BEST221: Mechanical Behavior of Materials
Fall 2017

Class times

Lectures:
M 11:30am - 1:20pm; CLSSRM 263.
Lectures will start promptly; *you are expected to arrive on time* to hear important announcements that include the learning objectives for each lecture.

Discussion Section:
W 11:30am - 1:20pm; CLSSRM 263.
Attendance will be recorded.

Course goals

Matrices, tensors and representation surfaces will be used to describe stress, strain, and related material behavior (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. Practical relevance to the processing, strengthening, and failure of materials will be emphasized, drawing on historical and current case studies.

Learning outcomes

To achieve the *course learning outcomes*, you will

- use matrices, tensors and representation surfaces to describe the response of materials to complex three-dimensional stress states, at a level that is consistent with relevant professional literature;
- use second-, third- and fourth-rank tensors to quantify anisotropic physical properties of materials, and to predict and analyze the behavior of materials that exhibit such properties;
- account for the effects of symmetry on the physical (especially mechanical) behavior of materials;
- identify the significant microstructural and macrostructural changes that accompany plastic deformation in a variety of practical contexts, and thus predict the time-dependent consequences of plastic deformation;
- apply your understanding, knowledge and insights to provide leadership-quality advice regarding design and selection of (i) optimal forming (shaping) operations during materials processing, and (ii) optimal strengthening strategies to limit deformation and failure under various in-service conditions.

You will practice the related skills in homework and discussion exercises. You will demonstrate your proficiency formally in the midterm and final examinations, and in the research paper that you will submit in the final week of the semester.

The course learning outcomes contribute strongly to the attainment of the following BEST program learning outcomes:

PLO-1: Core Knowledge – Graduates will possess the fundamental knowledge needed to understand and critically evaluate current research literature in their chosen field of biological engineering, materials science and engineering, and micro/nanotechnology;

PLO-4: Ethics - Graduates will understand and promulgate the importance of research and professional ethics, and maintaining the trust of governmental and non-governmental scientific organizations, professional colleagues, and the public.

Lead instructor

Christopher Viney
Office hours:
TBD.
*E-mail is **not** a useful medium for obtaining help with homework.*

Teaching assistant (TA)

Edwin Shen
Office hours:
TBD.

Prerequisites

Introductory materials course (ENGR45 or equivalent). Graduate standing in BEST, Applied Mathematics, Mechanical Engineering, or Physics.

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.

Discussion sections

Learning a subject is enhanced by ***interacting with*** the subject – which includes discussing concepts and solving 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. Attendance will be recorded.

Homework

Homework is a critical component of this course and is designed to help you learn, understand and practice the material. Seven sets of homework exercises will be issued during the semester. Homework is due on the dates indicated in the detailed schedule provided to course participants via CatCourses. **Late homework will not be accepted unless the circumstances are exceptional.**

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.

Exams

There will be two in-class midterm exam as indicated on the detailed 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, provided that they are not used to store data or formulae pertaining to the course.

Research paper

You will write an in-depth, journal-length research paper on a topic related to the mechanical behavior of materials, that you will select in consultation with the lead instructor and your research adviser. The topic will have some relevance to your field of research. Detailed guidelines will be provided.

Grade determination

Your final grade will be based on the following components:

- homework (10%).
- first midterm (20%)
- second midterm (20%)
- research paper (10%)
- final exam (40%)

Note that grades will not be assigned on a curve, but will be based on an absolute measure of your work.

Dropping the course

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

CatCourses

The CatCourses site "BEST 221 01/MSE 121 01" will be used for periodic course announcements, and for the distribution of class notes, discussion exercises, homework sets, and (some) solutions. You can also check the scores that you have received on your homework assignments and exams.

Warning: pay no attention to any letter grade that is reported on CatCourses, *except* for the final grade.

Special accommodations

UC Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. If you qualify for accommodations because of a disability, please submit a letter from the Disability Services Center to me in a timely manner (during the first three weeks of the semester, except for unusual circumstances) so that your needs may be addressed. Student Affairs determines accommodations based on documented disabilities.

