AAE 690 - Modeling Damage and Strengthening Mechanisms in Materials

Offered: Spring 2014; TuTh 10:30 – 11:45 am in ARMS 3115
Instructor: Prof. Michael D. Sangid

This course is intended to be a graduate level course, which focuses on modeling at the microstructure level of primarily metals but also composites. The course will contain 3 projects and HW, each comprising 25% of the student's grade. The pre-requisites for this class is an entry-level class in solid mechanics (such as elasticity or continuum mechanics) that covers indicial notation and basic equilibrium/compatibility conditions. The course topics and modules are defined as follows:

I. Eshelby inclusion problem (1/4 Class)
   - Advanced micromechanics analysis of modern engineering materials with emphasis on relating elastic microstructural phenomena to the mechanics of material behavior.

Project 1: Application to fiber reinforced composites – Mori-Tanaka implementation

II. Overview of classical plasticity (1/4 Class)
   - Phenomenological and mathematical formulation of the constitutive laws of plasticity.
   - Yielding, yield surface; von Mises, Tresca yield criteria; Drucker's stability postulate; strain or work hardening, normality rule, J_2 flow theory (Prandtl-Reuss equations for isotropic materials with isotropic hardening), perfect plasticity, and stress-strain law

III. Crystal plasticity (1/4 Class)
   - Physical and mathematical foundation for plasticity in crystalline materials, with application to deformation processes.

Project 2: Bishop and Hill implementation in Taylor problem for deformation of polycrystals

IV. Concepts of dislocations leading to strengthening mechanisms in metals (1/4 class)
   - Study of anisotropy of material and elastoplastic properties at crystal level, microstructural basis for deformation in metals, polymers, and ceramics.
   - Failure mechanisms and toughening in metals, with primary emphasis on work/strain hardening, solid solution hardening, precipitate hardening, and grain boundaries.

Project 3: The topic of this project must be relevant to this class and discussed with the instructor. Students are required to give a class presentation (10-15 minutes) and turn in a report. Although it is helpful to choose a topic relevant to your research, this work cannot be completed prior to this semester or used to satisfy another requirement.