

**BENG 112A SOFT TISSUE BIOMECHANICS**  
Winter Quarter, January 4<sup>th</sup> – March 24<sup>th</sup>, 2021  
Tuesdays and Thursdays 9:30-10:50 and 11:00 am - 12:20 pm, Online *via* Zoom  
Lecture Zoom Password: Cauchy

**Instructor**

Dr. **Daniela Valdez-Jasso**, Assistant Professor of Bioengineering  
Email: [dvaldezjasso@ucsd.edu](mailto:dvaldezjasso@ucsd.edu)

**Office Hours:** will be held *via* Zoom Wednesday and Friday from 3:00-4:00 pm or by appointment. For information on the Zoom link, go to canvas.

**Graduate Student Instructors**

**Becky Hardie**, Bioengineering graduate student, [rahardie@eng.ucsd.edu](mailto:rahardie@eng.ucsd.edu)  
**Kristen Garcia**, Bioengineering graduate student, [k1garcia@eng.ucsd.edu](mailto:k1garcia@eng.ucsd.edu)

**Discussion Sections**

Section	Day	Time	Zoom link
A01	Monday	2:00 - 2:50 pm	Check Canvas
B01	Monday	3:00 - 3:50 pm	Check Canvas

**Online classroom instruction**

This course will be taught using live, online audio and visual instruction and will take place during the times indicated in the UCSD Schedule of Classes.

Given the occasional disruptions that inevitably occur when using online conferencing tools (due to WiFi drops, service drops, etc.) we will adhere to the following plan of action for each and every online class meeting.

1. The course will be initiated by the instructor using Zoom. Students can join the meeting by clicking on the link provided in the course schedule in Canvas.
2. If Zoom fails, the backup plan will be to immediately transition to lecturing via Explain Everything. This application can be joined directly through a second link provided in the course schedule in Canvas.

All attempts possible will be made to record lectures and post them to Canvas in a timely manner. However, recorded lectures cannot be guaranteed but you can always count on the lecture notes to be posted.

As we as a campus community transition to online instruction, please be aware that your Professors and Administrators are adapting at the same time that you are. Let us all pledge to remain respectful, supportive, and adaptable to ensure that educational goals are met.

**Learning Objectives**

Within the framework of continuum mechanics, concepts, notations, theories and applications of solid mechanics to mammalian tissue physiology will be covered in this course. Key concepts include kinematics and kinetics of deformable body systems, the stress and strain tensors, constitutive properties of solids, viscoelasticity, finite elasticity, and the field equations for conservation of mass and momentum in a continuum. Theoretical problem-solving and the role of engineering design will be emphasized with weekly

homework assignments posted at this website. The last assignment of the quarter will be a two-week design project.

### Course Material

We make every effort to give you access to a wide range of course materials by recommending *textbook reading*, providing copies of *lecture notes*, additional *handouts*. Because this course is an introduction to three big topics in mechanics—continuum mechanics, linear and nonlinear elasticity— these books and materials *inevitably go significantly beyond the scope that can be covered in one quarter*. We encourage you to take advantage of these reference materials, but please be reassured that you will *only be examined on materials that we cover in lectures, discussion sections and homework assignments*. We wish there was a single textbook that only covered the scope of this course but unfortunately there isn't one. The *only way to know* whether you should study a particular topic for midterms and finals is to show up to lectures and complete the homework assignments and practice problems in the Discussion sessions.