We will make every effort to accommodate all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please speak with the lead instructor (CV) during the first week of class regarding any potential academic adjustments or accommodations that may arise due to religious beliefs.

Academic honesty and conduct

Students are expected to complete their own work and to abide by the UC Merced Academic Honesty Policy, which can be found on the Student Life website http://studentlife.ucmerced.edu/ under the "Office of Student Conduct" link. Any work submitted by a student in this course for academic credit will be the student's own work.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, (for example) in the form of an email, an email attachment file, an online file in a shared folder, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.

You must do your own work during examinations. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Note that most of the handouts provided in this course are protected by copyright, and are flagged accordingly on CatCourses. They are for your *personal* use only. Re-posting the files or their contents on sites such as (for example) "Course Hero" is an explicit violation of this copyright.

Students and instructors are expected to honor UC Merced's Founding Principles of Community: http://www.ucmerced.edu/principles-of-community.

Additional Syllabus Resources from ASUCM

Counseling and Psychological Services
The mission of UC Merced Counseling and Psychological Services (CAPS) is to support the mental health and well-being of our students. It is the intention of all CAPS staff to provide a safe, confidential atmosphere of acceptance and accessibility to professionals in the field of psychology.

Contact Information (Confidential Help)
Phone: (209) 228-4266
counseling@ucmerced.edu

Discrimination & Sexual Violence Prevention
The University of California is committed to creating and maintaining a community where all individuals who participate in university programs and activities can work and learn together in an environment free of harassment, exploitation or intimidation.

Contact Information
Phone: (209) 285-9510
msalvador2@ucmerced.edu, Michael Salvador, Director of Compliance,

CARE Office
Campus Advocacy, Resources, & Education (CARE) provides prevention education for the UC Merced community to achieve an environment free from the threat of sexual violence, dating/domestic violence, and stalking. They provides free and confidential assistance for all UC Merced affiliates (including Undergraduate students, Graduate students, Staff and Faculty. Stop by KL 107.

Contact Information (Confidential Help)
Campus Advocate: Val
(209) 386-2051
Valley Crisis Center
24/7 Hotline
(209) 722-4357

Food Assistance (HEROES)
CalFresh is a monthly stipend system that allows you to purchase food for no cost at all on your part. If you qualify for work study you most likely qualify for CalFresh.

Contact Information
Phone: 209-228-4187
heroes@ucmerced.edu

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 us know. We 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: 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!

MSE121 / BEST221--Mechanical Behavior of Materials--Fall 2017 Schedule

Week	Day	Date	Lecture	Discussion	Provisional scope and contents	HW
1	M	21-Aug				
	T	22-Aug				
	W	23-Aug		*D1*	*Introduction. Course structure and expectations.*	
	R	24-Aug				
	F	25-Aug				
2	M	28-Aug	L1		Description of anisotropic properties. Principal axes. Symmetry. Matrices and tensors. Notation conventions. Useful matrix theorems. Transformation of axes. Tensors of zeroth through fourth rank.	
	T	29-Aug				
	W	30-Aug		*D2*	*Explore the effect of symmetry on anisotropic properties.*	
	R	31-Aug				
	F	1-Sep				
3	M	4-Sep			(Labor Day)	
	T	5-Sep				
	W	6-Sep			(no discussion)	
	R	7-Sep				
	F	8-Sep				
4	M	11-Sep	L2		Representation surfaces for tensors. Properties of representation surfaces. Calculation of properties in particular directions in anisotropic materials.	
	T	12-Sep				
	W	13-Sep		*D3*	*Practice using different techniques to calculate the value of a physical property in a particular direction in anisotropic material.*	HW1 due
	R	14-Sep				
	F	15-Sep				
5	M	18-Sep	L3		Tensor description of stress. Resolution of stresses. Total, normal and shear stresses. Piezoelectric effect.	
	T	19-Sep				
	W	20-Sep		*D4*	*Exercises involving transformation laws and principal axes.*	
	R	21-Sep				
	F	22-Sep				
6	M	25-Sep	L4		Tensor description of strain. Converse piezoelectric effect. Electrostriction. Elasticity of anisotropic media.	
	T	26-Sep				
	W	27-Sep		*D5*	*Exercises involving stress, strain, compliance and piezoelectric tensors.*	HW2 due
	R	28-Sep				
	F	29-Sep				
7	M	2-Oct	L5		Elasticity of cubic materials. Elasticity of isotropic materials.	
	T	3-Oct				
	W	4-Oct		Midterm 1		
	R	5-Oct				
	F	6-Oct				
8	M	9-Oct	L6		Plastic deformation. Geometry of dislocations. Motion of dislocations.	
	T	10-Oct				
	W	11-Oct		*D6*	*Discover some surprises about the geometry of edge dislocations. Explore some properties of stereographic projections.*	HW3 due
	R	12-Oct				
	F	13-Oct				

