

BME3234 Mechanical Behavior of Biological Tissues and Systems

Class Periods: T (3:00 – 4:55 pm), R (4:05 – 4:55 pm); Period 8-9

Location: CHE0237; **Academic Term:** Fall 2018

Instructor: W. Lee Murfee
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352-294-8813

Office Hours: W 10:00 am -12:00 pm; (Also, COME SEE ME!)

Course Description

The objective of this course is to introduce the principles of continuum mechanics in the context of biological systems. The course will review the fundamentals of statics, strength of materials, and fluid mechanics culminating in the introduction viscoelastic models to describe constitutive behavior of hard and soft tissues. In order to emphasize the importance of understanding fundamental biomechanical principles, lectures will be designed to highlight how these fundamentals relate to studying the function and adaptation of living tissues at the tissue, cellular and molecular scales.

Course Pre-Requisites / Co-Requisites

BME 3060 with minimum grade of C and EGM 2511

Course Specific Aims

1. Students will be able to apply fundamental concepts of statics and mechanics of materials to the understanding of physiological function.

Students will be able to apply force balance and stress-strain relationships to understand how molecular structures contribute to cell and tissue function.

2. Students will learn the introductory concepts of continuum mechanics.

Students will be comfortable with the necessary mathematics, including tensor algebra using indicial notation. Given a stress tensor students will be able to determine the principal stress values.

3. Students will learn the fundamental concepts of viscoelasticity.

Students will be able to understand how the combination of the elastic and fluid components contribute to the stress relaxation and creep functions of Maxwell, Voight, and Kelvin model. Students will be able to derive the respective stress relaxation functions for each model.

4. Students will be comfortable designing experiments to measure the mechanical properties of various tissues.

Students will be able to explain specific experimental techniques to measure cellular or tissue material properties. Students will also conduct experiments to measure and compare the elastic moduli of hard and soft tissues.

5. Students will become aware of the fundamental concepts of fluid mechanics, including Reynolds Number and Poiseuille Flow.

Students will be able to calculate the shear stress distribution and volumetric flow rate for laminar, Newtonian fluid flow through a blood vessel. In addition, students will be able to determine the Reynolds Number for a given flow and assess the relative contribution of inertial and viscous forces.

6. Students will be able to identify the role of mechanical forces in tissue function, tissue engineering and pathological conditions.

Students will be able to discuss multiple examples of how mechanical forces influence physiology. In particular students will be able to explain the influences of circumferential wall stress and fluid shear stress vascular wall remodeling and endothelial cell function.

Professional Component (ABET):

This course will prepare students to apply advanced mathematics to solve problems at the interface of engineering and physiology. Specific to the UF BME program educational outcomes, students will gain

experience applying a knowledge of biotransport fundamentals to solving open ended biomedical engineering challenges related to therapeutic design and basic science discovery.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
a. an ability to apply knowledge of mathematics, science, and engineering	High (3)
b. an ability to design and conduct experiments, as well as to analyze and interpret data	Medium (2)
e. an ability to identify, formulate, and solve engineering problems	Medium (2)
i. a recognition of the need for, and an ability to engage in life-long learning	Low (1)
j. a knowledge of contemporary issues	Low (1)

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course. 1 point = 0.33 credit hours; points reflect an alternative indicator of relative coverage.

Required Textbooks

Introductory Biomechanics, C. Ross Ethier and Craig A. Simmons, 2007. *Biomechanics*, Y.C. Fung, 2nd Edition, 1993 will be used as a reference, but is not required.

Course Topics (see course schedule for specific class dates, assignments, presentations and exams)

Introduction to problems in biomechanics

Fundamental concepts of statics and mechanics of materials

Free body diagrams

Constitutive equations

Stress-strain relations

Introduction to continuum mechanics

Indicial and vector notation

Cauchy's stress tensor

Traction vectors

Viscoelasticity

Maxwell, Voight, and Kelvin models

Stress, strain relaxation functions

Cell mechanics

Red blood cell mechanics

White blood cell mechanics

Tissue mechanics

Tendon and ligament mechanics

Bone mechanics

Skin/Cartilage mechanics

Blood vessel mechanics

Fundamental concepts of fluid dynamics

Blood flow in the microcirculation

Computational modeling for understanding physiological systems

Role of biomechanics in tissue engineering

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is expected, required, and noted by the instructor each class. Excess absences, class disruption, and lack of engagement will influence the class participation grade. All assignments are due at the beginning of class. Late work will not be accepted. Exams may be made up if extenuating circumstances are discussed beforehand or due to medical/family emergency.

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework Assignments	24%
Midterm Exams (2)	30%
Final Exam	25%
In Class Participation/Exercises	20%
Student Evaluation	1%
TOTAL	100%

Grading Policy

Final grades will be influenced by the class average, the guiding grade range below, and the instructor's discretion.

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E
≥92	90-91	87-89	83-86	80-82	77-79	73-76	70-72	67-69	63-66	60-62	< 60

This course is not a *critical tracking course*. In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. More information on UF grading policy may be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

Campus Resources

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.
<https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.