GRADUATE COURSE
Spring 2009

ES516: <u>Spectral Methods</u> (3-0) 3

Prerequisite : Instructor's Consent.

This course is about one of the big three technologies for the numerical solution of DEs as follows:

    1950s: Finite Difference Methods
   1960s: Finite Element Methods
    1970s: Spectral Methods.

If one wants to <u>solve an ODE or PDE to high accuracy</u>, and if the data defining the problem are smooth, then spectral methods are usually the best tool.

<u>For example</u>, consider the variable coefficient wave equation

$$u_t + c(x)u_x = 0, \quad \text{for } x \in [\,0, 2\pi\,], \ t > 0 \quad \text{where } c(x) = 1/5 + \sin^2(x-1)$$

with periodic boundary conditions and initial condition $u(x,0) = \exp(-100(x-1)^2)$. In the following figures, we compare the numerical solutions obtained by applying two methods at the <u>same spatial and temporal resolution</u>. The wave remains coherent and clear with no ripples in the case of spectral method indicating the high accuracy obtained.

Spectral Method

Finite Difference Method
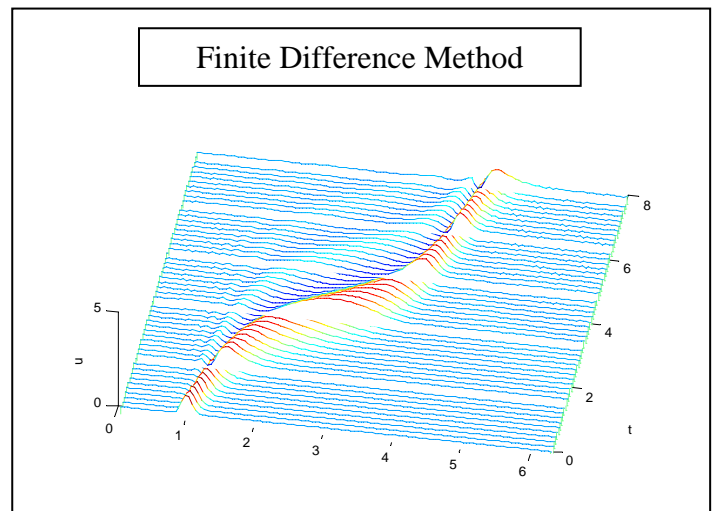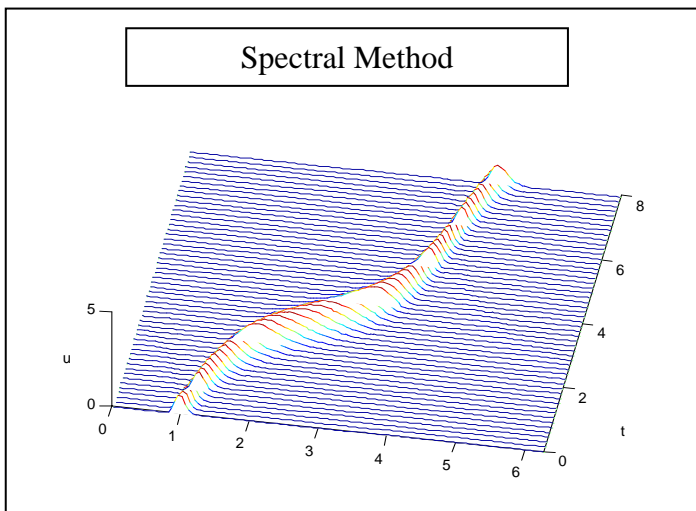
This course will present some of the fundamental ideas and techniques of spectral methods. The emphasis is on spectral collocation ("pseudospectral") methods. The teaching teachnique will be based on <u>problem solving</u>. There will be many examples and case studies drawn from various fields.

MATLAB will be the <u>main computational tool</u> throughout the course. With this tool, one can present advanced numerical algorithms and solutions of nontrivial problems in complete detail with great brevity. This course will be <u>a good opportunity</u> to get acquainted with and get fluent in MATLAB.

Topics List

- Fourier - Spectral Differentiation
- Chebyshev - Spectral Differentiation
- Boundary Value Problems
- Initial Value Problems

- Polar Coordinates
- Unbounded Domains
- Iteration and Preconditioning
- Spectral Element Method

Main Text : Spectral methods in MATLAB by Lloyd N. Trefethen.

First Meeting : Feb. 24, Tuesday / 09:40 / MM 321.

Instructor	:	Hakan I. Tarman
Office	:	MM905
Phone	:	210-2385
e-mail	:	tarman@metu.edu.tr