ENME 674
Finite Element Methods

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Course Objectives: This course is directed towards early graduate-level engineering students and advanced undergraduate students. We will learn the basics of how to model engineering problems using differential equations and then solve those equations on computers using the Finite Element Method. Nearly all engineering problems can be modeled with differential equations. Thus the understanding of how solutions to such equations can be obtained with FEM can be used in very powerful ways. We will cover a) the background of FEM and b) the techniques for translating that knowledge into computer code. Students will be required to have undergraduate experience in an engineering field and basic knowledge of matrix-vector arithmetic. Some exposure to partial differential equations and experience with Matlab or a compiled language will be helpful but are not required. Software training or the use of commercial FE software products is not a focus.

Grading: 20% Midterm Exam, 60% Homework Assignments, 20% Final Exam

Recitations: Extra recitation sessions may be offered during the semester as needed.

Topics Covered:

1. Continuum Mechanics
Governing equations for stress analysis, fluid flow, and/or heat & mass transfer. Variational principles, the principle of virtual work, weak form, method of weighted residuals

2. Finite Element Method
Uniaxial bar problem, Direct Method, shape functions, quadrature, strong & weak forms, construction of element stiffness matrix and force vector, global matrix and vector assembly

3. Mathematical Concepts
Partial differential equations (elliptic, parabolic, hyperbolic), variational methods, error estimation, convergence

4. Two and Three Dimensional Solids
Isoparametric formulation, shape functions, numerical integration, calculating stress & strain, boundary conditions and constraints, determination of displacement and stress, axial symmetry, generalized plane elements

5. Flexural Problems
Beam and plate elements (4^{th} order BVP), C1 shape functions, shear-deformable beams and plates: shear locking, solid shell elements

6. Transient Problems: Structural Dynamics and Initial Value Problems
Time integration, algorithm stability, consistent mass matrix, damping matrix, eigenvalue problems, modal superposition

7. Structural Stability
Columns/shells under compressive load, linearized buckling analysis

8. Other Topics

Non-linearity, heat & mass transfer, fluid mechanics and acoustics, electromagnetics, nanomechanics & quasicontinua

Term Project: The goal of the term project is to offer an opportunity to exercise the concepts of the course through the development of a finite element computer code. Students will be provided with an incomplete or partially complete computer code and will be expected to use the principles covered in the course to develop a functioning code, verify the results, and document the approach and findings through a final report. Further details for the Term Project will be provided.

Homework: Weekly homework exercises will be assigned. Assignments will be submitted using GRADESCOPE.

Teamwork: Discussions are allowed on the homeworks and project, but not for exams. When permitted, you are encouraged to discuss, debate or work through any problems in the homework or project with your colleagues. However, each student is still responsible for **independently** preparing and submitting their own work. Thus sharing of data or figures is not allowed. Collaborations with any source must be fully acknowledged on your assignment.

Exams: One midterm and one final exam will be administered. Exams are expected to be completed **entirely** on your own without any external help except as defined prior to the exam.

COURSE POLICIES:

- **HTTP://WWW.UGST.UMD.EDU/COURSERELATEDPOLICIES.HTML**

Texts: TBD.

Supporting References:

Materials used in the lectures, homework, or exams come from many sources. A partial list of these sources includes:

1. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, Inc., New York, 2000.
2. O. C. Zienkewicz and R. L. Taylor, The Finite Element Method: Fourth Edition, Vols 1 and 2, McGraw-Hill, London, 1994.
3. J. N. Reddy, An Introduction to the Finite Element Method, McGraw-Hill, New York, 1993.
4. K. J. Bathe, Finite Element Procedures, Prentice Hall, New Jersey, 1996.
5. J. L. Volakis, A. Chatterjee, L. C. Kempel, Finite Element Method for Electromagnetics, Wiley-Interscience, 1998.
6. R. D. Cook et al., Concepts and Applications of Finite Element Analysis, John Wiley, 2001.

Academic Integrity:

The University of Maryland, College Park has a nationally recognized code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduates and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be *aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information, please visit http://www.shc.umd.edu/.*

The University has approved a Code of Academic Integrity available on the web at http://www.testudo.umd.edu/soc/dishonesty.html. The Code prohibits students from cheating on exams, plagiarizing papers, forging signatures, etc.

The University Senate requires that students sign this statement if it is included on an exam or assignment:

> *"I pledge on my honor that I have not given or received any unauthorized assistance on this examination (or assignment)."*