Finite Element Analysis

ME 478
University of Washington, Seattle — Spring Quarter 2012

Location:	Loew 206 (Lecture) MEB 231 (Computer Lab)		**Time:**	M-W 10:30-11:20am F 10:30-11:20am
Instructor:	Prof. Nathan J. Sniadecki MEB 318		**e-mail:**	nsniadec@uw.edu
TA:	Jin Lee MEB 107		**email:**	jinhlee@uw.edu

Office Hours:

NS:	T	9:30-10:20am	MEB 318
	F	3:00-4:00pm	MEB 318
TAs:	F	9:20-10:20pm	MEB 107
	F	11:30-12:30pm	MEB 107
	M	3:00-4:00pm	MEB 107

Website: `http://courses.washington.edu/nsniadec/ME478/S12`

GoPost: `https://catalysttools.washington.edu/gopost/board/nsniadec/27012/`

Description: This course is an introduction to finite element analysis. The basic mathematical theory of finite element analysis will be introduced throughout the quarter. The course will also introduce you to a commercial finite element packages through several design projects in the area of linear solid mechanics, thermal analysis, and vibration analysis. At the end of the quarter you should be familiar with the theory and capable of designing and analyzing structures using finite element analysis. Lecture and Computer Recitations.

Prerequisites:
M E 123 – CAD
M E 374 – Systems Dynamic Analysis and Design
MATH 308 – Matrix Algebra with Applications
(or) AMATH 352 – Applied Linear Algebra

Required Text:

[1] Moevani, Saeed, *Finite Element Analysis: Theory and Application with ANSYS, 3rd edition*, Pearson/Prentice Hall, Upper Saddle Ridge, NJ (ISBN: 0131890808)

Recommended Texts:

[2] Hibbeler, R.C., *Mechanics of Materials*, Pearson/Prentice Hall, Upper Saddle Ridge, NJ

Grading:

1)	Homework	15%
2)	Labs	10%
3)	Projects	40%
4)	Midterm Exam	15%
5)	Final Exam	20%

Course Policies:

Homework Policy: Homework will be assigned on Monday and is due on Tuesday of the following week. All assignments must be handed in before class starts on Tuesdays. If you used MATLAB or other software to complete your homework, print out the code and results and circle your answer. Late homework will be accepted if and only if arrangements are made by Sunday evening.

Lab Policy: There will be 8 lab sessions for this course where you will run tutorials from the book in ANSYS or Matlab. Upon completing the tutorial, you are required print out a final plot of your results and hand it into your TA before you leave the computer lab. You will not receive credit if you do not turn in a final plot.

Project Report Policy: This course has 4 projects that require you to run ANSYS and write a memo report on the results. Late reports will not be accepted. All reports are to be printed and handed in before class starts on Friday.

Collaboration Policy: You may discuss projects and homework with your fellow students, and even collaborate on the solution, but you must list on the report or homework the name of the person(s) that collaborated with you on the effort. You may not copy someone else's reports, data, or figures.

Exam Policy: All exams must be completed on the specified date. Only under proven, extraordinary circumstances will a makeup exam be permitted. Bring your engineering calculators and a one-page sheet of handwritten notes are permitted.

Classroom Policy: Please consider the learning mission of the course and refrain from activity that is disruptive during lectures or computer lab sessions.

Grading Policy: The instructional team pledges to return your homework within two week and your lab reports within three weeks.

I have a zero-tolerance for cheating or plagiarism. Please refer to UW's Student Conduct Code.
http://www.washington.edu/students/handbook/conduct.html

Course Outcomes and Assessment:

By the end of this course, the student will be able to:

1. Derive the element stiffness matrices for truss, beam and simple planar elements
2. Understand the advantages/disadvantages of different discretization techniques
3. Able to apply appropriate constraints and boundary conditions to finite element models
4. Use the commercial FEA code ANSYS to solve linear static solid and structural mechanics problems

Contribution of Course to Professional Development:

The aim of the course is to prepare students for engineering practices by familiarizing them with finite element analysis and computational packages, advancing their fundamental engineering knowledge, and developing their technical communication abilities.

Project Report Requirements:

The reports you submit for the four projects in this class are to be in the form of a technical memo. The following items are required in the report:

1. Write-up – You should briefly describe what you did, why and how you solved the problem, explaining your analytical procedure. The report should be no more than 3 pages in length and have an abstract, introduction, procedure, results, discussion, and conclusions section. You may include an appendix with additional figures in needed.
2. The object – You should include a computer drawn figure of your model's geometries showing labeled dimensions and material properties used.
3. The model – You should include plots from ANSYS of the finite element mesh and all applied loads and boundary constrains.
4. The results – You should include a plot of the results (stresses, displacements, etc.) and all required tables wherever necessary.
5. The verification – You should explain the calculations you performed to validate your ANSYS solution wherever applicable.

Project Grading:

The memo reports will be graded out of 100 points and based upon the grading items in Table 1.

