Course  
ME 545 — Finite Element Analysis: Advanced Theory and Application

Type of Course  
Required course for MSE-ME specialization

Catalog Description  
Theory of the course covers various algorithms for non-linear and time-dependent problems in two and three dimensions. Applications of the course cover the advanced topics with problems chosen from chosen solid mechanics, heat transfer, and fluid dynamics. Commercial FEA packages such as ANSYS and/or Abaqus are applied to solve various engineering problems. Students must possess an appropriate level of mathematics and programming skills to understand, develop and problem solvers for finite element models.

Credits  
3

Contact Hours  
3

Prerequisite Courses  
Graduate Standing or ME 480 (or equivalent course)

Corequisite Courses  
None

Prerequisites by Topics  
Numerical calculation and Matlab programming skills

Textbook  

Course Objectives  
To review the fundamentals of basic FEA and to introduce advanced topics which are not covered in sufficient detail in an introductory course of FEA. Emphasizes are on the mathematical foundations of the method, numerical algorithms for software implementation, and analysis of problems with materials and geometric nonlinear behavior. The course aims at giving the students a chance to investigate practical problems of their interest in detail.

Course Outcomes  
Students who successfully complete this course will be able to:

[1]. An ability to perform complete FE formulations for engineering analysis \(\textbf{(1,2)}\)

[2]. An ability to write codes for a finite element model \(\textbf{(1,2)}\)

[3]. An ability to use commercial FEA software to solve engineering problems \(\textbf{(1,2)}\)
[4]. An ability to apply finite element methods in design engineering components or systems (1,2,6)
[5]. An ability to write technical reports and convey engineering message efficiently (4,7)

Lecture Topics
1. Overview of Basic FEA and Nonlinearity
   • Mathematical preliminaries
   • Finite element analysis preliminaries
   • Material nonlinearities
   • Dynamic problems
   • Various formulations
   • Solution of linear and nonlinear algebraic equations
2. Programming and Software tools of FEA
   • Finite element analysis using ABAQUS (optional)
   • Finite element analysis using ANSYS
   • MATLAB Programs for finite element analysis
3. Solid Mechanics Problems
   • Finite element formulations of solid continua
   • Nonlinear heat transfer and other field problems in one-dimension
   • Nonlinear bending of beams
   • Nonlinear bending of elastic plates
   • Dynamic Analysis
4. Heat Transfer Problems
   • 1-D nonlinear heat transfer and other field problems
   • 2-D nonlinear heat transfer and other field problems
5. Fluid Mechanics Problems
   • Flow of viscous incompressible fluids
   • Nonlinear analysis of transient problems
   • Compressible flows
   • Solid-fluid interactions
6. Electromagnetic Problems
   • Steady-state problems
   • Poisson’s Equation
   • Transient Field Problems.

Computer Usage
High

Laboratory Experience
low

Design Experience
Low

Coordinator
Zhuming Bi, Ph.D.,

Date
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