ME EN 5510 INTRODUCTION TO FINITE ELEMENTS
ME EN 6510 INTRODUCTION TO FINITE ELEMENTS

Fall 2009, Tues & Thurs 03:40 PM-05:00 PM , WEB 101 , 3 credit hours
Course materials and assignments distributed via Blackboard Vista

Instructor: Rebecca Brannon, 2134 MEB, brannon@mech.utah.edu, 801-581-6623 (Cell: 801-662-8340)
Office hours: Tues & Thurs 10:00-12:00 (or by appointment, or drop-in *if instructor is available*)

Course descriptions and prerequisites

5510 Introduction to Finite Elements (3) Prerequisite: ME EN 1300 and MATH 2210 and MATH 2250 and upper division ME EN status.

Practical approach to finite-element analysis of solid mechanics, diffusion, and fluid mechanics problems. Introduction to use of commercial finite element programs. Introduction to theoretical basis; simple elements, element stiffness, boundary conditions, and modeling considerations. Meets with ME EN 6510.

6510 Introduction to Finite Elements (3) Prerequisite: ME EN 1300* and MATH 2210 and 2250 and Graduate status.

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Textbook:

Finite Element Analysis: Theory and Application with ANSYS, 3rd Edition, by Saeed Moaveni, Pearson Prentice Hall (2008) ISBN 978-0-13-189080-0

Grading:

(H) Homework and ANSYS Exercises	55%
(E_1) Midterm Exam #1	20%
(E_2) Midterm Exam #2	20%
(P) Programming project	20%
(F) Final Exam (Tues, Dec 15, 2009, 3:30 – 5:30 pm)	25%
TOTAL=	**140% minus 20% from two lowest = 100%**

Formula: COURSE_SCORE = $(55H + 20E_1 + 20E_2 + 20P + 25F - 20L_1 - 20L_2) / 100$, where L_1 and L_2 are your lowest two scores in the above five categories (each of which are themselves on a 100 point scale). This formula allows you to completely bomb a midterm (even get a zero) without hurting your grade. Poor performance in the homework or final *will* hurt your score because their weights can't reduce to zero. The course score is assigned a letter grade according to the following table.

0-59	60-62	63-66	67-69	70-72	73-76	77-79	80-82	83-86	87-89	90-92	93-96	97-100
E	D-	D	D+	C-	C	C+	B-	B	B+	A-	A	A

The instructor reserves the right to lower the score required for any letter grade. There is no curve.

Course Objectives: *By the end of this course, you are expected to...*

1. Know the mathematical theory of the finite-element method (FEM), including its limitations and how it differs from other numerical methods.
2. Perform finite-element analysis (FEA) of simplified linear boundary-value problems using a commercial FEM code. Problem formulation must include correct boundary conditions as well as appropriate exploitation of problem symmetries. Post-processing must include extraction of output to external data files.
3. Write, document, and deploy your own one-dimensional FEM code for second-order linear self-adjoint differential equations. Here, "deploy" means that someone else successfully uses your code by following your documentation.
4. Understand basic FEA and FEM principles well enough to combine and apply them to solve larger problems.
5. Introduce reasonable approximations or guesses when needed for tractability or when needed because of ambiguity in the problem statement.
6. Understand and apply principles of numerical verification and validation.
7. Identify and properly enforce boundary conditions (especially when used to exploit symmetries) for problems in solid mechanics, fluid mechanics, and heat transfer.
8. Articulate limitations of FEM; be able to cite alternatives to FEM.

Homework Policies

A homework *assignment* is a set of *problems*. A problem of median difficulty is worth 100 points. Easy problems are worth less. Hard problems are worth more. A homework problem will be given a grade of zero if it is incoherent or if it fails to follow the following format:

Problem: What is given, and what is required?

Solution: word explanations *must* accompany each equation and the final result should be boxed.

