San José State University
College of Engineering
Biomedical Engineering Department

BME 165, Applied Engineering Biomechanics, Fall 2022

Course and Contact Information (Required - Delete the word "Required" in final draft)

Instructor:	Dr. Matthew Leineweber, Ph.D.
Office Location:	ENG 233G (Limited availability in Fall 2022)
Zoom Office:	https://sjsu.zoom.us/j/9502269007
Telephone:	(408) 924-3931
Email:	matthew.leineweber@sjsu.edu
Office Hours:	Monday 9:00am-10:00am Wednesday 2:45pm-3:45pm
Class Days/Time:	MW 13:30-14:45
Classroom:	Zoom: https://tinyurl.com/y7dmxjc5 Canvas: https://sjsu.instructure.com/
Prerequisites:	CE 95, CE 99, BME 65 or equivalent; MATE 25 or BME 68 or equivalent

Course Description

Exploration of structural biomechanics applied to the human body. Students compare linear and nonlinear elastic, and viscoelastic models for describing the behavior of musculoskeletal tissues and implants. Concepts include bone remodeling, osteoarthritis, implant failure, muscle contraction, and cardiac mechanics.

Online Course – Flipped Classroom, Synchronous Format

This course is held in an online format using a flipped classroom delivery. This means that live Zoom meetings will be held at the posted times each week, and that video lectures are posted to the course Canvas site every week. Students are responsible for watching the posted videos and completing the reading for every week prior to attending the Zoom meeting. In addition to Canvas, this course uses the Gradescope platform for the submission of all work. Gradescope can be accessed through Canvas, and all students will be automatically registered for the Gradescope course upon registering in Canvas.

The live Zoom meetings will require an active internet connection to participate in group work and in-class assignments. The iClicker Reef application will be used for extra credit opportunities and to gauge understanding of the course material. Homework and the take-home/virtual lab assignments will focus on modeling and quantifying biomedical systems using both analytical and numerical (MATLAB/Python) approaches.

Faculty Web Page and Canvas Site

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the Canvas Learning Management System course login website. For help with using Canvas see Canvas Student Resources page.

The Discussion platform in Canvas will be used for discussions and questions on homework, exams, and all other course material. This discussion board will be the fastest way for you to ask technical questions to the professor and classmates, while allowing them to share their response to all students at once. You may post

questions anonymous to other students (instructor will see who you are). Students may also answer your questions, endorse responses made by other students, and mark duplicate questions. Occasionally, participation in online discussions will be required as part of the *In-Class Assignments.*

To ensure fair treatment of all students and to provide students with the most rapid and consistent instructional information, **the instructor will not answer technical and policy questions by email.** Technical and policy questions include those regarding homework content, exam content, assignment deadlines, etc. Students should instead post to the class discussion board on Canvas. For help with using Canvas see Canvas Student Resources page.

Course Goals (Delete if not applicable)

The basic concepts of *structural biomechanics* can be separated into two areas:

1. Equilibrium of forces, moments, and torque.
2. Deformation of biomaterials and biological tissues under load.

In this course, we will explore these areas as they apply to the human body. We will use free-body diagrams to represent real-world systems so that we can apply both analytical and numerical tools to solve for unknown quantities. We will apply the concepts developed for engineering statics and strengths of materials, including conservation principles to understand and describe musculoskeletal mechanics. Specifically, we will explore the concepts of stress and strain, including constitutive relations, to describe how the musculoskeletal tissues and biomedical materials perform and fail under loading.

