# Advanced Computational Solid Mechanics

MAE5007
Spring Semester 2024

**Instructor**: Dr. Ju Liu, Assistant Professor
Office: Room 1004 North Engineering Building
E-mail: liuj36@sustech.edu.cn

**Teaching assistants**: TBA

**References**:

- The Finite Element Method: linear static and dynamic finite element analysis, Thomas J.R. Hughes, Dover 2000.
- Computational Inelasticity, J.C. Simo and T.J.R. Hughes, Springer, 2000.
- Nonlinear Finite Elements for Continua and Structures, W.K. Liu, B. Moran, T. Belytschko, and K. Elkhodary, Wiley, 2014.
- Computational Methods for Plasticity: Theory and Applications, E.A. de Souza Neto, D. Peric, and D.R.J. Owen, John Wiley & Sons, 2008.
- Nonlinear Solid Mechanics: a continuum approach for engineering, G.A. Holzapfel, John Wiley & Sons, 2000.
- Methods of Applied Mathematics, T. Arbogast and J.L. Bona, 2008.

**Goals**: This course aims at providing students an in-depth understanding of the finite element method with a focus on nonlinear and inelastic problems. 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**: Differential calculus, Linear algebra, and MATLAB programming.

**Grading**:

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| Homework assignment | 40% |
| Midterm exam | 25% |
| Final presentation | 32% |
| Class participation | 3% |

**Schedule**:

| Class | Topic |
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| Week 1 | Review of linear elasticity, weak-form problem, and Galerkin formulation |
| Week 2 | Review of the finite element implementation |
| Week 3 | Review of elastodynamics and time stepping algorithms |

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| Week 4 | Solution method of nonlinear systems: Newton-Raphson method |
| Week 5 | Solution method of nonlinear systems: line search, BFGS, and arc-length |
| Week 6 | Formulation of small-strain nonlinear heat conduction and elastostatics |
| Week 7 | Finite deformation hyper-elastostatics: kinematics |
| Week 8 | Finite deformation hyper-elastostatics: balance equations and consistent linearization |
| Week 9 | Finite deformation hyper-elastostatics: material models and implementation details |
| Week 10 | Finite deformation hyper-elastodynamics: Newmark-$\beta$ and generalized-$\alpha$ method |
| Week 11 | Finite deformation hyper-elastodynamics: Energy-momentum scheme |
| Week 12 | Viscoelasticity: linear theory and integration algorithms |
| Week 13 | Viscoelasticity: nonlinear model |
| Week 14 | Elastoplasticity: one-dimensional motivation and formulation |
| Week 15 | Elastoplasticity: J2 flow theory and return mapping algorithm |
| Week 16 | Contact and impact |