Computational Solid Mechanics

MAE 310
Fall Semester 2025

Instructor: Dr. Ju Liu, Assistant Professor
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Textbook:

- The Finite Element Method: linear static and dynamic finite element analysis, Thomas J.R. Hughes, Dover 2000.

References:

- Finite element procedures, K.J. Bathe, 2014.
- Finite elements: an introduction, Eric B. Becker, Graham F. Carey, and J. Tinsley Oden, 1981.

Goals: This course aims to give students an in-depth understanding of the finite element method. In particular, the theoretical foundation as well as the implementation of the finite element method will be covered with applications primarily in the static and dynamic analysis of solids and structures.

Prerequisites: Calculus, Linear algebra, and a technical programming language.

Grading:

Homework assignment	35%
Midterm exam	25%
Final project	30%
Class participation	10%

Class	Topic
Week 1	History of the finite element method; Mathematical preliminaries; A one-dimensional elliptic boundary value problem.
Week 2	The weighted residual formulation.
Week 3	Equivalence between the strong-form and weak-form problems; Natural boundary condition; Galerkin approximation; The matrix problem.
Week 4	Piecewise linear finite element space; Properties of the stiffness matrix; Element point of view.
Week 5	Accuracy analysis; Data structure for implementation.
Week 6	Classical linear heat conduction in multi-dimensions; its strong-, weak-, and Galerkin formulations.

Week 7	Data processing arrays for implementation.
Week 8	Small-strain linear elastostatics; weak-form problem for three-dimensional elasticity.
Week 9	**Mid-term exam**; Galerkin approximation of linear elasticity.
Week 10	Voigt notation; Assembly of the global arrays; Properties of the stiffness matrix.
Week 11	Preliminary concepts in element technology; Isoparametric elements.
Week 12	Shape function routine; Element stiffness formulation.
Week 13	Best approximation theory and error estimates.
Week 14	Strong- and weak-form problems of elastodynamics; Semi-discrete formulation; Rayleigh damping matrix.
Week 15	Modal reduction; Time-stepping procedures for the semi-discrete formulation.
Week 16	Numerical dissipation; Implicit-explicit solution strategy; Generalized-α method.