ME 4180
Finite Element Analysis in Mechanical Engineering Design
Summer 2015 (Online)

Department:	**Mechanical Engineering**
Semester:	**Summer, 2015**
Class Location:	**Online Only**
Course Start Date:	**Wednesday, June 24, 2015**
Course End Date:	**Monday, August 3, 2015**
Instructor:	**Gang Li, Associate Professor**
Email:	**gli@clemson.edu**
Virtual Office Hours:	**M-F, 9am-12pm**
Office Location:	**Online Only**

Course Description

Introduction to the finite element method and solid modeling; finite element modeling and analysis using commercial codes; analysis strategies using finite elements; applications to heat transfer and structures.

Text Book

Handouts and online course materials

Course Requirements

- Computer system requirements.
- Computer speakers and headphones (This course includes audio and video components).
- Blackboard (course website).
- ANSYS Workbench (installed by CCIT).
- MATLAB (installed by CCIT).
- Ancillary information (texts, videos, audio, slides) is provided in the online course site and through Internet links.

Course Objectives

- To introduce the students to the basic concepts, mathematical formulation and general procedure of the finite element method (FEM) as related to solving engineering problems in solids and heat transfer.
- To provide students with a working knowledge of computer-aided engineering analysis tools and their use in design.

Student Learning Outcomes

At the conclusion of this course, students should be able to

- demonstrate a basic understanding of the concepts, mathematical formulation and numerical implementation underlying the FEM as applied to solid mechanics and thermal analysis;
- create his/her own FEM computer programs to solve simple mechanical and heat transfer problems;
- analyze more complex mechanical and heat transfer problems using commercial FEA software ANSYS;
- demonstrate the ability to invoke appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems;
- demonstrate the ability to perform parametric and convergence studies for mechanical and thermal analysis and design;
- demonstrate the ability to give a professional and well organized presentation and report of their work;

Course Topical Content

Instructional content is organized in modules grouped with corresponding assessments.

- **Module 1: Spring and truss elements**
  - Basic concepts of finite element analysis (FEA) and its application in mechanical analysis of discrete systems such as spring and truss systems.
  - Students will (1) obtain a basic understanding on the concepts of FEA, (2) be able to perform FEA analysis of spring and truss systems by using FEA software ANSYS Workbench, (3) be able to implement a simple computer program to perform FEA analysis of spring and truss systems.
- **Module 2: FEA procedures: 1-D mechanical and heat transfer problems**
  - Mathematical foundation and general procedure of finite element analysis of continuum systems. Application of the method to solve 1-D mechanical and heat transfer problems.
  - Students will (1) obtain a basic understanding on the formulation and general procedure of FEA, (2) be able to perform FEA analysis of 1-D continuum systems by using FEA software ANSYS Workbench, (3) be able to implement a simple computer program to solve 1-D mechanical and heat transfer problems.
- **Module 3: 2-D and 3-D elastic structures**
  - Finite element formulation and implementation for mechanical analysis of 2-D and 3-D elastic structures.
  - Students will (1) obtain a basic understanding on how the finite element formulation for 1-D problems can be extended to 2-D and 3-D systems, (2) be able to perform FEA analysis of 2-D and 3-D structures by using FEA software ANSYS Workbench.

- **Module 4: Structural modeling**
  - Modeling techniques for creating mechanical components with complex geometry. Preprocessing considerations, such as element type, mesh size and numerical methods, for the efficiency and accuracy of the analysis.
  - Students will (1) learn a set of modeling techniques for creating complex structures in ANSYS Workbench, (2) depending on the problem given, be able to select optimal preprocessing options for efficient and accurate analysis of complex structures.
- **Module 5: Beams and shells**
  - Finite element theory and formulation for thin beams and shells.
  - Students will (1) obtain a basic understanding on the mechanics theory of beams and shells, (2) be able to derive the finite element formulations for beams and shell, (3) be able to perform mechanical analysis of beams and shells using beam and shell elements.
- **Module 6: Large deformation and nonlinear materials**
  - Mechanics involving geometrical and material nonlinearities. Finite element theory and formulation for nonlinear mechanical problems. Finite element analysis of nonlinear structures and materials.
  - Students will (1) obtain a basic understanding of geometrical and material nonlinearities and their implications in finite element formulation, (2) be able to perform nonlinear mechanical analysis using ANSYS Workbench.
- **Module 7: Dynamics**
  - Finite element theory and formulation for dynamic analysis of mechanical structures. Finite element analysis of dynamic behavior of structures.
  - Students will (1) obtain a basic understanding of the theory, formulation and procedure of a dynamic analysis, (2) be able to perform dynamic mechanical analysis using ANSYS Workbench.
- **Module 8: Structural vibration and dynamics**
  - Finite element theory, formulation and procedure for vibration and dynamic analysis of mechanical structures.
  - Students will (1) obtain a basic understanding of the theory, formulation and procedure of a dynamic analysis, (2) be able to perform dynamic mechanical analysis using ANSYS Workbench.
- **Module 9: Thermal analysis**
  - Finite element theory, formulation and procedure for heat transfer analysis of 2-D and 3-D mechanical structures.
  - Students will (1) obtain a basic understanding of the theory, formulation and procedure of heat transfer analysis of multidimensional systems, (2) be able to perform heat transfer analysis of 2-D and 3-D structures using ANSYS Workbench.

