Course Registration Numbers: 11409

Schedule: Tuesdays and Thursdays at 10:30 – 11:45 am in 3115 ARMS

Instructor: Michael D. Sangid; Email: msangid@purdue.edu
Office: 3329 ARMS; Telephone: 494-0146
Office Hours: Tuesdays and Thursdays: TBD

Please note: To ensure that everyone has the same access to questions/answers, please ask questions about the HW/projects during class or office hours. Emailing questions should be avoided. Also, please do not ask general/vague questions, such as ‘how do I do #X (while showing up with no prior work)?’, ‘can you find the bug in my code’, or ‘is this right?’

Prerequisites: An entry-level class in solid mechanics (such as elasticity or continuum mechanics) that covers indicial notation and basic equilibrium/compatibility conditions.

Required Text: None
Will supply journal papers / book chapters as hand-outs


Supplemental Texts:
- The Mechanics of Crystals and Textured Polycrystals, William F. Hosford, Oxford
- Crystals, Defects, and Microstructure, Rob Phillips, Cambridge
- The Mathematical Theory of Plasticity, R. Hill, Oxford
- Introduction to Texture Analysis, O. Engler, V Randle, CRC Press
- Strengthening Mechanisms in Crystal Plasticity, A.S. Argon, Oxford

Grading: 3 Credit Hours – HW (25%), Project 1 (25%), Project 2 (25%), and Project 3 (25%). In general, we will have a 90%|80%|70%|60% grade scale with +/- grades. Depending on how the class performs on its assignments and projects, the instructor reserves the right to curve the scale in the favor of the class, if necessary, based on his discretion. Grades will never be curved downward.

Exams: There will be no exam or finals, as part of this class.
Homework: There will be a HW assignments given roughly every other week during the semester. You may work in teams of 1 to 3 on the HW. Please write each of your names on the HW assignment that you turn in.

The HW is for your own benefit and is necessary to properly learn the material. It is expect that each student put forward an honest effort in solving each problem. Working together is not a means to ‘divide up’ the work. If you turn in an assignment with more than one name on it; each person must have put forth their best effort on every problem and discussed this problem with the group. Any abuse of this policy and we will go back to individual assignments.

Project: Each student is expected to turn in his/her own project, containing a written report with figures, tables, equations, codes, references, etc. For Projects 1 and 2, the entire class will work toward the same project: (i) Mori-Tanaka implementation of the Eshelby inclusion model and (ii) Bishop and Hill implementation of a Taylor crystal plasticity model. For the third project, each student must choose his/her own topic, which must be relevant to this class and discussed with the instructor. Additionally, for the third project, students are required to give a class presentation (10 min). 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.

Course Description: 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 topics and modules are defined as follows:

I. Eshelby inclusion problem (1/4 Class)
   o 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)
   o Phenomenological and mathematical formulation of the constitutive laws of plasticity.
   o 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)
   o 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)
   o 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 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.

CS&E Program: This class is listed as a Relevant Course to count towards the requirements of the CS&E Program.

Approach: Active learning – classes are a mixture of lecture and discussion. Students are expected to be present and prompt for class, to keep up with the materials and homework assignments, and to live up to the highest standards of honesty and integrity. Students are encouraged and expected to be lively and participate with the lectures. The class notes will be given on the blackboard with figures shown on the overhead (the figures will be made available through the class website). It is expected that the students come to class and take notes. If a student cannot make it to class, they should arrange to get the notes from one of their classmates.

Definition of Academic Dishonesty: Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty" (University Regulations, Part 5, Section III, B, 2, a). Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest" (University Senate Document 72-18, December 15, 1972).

Academic Integrity: "Purdue University values intellectual integrity and the highest standards of academic conduct. To be prepared to meet societal needs as leaders and role models, students must be educated in an ethical learning environment that promotes a high standard of honor in scholastic work. Academic dishonesty undermines institutional integrity and threatens the academic fabric of Purdue University. Dishonesty is not an acceptable avenue to success. It diminishes the quality of a Purdue education which is valued because of Purdue's high academic standards" (S. Akers, Academic Integrity, A Guide for Students, 1995, revised 1999). Also, see PURDUE UNIVERSITY CODE OF HONOR.

Students with Disabilities: Students with disabilities requiring additional assistance should make themselves known to the instructor.

Campus Emergency: In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor’s control.

Additional Information: This class will uphold Purdue University’s policies on ‘Attendance and Grief Absence’, ‘Adverse Weather’, ‘Campus Emergency’, etc. Please consult purdue.edu for more information.