

# Finite Element Analysis of Solids and Fluids

## Course Description

This course introduces finite element methods for the analysis of solid, structural, fluid, field, and heat transfer problems. Steady-state, transient, and dynamic conditions are considered. Finite element methods and solution procedures for linear and nonlinear analyses are presented using largely physical arguments. The homework and a term project (for graduate students) involve use of the general purpose finite element analysis program ANSYS. Applications include finite element analyses, modeling of problems, and interpretation of numerical results

## Course Introduction

We focus on modern practical finite element methods for solids and fluids using physical explanations of the finite element methods. The analysis procedures are used extensively in the various fields of engineering and the sciences.

Some strong reasons for taking this course:

- You learn modern analysis techniques used widely in engineering practice and the sciences, and you use these techniques in a general finite element program.
- You learn how to establish computational models of problems of solids and fluids, solve them on your laptop, and assess the accuracy of the results.
- You capitalize on your knowledge of mechanics, reinforce your knowledge, and solve problems that can only be tackled numerically on the computer.

Great knowledge in your toolbox whatever your goals!

## Topics

- Finite element analysis of solids, structures, fluid-flows, fluid-structure interactions, steady-state and transient problems.
- The finite element methods explained physically: why they work, what they can be used for.
- Modeling of problems, solution of response, how to check the results, how to assess the accuracy of the results.
- Use of a general finite element computer program.

Hence in the course we focus on the actual analysis of problems, the physical explanation of the finite element methods, and the use of a general computer program. We shall consider solids and fluids and keep the theoretical discussions of finite element methods to a minimum.

The methods studied in this course are practical procedures that are employed extensively in the mechanical, civil, ocean and aeronautical industries.

## Textbook

You will find readings and references to special topics in the textbook.

Bathe, K. J. *Finite Element Procedures*. 2nd ed. Klaus-Jürgen Bathe, 2014. ISBN: 9780979004957

## Grades

The student's course grade will be based on:

- Weekly homework 10%
- Term project 20%
- Midterm exam 30%

- Final exam 40%

## Use of Finite Element Computer Program

We will use ANSYS and ABAQUS for all finite element program related homework and for the projects. You will not be required to develop a computer program. However, some homework will require that you use the graphical user interface of the finite element program system ANSYS and ABAQUS, which can be run on your laptop.

SES	TOPICS	KEY DATES
1	Introduction: why to study FEA	
2	The finite element analysis process	
3	Analysis of solids/structures and fluids	Homework 1 out
4	The principle of virtual work	
5	The finite element formulation	Homework 1 due, Homework 2 out
6	Finite element solution process	
7	Finite element solution process, cont'd	Homework 2 due, Homework 3 out
8	Demonstration on using ANSYS, part 1	
9	Demonstration on using ANSYS, part 2	Homework 3 due, Homework 4 out
10	Nonlinear finite element analysis of solids and structures	Homework 4 due, Homework 5 out
11	Heat transfer analysis	
12	Finite element analysis of heat transfer and incompressible fluid flow	Homework 5 due
13	Physical explanation of Gauss elimination	
14	Midterm 1	Homework 6 out
15	Solution of dynamic equilibrium equations	

SES	TOPICS	KEY DATES
16	Solution of dynamic equilibrium equations, cont'd	Homework 6 due, Homework 7 out
17	Demonstration on finite element methods in ANSYS; focus on student projects	
18	Modeling for dynamic analysis and solution	
19	Modeling for dynamic analysis and solution, cont'd	Homework 7 due
20	Wave propagation response	
21	Solution of the generalized eigenvalue problem	
22	Midterm 2	
23	Solution of $\mathbf{K}\boldsymbol{\phi} = \lambda\mathbf{M}\boldsymbol{\phi}$	Homework 8 out
24	Wrap up, review	
25	Wrap up, review, cont'd	Homework 8 due
26	Final Exam	