computational electromagnetism.
At the end of this course, a student should be able to:
1. formulate a design problem as an inverse problem, and select an appropriate field model to solve the associated direct problem;
2. define properly design variables, objective function, constraints;
3. select a numerical procedure for field analysis and objective function minimisation.

**Programme**

Direct problems
1. Distributed-parameter systems
2. Differential formulation (Laplace-Poisson's equation)
3. Integral formulation (Fredholm's equation of the first kind)

Inverse problems
1. History of inverse problems
2. Classification of inverse problems
3. Insidiousness of inverse (and direct) problems: one, no, infinite solutions

Matrices and linear systems of equations
1. Quasi-solution of an over-determined (or under-determined) system
2. Singular-value decomposition, regularization

Solution of an inverse problem by minimising a functional
1. Minimisation methods
2. Deterministic and stochastic algorithms
3. Scalar and vector minimisation

Case studies
1. Synthesis of the magnetic field along the axis of a solenoid
2. Identification of the B-H curve of a ferromagnetic material
3. Optimal shape design of an antenna for magnetic induction tomography
4. Optimal shape design of a magnetic levitator for high-temperature superconductors

**Prerequisites**
Elementary electromagnetism, basic vector analysis and fundamentals of numerical analysis are assumed to be known subjects.

**Reference textbooks**
P. Di Barba, A. Savini, S. Wiak: Field Models in Electricity and Magnetism. Springer, 2008.
P. Neittaanmaki, M. Rudnicki, A. Savini: Inverse Problems and Optimal Design in Electricity and Magnetism. Clarendon Press, 1996.

**Examination**
Oral presentation and discussion of one of the topics of the course.