

San José State University
College of Engineering
Biomedical Engineering Department

BME 165, Applied Engineering Biomechanics, Spring 2020

Course and Contact Information

Instructor:	Matthew Leineweber
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Office Hours:	TBD
Class Days/Time:	MW 15:00-16:15
Classroom:	ENG 331
Prerequisites:	CE 095 or CE 099 or BME 065, or equivalent BME 068 or MatE 25, or equivalent

Course Format

The course will emphasize application of engineering mechanics to studying biomedical systems. The course consists of two 75 minute lectures per week. Homework and a semester project will focus on modeling and quantifying biomedical systems using both analytical and numerical (MATLAB) approaches.

Canvas and Piazza

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the [Canvas Learning Management System course login website](http://sjsu.instructure.com) at <http://sjsu.instructure.com>. You are responsible for regularly checking with the messaging system through Canvas to learn of any updates.

In addition to Canvas, the online Piazza platform (piazza.com/sjsu/spring2020/bme165/home) will be used for discussions on homework, exams, and all other course material. You will be responsible for enrolling yourself using the signup link provided (piazza.com/sjsu/spring2020/bme165). Piazza is the fastest way for you to ask technical questions to the professor 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.

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 Piazza.

Email Policy

Please send **emails regarding personal issues** (academic integrity issues, personal grades, medical issues, etc.) to the instructor. To receive the most rapid response to your email message, please start the subject line with the characters “**BME165**”. Out of fairness to all students, email communications related to technical questions or course policy will *not* be returned (please post these types of questions to the course Piazza site).

Course Description

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.

Catalog Description

This course explores 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.

Course Goals

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

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

1. **Describe** and understand 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. **Communicate** effectively to interpret and explain biomechanics data, including writing cohesive and lab reports.

Required Texts/Readings

Required Textbook

Özkaya et al., *Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation*. 4th Ed., Springer, 2017.

Recommended Textbook

1. Oomens et al., *Biomechanics Concepts and Computation*. Cambridge University Press, 1st Ed, 2009.
2. Simmons et al., *Introductory Biomechanics: From Cells to Organisms*. Cambridge University Press, 2007.

Other technology requirements / equipment / material

iClicker Reef polling app or iClicker remote (see “In-class iClicker questions” section of this syllabus).

Library Liaison

Anamika Megwalu

Phone: (408) 808-2089

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Course Requirements and Assignments

SJSU classes are designed such that in order to be successful, it is expected that students will spend a minimum of forty-five hours during the semester for each unit of credit (normally three hours per unit per week), including preparing for class, participating in course activities, completing assignments, and so on. More details about student workload can be found in [University Policy S12-3](http://www.sjsu.edu/senate/docs/S12-3.pdf) 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.

Reading Quizzes

Weekly “Reading Quizzes” will be given online through Canvas, and will cover assigned reading and previous lecture materials. Quizzes are posted one week prior to the due-date, and should be completed before the beginning of the first class of the week. Missed quizzes cannot be re-taken or made-up and will be scored as zero, 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 quiz 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. Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. Homework must be turned in before the beginning of class on the due date. Late assignments will not be accepted. The lowest homework score at the end of the semester will be dropped.

Quizzes

Three short quizzes will be administered throughout the semester. These quizzes will be administered either in class, or through Canvas during a set window of time. Quizzes will last approximately 15 minutes, and will cover core concepts and problem-solving techniques discussed in lecture and covered on homework.

Take-Home Labs

A series of take-home labs will be assigned throughout the semester. Labs will be completed in groups of 2-3 students, using lab-kits provided by the instructor. These kits are **rental kits only**, and must be returned to the instructor before the end of the semester. Final grades will not be assigned until kits are returned.

Each take-home lab will require students to submit a lab report documenting their findings. The format and requirements for these reports will be provided with the lab assignments. Students are responsible for coordinating with their groupmates to ensure all work is completed on time in its entirety.

All report submissions will be automatically scanned by Turnitin to locate matching or similar text within the paper. The instructor will decide whether there is plagiarism on a case-by-case basis, in which case academic and administrative sanctions will be assigned according to the [University Academic Integrity Policy \(S07-2\)](#).

Midterm examinations

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. During the exam, students can have only a non-programmable scientific calculator. Internet-connected devices, books and notes are not allowed. The date of the mid-semester examination is indicated in the Course Schedule.

Final Examination

The final examination will be held on the date and time stipulated by SJSU's Final Examination Schedule 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. During the exam, students can have only a non-programmable scientific calculator. Internet-connected devices, books and notes are not allowed.

