Department of Mechanical Engineering
ME EN 5530/6530 · Continuum Mechanics
Fall 2022

Syllabus

Instructor:	Prof. Spear, MEK 2151, *email correspondence via course website only*
TA:	Laura Ziegler, *email correspondence via course website only*
Units:	3
Meeting times:	T/TH: 2:00-3:20pm, WEB L122
Office hours:	M/W: 2:00-3:00pm *or by appointment*, MEK 2151

Recommended textbook:

Lai, Rubin, & Krempl, *Introduction to Continuum Mechanics*, 3rd Ed., ISBN 0750628944. [a digital version is provided via Canvas free of charge]

Useful resources:

- J.N. Reddy, *An Introduction to Continuum Mechanics*, ISBN-13: 978-0521870443.
- http://www.continuummechanics.org/
- G.E. Mase, *Schaum's Outline of Continuum Mechanics*, ISBN-10: 07-040663-4.
- Essence of Linear Algebra (YouTube channel): https://www.youtube.com/playlist?list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab

Co/Prerequisites:

1. "C-" or better in ME EN 3300 OR ME EN 3310 AND ME EN 3315 AND MATH 2210 OR MATH 1260 OR MATH 1321 OR MATH 3140 Corequisites: "C-" or better in (MATH 3140 OR MATH 3150).
2. Ability to use a symbolic mathematics program (e.g., Mathematica, Matlab, Python, Maple).

Course summary:

This course is a general introduction to the fundamental concepts of continuum mechanics. The topics covered include vector and tensor algebra; vector and tensor calculus; kinematics of continuum deformation; derivation of field equations using conservation laws for mass, momentum, and energy; constitutive equations; and methods for solving linearized problems in elasticity.

Course objectives:
By the end of this course, students should be able to:

- Perform vector and tensor manipulations in Cartesian coordinate systems
- Formulate and solve basic problems using the language and methods of continuum mechanics
- Describe motion, deformation, and forces in a continuum
- Derive equations of motion and conservation laws for a continuum
- Articulate basic principles and equations applicable to all constitutive models
- Set up and solve simple boundary value problems
- Articulate the applicability limits of continuum mechanics

Course websites:
Canvas - The course syllabus, assignments, supplementary lecture materials, and important announcements will be posted in Canvas. You can request help or schedule office hours using the messaging system in Canvas. Please ensure that you check Canvas regularly and receive notifications when announcements are posted in Canvas.

Gradescope - All assignments will be uploaded, graded, and returned via Gradescope (https://www.gradescope.com/). Because of the number of students and limited work hours for TAs, a limited number of problems from each assignment will be graded in detail and the remaining problems will be graded based on completion. Complete solutions to all problems will be posted after the assignment is due. It is your responsibility to compare the solutions to your own and to follow up in a timely manner if you have questions.

Deliverables and grading:

Assignments	30%
Labs	20%
Mid-term exam	25%
Final exam	25%

The total score is the weighted average of assignments, two labs, and two exams, as described in the table above. A curve (upward) will be applied only if the scores on exams or assignments are lower than expected. Otherwise, no curve will be applied.

≥93.0	<93.0 ≥90.0	<90.0 ≥87.0	<87.0 ≥83.0	<83.0 ≥80.0	<80.0 ≥77.0	<77.0 ≥73.0	<73.0 ≥70.0	<70.0 ≥67.0	<67.0 ≥63.0	<63.0 ≥60.0	<60.0
A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E

Exams:
Exam 1: Tuesday, October 25 (in class)
Exam 2: Friday, December 16 (1-3pm)
Exams cannot be taken at different times/dates, except in accordance with university policy. Content for each exam will be specified in a timely manner.

Assignment guidelines:
This is a graduate-level course; therefore, it is expected that assignments will be presented in a professional manner. Specifically, the assignments should:

- *Clearly* define and articulate the problem statement using words and figures.
- *Clearly* describe the solution method or approach, including explicit mention of any assumptions that are made.
- *Clearly* state the final solution, including units (if applicable) and a statement about the reasonableness and possible implications of the findings.

1. **Format and engineering paper**. Engineering paper should be used for all hand-written assignments. There should be no more than one problem solution on any page, and you should only use the front side of the paper. The final answer should be clearly demarcated (e.g. boxed or circled). In the header, include the following information:

	Your Name	Homework # - Problem #	Due Date	Page #

   The main body of the homework should include the following sections:
   <u>Given:</u>
   <u>Find:</u>
   <u>Assumptions:</u> (if any)
   <u>Solution:</u>

2. **Neat and legible.** Homework assignments that are not readable or are otherwise difficult to decipher will be returned with a zero or reduced score. It is your responsibility to ensure that handwriting and scan quality are sufficient for the TA to interpret. If the scan quality is poor, you will not receive credit for that assignment.
3. **Show all work.** Clearly show all steps of the problem solution. Partial credit can only be given if a sufficient amount of detail is shown. If you only provide the final answer with no work to communicate how you obtained that answer, no points will be given.
4. **Working with others is encouraged.** Part of the learning process comes from communicating with others. However, you will learn nothing from simply copying others' work. Therefore, each student must submit his/her own work.
5. **Submission deadline.** Homework must be submitted via Gradescope by the date and time specified at the top of the assignment. <u>Late homework will NOT be accepted for any reason.</u> If you are participating in a university-sanctioned event or have something more long-term going on in your life that will prevent you from submitting homework on time, please coordinate with me ahead of time.