### Course Expectations

<i>What I expect of you</i>	<i>What you can expect of me</i>
<i>Be informed.</i> Read this syllabus carefully and completely so you understand the course structure and expectations.	<i>Enthusiasm.</i> To be prepared for each class and to bring my enthusiasm for teaching to each lecture, lab, and office hour meeting.
<i>Be attuned.</i> Keep up with readings and class assignments, as each one builds on the previous one. Be attentive and participate in class.	<i>Responsiveness.</i> To respond to emails within 32 hours. For those that know me already, you know that I usually respond faster than this. Emails received on weekends may take longer.
<i>Ethical.</i> A good attitude and maintenance of honest and ethical principles towards me, your classmates, and the execution of the course. Please read UC San Diego's <u>Principles of Community</u> and <u>Conduct Code</u> .	<i>Timely feedback.</i> To make every effort to return graded assignments within one week of the submission date and to post solutions as soon as is reasonably possible after the submission date.
<i>Integrity.</i> An honest, fair, responsible, respectful, trustworthy, and courageous effort on all academic work and collaboration. Please read UC San Diego's Policy on <u>Integrity of Scholarship</u> . Then, take the <u>integrity pledge</u> !	<i>Integrity.</i> To uphold integrity standards and create an atmosphere that fosters active learning, creativity, critical thinking, and honest collaboration.
<i>Be flexible.</i> Sometimes my schedule gets affected by unavoidable work travel, necessitating some office hour rescheduling at the last minute.	Reasonable accommodation and understanding for student situations that arise; however, I will not make exceptions for one person that are not available to every other person in the course.

### Learning Management Systems

The TAs will use **Canvas and Gradescope** for grade distribution and course materials, which you can access with your [ucsd.edu](http://ucsd.edu) account. All announcements and homework assignments must be submitted online via Canvas.

### Textbooks

The *required* textbook for this course is Humphrey and O'Rourke. However, while lecture notes covering the full scope of the course content are provided, background reading is very helpful and many students

find it essential. There are many continuum mechanics textbooks as well as a few biomechanics books that cover some of the material in this course. The main differences are in notations and problem sets. Fung's book on continuum mechanics has many exercises and problems. Spencer has few problems but uses the same continuum mechanics notations that will be used in class. Used copies of these books are often available and earlier editions are satisfactory. Note that the first Edition of Humphrey and O'Rourke is by Humphrey and Delange.

- **JDH** JD Humphrey and SL O'Rourke, [An Introduction to Biomechanics: Solids and Fluids, Analysis and Design](#), Springer-Verlag, 2015.
- **Kelly** Online book by Prof. PA Kelly at the University of Auckland [Mechanics Lecture Notes](#)
- **GAH** Gerhard A. Holzapfel. Nonlinear Solids Mechanics: A Continuum Approach for Engineering. Willey

## Grading

Homework Assignments	40%
Design Project	10%
Midterm Examinations (closed book and notes) 2 x 10% each	30%
Final Examination (closed book and notes)	20%

## Grading Scale

**A** = 90-100%    **B** = 80-89%    **C** = 70-79%    **D**=60-69%    **F** = 59%-below

## Homework Submission

While students are encouraged to study together, homework turned in must be your own work and must be handwritten unless otherwise specified, such as for computing assignments. Homework assignments can only be submitted online via your Canvas account as a single PDF file scanned or photographed from the original. Work is only regraded when there is evidence of grading error. We reserve the right to regrade an entire piece of work.

## Attendance policy

Live lecture attendance is not required but is highly encouraged so that questions can be asked and answered during the lecture and interactive discussions can be carried out. Also, when possible, there will be breakout rooms for small group discussions.

## Communication

In an online course, the majority of our communication takes place in forums that are visible and/or audible to all. However, when we have a need for communication that is private, whether personal, interpersonal, or professional, we will use individual email. For timely response to course questions, please contact TAs first. As needed, TAs will refer questions that they cannot answer to me.

## Netiquette

To minimize background noise and promote clear communications:

1. Use headphones to tune into audio.
2. Keep your microphone on MUTE until you need to ask a question. Then return your microphone to MUTE.

In an online classroom, another major method of communication is written. The written language has many advantages: more opportunity for reasoned thought, more ability to go in-depth, and more time to think through an issue before posting a comment or sending an email. However, written communication also has certain disadvantages, such as lack of the face-to-face signaling that occurs through body language, intonation, pausing, facial expressions, and gestures. As a result, please be aware of the possibility of miscommunication and compose your comments/emails in a professional, respectful, and constructive manner.

