

BME 4250: BIOMECHANICS I
Fall Semester 2019
Tues., Thurs., 10:45am-12:05pm; WEB L103

Syllabus

- Course Description:** The overall purpose of this course is to introduce the fundamental principles of mechanics applied to the study of biological systems. BME 4250 is required for all undergraduates in the Biomedical Engineering Program and is the starting point for coursework in biomechanics. Students should be familiar with the concepts covered in this course before enrollment in Biomechanics II (BME 6250), Biofluid Mechanics (BME 6220), Biomechanics Research (BME 6480), and Computational Biomechanics (BME 7210).
- Course Outcomes:** Following completion of this course, students will be able to:
- (1) use both index and direct notation
 - (2) understand transformation of coordinate systems and how to solve problems in rigid body kinematics
 - (3) apply finite deformation kinematics to analyze deformation and strain
 - (4) understand the concept of stress
 - (5) apply linear elasticity to analyze stresses and strains in materials under homogeneous deformation
 - (6) derive and interpret the equations of motion for deformable bodies
 - (7) interpret differences in the material behavior of biological materials in terms of their constituents and organization
 - (8) perform analysis of viscoelastic systems based on discrete element models
- Prerequisites:** Major status in the Biomedical Engineering program or instructor approval.
- Credit Hours:** 4
- Instructor:** Lucas H. Timmins, Ph.D.
Office: MEB 2474
lucas.timmins@utah.edu (preferred method of contact)
Phone: 801-581-8112
- Office Hours:** T, Th 1:00 – 2:00pm, MEB 2474; other times by appointment
- TA:** Elliott Hurd, u0873436@utah.edu
Carolyn Taylor, carolyn.taylor@utah.edu
Office Hours: Mondays 3:00-4:30pm, Wednesdays 9:00-10:30am, MEB 2475
- Graders:** TBD
- Web Page:** Canvas, <https://utah.instructure.com/courses/567992>
Gradescope, <https://www.gradescope.com/courses/50504>
- Textbook:** There is not an official textbook for BME 4250. However, there are several texts that cover different parts of the material in this class. The following books are on reserve at the Marriot Library as non-circulating items, and optional reading assignments are listed next to some of the lectures in the syllabus. Information on course reserves can be found at the following link:
http://campusguides.lib.utah.edu/course_reserves_guide. These textbooks include:
- *Continuum Mechanics*, A.J.M. Spencer, Dover Publications, Mineola, NY, 1980 (ISBN-13: 978-0486435947, call #QA808.2 .S63 2004). Although this is an optional textbook for the class, I **strongly recommend purchasing a copy of this textbook for yourself**. It is a good book and worth owning as a reference, and it will serve you well both for this class and for all subsequent classes in biomechanics. It can be purchased from Amazon for only \$15.33 plus shipping.
 - *A First Course in Continuum Mechanics: For Physical and Biological Engineers and Scientists*, Y.C. Fung, Prentice Hall, Englewood Cliffs, NJ, 1994 (ISBN-13: 978-0130615244, call #QA808. F86 1994)
 - *Introduction to the Mechanics of a Continuous Medium*, L.E. Malvern, Prentice-Hall, 1969 (ISBN-13: 978-0134876030, call #QA808.2 .M3)

- *Biomechanics: Mechanical Properties of Living Tissue, 2nd Edition*. Y.C. Fung, Springer, New York, 1993 (ISBN-13: 978-0387979472, call #QP88.F87 1993)

Grading:	Homework (6 sets)	25% total
	Exams (2)	50% total
	Lab reports (3)	25% total

Grade Scale:	A ≥ 92.5%	C ≥ 73.3%
	A- ≥ 90.0%	C- ≥ 70.0%
	B+ ≥ 86.6%	D+ ≥ 66.6%
	B ≥ 83.3%	D ≥ 63.3%
	B- ≥ 80.0%	D- ≥ 60.0%
	C+ ≥ 76.6%	E < 60.0%

Homework: All homework must be submitted electronically, as a .pdf file, through Gradescope. Assignments are due at the beginning of lecture on the specified day, as listed in the Course Schedule below. Please read the file *BME_4250_Instructions_for_Preparing_Homework.pdf* on Canvas for important instructions on preparing your homework.

Laboratories: Labs are held four times during the semester and meet on M, T, W, Th, and F from 2:00 – 5:30pm in MEB 2565. Please check the section you enrolled in to determine the appropriately day to attend lab. At the beginning of each lab, a quiz will be given to ensure students have read and are familiar with the entire lab protocol. All lab reports will be submitted electronically, as a single .pdf file, through Gradescope. Reports are due at the beginning of lecture on the specified day, as listed in the Course Schedule.

