Western University
Faculty of Engineering
School of Biomedical Engineering

Medical Biophysics 9530A / BME 9529A
HUMAN BIOMECHANICS WITH BIOMEDICAL APPLICATIONS

COURSE OUTLINE – Fall 2021

DESCRIPTION
The course tackles the mechanical properties of biological structures and fluids in relation to function: deformability, strength, and viscoelasticity of hard and soft tissues, modes of loading and failure. Special topics include mechanics of synovial joints, finite element methods, mechanics of hearing, and mechanics of orthopedic implants and joint replacement.

PREREQUISITES
One of Calculus 1000A/B, Mathematics 1225A/B, Applied Mathematics 1413, or an equivalent 1000-level Calculus course; one of Physics 1028A/B, 1301A/B, 1401A/B or 1501A/B, and one of Physics 1029A/B, 1302A/B, 1402A/B, 1502A/B or an equivalent 1000-level Physics course. A 1000-level Biology course is advantageous.

3 lecture hours, 2 laboratory/tutorial hours, 0.5 course.

Lectures:
Tuesdays 11:30 am – 12:30 am / PAB-148
Thursdays 11:30 am – 1:30 pm / PAB-148

Tutorial / Laboratory:
Fridays 3:30 pm – 5:30 pm / PAB-150

Senate regulation regarding the student's responsibility regarding requisites:
Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Instructor and TA Information

Instructors and TAs	E-mail	Office	Office Hours
Instructor: Dr. Abbas Samani	asamani@uwo.ca	MSB402	Wednesday 12:30pm – 1:30pm
TA: Niusha Kheirkhah	nkheirkh@uwo.ca	TEB 206	TBD or by appointment

AIMS and OBJECTIVES

Biomechanics is a broad topic, drawing on the laws and principles of mechanics across the whole spectrum of biology – from subcellular biology to large organisms and structures. This course is restricted to human mechanical aspects of biology and biophysics. It is geared toward learning the true mechanical behaviour of tissues, organs and some human body systems, and to recognize these qualities when making assumptions, predicting behaviour and solving problems.

Special examples include the orientation-dependent elasticity of skin and its importance to the plastic surgeon, synovial fluid – the magical fluid that lubricates and protects the sliding surfaces of mammalian joints – and interaction between bone and prosthetic material and its impact on the prosthesis longevity. Finite Element Method (FEM) is a numerical technique to solve complex differential equations. To complement the basic mechanics laws and analytical solutions presented in the course, FEM is introduced and some of its applications in biomedicine is discussed.

Our objectives, through assignments, lectures and tutorials, are to demonstrate the basic laws of mechanics, the development of internal stresses in tissues under external load – in order that students will develop skills in integrating the concepts in mechanics for interpreting the behaviour of tissues and anatomical structures. Another objective is to provide exposure to more advanced tools such as FEM software (ABAQUS) to solve complex biomechanics problems.

SPECIFC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	40%	• Assignments • Project • Examinations	• Understanding of introductory and advanced concepts and theories of tissue mechanics • Awareness of important current problems in biomechanics • Understanding of computational and/or empirical methodologies to solve biomechanics problems
Research & scholarship	20%	• Project	• Ability to conduct critical evaluation of current advancements in tissue mechanics • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	20%	• Assignments • Project • Examinations	• Ability to apply knowledge in a rational way to analyze tissue stress and understand implications • Ability to use coherent approach for preliminary design of bone prosthesis components
Communication skills	10%	• Assignments • Project	• Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	• Project	• Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge analytical limitation due to complexity of practical problems