## Integrity of Scholarship

The Department of Bioengineering adheres to the UCSD Policy on Integrity of Scholarship. This Policy states that "Students are expected to complete the course in compliance with the instructor's standards. No student shall engage in any activity that involves attempting to receive a grade by means other than honest effort ..." The full descriptions of these policies, as well as others regarding acceptable behavior are given in the Student Code of Conduct at [http://students.ucsd.edu/student-life/\\_organizations/student-conduct/regulations/22.00.html](http://students.ucsd.edu/student-life/_organizations/student-conduct/regulations/22.00.html). The regulations on exams, grading and integrity of scholarship are also in the General Catalog at <http://www.ucsd.edu/catalog/front/AcadRegu.html>. Helpful resources on understanding and complying with these regulations can be found at: <http://students.ucsd.edu/academics/academic-integrity/index.html>

Students are not discouraged from discussing homework assignments among themselves or engaging in group study. However, **individual homework assignments must be the sole work of the submitting student**. Specific guidance will be given in the case of group projects. When submitted coursework incorporates material authored by a third party, the source should always be attributed according to the accepted standards of scholarly endeavor. Material taken from the internet or other forms of electronic media are subject to the same requirements of attribution applicable to printed reference sources or materials. Work suspected of being tainted by plagiarism will receive no credit. **All cases of suspected academic dishonesty** including *collaboration*, *plagiarism* and *cheating* as defined by UCSD regulations **will be referred to the UCSD Academic Integrity Coordinator**.

In cases of suspected academic dishonesty including cheating in an examination or altering graded work and resubmitting it, the student will be handed a copy of the student conduct code, and the case will be referred to the appropriate dean. The academic penalty for serious academic dishonesty will generally be a grade of F.

## Computing

Computer and network access will be needed for some assignments in this course. All UCSD engineering students are eligible for computer accounts through Academic Computing Services. You can see what kind of account you have on-line using the Account Lookup Tool at <https://sdacs.ucsd.edu/~icc/index.php>.

For assistance with UCSD instructional computing facilities, do not come to the instructor or TAs as they are not managed by departmental personnel. You can email questions to [acs-consult@ucsd.edu](mailto:acs-consult@ucsd.edu).

## ACADEMIC SUPPORT

<a href="#">Geisel Library</a>	Research tools and eReserves
<a href="#">Content Tutoring with the Teaching + Learning Commons</a>	Drop-in and online tutoring through the Academic Achievement Hub
<a href="#">Supplemental Instruction with the Teaching + Learning Commons</a>	Peer-assisted study sessions through the Academic Achievement Hub to improve success in historically challenging courses
<a href="#">Writing Hub Services in the Teaching + Learning Commons</a>	Improve writing skills and connect with a peer writing mentor
<a href="#">Learning Strategies Tutoring</a>	Address learning challenges with a metacognitive approach
<a href="#">OASIS</a>	Intellectual and personal development support
<a href="#">Student Success Coaching Program</a>	Peer mentor program that provides students with information, resources, and support in meeting their goals
<a href="#">Academic Integrity</a>	Policy on Academic Integrity of Scholarship and strategies to excel with integrity
<a href="#">Technical Support</a>	Assistance with accounts, network, and technical issues

## STUDENT RESOURCES

UC San Diego (as an institution) and I (as a human being and instructor of this course) are committed to full inclusion in education for all persons. Services and reasonable accommodations are available to students with temporary and permanent disabilities, to students with DACA or undocumented status, to students with health or other personal concerns, and to students with other kinds of support needs. Please feel free to let me know if there are circumstances affecting your ability to participate in class. Some resources that might be of use include:

<a href="#">Basic Needs</a>	Provides access to food, housing, and financial resources
<a href="#">Counseling and Psychological Services (CAPS)</a>	Provides services like confidential counseling and consultations for psychiatric services and mental health programming
<a href="#">Community Centers</a>	As part of the <a href="#">Office of Equity, Diversity, and Inclusion</a> the campus community centers provide programs and resources for students and contribute toward the evolution of a socially just campus
<a href="#">Counseling and Psychological Services</a>	Individual, group, couples, and family psychotherapy services for registered undergraduate and graduate students
<a href="#">Office for Students with Disabilities</a>	Documents student disabilities, provides accessibility resources, and reasonable accommodations
<a href="#">Triton Concern Line</a>	Report students of concern at (858) 246-1111

<a href="#">Undocumented Student Services</a>	Programs and services are designed to help students overcome obstacles that arise from their immigration status and support them through personal and academic excellence
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## **CAMPUS POLICIES**

### **UC San Diego Principles of Community**

The University of California, San Diego is dedicated to learning, teaching, and serving society through education, research, and public service. Our international reputation for excellence is due in large part to the cooperative and entrepreneurial nature of the UC San Diego community. UC San Diego faculty, staff, and students are encouraged to be creative and are rewarded for individual as well as collaborative achievements.

To foster the best possible working and learning environment, UC San Diego strives to maintain a climate of fairness, cooperation, and professionalism. These principles of community are vital to the success of the University and the well being of its constituents. UC San Diego faculty, staff, and students are expected to practice these basic principles as individuals and in groups.

[Click here for the complete UC San Diego Principles of Community in English and Spanish.](#)

### **Nondiscrimination and Harassment Policy Statement**

The University of California, in accordance with applicable federal and state laws and university policies, does not discriminate on the basis of race, color, national origin, religion, sex, gender, gender identity, gender expression, pregnancy, physical or mental disability, medical condition, genetic information, ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services. The university also prohibits harassment based on these protected categories, including sexual harassment, as well as sexual assault, domestic violence, dating violence, and stalking. The nondiscrimination policy covers admission, access, and treatment in university programs and activities.

If you have questions about student-related nondiscrimination policies or concerns about possible discrimination or harassment, they should contact the Office for the Prevention of Harassment & Discrimination (OPHD) at (858) 5348298, [ophd@ucsd.edu](mailto:ophd@ucsd.edu), or [reportbias.ucsd.edu](http://reportbias.ucsd.edu).

## BENG 112A: Soft Tissue Biomechanics

- **JDH** JD Humphrey and SL O'Rourke, [\*An Introduction to Biomechanics: Solids and Fluids, Analysis and Design\*](#), Springer-Verlag, 2015.
- **Kelly** Online book by Prof. PA Kelly at the University of Auckland [Mechanics Lecture Notes](#)
- **GAH** Gerhard A. Holzapfel. Nonlinear Solids Mechanics: A Continuum Approach for Engineering. Willey

Week	Topic	Reading Material
1	Introduction to Tissue Biomechanics Vectors and Tensors	JDH 1.3 Kelly 1.8
2	Tensor Properties	Kelly 1.8-1.10 GAH 1.2-1.6
3	Kinematics: deformation and strain	Kelly 2.1-2.2 GAH 2.1-2.6
4	Strain Analysis: Measuring shape changes in soft tissues	Handouts
5	Stress: Cauchy Stress Tensor	Kelly 3.1-3.3 JDH 2.1-2.4 GAH 3.1-3.3
6	<b>Midterm 1 February 8<sup>th</sup></b> Equilibrium of Stresses: force balances for arteries, aneurysms, etc.	Kelly 3.5 JDH -3.63.1
7	Mechanics of Soft Tissues	JDH 1.4-1.7
8	Viscoelasticity of skin, heart, bladder	Handouts and articles
9	<b>Midterm 2 March 1<sup>st</sup></b> Constitutive Equations	GAH 6.1
10	Nonlinear Elasticity: hyper-elasticity laws for soft tissues	GAH 6.2-6.5 JDH 6.2-6.6