Discussion: How might the result be used? Is the answer reasonable? Discussion includes "sanity checks" that note features such as: the magnitude and sign are reasonable, the solution reduces as expected in a special case, all steps in the derivation obey indicial notation rules, the same solution is obtained in two very different ways (e.g., by hand and by using math software), the physical units are correct, etc. You can even say that your answer agrees with a similar problem found online (URL must be given) or your solution agrees that of a fellow student (whose name must be given).

The use of symbolic software (Matlab, Mathematica, Maple, etc.), as well as collaboration on concepts and procedures is expected, encouraged, and occasionally even required. Collaboration does not sanction copying. You are allowed to submit only work that you have completed individually. Submitting any work that is not the result of your own effort is considered cheating. Academic misconduct may result in a failing grade, dismissal from the program or the University, revocation of the student's degree or certificate, or other sanctions. See the Student Handbook for further details.

Late homework policy: Unless otherwise announced, homework is due one week after it is assigned. Late homework is not accepted. To make up for this tough stance, the following strange formula will be used:

$$\text{homework grade (on scale from 0 to 100)} = 50\left[1+\frac{h}{H}-\text{Exp}\left(\frac{-h}{H-h}\right)\right],$$

where h is your total amassed homework points and H is the total number of available homework points. Suppose, for example, that you earn 74% of the available homework points (h=0.74H). Rather than getting a "C" by a conventional grading scale, the above formula would improve your homework grade to a "B". The bonus and resubmittal policies (below) further compensate for the "no late homework" policy.

Bonus policy: Can you boost your grade by doing extra work? Yes, but not at the end of the semester as a last-minute attempt to fix a low grade. Bonus points will be awarded for extra work if it is… **(1)** clearly beyond the scope of the assignment, **(2)** relevant to the assignment, and **(3)** handed in with the assignment.

Resubmittal policy: Students may request resubmitting a homework problem to recoup as many as 90% of missed points if the initial score was at least 20% and if the request is made within one week of when the assignment is first returned to students. Resubmitted work is due one week after the resubmittal request is granted. No more than 500 points over the entire semester may be recouped by resubmitted.

Sequence and relative emphasis of topics in this course

lecture weight	Topic	Reading
5	Matrix Algebra (as needed during the course)	p. 66-101
0	Matrices in Matlab (not covered in lecture)	p. 102-106
0	Matrices in Excel (not covered in lecture)	p. 106-112
5	Symbolic math in *Mathematica* (as needed)	notes
2	Introduction to FEA and FEM	p. 1-6
8	Introduction to verification analysis	p. 48-53
5	Boundary conditions for 1D ODEs	notes
3	Steps of FEA and FEM (overview)	p. 6-8
10	FEA/FEM via direct stiffness (bar with variable x-sect)	p. 8-20
10	Algorithm for a 1D bar code	notes
8	Introduction to interactive ANSYS (bar with variable x-sect)	TA notes
8	Introduction to batch ANSYS (bar with variable x-sect)	p. 778-792
5	Verification (exact solution to bar with variable x-sect)	p. 42-43
5	Minimum total potential energy formulation	p. 37-41
5	Introduction to shape functions	p. 264-266
5	3D elements	p. 687-703
5	3D solid modeling and meshing in ANSYS	p. 704-715
10	Verification of ANSYS 3D element (bar with variable x-sect)	TA notes
10	Weighted residuals (collocation, Galerkin, and least squares)	p. 43-48
5	Axial Members (bar with distributed loads and point forces)	p. 189-197
5	Generalizing the 1D bar to solve 2D and 3D truss problems	p. 117-137
5	Verification of truss simulations	p. 177-178
10	Examples using ANSYS for trusses	p. 137-175
8	FEA/FEM via direct stiffness (1D conduction and convection)	p. 20-29
8	FEA/FEM via direct stiffness (1D torsion)	p. 29-32
5	Elements in parallel	p. 32-36
10	Fluids (direct stiffness formulations)	p. 643-659
10	Fluids in ANSYS	p. 659-679
5	Fluids verification analysis	p. 679-680
10	3D thermal problem using ANSYS	p. 715-731
10	3D structural problem using ANSYS	p. 732-745
5	Design and Design optimization using FEA	p. 754-778