Table 1. Report Grading Points

Item	Points
Overall grammar, spelling, and punctuation	10
Abstract:	
Briefly describe what was done, why it was done, and what was the finding. The most important point should be made in the first sentence.	5
Introduction:	
Very brief background and purpose for the model.	5
Procedure:	
Indicate the elements used, the boundary conditions/loads assigned, and how the model was meshed (number of nodes, node seeding if any, etc.).	20
Results (and Appendices):	
Analysis of the modeling data is complete, clear, and correct.	15
Results in figures, graphs, and tables are accurate and important features are described in the text.	20
Format of graphs and tables is professional looking. Appropriate units are indicated. Captions to describe the contents of the graph or table. Reference to graphs, tables, and appendices are made in the memo.	10
Discussion:	
Describe your engineering insight on the results of the model and explain any errors or differences between model and theory	10
Conclusions:	
Summarize the modeling results and give recommendations based upon your findings.	5

Table 2. ME 478 Course Schedule

	Day	Room	Book Readings	Lecture/Lab Topic	Assign	Due
Week 1	26-Mar M	Loew 206	Ch 1.1-1.4	Introduction to Finite Elements	Hw 1	
	27-Mar T	Loew 206	Ch 1.5	Direct Formulation		
	28-Mar W	Loew 206	Ch 1.5	Direct Formulation		
	30-Mar F	MEB 231	Ch 2, App. F	LAB 1: Example 2.1 (revisited), 2.8, F.7, and F.8		
Week 2	2-Apr M	Loew 206	Ch 3.1-2	Trusses	Hw2	
	3-Apr T	Loew 206	Ch 3	Ex Prob 3.1 (Statically indeterminate)		Hw 1
	4-Apr W	Loew 206	Ch 1.6	Minimum Potential Energy		
	6-Apr F	MEB 231	Ch 3.4, 3.5	LAB 2: Example Problem 3.1 in ANSYS	Project 1	
Week 3	9-Apr M	Loew 206	Ch 4.1	Columns	Hw3	
	10-Apr T	Loew 206	Ch 4.2-3	Beams		Hw2
	11-Apr W	Loew 206	Ch 4.4-4.5	Frames and Beams in 3D		
	13-Apr F	MEB 231	Ch 4.5, 4.6	LAB 3: Example Problem 4.5 in ANSYS		Project 1
Week 4	16-Apr M	Loew 206	Ch 10.2	Plane Stress	Hw4	
	17-Apr T	Loew 206	Ch 10.2, 9.3	Plane Stress using Triangle Elements		Hw3
	18-Apr W	Loew 206	Ch 10.3	Example 10.2		
	20-Apr F	**Loew 206**		**EXAM on Chapters 1-4**	Project 2	
Week 5	23-Apr M	Loew 206	Ch 7.3-4	Linear and Quadratic Triangle Elements	Hw5	
	24-Apr T	Loew 206	Ch 7.1-2	Linear and Quadratic Quad Elements		Hw4
	25-Apr W	Loew 206	Ch 10.3, 7.6	Isoparametric Formulation for 2D Solids		
	27-Apr F	MEB 231	Ch 8.10, 10.5	LAB 4: Ex 8.10 in ANSYS & Failure Theory		Project 2
Week 6	30-Apr M	Loew 206	Ch 10.3, 7.6	Isoparametric Formulation for 2D Solids	Hw6	
	1-May T	Loew 206	Ch 7.5	Axisymmetric Elements		Hw5
	2-May W	Loew 206	Ch 10.4	Axisymmetric Formulation for 2D Solids		
	4-May F	MEB 231	Ch. 10.6	LAB 5 : Ex. 10.3 in ANSYS	Project 3	
Week 7	7-May M	Loew 206	Ch 13.1-2	3D Formulation with Simple Tets	Hw7	
	8-May T	Loew 206	13.3-5	Tets and Bricks for 3D		Hw6
	9-May W	Loew 206	Ch 13.6-7	3D Examples, Meshing Control		
	11-May F	MEB 231	Ch 13.7	LAB 6: Ex. 13.3 in ANSYS		Project 3
Week 8	14-May M	Loew 206	Ch 9.1	Basics of Heat Transfer	Hw8	
	15-May T	Loew 206	Ch 9.2	Heat Transfer with Quad elements		Hw7
	16-May W	Loew 206	Ch 9.2	Heat Transfer with Triangle elements		
	18-May F	MEB 231	Ch. 9.7	LAB 7: Ex. 9.7 in ANSYS		
Week 9	21-May M	Loew 206	Ch 11.2	Review of Vibrations	Hw9	
	22-May T	Loew 206	Ch 11.3	Lagrange's Equations		Hw8
	23-May W	Loew 206	Ch 11.4	Finite Element Formulation of 1D Members		
	25-May F	MEB 231	Ch 11.6	LAB 8: Ex 11.8 in ANSYS	Project 4	
Week 10	28-May M			*No Class (Memorial Day)*		
	29-May T	Loew 206	Ch 15.1	Intro to Design Optimization		Hw9
	30-May W	Loew 206		Demo of other FEM packages		
	1-Jun F	MEB 231		Course Review		Project 4
	4-Jun M	Loew 206		**Final Exam on chapters 7-11 & 13**		