To this end, the goals of this course are as follows:

1. To **learn** how to apply engineering mechanics to analyzing the human musculoskeletal system.
2. To **understand** the mechanical and physiological properties of musculoskeletal and cardiovascular tissues (bones, muscles, arteries, heart, cartilage, tendons, ligaments) and their relationships to one another.
3. To **understand** the biomechanical aspects of the coupling of bones and orthopedic implants.
4. To **understand** the relationship between joint anatomy, loading, and musculoskeletal disorders, particularly osteoarthritis.
5. To **identify** the effects of the underlying assumptions made during mechanical analysis of musculoskeletal tissues, and how these assumptions affect the accuracy of the results

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

1. **Describe** the functional anatomy of the human body as it pertains to generating and transmitting forces, and supporting externally applied loads.
2. **Apply** the principles of biomechanics to different components of the human musculoskeletal systems.
3. **Formulate** the physical models, simplified linear-elastic models, viscoelastic, and nonlinear mathematical models describing static equilibrium and fluid mechanics related to the human body.
4. **Solve** biomechanics problems quantitatively, and assess the accuracy of the solution with respect to the underlying engineering assumptions.
5. **Troubleshoot** a biomechanical system by dividing it into subcomponents and narrowing the failure to single subsystem or an interaction
6. **Communicate** effectively to interpret and explain biomechanics data, including writing cohesive and lab reports.

Required Texts/Readings (Required - Delete the word "Required" in final draft)

Textbook

Electronic versions of following textbooks are freely available through SJSU by using the Leganto service linked through Canvas.

- Özkaya et al., *Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation*. 4th Ed., Springer, 2017.
- Pruitt, L. et al. *Mechanics of Biomaterials: Fundamental Principles for Implant Design*. Cambridge University Press. Cambridge. 2011.

Other Readings

Additional suggested readings and resources are posted on Canvas through the Leganto link. Occasionally, the reading assignments will reference one of these articles or book chapters.

Other technology requirements / equipment / material

- iClicker Reef polling app or iClicker remote (see "In-class iClicker questions" section of this syllabus).
- MATLAB will be frequently used throughout the course. See the SJSU MATLAB page (https://www.mathworks.com/academia/tah-portal/san-jose-state-university-31511582.html) for details on how to access this software.

Library Liaison

Anamika Megwalu
Phone: (408) 808-2089
Email: anamika.megwalu@sjsu.edu

Course Requirements and Assignments

Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus.

More details about student workload can be found in University Policy S12-3 at http://www.sjsu.edu/senate/docs/S12-3.pdf.

Attainment of the learning objectives (as listed above) will be assessed via homework, quizzes, lab reports, midterm examination, and the final examination.

Pre-Lecture Discussions

Online pre-lecture discussions will be assigned through Canvas each week. These discussions are meant to facilitate conversations about the reading materials and posted video lectures prior to the in-person Zoom meetings each week. They are posted at least one week prior to the due-date, and should be completed before the beginning of the first class of the week. **Missing the deadline to post, or not following the instructions provided for the post will result in a zero score for that week, unless prior approval has been given**. Prior approval will only be given under exceptional circumstances, or if the instructor is informed at the beginning of the semester. The lowest discussion score of the semester will be dropped.

Homework

Homework assignments will include questions and problems related to the materials covered in the lectures, and may require the use of MATLAB. They will be posted to Canvas, and should be submitted through the Gradescope interface linked to each assignment. Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. Homework must be turned in by 11:59 PM on the due date. Late assignments will not be accepted. The lowest homework score at the end of the semester will be dropped. **Students are responsible for uploading their work on time and checking that their submissions are correct and complete. Work that is submitted corrupted, or late will not be graded, and will be marked a zero.**

Quizzes

Three short quizzes will be administered online throughout the semester. These quizzes will be administered through Canvas/Gradescope during a set window of time. Quizzes will last approximately 25-30 minutes, and will cover core concepts and problem-solving techniques discussed in lecture and covered on homework.

Midterm examination

There will be one mid-semester examination. The midterm will cover the entire course material covered until the time of the examination. The examination may include multiple-choice questions, open-ended questions, and long-answer problems, and will be administered through Canvas and/or Gradescope. The date of the mid-semester examination is indicated in the Course Schedule. For free response questions, **students are responsible for uploading their work on time and checking that their submissions are correct and complete. Work that is submitted corrupted, or late will not be graded, and will be marked a zero.**

Final Examination or Evaluation

Faculty members are required to have a culminating activity for their courses, which can include a final examination, a final research paper or project, a final creative work or performance, a final portfolio of work, or other appropriate assignment. The final examination will be held on the date and time stipulated by SJSU's Final Examination Schedule (https://www.sjsu.edu/classes/final-exam-schedule/index.php) for the particular semester**.** The final examination will cover the entire course material covered during the semester. The final examination may include multiple-choice questions, open-ended questions, and problems.

