

## **CE 49E NUMERICAL MODELING IN CIVIL ENGINEERING**

Elective Course

**Spring 2009**

**Instructor:** Name: Osman S. Börekçi

Office Hours: M T W 7

Office No.: M 3145

**Course Data:** Hours: M 6, Th 7-8

Room: VYM 4

### **Course Description :**

#### **CE 49E Numerical Modeling in Civil Engineering**

(3+0+0)3

Numerical modeling; numerical experimentation; classical and modern methods; mathematics review; radial basis functions (RBFs); collocation using RBFs; interpolation using RBFs; the unsymmetrical RBF collocation method (RBFCM), solution of ordinary differential equations; solution of linear partial differential equations (Laplace, Poisson, Helmholtz); solution of nonlinear partial differential equations (Burger); methods of time integration; single step, multiple step and predictor corrector methods; solution of transient partial differential equations (convection-diffusion); symmetrical RBFCM, augmented RBFs; RBFCM with additional PDE collocation on the boundary; problems with moving boundaries.

**Prerequisite:** MATH 202, CMPE 100 or approved equivalents.

#### **Course Objectives (Learning Outcomes):**

To introduce students to the role of numerical modeling and experimentation in modern engineering.

To enable students to put to use their training in mathematics and computer programming.

To provide those students planning on graduate work in engineering with a computational tool.

#### **Textbook: (Lecture Notes)**

Börekçi, O.S., "The Radial Basis Function Collocation Method: A Meshless Method for the Solution of Boundary Value Problems", Lecture Notes, 2005.

#### **Reference Books:**

Chen, C.S., Hon, Y.C., Schabak, R.A., "Scientific Computing with Radial Basis Functions", Draft, Version 0.0, 2004.

#### **Curricular Context**

This elective course promotes the usage of fundamental mathematics, computation and science topics to solve engineering problems. Design content 0%.

#### **Laboratory and Computer Usage:**

Computer usage is required for model development and for report writing.

#### **Class Policies:**

The term grade is based entirely on assignments (7 equally weighted assignments)

#### **Contribution of the Course to Program Outcomes:**

(a) An ability to apply knowledge of mathematics, science and engineering

(e) An ability to identify, formulate and solve engineering problems

(k) An ability to use the techniques, skills and modern engineering tools necessary for engineering practice

#### **Course Assessment:**

Course will be assessed on the basis of the accomplishments regarding the course objectives and the contributions to the program outcomes. The evaluation will consist mainly of the responses from the students, who will provide their comments to various course related questions in the final week of the semester.

<b>Week</b>	<b>Topic</b>	<b>Reading</b>	<b>Assignment</b>
1	Introduction: The modern scientific method, the roles of numerical modeling and numerical experimentation; classical and modern methods, meshless methods.		
2	Mathematics review : Indicial notation, ODE's and PDE's, boundary conditions, initial conditions, types of errors, estimation of errors.	Related handouts	
3	Radial basis functions, types of RBFs, derivatives of RBFs, the unsymmetrical radial basis function collocation method (RBFCM), curve fitting and interpolation using RBFCM, example problem.	Lecture Notes Chapter 1	Assignment #1
4	Solution of ode's using the unsymmetrical RBFCM, catenaries; example problem		Assignment #2
5	Solution of linear PDEs: Laplace and Poisson equations; Laplace equation benchmark problem (inviscid flow between parallel plates); Helmholtz equation.	Lecture Notes Chapter 2	Assignment #3
6	Solution of nonlinear equations; linearization of equations; steady Burger's equation.	Lecture Notes Chapter 2	
7	Methods of time integration: Euler, Heun, Runge-Kutta , Adams-Bashforth and Milne-Hamming methods	Lecture Notes Chapter 2	Assignment #4
8	The unsteady convection-diffusion equation; boundary/initial conditions; Peclet number; discussion of methods of solution.	Lecture Notes Chapter 2	
9	Symmetrical RBFCM : development of the method; the Laplace equation benchmark revisited.	Related handouts	Assignment #5
10	The need for augmented RBFs, Pascal's triangle; polynomial augmentation; global sine and cosine augmentation, details of the implementation; symmetrical RBFCM with augmented RBFs; the Laplace equation benchmark revisited.	Related handouts	
11	RBFCM with additional PDE collocation on the boundary; example problem; the Laplace equation benchmark revisited.	Related handouts	Assignment #6
12	Comparison and discussion of methods studied and difficulties encountered in modeling.		
13	A problem with a moving boundary: surface wave propagation; locating the phreatic surface in groundwater problems.	Related handouts	Assignment #7