UNIVERSITY OF CALIFORNIA, MERCED
MSE-121: Mechanical Behavior of Materials

Fall 2021
Lecture M 1:30-3:20 PM, Kollig 217
Discussion 1 W 1:30-3:20 PM, COB 110
Discussion 2 W 3:30-5:20 PM, COB 110

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Office Hours: Tuesdays, 3-4 pm. Zoom Virtual Room

1. Course Goals

Matrices, tensors and representation surfaces will be used to describe stress, strain, and related material behavior (*e.g.*, elastic deformation, plastic deformation, photoelastic effects and piezoelectric effects). These tools will be applied to explore the microscopic and macroscopic response of isotropic and anisotropic materials to stress, including plasticity that is due to dislocation motion, twinning and martensitic transformations. Practical relevance to the processing, strengthening, and failure of materials will be emphasized.

2. Learning outcomes

You will:

• acquire an understanding of matrices, tensors and representation surfaces that will enable you to describe the response of materials to stress, at a level that is consistent with relevant professional literature;

• acquire collateral knowledge of physical properties that can be represented by second-, third and fourth-rank tensors, and how these properties are quantitatively affected by anisotropy;

• acquire insight into the microstructural and macrostructural changes that accompany plastic deformation;

• be able to relate your understanding, knowledge, and insights to the practical contexts of how materials are formed (shaped) during processing, how they are strengthened to resist deformation when in service, and how they fail.

You will practice the related skills in homework and discussion exercises. You will demonstrate your proficiency formally in the midterm and final examinations.

3. Outline of topics

Week	Date	Lecture topics
1	08/30-09/03	Matrices and tensors. Notation conventions. Useful matrix theorems. Transformation of axes. Tensors of zeroth through fourth rank.

2	09/06-09/10	Principal axes. Representation surfaces for tensors. Properties of representation surfaces. Calculation of properties in particular directions in anisotropic materials.
3	09/13-09/17	Tensor description of stress, strain, and elastic behavior. Invariants. Interdependence of elastic constants.
4	09/20-09/24	Photoelastic effects. Piezoelectric effects.
5	09/27-10/01	Dislocation geometry. Force on dislocation when material is deformed. Energy of dislocations. Stress and strain fields of dislocations. Midterm 1.
6	10/04-10/08	Interactions between dislocations. Dislocation locks. Partial dislocations and stacking faults. Cross-slip.
7	10/11-10/15	Slip in single crystals. Identification of operating slip system. Stereographic projection. Schmid's Rule. Duplex slip.
8	10/18-10/22	Plastic deformation due to twinning and martensitic transitions.
9	10/25-10-29	Slip in polycrystalline materials. Need for 5 independent slip systems. Yield criteria.
10	11/01-11/05	Strengthening mechanisms. Interaction between stress fields of dislocations and stress fields of obstacles. Midterm 2.
11	11/08-11/12	Rate phenomena in plasticity. Effects of temperature. Diffusional flow. Work hardening and recovery. Superplasticity.
12	11/15-11/19	Molecular basis of polymer deformation.
13	11/22-11/26	Exploiting plasticity: materials processing.
14	11/29-12/03	Ductile failure mechanisms.
15	12/06-12/10	Brittle failure mechanisms. Statistical descriptions of failure.
16	12/11	Final exam, 11:30 am – 2:30 pm

4. Pre-requisites

ENGR45 or equivalent. Upper division standing in Engineering.

5. Text

The scope of this class is not covered by any textbook. Your class notes will be your primary source of reference material. In addition, readings from current research and professional literature will be assigned.

6. Discussion sections

Learning a subject is enhanced by ***interacting with*** the subject – which includes discussing concepts and solving (many) practice problems. Your discussion sections are designed to support your efforts to learn the course material by working with it in as many ways as possible.

7. Homework

Homework is a critical component of this course and is designed to help you learn, understand, and practice the material. Homework will be *due each week*. **Late homework will not be accepted.** To account for illness and other emergencies, the lowest homework score will be dropped.

You are encouraged to work with your peers when doing homework. However, each student must turn in his/her own homework assignment and it must reflect his/her own work. You must explicitly identify all peers with whom you worked.

8. Exams

There will be two in-class midterm exams as indicated on the accompanying schedule. There will also be a comprehensive final exam. There will be no make-up exams. If you are sick during a regularly scheduled exam, please bring a note from the university clinic or your own doctor verifying your illness. Your course grade will then be determined by the rest of your work.

Crib sheets will not be allowed during any of the exams. However, calculators will be allowed when necessary, if they are not used to store data or formulae pertaining to the course.

9. Quizzes

There will be a weekly quiz at the beginning of either lecture or discussion session. The quizzes are intended to help you stay on top of the last week's material.

10. Grade determination

Your final grade will be based on the following components:

- homework (20%)
- first midterm (20%)
- second midterm (20%)
- quizzes (15%)
- final exam (25%)

11. Dropping the course

Please see the UC Merced General Catalog and the Registrar's / Student First website for details.

12. CatCourses

CatCourses will be used for periodic course announcements, and for the distribution of class notes, discussion exercises, homework sets, and solutions. You can also check the scores that you have received on your homework assignments and exams.

Warning: The CatCourses software does calculations in ways that are difficult to decipher, so its assessment of your grade may differ from mine. Pay no attention to any letter grade that is reported on it, except for the midterm and final grades. Handouts for a given week will normally be posted during the preceding weekend and can be annotated electronically or printed. Full copies of lecture slides will normally be posted during the weekend following the lecture. To encourage you to take effective notes, and to think about the material, the lecture slides are "read only".

CatCourses may also be used to distribute recorded lectures. These can be used best in conjunction with the slides.

13. Final thoughts

If you are in trouble (behind in homework, doing worse in the course than you would like, etc.)

for whatever reason, please let me know. I will try to help.

Because this is a 4-unit course, you should plan to do *at least* 12 hours of work on it, per week. Here is one suggestion for how to spend this time effectively:

• reading assigned material ahead of the lectures:	2 hours/week
• attending lectures and office hours:	3 hours/week
• attending and participating in discussion:	2 hours/week
• homework:	3 hours/week
• review, and preparation of review notes:	2 hours/week

It is a good idea to explicitly block out time for all these activities in your schedule. The same is true for your other courses too!