Grading Information

Determination of Grades

Grades will be determined based on your completion of the course material, including homework, pre-lecture quizzes, exams, quizzes, and virtual labs. The percentage weights of each of these categories is described below:

Homework	10%
Pre-Lecture Discussions	15%
Quizzes	15%
Midterm Exam	20%
Final Exam	20%
Virtual Labs	20%

Grade	*Percentage*
A plus	*96 to 100%*
A	*93 to 95%*

Grade	*Percentage*
A minus	*90 to 92%*
B plus	*86 to 89 %*
B	*83 to 85%*
B minus	*80 to 82%*
C plus	*76 to 79%*
C	*73 to 75%*
C minus	*70 to 72%*
D plus	*66 to 69%*
D	*63 to 65%*
D minus	*60 to 62%*

The following **extra credit** opportunities will be offered throughout the semester. These opportunities are made available to all students. No additional extra credit will be awarded to students on an individual basis.

- Attending the *Pathways in BME* seminar series earns extra credit up at a rate of 10 points per seminar, for a maximum of 30 points applied towards homework scores. Attendance at all three seminars will earn equivalent to one full homework assignment.
- Completion of *In-Class Activities, Pre-Lecture Quizzes,* and *iClicker Quizzes.* Up to 3% extra credit applied towards the final grade can be earned through completion and correction of these assignments as follows:
    - *In-Class Activities* will be scored 80% on completion and 20% on correctness. Assignments can be completed in groups, but must be submitted individually.
    - *Pre-Lecture Quizzes* are to be completed through Canvas, and are graded for correctness. Up to three attempts can be made per quiz.
    - *iClicker Quizzes* will be routinely administered in class using the REEF polling system. Students will typically be given two opportunities to answer the question: once before and once after discussion with peers. The second response will be recorded and graded for possible extra credit applied at the end of the semester.

Classroom Protocol

Students are expected to log into the Zoom lectures on time and ready to learn. Microphones should be muted at all times, except for during breakout room discussions and when asking questions to the instructor. Cameras may be turned off, but turning them on is highly recommended.

Questions can be asked through the chat window or by "raising a hand" in the "Participant" window and being called on by the instructor. Students should remain respectful of each other at all times. Students will respect a diversity of opinions, ethnicities, cultures, and religious backgrounds. Interruptive or disruptive attitudes are discouraged.

Webcams and Recording Lectures

This course or portions of this course (i.e., lectures, discussions, student presentations) will be recorded for instructional or educational purposes. The recordings will only be shared with students enrolled in the class through Canvas. The recordings will be deleted at the end of the semester. If, however, you would prefer to remain anonymous during these recordings, then please speak with the instructor about possible accommodations (e.g., temporarily turning off identifying information from the Zoom session, including student name and picture, prior to recording).

Students are prohibited from recording class activities (including class lectures, office hours, advising sessions, etc.), distributing class recordings, or posting class recordings, unless specifically told to do so by the instructor. Materials created by the instructor for the course (syllabi, lectures and lecture notes, presentations, etc.) are copyrighted by the instructor. This university policy (S12-7) is in place to protect the privacy of students in the course, as well as to maintain academic integrity through reducing the instances of cheating. Students who record, distribute, or post these materials will be referred to the Student Conduct and Ethical Development office. Unauthorized recording may violate university and state law. It is the responsibility of students that require special accommodations or assistive technology due to a disability to notify the instructor.

Technical Difficulties

Internet connection issues: Canvas autosaves responses a few times per minute as long as there is an internet connection. If your internet connection is lost, Canvas will warn you but allow you to continue working on your exam, quiz, or discussion. A brief loss of internet connection is unlikely to cause you to lose your work. However, a longer loss of connectivity or weak/unstable connection may jeopardize your exam.

