Last updated August 22, 2011

ASEN 5007 — Fall 2011
Introduction to Finite Element Methods

A first-year graduate course on the numerical solution of linear structural problems by finite element methods. Emphasizes formulation. Teaches hands-on understanding of how finite element methods work rather than black-box recipes. Provides the foundation for other graduate courses in applied and computational mechanics.

Follow-on ASEN graduate courses in the Finite Element Sequence are: **Nonlinear Finite Element Methods**, offered every 2-3 years (next one: Spring 2012), **Advanced Finite Element Methods**, offered every 2-3 years (next one: Spring 2011). A spin-off Special Topics course is **Fluid-Structure Interaction**, offered irregularly.

Instructor:	Carlos A. Felippa, carlos.felippa@colorado.edu. Department of Aerospace Engineering Sciences
Office/Phone:	ECAE 187, 492-6547
Textbook:	No required books. All course material, including notes, HW assignments, solutions, class slides, software, . . . are posted at the web site: `http://www.colorado.edu/engineering/CAS/courses.d/IFEM.d/Home.html`
Time/Place:	TuTh 3:30–4:45 PM, ECCS 1B12
Instr Office Hrs:	Mo 2–3, W 10–12 at ECAE 187. If a large number of students shows up we might move office hrs to ECAE 150.
Course Assistant:	TBA
Credit units:	3
Prerequisites:	*Important*: matrix algebra; structures (Mechanics of Materials level); access to *Mathematica* 4.0 or higher version; access to Web with a PDF viewer and ability to print PDF files. *Recommended*: matrix structural analysis and continuum mechanics. Re campus license of *Mathematica* by Information Technology Services, see http://www.colorado.edu/ITS/tpsitelic. ITS licenses expire after 1 year, free to registered students. If you plan continuing use after leaving CU, it may be convenient to purchase *Mathematica for Students* at the CU or Colorado bookstore, since it does not expire. See Chapter 4 of Notes for more details.

Course Outline

I. Finite Element Discretization and the Direct Stiffness Method

Basic concepts of structural modeling. Finite element discretization: interpretations. Review of the direct stiffness method (DSM) of structural analysis. MoM elements. Modeling stiffness, loads, boundary conditions and constraints. Substructuring.

II. Formulation of Finite Elements

Mathematical interpretation of finite elements: variational formulation. Shape functions. Structural and continuum elements. Isoparametric elements. Numerical integration.

III. Computer Implementation of the Finite Element Method

Model definition. Element level calculations. Equation assembly. Equation solver. Strain/stress recovery and post-processing.

OVER

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GRADING WEIGHTS

Homework 35%, bottom grade dropped (Normally 75% of the HW grade is based on technical content and 25% on presentation). Two midterm quizes 40%, @ 20% each. Final take home exam 25%.

HOMEWORK

Normally one assignment will be made per week announced and web-posted before Thursday's class, often on Wednesday. (The assignment may be posted on Monday or Tuesday if there is no class on Thursday. They are due the following Thursday (or Tuesday in case of shortened week) at the beginning of the class. They will be normally graded and returned the following week. Solutions are posted on the web site. No homework is assigned the week before midterms.

You are encouraged to discuss the approach to homework assignments with other students in the course as well as with the T.A. and instructor.

GROUP HOMEWORK IS STRONGLY ENCOURAGED, except for extenuating circumstances such as deep paranoia or being a CAETE student. The group should contain 2 or 3 students; for more check with instructor. Homework done as a group will be graded as a group. Submit only one solution per group, with everybody's name on it. Individual homework is DISCOURAGED. Groups may change during the semester.

LATE HOMEWORKS WILL NOT BE ACCEPTED FOR CREDIT. This is a consequence from the fact that group homework is expected. If you have to miss a class when a HW is due, make appropriate arrangements with the instructor for delivering the HW on time. If you are in a group, this situation should rarely happen.

Homework presentation guidelines are separately posted on the web site.

EXAMS

There will be two 75-minute individual midterm quizes during the semester. These are given in a Thursday class slot and are open book. They cover Part I and II of the course, respectively. Specific examination material is detailed in the last HW assignment returned before the test. The class before the exam is a Q/A review.

The final exam is *take home*, which covers the full course and may include computer work. This is posted on the course web site the day of the next to last lecture, and is due one week thereafter. There is no class review for this exam.

All exams are strictly individual; i.e., groups are not allowed.

COMPUTER WORK

Much of the course (especially the last third part) involves hands-on computer assignments. All exercises will be done with *Mathematica* versions 4.0 or higher, with a Notebook front end. Source files for computer work will be posted on the web site, from which they can be downloaded.

COURSE MATERIAL, WEB SITE, ANNOUNCEMENTS

All course material will be available on the Web at

`http://www.colorado.edu/engineering/CAS/courses.d/IFEM.d/Home.html`

Click on the appropriate entry. You will need a PDF plug-in compatible with Adobe Acrobat 4.0 (or higher) to view and print course files.

HW assignments will also be posted on the Web, linked from the course home page. **Please be sure to scan the web site periodically for postings. No material will be distributed in class except initial course handouts** (like this one) **and Midterm Exams**. The final take-home exam will also be posted.

Important. The web site was first constructed in Fall 1997 and updated during 1998–2010. Part of the material will be revised and updated during the current offering. Therefore, *be sure to download only material identified as having been updated in 2010*. Ready-to-download material is marked by a leading asterisk (*) in the link.

Quick Announcements. Announced in class, HW and (if necessary) broadcast by e-mail.