- **Module 10: Thermomechanical analysis**
  - Thermomechanics theory and FEA procedure for thermomechanical analysis of 2-D and 3-D systems.
  - Students will (1) obtain a basic understanding of the thermomechanics theory and the FEA procedure of thermomechanical analysis, (2) be able to perform thermomechanical analysis of mechanical structures using ANSYS Workbench.

Prerequisites

MTHSC 3650, ME 2040, ME 3040, ME3060 or consent of instructor.

Course Structure

- The course will be delivered completely online. Course presentation and tutorial video clips, handouts and other online course materials will be posted following the progress of the course.
- MYCLE/Blackboard at http://mycle.clemson.edu will be used as the course website. Lectures and tutorial video clips, handouts, homework assignments and solutions, and other online materials will be posted on the website. The website will also be used for homework submission, group discussion and online tests.
- The course content is modularized into a set of learning modules (see Course Topical Content), each consisting of some or all of the following components:
  - **Video Watching:** In each module, you will watch 2-3 lecture videos and 2-5 simulation tutorial videos which will be made available to you in the online course site.
  - **Handout Reading:** In each module, you will read several handouts and/or other course materials made available to you in the online course site.
  - **Assignments:** Students are expected to complete each learning module within a specified period of time. A mini-project will be assigned for each learning module. Students are expected to complete the mini-projects no later than their specified due dates. Directions for completing course assignments are provided in the Modules area in the online course site.
  - **Online Discussions:** You will participate in online discussions. Research depends on collaboration and conversation. You should post an initial response to the discussion and a minimum of two responses to other student posts. Please proofread your posts for correct grammar, punctuation, spelling, and capitalization. Do not use all capital letters or all lowercase letters, and do not use instant messaging or text chat abbreviations in your posts.
- MATLAB is used in some homework assignments. Commercial FEA software ANSYS Workbench are utilized in several assignments in which students learn modeling practices necessary to obtain reliable results and the proper role of FEA in the overall design process.

- Instructor response time is 24 hours for questions posted in the the **Ask the Instructor** forum. This response times excludes weekends, official University closures, and other times as noted by the instructor. Should you need live assistance, email me to arrange an online or phone consultation.
- Online exams will be held on specified dates and time.
- A discussion group will be set up on the Blackboard system for student-student and instructor-student interactions.

Homework Assignments

There will be 10 mini-projects for the course. Some of the mini-projects will be design/analysis case studies using ANSYS Workbench and some will be implementing finite element programs using MATLAB. Project reports along with electronic files of FE models or MATLAB programs will be due on the date specified for each assignment. Students will submit their files electronically.

Exams

A midterm exam and a final exam will be given. Both are online exams delivered through Clemson University's Blackboard system.

Grading

Assignments in this course are divided into these general categories, which carry the following weight in your final grade calculations:

Assignments	10@70 points	700 points
Midterm Exam	1@100 points	100 points
Final Exam	1@100 points	100 points
Discussions	5@20 points	100 points
Total		1000 points

Homework that is turned in late will be accepted and graded. However, late homework will receive at most 50% credit. No homework will be accepted after the final exam.

This course follows the typical grading guidelines:
A = 90 to 100%
B = 80 to 89%
C = 70 to 79%
D = 60 to 69%
F = 0 to 59%

Communicating with Your Instructor

You have numerous ways of communicating with your instructor: phone, email, the **Ask the Instructor** forum, and live consultations by appointment.

If you have a question about an assignment or class procedure, consider posting it in the **Ask the Instructor** forum so that other members of the class can benefit from it, too. A lot of learning can happen in this forum if you use it, so please do!

If you have a personal concern (such as a question about a grade), send a message to your instructor through the online course site or through your Clemson email account.

I am here to help you, so please ask questions and seek clarification as early and as often as needed. Delay will only hinder your learning.

Academic Integrity

The Clemson University Academic Integrity Statement

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.

A simple definition of plagiarism is when someone presents another person's words, visuals, or ideas as his or her own. The instructor will deal with plagiarism on a case-by-case basis. The most serious offense within this category occurs when a student copies text from the Internet or from a collective file. This type of academic dishonesty is a serious offense that will result in a failing grade for the course as well as the filing of a formal report to the University.

See the Undergraduate Academic Integrity Policy website for additional information about academic integrity and Clemson procedures and policies regarding scholastic dishonesty.

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The Clemson University Title IX (Sexual Harassment) Statement:

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.)in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. To locate information on the Title IX policy, visit http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Mr. Jerry Knighton is the Clemson University Title IX Coordinator, and is also the Director of Access and Equity. His office is located at 111 Holtzendorrf Hall, 864.656.3181 (voice) or 864.565.0899 (TDD).