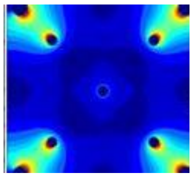
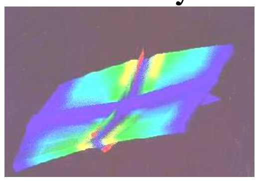
Finite Element Method
Course Number: ME - 610
(Fall 2014) – San Diego State University

Time: 4:00-7:00 PM (W)
Place: E301
Instructor: Prof. Sam Kassegne

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Course Description:

The Finite Element Method **(FEM)** is a very versatile and powerful analytical tool that has wide applications in a multitude of physical problems such as **stress analysis, heat transfer, fluid flow, acoustics, microfluidics, electromagnetism,** etc. The major focus of this course is to provide graduate students with an understanding of the basic principles upon which **FEM** is based and also educate them on how **FEM** could effectively be used to understand the behavior and response of physical models to external effects such as stress, heat, vibration, electrical and magnetic field etc.

Instruction is geared towards applying **FEM** to a broad variety of physical problems that illustrate its principles such as CFD, structural mechanics, heat transfer and basic electromagnetic analysis.

Course Objectives:

Upon completion of the course work, students will:

- Develop comprehensive knowledge in the fundamental mathematical and physical basis of FEM.
- Know how to build FEM models of physical problems and apply appropriate constraints and boundary conditions along with external loads followed by an analysis.
- develop and exercise critical thinking in interpreting results from FEM analysis. This will include the ability to identify bad results by looking at deflected shapes, stress contours, eigenfrequency animations as well as field distributions.

Instructor:

Dr. Kassegne is associate professor of mechanical engineering at the Mechanical Engineering department of SDSU. He was previously at Marc Madou's BioMEMS Research Group at UC Irvine and had also worked at Microfabrica, a MEMS company and Nanogen, a San Diego based DNA-chip Company. He has also consulted Corning, SAIC, Nevada Nanotech, OxyHeal, and Nokia companies. Dr. Kassegne conducts research in the areas of MEMS, microfluidics, polymer photovoltaics, sensors and actuators and next generation lithography. He has taught several courses in FEA and MEMS at UCSD and UCI.

Grading and Assignments:

Homework – 25%
1 Mid-term – 40%
Design Project – 35%

Office Hours: M/W, 1:00-4:00 PM.

Text Book and References

1. Finite Element Modeling for Stress Analysis by Robert D. Cook, John Wiley and Sons, 1995 - standard text for course.
2. Introduction to the Finite Element Method, J.N. Reddy, McGraw Hill Publishers, 2nd Edition - Excellent reference.
3. Finite Element Procedures in Engineering Analysis, K.J. Bathe, Prentice Hall, 2nd Edition.

Software

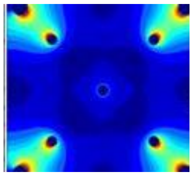
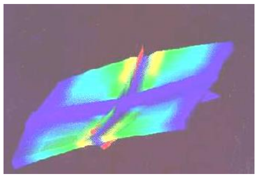
The multiphysics **FEM** package COMSOL (FEMLAB) will be used to train students on the application of the basic principles and fundamentals covered in the lectures.

Design Project

The design project involves a group work on the complete FEM simulation of a mechanical or electrical device or system. The development of FEM code involving new element, new constitutive equation or a novel approach is also considered acceptable and encouraged for PhD students and interested MS-level students. The project involves problem definition, acceptance of proposal by the professor, outline of FEM approach, presentation of results, and evaluation of results. For all projects, the minimum requirements are: (i) solution of a non-trivial system, (ii) nonlinear or transient analysis, (iii) use of advanced elements (not 1D element), (iv) convergence study, and (v) parametric study whenever applicable.

The final design will be presented at the end of the semester.

Finite Element Method - Course Number: ME 610 - (Fall 13)

Lecture Outline

Lecture 1 – Introduction

- Basic Principles of Finite Element Method.
- Some basic but important mathematical and physical concepts in FEA.
- Concepts such as elements and nodes, discretization and other approximations.
- Build Beam Model

Lecture 2 – 1D FEA

- Dimensional FEs (e.g., beams, bars, cables and springs).
- Stiffness and load vector formulations and boundary conditions.
- Build Model for a 1-D FEA problem.

Lecture 3 – Shape Functions

- Shape Functions.
- Numerical Quadrature.

Lecture 4 – 2D FEA (Plane Stress)

- 2-Dimensional Finite Elements.
- Discussion includes plane elements (plane-stress and plane-strain), and plate elements.
- Build Model for a 2-D FEA problem.

Lecture 5 – Thermal Analysis

- Thermal Analysis. Basic Equations, FEs for thermal analysis, Thermal transients.
- Build Model for a thermal problem.

Lecture 6 – CFD

- CFD. Basic Navier- Stokes Equations, FEs for fluid flow analysis, fluid flow transients.
- Build Model for a CFD problem.

Lecture 7 – Dynamics & Nonlinear Analysis

- Dynamic Analysis - Free vibration and dynamic problems. Include response spectra analysis.
- Nonlinearity sources (material and geometric), techniques for nonlinear analysis.
- Build Model for dynamic and nonlinear problems

Lecture 8 – Basic Electromagnetics or Nonlinear Analysis

- Basic Electromagnetic Equations, FEs for field equations, transients.
- Build Model for electromagnetic problem.