Gradescope: This course will utilize Gradescope for all assignment submissions, returned graded assignments, and requested regrades. All assignments must be submitted as a .pdf file. Homework submissions are to be separated into pages for each problem as defined in the submission portal. Lab report submissions are to be submitted as a single file. Gradescope syncs with Canvas, however, you will only be able to see your complete course grade in Canvas.

Exam 2: The second exam will be held during Finals Week. The date and time are scheduled by the Office of the Registrar and therefore is not flexible (see <https://registrar.utah.edu/academic-calendars/final-exams-fall.php>). The final exam for BME 4250 for this semester is scheduled for **Tuesday, December 11, 2019, 10:30 am – 12:30 pm**.

Course Policies:

Attendance. Attendance in class is not required, although strongly encouraged. The PowerPoint slides covered in each lecture, which will be posted on Canvas following each lecture, only cover a portion of the material. Much of course content will be covered on the whiteboard, as well as in-class examples and discussions. Attendance at labs is mandatory to receive a grade for lab assignments.

Late Assignments. Any assignment submitted after the due date will be considered late and the grade penalized. Submissions ≤24 hours after the due date will be deducted 25% of the assignment grade, and submissions >24 but ≤48 hours will be deducted 50%. Submissions over 48 hours after the due date will be receive a 0 mark. There will be no exceptions to this policy. Late homework and lab reports will be accepted with no penalty if a medical note is provided to the instructor.

Exams. Students are expected to attend all exams. Therefore, except for a University approved absence (Type I), which are explicitly listed in Policy 6-100.III.O (<http://regulations.utah.edu/info/policyList.php>), permission to be excused from an exam will only be granted for extremely unusual circumstances. All planned absences must be discussed in advance with the professor and supported by documentation. In the event of an unplanned absence (Type II), the reason for the absence must be communicated to the professor as soon as practically possible and documentary evidence is required (e.g., a doctor's note in the case of illness). Failure to provide evidence for the absences will result in a zero for that exam, with no exceptions. No request to take the exams at an alternative time or date will be allowed for any reason.

Regrades. Regrade requests must be submitted within one week after return of the work in question. Challenges to grades given on homework assignments, lab reports, or exams should be submitted via Gradescope. The regrade request must include a detailed statement of what portion of the assignment was misgraded and why the grading was incorrect. Failure to comply with this policy will result in no action on the requested regrade.

Academic Misconduct. The Department of Biomedical Engineering has a zero-tolerance policy for any form of academic misconduct. Students are expected to abide by the University of Utah Code of Student Rights and Responsibilities (see

<http://regulations.utah.edu/academics/6-400.php>). Academic misconduct, which includes cheating, misrepresenting one's work, inappropriately collaborating, plagiarizing, and fabrication of falsification of information, will not be tolerated. **In this course, any form of academic misconduct will result in a 0 mark for that assignment.** Any instances of academic misconduct will be immediately reported to the Department Chair, Associate Chair for Undergraduate Studies, and Dean of Students.

Cell Phones. Cell phones must be silenced during all lectures, exams, and laboratory sessions. Students are expected to avoid texting during lecture. Failure to comply with this policy may result in removal from the classroom.

Email Etiquette. The University of Utah is a professional environment and all members of the campus community are expected to act accordingly. This extends to the use of email. Email inquiries to the course instructor, TAs, or graders should be addressed with "Dear Dr. ____" or "Dear Mr./Ms. ____" (as appropriate), and signed with a student's first and last name. Failure to act in accordance with this policy may result in not receiving an email response.

College of Engineering Policies:

The College of Engineering publishes semester guidelines on Appeals Procedures, Withdrawal Procedures, Adding Classes, and Repeating Courses. Information on these policies can be found at the following link:

<https://www.coe.utah.edu/students/academic-affairs/academics/semester-guidelines/>

University Policies:

The Americans with Disabilities Act. The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

Addressing Sexual Misconduct. Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status, or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

Student Names & Personal Pronouns. Class rosters are provided to the instructor with the student's legal name as well as "Preferred first name" (if previously entered by you in the Student Profile section of your CIS account). While CIS refers to this as merely a preference, the instructor will honor you by referring to you with the name and pronoun that feels best for you in class, on papers, exams, group projects, etc. Please advise the instructor of any name or pronoun changes (and update CIS) so he can help create a learning environment in which you, your name, and your pronoun will be respected. If you need assistance getting your preferred name on your UIDcard, please visit the LGBT Resource Center Room 409 in the Olpin Union Building, or email bpeacock@sa.utah.edu to schedule a time to drop by. The LGBT Resource Center hours are M-F 8am-5pm, and 8am-6pm on Tuesdays.