Important dates

First lecture	Tues, August 25
Last day to register without a permission code	Sun, August 30
Informal student feedback survey #1	Tues, September 1
Last day to drop (delete) classes	Wed, September 2
Labor day	Mon, September 7
Last day to register, elect CR/NC, or audit classes	Tues, September 8
Midterm EXAM #1	**Thur, October 8**
Fall Break	Mon.-Sat, October 12-17
Informal student feedback survey #2	Thurs, October 22
Last day to withdraw from classes	Fri, October 23
Midterm EXAM #2	**Tues, November 24**
Thanksgiving Break	Thurs.-Fri., Nov. 26-27
Last day to reverse CR/NC option	Fri, December 4
Last lecture (final informal feedback survey)	Thurs., December 10
Comprehensive final exam	TBD (Dec. 14-18)
Grades Available	Tues, December 29

NOTICES:

The above dates are are provided only for convenience. For official dates, refer to the 2009 academic calendar at **http://www.sa.utah.edu/regist/calendar/datesDeadlines/Fall2009.htm**. The instructor retains the right to revise this syllabus, with the proviso that students retain a right to reasonable notice of changes.

The following COE guidelines are available at the COE website, http://www.coe.utah.edu/current-undergrad/policies_appeals.php .

COLLEGE OF ENGINEERING GUIDELINES

http://www.coe.utah.edu **Spring Semester 2009**

Appeals Procedures

See the Code of Student Rights and Responsibilities, located in the Class Schedule or on the UofU Web site for more details

Appeals of Grades and other Academic Actions
If a student believes that an academic action is arbitrary or capricious he/she should discuss the action with the involved faculty member and attempt to resolve. If unable to resolve, the student may appeal the action in accordance with the following procedure:

1. Appeal to Department Chair (in writing) within 40 business days; chair must notify student of a decision within 15 days. If faculty member or student disagrees with decision, then,
2. Appeal to Academic Appeals Committee (see http://www.coe.utah.edu/current-undergrad/appeal.php for members of committee). See II Section D, Code of Student Rights and Responsibilities for details on Academic Appeals Committee hearings.

Americans with Disabilities Act (ADA)

The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you need accommodations in a class, reasonable prior notice needs to be given to the instructor and to the Center for Disability Services, 162 Olpin Union, 581-5020 (V/TDD) to make arrangements for accommodations. All written information in a course can be made available in alternative format with prior notification to the Center for Disability Services.

Repeating Courses

When a College of Engineering class is taken more than once, only the grade for the second attempt is counted. Grades of **W, I, or V** on the student's record count as having taken the class. Some departments enforce these guidelines for other courses as well (e.g., calculus, physics). See an advisor or departmental handbook. Students should note that anyone who takes a required class twice and does not have a satisfactory grade the second time may not be able to graduate.

Withdrawal Procedures

See the Class Schedule or web for more details ** Please note the difference between the terms "drop" and "withdraw". Drop implies that the student will not be held financially responsible and a "W" will not be listed on the transcript. Withdraw means that a "W" will appear on the student's transcript and tuition will be charged. **

Drop Period – No Penalty
Students may DROP any class without penalty or permission during the FIRST TEN calendar days of the term (Wednesday, January 21, 2009).

Withdrawal from Full Term Length Classes
Students may WITHDRAW from classes without professor's permission until **Friday, March 6th**. Please note that a "W" will appear on the transcript and tuition will be charged. Refer to Class Schedule, Tuition and Fees for tuition information.

Withdrawal from Session II
See the web page, for details:
http://www.sa.utah.edu/regist/pdfs/2008-2009.pdf

Withdrawals **after March 6th** will only be granted due to **compelling, nonacademic emergencies**. A petition and supporting documentation must be submitted to the Dean's Office, 1610 Warnock Engineering Building or University College (450 SSB) if you are a pre-major. Petitions must be received before the last day of classes (before finals week.).

