TAM 470 / CSE 450: Computational Mechanics
Fall 2016; 1:00 MWF, MEB 218
Prerequisites: {Math 385, Math 386, or Math 441}; CS 101

Goals: By the end of the semester, students should understand some of the more common BVP discretizations (FD/FEM/SEM) and common IVP discretizations (EF/EB, CN, ABk, BDFk, RK). They should be able to identify sources of error and instability, and be able to estimate computational costs/feasibility for these schemes. Finally, they should be able write and test (!) code to solve PDEs relevant to mechanics.

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Office Hours: Tuesday, 2-3, 4320 Seibel Center
Thursday, 11-12, 4320 Siebel Center

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Office Hours: Monday, 3-4, Rm. 404 Grainger Library
Friday, 2-3, Rm. 404 Grainger Library

Course Web Site: http://web.engr.illinois.edu/∼fischerp/tam470/
(Homework will be posted here.)

Text: P. Moin, *Fundamentals of Engineering Numerical Analysis, 2nd E.*, Cambridge, 2010.
Additional notes will be posted online.

Grading: Your course grade will be based on your performace on homework, two one-hour exams, and a final exam. The exams will be open book. The course grade will be determined as follows:

- **50% Homework**
- **30% In-class exams (2)**
- **20% Final exam**

The homework assignments will include programming exercises and will be due every two weeks. Students may choose an appropriate language for the homework assignments (Matlab, Python, Fortran, C, etc.). Examples and helpful routines will be provided in Matlab. The first assignment will be posted Wednesday, August 24, and due **Wednesday, September 7.**

Reference Materials:

- W.H. Press *et al.*, *Numerical Recipes* (Fortran, C, C++), Cambridge.
- W. Gautschi, *Numerical Analysis, an Introduction*, Birkhauser Boston, 1997.
- Deville, Fischer, and Mund, *High Order Methods for Fluid Flow*, Cambridge, 2002.

Schedule – TAM 470 Fall 2016 **P. Fischer**

Each topic is expected to cover approximately 3–4 lectures. The last topics will be subject to availability in the schedule.

1.
   - Overview: Computational Mechanics and Modeling
   - Interpolation (*Chapter 1.*): 1D/2D/splines

2.
   - Differentiation (*Chapter 2.*)
   - Differentiation in $\mathbb{R}^d$, d=1, 2, 3.

3.
   - Integration: trapezoid, Romberg (*Chapter 3.*)
   - Gauss quadrature & orthogonal polynomials
   - Integration in $\mathbb{R}^d$, d=1, 2, 3.
   - Adams-Bashforth

4.
   - Initial Value Problems (*Chapter 4.*)
   - Accuracy; stability diagrams; high-order

5.
   - Spring-mass systems; particle tracking; 1D Heat Eqn (IVP/BVP); 1D Advection equation (FD/spectral)

6.
   - Boundary Value Problems (*Chapter 5.*)
   - Finite differences in $\mathbb{R}^d$; Kronecker product rules; Spectral Galerkin.

7.
   - Slider bearing example.
   - Fast solvers, iterative methods, multigrid.

8.
   - Finite element method
   - Basis functions, matrix assembly, solution.

9.
   - Fourier methods (*Chapter 6.*)
   - Costs/Accuracy; History of FFTs at U of I.

10.
   - Unsteady advection-diffusion in R^2
   - Anisotropic diffusion
   - Navier-Stokes

- **In class Exam I: Wednesday, 10/5/16.**
- **In class Exam II: Wednesday, 11/16/16.**