Content Accommodation. Please review the syllabus to determine whether the content of the course or assigned readings conflict with any of your core beliefs. If you do see such a conflict, you may choose to drop the class, with no penalty, before the last day to drop courses. Please feel free to set up a time to discuss concerns regarding course content with the course instructor. For more information about the university's content accommodation policy, visit <https://regulations.utah.edu/academics/6-100.php>.

Personal Wellness. Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a student's ability to succeed and thrive at the University of Utah. For helpful resources contact the Center for Student Wellness at www.wellness.utah.edu or 801-581-7776.

Course Schedule

Week	Day	Date	Topic	Homework	Labs
1	Tues.	Aug. 20	Course introduction; History of biomechanics; Index notation		
	Thurs.	Aug. 22	Index notation (cont'd); Vector and matrix review; Direct notation ¹	HW #1 assigned	
2	Tues.	Aug. 27	Direct notation (cont'd); Finite deformation kinematics; Deformation map; Homogeneous deformations		
	Thurs.	Aug. 29	Homogeneous deformations (cont'd); Rigid deformations; Deformation gradient; Jacobian		
3	Tues.	Sept. 3	Polar decomposition; Strain		
	Thurs.	Sept. 5	Volumetric strain (dilation)	HW #1 due; HW #2 assigned	
4	Tues.	Sept. 10	Coordinate transformations; Rigid body kinematics; Euler angles; 2 nd order tensors ^{2,3}		Lab #1
	Thurs.	Sept. 12	Traction vector; Stress		
5	Tues.	Sept. 17	Stress (cont'd); Pressure; Dilational and deviatoric stress		Lab #2
	Thurs.	Sept. 19	Plane stress; Principal stresses	HW #2 due; HW #3 assigned	
6	Tues.	Sept. 24	Principal stresses (cont'd); Invariants of 2 nd order tensors		
	Thurs.	Sept. 26	Conservation of linear momentum		
7	Tues.	Oct. 1	Review for Exam 1	HW #3 due	
	Thurs.	Oct. 3	EXAM 1		
8	Tues.	Oct. 8	Fall Break – University Holiday		
	Thurs.	Oct. 10	Fall Break – University Holiday		
9	Tues.	Oct. 15	Constitutive equation; Objectivity; Material symmetry; Linearized elasticity ⁴ (required reading)		
	Thurs.	Oct. 17	Linearized elasticity (cont'd)		Lab #2 report due
10	Tues.	Oct. 22	Discuss Exam 1; Engineering elastic constants		Lab #3
	Thurs.	Oct. 24	Generalized Hooke's law; Tensorial vs. engineering strain	HW #4 assigned	
11	Tues.	Oct. 29	Bone physiology; Material behavior of bone		
	Thurs.	Oct. 31	Isotropic linearized elasticity; Stress-strain relationships; Beam theory		
12	Tues.	Nov. 5	Beam theory (cont'd); Bending of rectangular bending		
	Thurs.	Nov. 7	Equations for strain gauge analysis	HW #4 due	Lab #3 report due
13	Tues.	Nov. 12	Membranes and pressurized vessels	HW #5 assigned	Lab #4
	Thurs.	Nov. 14	Load sharing; Torsion		
14	Tues.	Nov. 19	Constituents of biosolids; Material testing of biologic materials	HW #6 assigned	
	Thurs.	Nov. 21	Thanksgiving – University Holiday		
15	Tues.	Nov. 26	Fatigue and failure	HW #5 due	
	Thurs.	Nov. 28	Viscoelasticity – discrete models		
16	Tues.	Dec. 3	Viscoelasticity – discrete models (cont'd); Harmonic oscillations		Lab #4 report due
	Thurs.	Dec. 5	Review for Final Exam	HW#6 due	
17	FINAL EXAM: Tuesday, December 11, 2019, 10:30am - 12:30pm				

Note that some topics will take somewhat less than one lecture to cover; others will require somewhat more than one lecture. The lecture schedule shown above is therefore approximate and subject to change.

Reading/Handouts (see syllabus for full citations): ¹Spencer, Chapters 2-3; ²Diff_Euler_Conventions.pdf
³Euler_angles.pdf; ⁴Linearized_elasticity.pdf