Week	Day	Date	Lecture	Discussion	Provisional scope and contents	HW
9	M	16-Oct	L7		Force required to move a dislocation. Energy of dislocation interactions. Stress and strain fields of dislocations. Slip in single crystals. Identification of operating slip system. Stereographic projection. Schmid's Rule. OILS Rule. Duplex slip.	
	T	17-Oct				
	W	18-Oct		*D7*	*Explore interactions between dislocations. Dislocation locks. Partial dislocations and stacking faults.*	
	R	19-Oct				
	F	20-Oct				
10	M	23-Oct	L8		Dislocation sources. Jogs and kinks. Climb and cross-slip. Plastic deformation of hcp and fcc single-crystal metals. Plastic deformation of polycrystalline metals.	
	T	24-Oct				
	W	25-Oct		*D8*	*Exercises involving the number of slip systems that are active during plastic deformation, and the number of independent slip systems that are needed for a general shape change of polycrystalline material.*	HW4 due
	R	26-Oct				
	F	27-Oct				
11	M	30-Oct	L9		Macroscopic and microscopic von Mises criteria. Strengthening mechanisms. Lüders bands. Portevin - le Chatelier effect.	
	T	31-Oct				
	W	1-Nov		Midterm 2		
	R	2-Nov				
	F	3-Nov				
12	M	6-Nov	L10		High temperature strength enhancement: precipitation hardening.	
	T	7-Nov				
	W	8-Nov		*D9*	*Explore microscopic and macroscopic consequences of low work-hardening rates. Stability of deformation.*	HW5 due
	R	9-Nov				
	F	10-Nov			(Veterans Day)	
13	M	13-Nov	L11		Rate phenomena in plasticity. Exploiting plasticity: materials processing. Superplasticity. Metal rolling.	
	T	14-Nov				
	W	15-Nov		*D10*	*Explore consequences of high work-hardening rates: wire drawing. Develop a stability criterion that is rate-dependent.*	
	R	16-Nov				
	F	17-Nov				
14	M	20-Nov	L12		Creep. Deformation maps. Creep (stress) relaxation. Creep-resistant superalloys.	
	T	21-Nov				
	W	22-Nov			(Non-Instructional Day)	HW6 due
	R	23-Nov			(Thanksgiving Holiday)	
	F	24-Nov			(Thanksgiving Holiday)	
15	M	27-Nov	L13		Statistical description of strength. Weibull distribution.	
	T	28-Nov				
	W	29-Nov		*D11*	*Practice / review / join dots.*	
	R	30-Nov				
	F	1-Dec				
16	M	4-Dec	(L14)		Wiggle room / review	
	T	5-Dec				
	W	6-Dec		*(D12)*	*Wiggle room / review*	HW7 due
	R	7-Dec				
	F	8-Dec			(Instruction ends)	
17	M	11-Dec				
	T	12-Dec				
	W	13-Dec				
	R	14-Dec				
	F	15-Dec			**Final Exam (8:00am–11:00am)**	