Regrade requests:
Regrade requests will only be considered if submitted via Gradescope within two weeks (14 days) of the graded item being returned.

Instructor and student responsibilities:
As your professor, I am responsible for providing you with the instruction and resources necessary to build a strong foundation in the course topic areas. I am also responsible for assessing whether you are competent in these areas. As the student, you are responsible for making sure that you understand the concepts (and demonstrate your understanding).

College of Engineering Policies (ADA, Withdrawal, Drop, etc.):
https://www.coe.utah.edu/semester-guidelines

Academic integrity:
Engineering is a profession demanding a high level of personal honesty, integrity, and responsibility. Therefore, it is essential that engineering students, in fulfillment of their academic requirements and in preparation to enter the engineering profession, adhere to the Department of Mechanical Engineering Policy for Academic Misconduct. This policy is based upon the University of Utah's Policy 6-400: Code of Student Rights and Responsibilities (https://regulations.utah.edu/academics/6-400.php) where *"Academic misconduct" includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarism, and fabrication or falsification of information. It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct."* ***Academic misconduct and dishonesty will not be tolerated in this course.***

Lecture	Date	Topic	Description	Reading*	Reading†	
1	T: Aug. 23	Introduction	Overview, continuum hypothesis, basis vectors	1.1-3	1.1-2	**Mathematics of Vectors and Tensors**
2	Th: Aug. 25	Indicial notation, Vector algebra	Rules for indicial notation, Kronecker delta, permutation symbol	2.1-2	2A1-2A5	
3	T: Aug. 30	Matrices and tensors	Matrix operations and properties, tensor definitions and properties	2.3	2B1-2B10	
4	Th: Sep. 1	Tensors	Indicial notation for tensors, tensor operations, change of basis	2.5	2B11-2B16	
5	T: Sep. 6	Tensors	Invariants, eigenvectors and eigenvalues	2.5	2B17-2B20	
6	Th: Sep. 8	Calculus	Calculus of scalar, vector, and tensor fields	2.4, 2.5.4	2C1-2C5	
7	T: Sep. 13	Descriptions of motion	Displacement field and mapping function	3.1-2	3.1-5	**Kinematics**
8	Th: Sep. 15	Analysis of deformation	Lagrangian and Eulerian descriptions, Deformation gradient tensor	3.3	3.2-4, 3.18	
9	T: Sep. 20	Analysis of deformation	Jacobian, Homogeneous deformation	3.4		
10	Th: Sep. 22	Strain measures	Cauchy deformation tensor, Green-Lagrange strain tensor	3.4, 3.7	3.7-8, 3.23-24	
11	T: Sep. 27	Strain tensors, Symm. pos. def. tensors	Infinitesimal strain/rotation, Eulerian strain, Symmetric positive def.	3.5-6	3.7-8, 3.11, 3.26	
12	Th: Sep. 29	Principal stretches/strains	Polar decomposition, Principal stretches/strains and directions	3.8-10	3.20-22	
13	T: Oct. 4	Compatibility, Introduction to stress	Compatibility conditions; Intro. to body forces, traction, stress	4.1-2	3.16, 4.1-3	**Mechanics**
14	Th: Oct. 6	Lab #1	Elastic deformation of a rubber sheet			
	T: Oct. 11	**NO CLASSES (Fall Break)**				
	Th: Oct. 13					
15	T: Oct. 18	Stress transformations, Principal stresses	Transformation, stress invariants, relation to Mohr's circle	4.3	4.5-6	
16	Th: Oct. 20	Other stress measures	First Piola-Kirchhoff (P-K) stress	4.4, 4.6	4.1	
	T: Oct. 25	**Exam**				
17	Th: Oct. 27	Derivation of equilibrium equations	Conservation of linear and angular momentum	5.1-4, 4.5	4.7, 4.11, 4.4	
18	T: Nov. 1	Constitutive relationships	Linear elasticity	6.1-2	5.1-2	**Constitutive Equations**
19	Th: Nov. 3	Constitutive relationships	Constitutive law for linear elastic, isotropic materials	6.2.5-6.2.7	5.3-5	
20	T: Nov. 8	Lab #2	Nonlinear elasticity of a rubber balloon			
21	Th: Nov. 10	Constitutive relationships	Nonlinear elasticity; Stiffness tensor for isotropic and orthotropic materials	6.2.8		
22	T: Nov. 15	Linearized elasticity problems	Fundamental concepts of boundary-value problems of elasticity	7.1-3, 7.5		**Linearized Elasticity Problems**
23	Th: Nov. 17	Linearized elasticity problems	Boundary-value problems; Reciprocal Theorem	7.6		
24	T: Nov. 22	Linearized elasticity problems	Types of solution methods; Plane stress and plane strain		5.20-23	
	Th: Nov. 24	**NO CLASSES (Thanksgiving)**				
25	T: Nov. 29	Linearized elasticity problems	2D BVP using direct solution method: Thin rotating ring	7.7.1-7.7.2		
26	Th: Dec. 1	Linearized elasticity problems	St. Venant's Principle; Airy's stress functions	7.7.3-7.7.5		
27	T: Dec. 6	Linearized elasticity problems	Airy's stress function example	7.8.1-7.8.2		
28	Th: Dec. 8	Review	Review			
	F: Dec. 16	**FINAL EXAM (1:00-3:00PM)**				

* Approximate corresponding sections from J.N. Reddy, *An Introduction to Continuum Mechanics* .

† Approximate corresponding sections from Lai, Rubin, Krempl, *Introduction to Continuum Mechanics* .