NOTE that [University policy F69-24](http://www.sjsu.edu/senate/docs/F69-24.pdf) at <http://www.sjsu.edu/senate/docs/F69-24.pdf> states that "Students should attend all meetings of their classes, not only because they are responsible for material discussed therein, but because active participation is frequently essential to insure maximum benefit for all members of the class. Attendance per se shall not be used as a criterion for grading."

REEF (iClicker) Questions

Lectures will routinely contain in-class concept questions and quizzes 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.

Grading Information

Letter Grades:

A+	over 97%
A	> 93% to 96%
A-	> 90% to 92%
B+	> 87% to 89%
B	> 83% to 86%
B-	> 80% to 82%
C+	> 77% to 79%
C	> 73% to 76%

C-	> 70% to 72%
D+	> 67% to 69%
D	> 63% to 66%
D-	> 60% to 62%
F	< 60%

Determination of Grades

Grades will be determined based on all the assignments and examinations, weighted as reported in the table below:

Quizzes	20%
Homework	10%
Midterm	25%
Final Exam	25%
Take-Home Labs & Reports	20%

Absence during examinations, without prior approval, will result in a zero. Prior approval will be given only under exceptional circumstances. Please contact the instructor as soon as possible if you have such a situation.

Note that “All students have the right, within a reasonable time, to know their academic scores, to review their grade-dependent work, and to be provided with explanations for the determination of their course grades.” See [University Policy F13-1](http://www.sjsu.edu/senate/docs/F13-1.pdf) at <http://www.sjsu.edu/senate/docs/F13-1.pdf> for more details.

Classroom Protocol

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.**

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.

Attendance and arrival times

Students are expected to be set up for lecture by the time the class begins and remain in the classroom for the duration of the lecture. Attendance in class is not mandatory and shall not be used per se as a criterion for grading. However, class attendance and participation are highly recommended.

Behavior

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. While in the classroom, the use of electronic devices (laptops, tablets, smartphones) **MUST** be limited to activities closely related to the learning objectives. While in the classroom, electronic devices should not be used for personal communication, included messaging and use of social media. All cell phones must be silenced prior to entering the classroom.

Safety

Students should familiarize themselves with all emergency exits and evacuation plans. In particular, if the class meeting ends in the evening, students should be aware of their surroundings when exiting the building, and are encouraged to carry a cell phone for emergency communications.

University Policies

Per [University Policy S16-9](http://www.sjsu.edu/senate/docs/S16-9.pdf) (<http://www.sjsu.edu/senate/docs/S16-9.pdf>), university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at <http://www.sjsu.edu/gup/syllabusinfo/>

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Tentative Course Schedule *(subject to change with fair notice)*

Week	Topic	
1	Introduction to biomedical applications of mechanics	LINEAR ELASTICITY
1	Review of internal forces, normal stress, shear stress	
2	Human joints and engineering representation	
2	Mechanics of Deformable Systems, Hooke's Law	
3	Uniaxial tensile testing and calibration	
3	Mechanics of Bone: Structure and Properties, Quiz 1	
4	Materials testing & characterization	
4	3D Hooke's Law and Stress Matrices	
5	Bending stresses in artificial joints (implants) I	
5	Bending stresses in artificial joints (implants) II	
6	Torsion and shear stresses in bones and implants	
6	Combined loading in bones and implants, Quiz 2	
7	Stress Transformations, Plane Stress	
7	2D Mohr's Circle	
8	Effective Stress and Failure Theories	NONLINEAR ELASTICITY AND TISSUE BEHAVIOR
8	Design of load-bearing implants	
9	Midterm Review	
9	Midterm Exam	
10	SPRING RECESS	
10	SPRING RECESS	
11	Mechanics of Bone: Strain Response and Remodeling	
11	Ligaments, Tendons, and Nonlinear Elasticity	
12	Viscoelasticity and Time-Dependent Behavior	
12	Engineering Models of Viscoelastic Behavior	
13	Mechanics of Articular Cartilage: Structure, load response, friction, and osteoarthritis	
13	Mechanics of Skeletal Muscle: Structure and Contraction, Quiz 3	
14	Mechanics of Skeletal Muscle, Passive and Active Force Production	
14	Cardiac Muscle and Tissue Mechanics	
15	Blood Vessels as Pressure Vessels - Comparisons with Real Behavior	VASCULAR MECHANICS
15	Stent mechanics and design	
16	Case Study: Failure analysis of artificial heart valves	
16	Final Exam Review	
Final Exam	Wednesday, May 13. 12:15-14:30	