MIE1804: Finite Element Method in Mechanical Engineering

Instructor: Professor S A Meguid

Ph.D., P.Eng., CEng, FIMechE, FASME FEIC LTSM-AIAA

Course Description:

The Finite Element Method (FEM) is a very powerful numerical tool that has wide applications in a multitude of real engineering problems. The main focus of this introductory course is to provide graduate students with a fundamental understanding of the principles upon which the FEM is based and how to use commercial codes (such as ANSYS Workbench) to solve complex engineering problems.

Specifically, students will learn how to apply the principles governing discretization of a continuum, solve the developed equations and scrutinize their model predictions to avoid the pitfalls of this elegant numerical approach. The instruction is designed around understanding and applying FEM to a broad range of engineering problems with the focus being solid and structural mechanics. Extensive demonstrations and use of ANSYS workbench will be provided in a specially designed computing labs.

This is a unique course as it combines both the theory and practice of the finite element method. Typically, either the theory or commercial codes are taught at universities.

Course Content:

- Fundamental concepts of a continuum discretization.
- Trial and shape functions, Rayleigh Ritz and weighted residual methods in stress analysis of engineering structures.
- Element formulations: Bar, Truss, Beam, Plane and 3D Elements.
- Consistent Loading and Gauss Quadrature.
- Element Stiffness, Assembly and reduction of Element Matrices.
- Adaptive Meshing and Mesh Convergence.
- Development and use of intrinsic coordinates, parent elements and Jacobian Matrix in finite element simulations.
- Stress Recovery, Mesh locking and Ill-Conditioned Matrices.
- Applied finite element, sources of errors and accuracy of FEM.
- Assignments: Students will be required to model three different physical problems using ANSYS Workbench involving bar, truss, beam and plane elements.
- Final projects: Students will apply all the knowledge gained in two final projects involving model development, discretisation, selection of appropriate elements, mesh convergence, optimization, and scrutiny of results.

Outcomes of Course:

Upon completion of the course work, students will develop:

- Comprehensive understanding of the fundamental formulations upon which FE is based.
- Fundamental understanding of domain discretization, its equilibrium and continuity.
- Ability to construct FEM models of real engineering problems
- Ability to apply varied loads and enforce the appropriate constraints to their models using ANSYS Workbench.
- Critical thinking in interpreting FE model predictions.
- Complete FEM solution strategy for the analysis of mechanical systems.
- Determine the effect of discretization, mesh locking and other sources of inaccuracies on model predictions.
- Validation of FE predictions.

MIE1804 is a graduate course open to doctoral and masters students in mechanical, aerospace, civil, and biomedical engineering seeking substantial knowledge in the theory and practice of the Finite Element Method applied to structures.

Prerequisites

A solid grasp of fundamentals of Mechanics of solids, theory of elasticity and calculus are essential prerequisites for this course.

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