Other technical difficulties: Immediately email the instructor a current copy of the state of your exam/quiz/discussion assignment and explain the problem you are facing. Your instructor may not be able to respond immediately or provide technical support. However, the copy of your exam and email will provide a record of the situation.

Contact the SJSU technical support for Canvas:

Technical Support for Canvas

Email: ecampus@sjsu.edu

Phone: (408) 924-2337

https://www.sjsu.edu/ecampus/support

If possible, complete your exam in the remaining allotted time, offline if necessary. Email your exam to your instructor within the allotted time or soon after.

Academic Integrity

All work completed by each student is expected to be his/her own, original work, including (but not limited to) all homework, quizzes, exams, and projects. Cheating and/or dishonesty of any form will not be tolerated. **ANY academic misconduct will be met with an automatic failing grade in the course, followed by a formal review by the SJSU Academic Affairs office.**

Students who are suspected of cheating during an exam, quiz, or any other assignment will be referred to the Student Conduct and Ethical Development office and depending on the severity of the conduct, will receive a zero on the assignment or a grade of F in the course. Grade Forgiveness does not apply to courses for which the original grade was the result of a finding of academic dishonesty.

The SJSU Academic Integrity Policy (http://info.sjsu.edu/static/catalog/integrity.html) will be strictly enforced. Please take the time to familiarize yourself with the policy and its definitions of cheating and plagiarism, consequences and sanctions, and academic review procedures following any incidents.

University Policies

Per University Policy S16-9 ,relevant university policy concerning all courses, such as student responsibilities, academic integrity, accommodations, dropping and adding, consent for recording of class, etc. and available student services (e.g. learning assistance, counseling, and other resources) are listed on Syllabus Information

web page (https://www.sjsu.edu/curriculum/courses/syllabus-info.php). Make sure to visit this page to review and be aware of these university policies and resources.

Course Number / Title, Semester, Course Schedule

BME 165 - Applied Engineering Biomechanics, Fall 2021

Course Schedule

Week	Topic	Deadlines/Quizzes
1 8/22-8/26	Course Overview , Intro to BME applications of mechanics Review: internal forces, engineering representation of human joints	
2 8/29-9/2	Normal stress and shear stress Mechanics of Deformable Systems, 1D Hooke's Law	
3 9/5-9/9	***No Class Monday – Labor Day*** 2D Hooke's Law, Poisson's Ratio and Plastic Deformation	
4 9/12-9/16	2D & 3D Hooke's Law, plane stress and plane strain Materials testing & characterization, calibration	**QUIZ 1: Weeks 1-3**
5 9/19-9/23	Pure bending stresses in artificial joints (implants) Transverse bending and shear-moment diagrams	
6 9/26-9/30	Transverse bending and shear-moment diagrams Torsion and shear stresses in bones and implants	
7 10/3-10/7	Combined loading in bones and implants Stress Transformations, Plane Stress	**QUIZ 2: Weeks 3-6**
8 10/10-10/14	2D Mohr's Circle Effective Stress and Failure Theories	
9 **10/19**	Design of load-bearing implants **Midterm Exam Review**	
MT Week 10/24-10/28	**Midterm Exam** Viscoelasticity and Time-Dependent Behavior	
10 10/31-11/4	Viscoelasticity and Time-Dependent Behavior Engineering Models of Viscoelastic Behavior	
11 11/7-11/11	Engineering Models of Viscoelastic Behavior Ligaments, Tendons, and Nonlinear Elasticity	
12 11/14-11/18	Mechanics of Bone: Strain Response and Remodeling Mechanics of Articular Cartilage, osteoarthritis	**QUIZ 3: Weeks 9-11**
13 11/21-11/25	Mechanics of Skeletal Muscle: Structure and Contraction ***No Class Wednesday – Thanksgiving***	
14 11/28-12/2	Mechanics of Skeletal Muscle, Modeling and testing Mechanics of Skeletal Muscle, Modeling and testing	
15 12/5-12/9	**Final Exam Review on 12/5** No Class Wednesday – Final Exams Begin	
Final Exam	**Tuesday, December 13 – 12:15-2:30 PM**	