San José State University
College of Engineering
Biomedical Engineering Department
BME 065, Biomedical Applications of Statics, Spring 2020

Course and Contact Information

Instructor:	Alessandro Bellofiore
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Office Hours:	Tuesday: 12:30 - 1:30 PM Thursday: 12:30 - 1:30 PM
Class Days/Time:	Tuesday: 16:30 – 17:20 PM Thursday: 16:30 – 17:20 PM
Classroom:	E 343
Prerequisites:	MATH 31, PHYS 50

Course Format

The course will emphasize application of engineering mechanics to studying biomedical systems. The course consists of two 50-minute lectures per week. The course adopts traditional lecturing as a primary teaching method, combined with in-class problem solving sessions. In class, each student is required to have an internet-connected device (e.g. smartphone, tablet, laptop) to be used exclusively for learning-related activities, including the iClicker technology available at SJSU. Homework and a semester project will focus on modeling and quantifying biomedical systems using both analytical and numerical (Solidworks, MATLAB) approaches.

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on Canvas Learning Management System course login website at http://sjsu.instructure.com. All communications relevant to the course will be sent out using the Canvas messaging system (Canvas email and announcement board). You are responsible for regularly checking with the messaging system through Canvas to learn of any updates.

You can contact the instructor via the Canvas messaging system or email. Please include "BME 065" in the subject line of all emails. To ensure faster response from the instructor, your communications should be appropriately concise, and each message should be about one topic. If you have more than one topic to discuss, it is okay to send multiple emails.

Course Description

Mechanical analysis of biomedical systems is typically referred to as *biomechanics*. This type of analysis applies engineering analysis techniques to quantify and describe the load-deformation relationship in human tissues, biomedical implants, surgical tools, and others. This course introduces students to the study of bodies in static equilibrium, as they apply to systems in the human body (e.g. joints). Static analysis is the first step in explaining how external forces (due to exercise, activities of daily living, accidents, etc.) are transmitted through body tissues (bone, ligament, muscle, tendon, cartilage, etc.). This course forms the foundation for

more in-depth biomechanical analysis of human tissues covered in BME 165 – Applied Engineering Biomechanics.

Catalog Description

Detailed study of bodies in equilibrium as they apply to biomedical systems. Two-dimensional analysis of human joints and load-bearing implants are explored. Topics include free body diagrams, anthropometric measurements, internal forces, loading types, and stress shielding.

Course Goals

1. Introduce the student to the process of using free-body-diagrams to model biomedical systems in static equilibrium, and the mathematical process of calculating internal and external forces and moments.
2. Demonstrate how the concepts of center of mass and moment of inertia, and the mathematical calculations involved, can be used to quantify shape and size differences in anatomical features.
3. Introduce the student to the internal stresses and strains as they apply to the interactions between bone, muscle, and biomedical implants.

Course Learning Outcomes

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

1. **Express** forces and moments as vectors, and perform vector operations (addition, subtraction, products) to create simplified equivalent systems for the purposes of static analysis.
2. **Represent** human joints with simplified engineering supports, and **identify** the corresponding degrees of freedom
3. **Draw** free-body diagrams of 2D structures, and correctly apply all loads and reactions
4. **Describe** the types of load carried by different tissue types, and how the body employs antagonistic systems to overcome functional limitations of certain tissues.
5. **Calculate** centroids, centers of gravity, and moments of inertia of 2D bodies with either uniform or non-uniform density.
6. **Analyze** over-constrained biological structures, such as bones acted on by multiple muscles, using indeterminate systems.
7. **Evaluate** the state of stress of simple models of anatomical structures.
8. **Discuss** how the design of medical devices can be improved to reduce the risk of failure under static loading.
9. **Perform** static analysis of simple models of anatomical structures using analytical (MATLAB) and numerical computational tools (Solidworks).

Required Texts/Readings

Required Textbooks

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

Recommended Textbooks

1. Gross et al., *Engineering Mechanics 1*. 2nd Ed., Springer, 2013.
2. Beer and Johnson. *Statics*. 12th Ed. McGraw-Hill, 2018.

Note: Özkaya and Gross textbooks can be accessed electronically (free for students) through the SJSU Library.

Other technology requirements / equipment / material

You will have several options available to participate in clicker sessions:

iClicker REEF app (iOS, Android, web app): Allows you to use your smartphone, tablet, or even laptop in class as a clicker to participate.

Clicker Remote: You can request to borrow a Clicker remote from eCampus (eCampus@sjsu.edu) for free. Remotes are to be returned to eCampus at the end of the semester.

How to set up an iClicker account and add a course

Follow the instructions available on the dedicated eCampus webpage (Student Resources section) at http://www.sjsu.edu/ecampus/teaching-tools/iclicker/index.html.

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 practice. Other course structures will have equivalent workload expectations as described in the syllabus. More details about student workload can be found in University Syllabus Policy S16-9 at http://www.sjsu.edu/senate/docs/S16-9.pdf.

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

Homework

Homework assignments will include questions and problems related to the materials covered in the lectures and assigned reading. Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. Homework must be turned in at the **beginning of class** on the due date. **Late assignments** will be assessed 10%/day off of the maximum possible score.

