MAE671 Finite Element Analysis Spring 2008

Instructor:

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Office Hours:

By appointment via e-mail, or anytime I am in my office with the door open.

Objectives:

The principle objectives of this course are: 1) to develop a fundamental understanding of the key elements of continuum analysis, 2) to demonstrate how these key elements are incorporated into finite element framework, and 3) to outline key considerations for building and evaluating finite element models.

Content:

Elements of elasticity, intermediate applied mechanics including variational calculate, the principal of virtual work, and energy approaches. The emphasis is on displacement-based finite element analysis, and includes details of element formulation, shape/interpolation functions, numerical integration, symmetry conditions, constraints, and non-linear solutions.

Recommended Text:

Concepts and Applications of Finite Element Analysis, by Robert D. Cook, David S. Malkus, Michael E. Plesha, and Robert J. Witt, John Wiley and Sons, Inc., ISBN 0-471-35605.

Grading:

Homeworks:	20%
Midterm Exam:	35%
Final Exam:	45%

Homework assignments:

1. Assignments will be a combination of analytical solutions and computer analyses (FEA); students may feel free to use any finite element package they are comfortable with provided the code offers the technical capability needed for the assignment. **Input decks and consulting expertise will be available using ABAQUS.**
2. Finite element analysis input decks (or Matlab code) should be included in reports as an appendix; ***these should be considerably reduced to include only the essential elements of the model.*** I.e., do not include all 10,000 element definitions and 20,000 node definitions. You should make sure analysis types and assumptions are clearly identified: for example, whether or not non-linear geometry effects are included in the analysis.
3. Homework is not pledged, but should never be copied. Students may consult each other and share ideas in development of homework solutions, but each student must complete his/her own homework primarily independently.
4. A due date will be given when homework is assigned. Late homework will be docked 10% for each fraction of a business day that it is lat
6. Homework should be neatly organized, with the answers to problems summarized at the appropriate locations. Students should regard homework problems as professional presentations. Sufficient detail must be included to permit satisfactory evaluation of student performance, but excessive detail should be avoided.

Tests:

All tests and examinations will be administered under the University of Virginia honor system. Students will be assumed to be familiar with the honor system, and will be bound by it. The honor system is a very important attribute of the University of Virginia, but only works if the concept of honor is taken seriously by all involved. Tests will be closed notes, closed book.

Extra credit:

A semester project is optional and will be graded for extra credit: the amount of credit with depend on the scope, completeness, and added understanding of FEA that the project generates for each individual. Students are strongly encourage to identify projects that are strongly aligned with their individual research focus: this is an excellent opportunity to receive free consulting regarding a numerical analysis of direct relevance to your research, while simultaneously improving your grade.

Recommended Reading:

Chandrupatla and Belegundu, "Introduction to Finite Elements in Engineering", Prentice-Hall, New Jersey

This an excellent introduction to finite elements, and strongly recommended for those without a strong background in solid/continuum mechanics. It is clearly written and easily followed - as such, this text can be used as the primary source for most of the introductory topics covered in class. This book has relatively little coverage of intermediate/advanced topics in FEA, and is not recommended for those who would like a book they can grow into.

Shames and Dym, "Energy and Finite Element Methods in Structural Mechanics", Hemisphere Publishing Corporation, New York

This book has an excellent treatment of beams, variational methods, and the basic framework for FEA. It is solid on the underlying mechanics fundamental to FEA, and was a strong candidate for a required text because of it's comprehensive coverage of intermediate to advanced coverage of mechanics. Many of the course lectures on variational principles, virtual work, potential energy, etc. closely follow this text. On the down side, I find it somewhat short of practical FEA implementation detail.

Zienkiewicz, "The Finite Element Method - Volume 1: Basic Formulation and Linear Problems", 4th Edition, 1989, MacGraw-Hill, London, O.C.

Zienkiewicz is one of the most widely known FEA experts, and his book is technically superb and covers many nice topics. The second volume is useful as well, but covers more advanced topics with a focus on non-linear problems. I have found both books to be excellent references that I refer to quite often - however, the notation that he uses differs from many standard formulations, and his presentation style is often inconsistent with my own personal taste. Overall, this two-volume set is a comprehensive treatment of FEA.

Bathe, "Finite Element Procedures in Engineering Analysis", 1982, Prentice-Hall, NJ

This is a graduate textbook that serves as an excellent reference, and covers in detail many advanced topics that are widely useful in solving more advanced problems. In particular, non-linear and dynamics solutions are covered in detail. This text covers many of the nuts and bolts techniques that are critical to understanding the finer points of FEA, and gives lots of good advice from a giant in the field.

Tentative Schedule:

1. Wednesday, 1/16:	3 Keys of continuum analysis
2. Friday, 1/18:	3 Keys of continuum analysis
0. Monday, 1/21:	***UVA holiday***
3. Wednesday, 1/23	Continuum mechanics
4. Friday, 1/25	Continuum mechanics
5. Monday, 1/28	Variational calculus
6. Wednesday, 1/30	Principle of virtual work (PVW)
7. Friday, 2/1	Principle of virtual work (PVW)
8. Monday, 2/4	1D FEA via PVW (trusses)
9. Wednesday, 2/6	Assembly, rotation and solution
10. Friday, 2/8	Quasi 2-D FEA
11. Monday, 2/11	Quasi 2-D FEA
12. Wednesday, 2/13	2D FEA
13. Friday, 2/15	2D FEA

14T. Monday, 2/18	***Laboratory exercise***
15T. Wednesday, 2/20	***Laboratory exercise***
16T. Friday, 2/22	***Laboratory exercise***
17. Monday, 2/25	Symmetry conditions
18. Wednesday, 2/27	Singular elements
19. Friday, 2/29	Infinite elements
00. Monday, 3/3:	***Spring Break***
00. Wednesday, 3/5:	***Spring Break***
00. Friday, 3/5:	***Spring Break***
20. Monday, 3/10	Singular and infinite elements
21. Wednesday, 3/12	Review for midterm
22. Friday, 3/14	**MIDTERM**
23. Monday, 3/17	Constraints
24. Wednesday, 3/19	Constraints
25. Friday, 3/21	Constraints
26M. Monday, 3/24	***Laboratory exercise***
27M. Wednesday, 3/26	***Laboratory exercise***
28M. Friday, 3/28	***Laboratory exercise***
29. Monday, 3/31	Contact modeling
30. Wednesday, 4/2	Contact modeling
31. Friday, 4/4	***Laboratory exercise***
32. Monday, 4/7	Non-linear FEA
33. Wednesday, 4/9	Non-linear FEA
34. Friday, 4/11	***Laboratory exercise***
35. Monday, 4/14	Non-linear FEA
36. Wednesday, 4/16	Non-linear FEA
37. Friday, 4/18	Non-linear FEA
38T. Monday, 4/21	***Laboratory exercise***
39T. Wednesday, 4/23	***Laboratory exercise***
40T. Friday, 4/25	***Laboratory exercise***
41. Monday, 4/28	Review for final
FINAL EXAM:	Date, time, location TBA: 3 hours, closed notes, closed book