Texas Tech University, Department of Mathematics and Statistics

COURSE SERIES ANNOUNCEMENT

TOPICS IN NUMERICAL ANALYSIS I-II

MATH 5344-5345, Fall 2015-Spring 2016

Instructor: Dr. Giorgio Bornia (giorgio.bornia@ttu.edu)
http://www.math.ttu.edu/∼gbornia

This two-semester series provides the students with the necessary ingredients to perform research in the fields of **Numerical Analysis of Partial Differential Equations** and **Scientific Computing**.

Partial Differential Equations (PDEs) are a privileged mathematical tool to describe real-life phenomena in several fields. Far from being exhaustive, one can mention fluid dynamics, structural mechanics, electromagnetism, chemistry and biology.

Students will learn to

- formulate numerical discretizations of PDEs;
- analyze finite element approximations and their theoretical convergence properties;
- implement algorithms using cutting-edge open-source software;
- perform software development in a collaborative way using version control systems.

Emphasis will be given to both **theoretical** and **practical** aspects. Students will be guided in a hands-on approach to the solution of challenging numerical problems with advanced algorithms, strongly motivated by theoretical results. To this end, classes will be held in the computer Lab.

Due to the generality and abstraction of the ideas and methodologies under discussion, this special topics series can serve the purposes of all graduate students in both applied and pure mathematics, as well as engineering and science.

Tentative list of topics

Numerical analysis of PDEs

- Overview of numerical methods for PDE
- Introduction to the finite element method. Variational formulation of elliptic problems
- Construction of a finite element space
- Finite element multigrid methods. Domain decomposition methods
- Variational crimes. Mixed finite element methods
- Optimal control

Scientific Computing

- Computer hardware; operating systems. Linux kernel, Linux distributions
- Programming languages: paradigms, typing disciplines, implementation
- C++ as a descendant of C. Types of variables, operators, functions
- Structures and classes: encapsulation; constructors and destructors
- Polymorphism: inheritance, operator overloading, templates
- Software development: integrated enviroments, build systems
- Simulation pre- and post- processing: mesh generation, visualization
- Programming practices. Version control systems
- Error detection: debugging, profiling
- Software testing, continuous integration systems
- Parallel computing: shared memory and distributed memory paradigms. HPC facilities
- Nonlinear problems: automatic differentiation

Attendance is mandatory. The exam consists in the discussion of an individual project.
Prerequisites: MATH 5334-5335, or departmental approval.