In-class quiz (iClicker)

There will be regular in-class quizzes based on multiple-answer questions. iClicker will be used as a student response system in class. iClicker helps the instructor to understand what you know and gives everyone a chance to participate in class. iClicker will NOT be used to keep track of attendance. Refer to the Grading Policy and Student Technology Resources section for additional details on iClicker.

Term project

All students are required to complete a term project. The project will focus on the use of Solidworks to solve a set of static analysis problems numerically. To successfully complete the term project, students will need a good understanding of the laws governing continuum mechanics, and be able to correctly formulate statics problems in Solidworks. Acquaintance with the software tools is essential, as well as a good understanding of the unique aspects and limitation of the software environment.

The requirements for the term paper and the evaluation criteria will be posted on Canvas. Students will work in teams of three. A final project report will be submitted by the students through Canvas, along with all the models created by the students in Solidworks. The report must include an Acknowledgments section indicating the specific contributions of each student. Students with no contribution will receive no credit for the term paper.

Late submissions of the term project report are strongly discouraged. However, under exceptional circumstances and pending instructor approval, in case of late submission of the term project report, points will be deducted as follows:

- One day late: -10%
- Two days late: -25%
- Three days late: -50%

No submission will be accepted later than three days after the deadline. Please note that this late submission policy only applies to the term project assignment.

Midterm examinations

There will be two mid-semester examinations. Each examination will cover the entire course material covered until the time of the examination. Examinations 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.
The tentative dates of the mid-semester examinations are indicated in the Lecture 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 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."

Grading Information

Letter Grades

A plus = 97 to 100%
A = 93% to 97%
A minus = 90% to 93%
B plus = 87% to 90%
B = 83% to 87%
B minus = 80% to 83%
C plus = 77% to 80%
C = 74% to 77%
C minus = 70% to 73%
D plus = 67% to 70%
D = 64% to 67%
D minus = 60% to 63%
F = 60% or lower

Determination of Grades

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

Homework = 10%
Midterm 1 = 20%
Midterm 2 = 20%
Final Exam = 35%
Term Project = 15%
Extra-credit (iClicker) = 1%

Participation with iClicker will be the only extra credit assignment. Participating in at least 75% of the iClicker quizzes over the semester is necessary to obtain the extra credit.

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 at http://www.sjsu.edu/senate/docs/F13-1.pdf for more details.

Classroom Protocol

Attendance and arrival times

Students are expected to be set up for lecture by the time the class begins. 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)*, relevant information to all courses, such as academic integrity, accommodations, dropping and adding, consent for recording of class, etc. is available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/". Make sure to visit this page, review and be familiar with these university policies and resources.

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Course Schedule

(subject to change with fair notice)

Week	Date	Lecture topics, Workshops, Examinations
1	January 23	Introduction to BME applications of Statics. The syllabus
2	January 28	Forces on particles. Forces as vectors. Distributed forces. Frictional forces.
2	January 30	Vector calculus. Decomposition of vectors. **Intro to the Project**
3	February 4	Forces on rigid bodies. Moment and torque in 2D. Weight lifting
3	February 6	Moment and torque in 2D: couple. Translation of forces (equivalent systems)
4	February 11	Newton's Second Law, 2D Equilibrium at a Point
4	February 13	Free-Body Diagrams. Analysis of systems in equilibrium
5	February 18	***Solidworks workshop 1: create simple models for static analysis***
5	February 20	Constraints and reactions: simple Supports, cable-pulley systems
6	February 25	***Solidworks workshop 2: define constraints and applied loads***
6	February 27	**Midterm 1 review**
7	March 3	**Midterm 1 exam**
7	March 5	**Midterm 1 solution.** Anthropometrics. Center of Gravity vs. Center of Mass
8	March 10	Anatomy: skeletal joints and muscles. 2D analysis of joints: elbow, shoulder
8	March 12	2D analysis of joints: spinal column, hip, knee, ankle
9	March 17	***MATLAB workshop: 2D analysis of joints***
9	March 19	Analysis of Trusses: method of joints
10	March 24	Analysis of Trusses: method of sections. Trusses in biological tissues and
10	March 26	***Solidworks workshop 3: static analysis of trusses***
11	March 31	**Spring Recess – NO CLASS**
11	April 2	**Spring Recess – NO CLASS**
12	April 7	**Midterm 2 review**
12	April 9	**Midterm 2 exam**
13	April 14	**Midterm 2 solution.** Static analysis: external and internal forces, method of
13	April 16	Stress-strain diagram. Elastic and plastic behavior. Poisson's ratio & Hooke's
14	April 21	***Solidworks workshop 4: static analysis of beams***
14	April 23	Stress transformations. Principal stresses
15	April 28	Mohr's circle. Failure theories
15	April 30	***Solidworks workshop 5: failure analysis***
16	May 5	Factor of safety for medical devices. Design considerations for implants
16	May 7	**Final exam review**
	May 13	**FINAL EXAM (14:45 - 17:00)**