Finite Element Analysis I

Course Outline

- **Introduction**

Historical aspects of the FEM, Range of application and limitations of the FEM, Review of beam formulations, Properties of the stiffness matrix, Factorization algorithms, Review of elasticity theory.

- **Variational Methods**

Variational principles, Virtual work and potential energy, Approximate solutions and convergence requirements, 1D finite elements, Assembly by the direct stiffness method.

- **2D continua**

Plane stress, Plain strain and Axisymmetry, Element formulation, Shape functions, Constant strain triangle (CST), Bilinear rectangles, Continuity and completeness of displacement models, Numerical solutions, and Boundary conditions.

- **Higher-order and mapped elements in 2D and 3D**

Natural coordinates and isoparametric elements, Shape functions, Numerical integration, Element behavior, Shear locking, Reduced integration, Spurious zero energy modes (SZEM), hourglass control, Numerical solutions, Mesh design, Patch test and other tests, Stress recovery techniques.

- **FEA of plates**

Kirchhoff plate and Mindlin-Reissner plate.

- **Introduction to FEA of Shells**

Shell analysis and behavior, Isoparametric shell elements from degenerate solid elements

- **Special topics**

Error estimation, adaptativity, convergence, special elements and dynamics, etc.

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No.	Date	Topics	HW
1	8/23 (Tu)	Introduction and Review Basics	
2	8/25(Th)	Direct Method	
3	8/30 (Tu)	Shape Functions	HW 1
4	9/1 (Th)	Principle of Virtual Work (PVW) 1	
5	9/6 (Tu)	PVW 2 and Principle of Stationary Potential Energy (PSPE) 1	HW 2
6	9/8 (Th)	PSPE 2 and Ritz Method	
7	9/13 (Tu)	Ritz Method and FE Approximation	
8	9/15 (Th)	Strong Form and Weak Form	HW 3
9	9/20 (Tu)	**NO CLASS**	
10	9/22 (Th)	**NO CLASS**	
11	9/27 (Tu)	Method of Weighted Residual	
12	9/29 (Th)	**EXAM I (Topic 1-8)**	
13	10/4 (Tu)	FEA using ABAQUS (Computer Lab)	HW 4
14	10/6 (Th)	Isoparametric Element 1	
15	10/11 (Tu)	Isoparametric Element 2	
16	10/13 (Th)	Numerical Integration by Gauss Quadrature	
17	10/18 (Tu)	Higher-Order Isoparametric Element	HW 5
18	10/20 (Th)	Incompatible Element & Selective Reduced Integration	
19	10/25 (Tu)	Element Mesh Stability	
20	10/27 (Th)	FE Programming (Computer Lab)	HW 6
21	11/1 (Tu)	**EXAM II (Topic 11-20)**	
22	11/3 (Th)	Loads on Isoparametric Quadrilateral Element	
23	11/8 (Tu)	Isoparametric Triangular Element	
24	11/10 (Th)	Axisymmetric Element	HW 7
25	11/15 (Tu)	Coordinate Transformation	
26	11/17 (Th)	Solution of Equilibrium Equation	
27	11/22 (Tu)	Error estimation and Stress Recovery	HW 8
28	11/24 (Th)	**NO CLASS (Thanksgiving Break)**	
29	11/29 (Tu)	Review	
30	12/1 (Th)	Review	
	TBA	**Final (Comprehensive)**	

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Instructor
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Office hour: Wednesday 3:00 pm ~ 5:00 pm or email to make an appointment
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General Information
Class hour: TuTh 5:10 pm ~ 6:25 pm
Classroom: Olin 103
Class web site: Springboard ***https://springboard.uakron.edu/index.asp***
Classnotes, exams, homework, sign-off problems solutions and handouts will be posted in Springboard. You can also check your updated final grades.

Requisites
The prerequisite for this course is 4300:554 Advanced Mechanics of Materials or equivalent.

Course Objectives
The objective of the course is to study the theory, implementation, practical aspects and utilization of finite element analysis in order to become intelligent users of finite element capabilities now widely employed in engineering practice, develop a feel for deformation and stress behavior and be prepared to go on to further study (formal or personal) for more advanced understanding, research and /or development. Moreover, the student will be exposed to practical aspects of finite element modeling by using some relatively sophisticated analysis software (i.e. ABAQUS)

Textbook
R.D. Cook, D.S. Malkus, M.E. Plesha and R.J. Witt (2002). *Concept and Applications of Finite Element Analysis*, 4th Edition, John Wiley and Sons (ISBN 0471356050)

Optional Textbooks (classical books)

K.J. Bathe (1995), Finite Element Procedures, Prentice Hall (ISBN 0133014584)

T.J. Hughes (2000) The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications (ISBN 0486411818)

J.N. Reddy (1993) An Introduction to the Finite Element Method, 2nd Edition, McGraw Hill (ISBN 0070513554)

R.D. Cook (1995) Finite Element Modeling for Stress Analysis, John Wiley and Sons (ISBN 0471107743)

O.C. Zienkiewicz and R.L. Taylor (2005) The Finite Element Method: Its Basis and Fundamentals, 6th Edition, John Wiley and Sons (ISBN 0750663200)

Homework (10%)

Late assignments will be accepted but penalized by 20% reduction. Students are encouraged to work together on homework assignments and analysis in the interest of gaining additional understanding. Exam questions will be used to measure individual student comprehension. In accordance with University policy, however, any evidence of direct copying of homework assignments will result in a zero for that assignment and/or University disciplinary action.

Project 1(15%) and Project 2 (15%)

I will provide topics for the project. However, feel free to identify a problem of your own choosing, perhaps related to your research, to work in another course, or to some other problem of personal interest. If you prefer to work on the project that you choose, then you must submit a brief proposal to obtain the Professor's approval for the project.

2 Mid-term Quizzes (30%)

A total of two one-hour exams will be given as indicated in the course schedule throughout the semester. All exams are closed book.

Final exam (30%)

Final exam covering the entire course will be given. Final is also closed book and notes. Date and Time: TBA.

Class attendance policy

Attendance is very important for success in this course. So attendance sheet will be passed around every class. If you can not attend class inevitably, please send an email with reasons for your absence before the class. Medical condition, emergency or more time for other courses or projects and any other unavoidable reasons will be accepted. *If you show full attendance throughout the semester, you will get 3% extra points out of 100%. For example, if your total grade is 86% (B+) and you attended every class, then your final grade will be 86% + 3 % = 89 % (A–).*

Instructor Note on Plagiarism

Copying others' homework or cheating in exams is academic dishonesty in this course. Please note that any form of academic misconduct in this course may result in the penalties of formal disciplinary probation, suspension, or dismissal. If you are unfamiliar with what constitutes plagiarism, I would advise that you read the University policy.

Grading

90 and above: A
87~89: A-
85~86: B+
80~84: B
75~79: C+
70~74: C
65~69: D+
60~64: D
Below 60: F