Adding Classes

Please read carefully: All classes must be added within two weeks of the beginning of the semester (deadline: January 26th). Late adds will be allowed January 27th – 30th, requiring only the instructor's signature. Any request to add a class after January 30th will require signatures from the instructor, department, and dean, and need to be accompanied by a petition letter to the Dean's office.

A $50 FEE WILL BE ASSESSED BY THE REGISTRAR'S OFFICE FOR ADDING CLASSES AFTER January 30. ***

STUDENT SURVEY

This form will be handed out two or three times during the semester.

Instructions: Circle the number corresponding to your response:
5=strongly agree 4=agree 3=neutral 2=disagree 1=strongly disagree.

1. The pace at which the course is proceeding is appropriate.
   5 4 3 2 1 COMMENTS:

2. The prerequisites for this course are reasonable.
   5 4 3 2 1 COMMENTS:

3. I (student) know the prerequisite material well enough to focus on new material.
   5 4 3 2 1 COMMENTS:

4. The instructor's use of class time is effective in helping me understand the material covered.
   5 4 3 2 1 COMMENTS:

5. The textbook and/or lecture notes are useful for learning the material covered.
   5 4 3 2 1 COMMENTS:

6. Homework problems are assigned in proper quantities and are of proper difficulty.
   5 4 3 2 1 COMMENTS:

7. The first midterm exam was a fair representation of subjects covered and was graded fairly.
   5 4 3 2 1 COMMENTS:

8. The instructor is respectful when pointing out issues or problems with student performance
   5 4 3 2 1 COMMENTS:

9. I believe that my knowledge of this subject will significantly help my professional career.
   5 4 3 2 1 COMMENTS:

10. I (student) am happy with the *effort* I have put into this course to date.
    5 4 3 2 1 COMMENTS:

11. I (student) am happy with my *performance* in this course to date.
    5 4 3 2 1 COMMENTS:

If I could change one thing about this course (and, of course, if I could justify the change to the taxpayers who subsidize this public institution) it would be...

IS THIS SURVEY MISSING ANY IMPORTANT AREA FOR FEEDBACK?
Please include additional comments, concerns, or suggestions on the back of this page.

ME EN 5510/6510 (INTRODUCTION TO FINITE ELEMENTS)
Student information & affirmation sheet

Student's Full Name (print legibly): _____
Name I prefer to go by: _____
UID: _____

I certify that...

☐ I have been given the course information (syllabus), which includes instructor contact information, prerequisite requirements, course objectives, evaluation methods, grading policy, course description, important dates, *tentative* topics list, and the College of Engineering Guidelines.

☐ I understand the course objectives that are listed in the syllabus.

☐ I understand that the instructor retains the right to revise the syllabus, with the proviso that students retain a right to reasonable notice of changes.

☐ I have satisfied the pre-requisites for taking this course as they are listed in the syllabus.

For each of the following pre-requisite topics, enter the typical grades you earned while learning the topic (e.g., did you usually get an A? B? C?). In the last column enter your *current* level of knowledge of the subject on a scale from 0 being no knowledge to 5 being so talented that you could teach it.

Prerequisite topic	Typical homework and exam grades you earned learning subject	Current level of knowledge
vector analysis		
multi-variable calculus		
linear algebra		
differential equations		
Forces, moments, and free bodies		
concept of stress and strain		
Hooke's law and elastic limits		
Uniaxial loading, torsion, and bending		

☐ I understand that each homework assignment must be legible and follow a format of (1) problem statement, (2) solution with words explaining each equation, and (3) discussion of the result (especially checking believability of results).

☐ I understand that several homework assignments might require math software of my choosing (Mathematica, Maple, Matlab, Python, etc.) and that a portion of the lecture time will be used to provide beginner's instructions on the use of such software.

_____ _____ _____
Name Signature Date