TOPICS

Topic #	Description	Learning Activities	Tentative timeline
1	Introduction to Biomechanics		
	Lesson 1: Course objectives; learning outcomes and course structure; history and applications	• Additional reading material	Week 1 (1)
	Lesson 2: Introduction to Continuum Mechanics – Static Review	• Additional reading material • Practice problems set • Tutorial session	Week 1 (2)
	Lesson 3: Biological Tissue Structure	• Additional reading material	Weeks 2 (1)
2	Tissue Elasticity		
	Lesson 4: a. Building blocks of animal tissues b. Elasticity and pure elastic structures c. Hooke's law (1D)	• Additional reading material	Week 2 (2)
	Lesson 5: a. Hooke's law (2D) b. Elasticity of biological tissue • Bone, tendon and ligament	• Additional reading material	Weeks 3(1)
	Lesson 6: Mechanics of skin and blood vessel	• Additional reading material • Tutorial session	Week 3(2)
	Lesson 7: Mechanics of tissue as composite materials	• Additional reading material	Weeks 4(1)
	Lesson 8: Measurement of *ex vivo* soft tissue specimens using direct and indirect methods	• Additional reading material • Tutorial session	Week 4(2)
	Lesson 9: Measurement of *ex vivo* soft tissue specimens using indirect methods	• Additional reading material	Week 5(1)
	Lesson 10: Measurement of soft tissues *in vivo* using elastography	• Additional reading material • Tutorial session	Week 5(2)
3	Tissue Nonlinearity and Viscoelasticity		
	Lesson 11: Tissue nonlinear behavior: source and modeling	• Additional reading material	Week 6(1)
	Lesson 12: a. Midterm Review b. Combination of elasticity and viscosity in biological materials	• Additional reading material • Practice problems set	Week 6(2)

	Lesson 13: a. Creep and stress relaxation, spring and dashpot idealizations b. Viscoelasticity models I	• Additional reading material	Week 7(1)
	Lesson 14: Viscoelasticity models II	• Additional reading material • Tutorial session	Week 7(2)
4	Mechanics of Joints		
	Lesson 15: a. Joint types b. Biomechanics of human spine	• Additional reading material	Week 8(1)
	Lesson 16: a. Lower back muscular contraction b. Joint friction c. Joint lubrication	• Additional reading material • Tutorial session	Week 8(2)
Reading week			
5	Bone Mechanics and Bone Fracture		
	Lesson 17: a. Introduction to bone mechanics b. Bone mechanical properties	• Additional reading material	Week 10(1)
	Lesson 18: a. Bone stress analysis b. Bending and torsion c. Combined stress I	• Additional reading material	Week 10(2)
	Lesson 19: a. Combine stress II b. Bone repair	• Additional reading material	Week 11(1)
	Lesson 20: a. Bone repair b. Stress concentration	• Additional reading material • Tutorial session	Week 11(2)
6	Introduction to Finite Element Method (FEM)		
	Lesson 19: Introduction: Theory and practical issues	• Additional reading material	Week 12(1)
	Lesson 20: FEM workshop	• Additional reading material • Tutorial session	Week 12(2)
7	Special Topics in Biomechanics		
	Lesson 21: Mechanical Challenges in Replacement Joints - Hip replacement	• Additional reading material	Week 13(1)

	Lesson 22: Middle ear biomechanics	• Additional reading material	Week 13(2)

ASSESSMENTS

Assessment Type	Material Covered	Tentative Due Date	Weight
Homework Assignments (six)	Topics 1, 2, 3, 4, 5, 6	As posted	25%
Midterm Test	Topics 1-2	October 15th	15%
Final Examination	Topics 1-7	TBA	30%
Project, including the following: 1. Project proposal 2. Progress report 3. Oral presentation 4. Final report *For more information refer to the project document available on the course OWL*		As posted	30%

Important notes on Assessments:

- Gradescope will be used for assignment submission and grading
- Assignment grades will be posted regularly through Gradescope and the class OWL site. After an assessment is returned, students should wait 24 hours to digest feedback before contacting their evaluator; to ensure a timely response, reach out within 7 days
- When applicable written assignments/project will be submitted to Turnitin (statement in policies below)

Activities in which collaboration is permitted:

- Only homework assignments can be done collaboratively by groups of students
- While collaboration groups can include up to three students, each student in a collaborative group should submit her/his individual assignment. Assignments submitted by individuals in a collaborative group must be substantially different in wording, organization etc. (i.e. submitting identical assignments will NOT be accepted)

Activities in which students must work alone (collaboration is not permitted):

- Collaboration in activities other than homework assignments is not permitted.

Laboratories/Tutorials:

- This course involves a problem solving / tutorial lab session every week unless otherwise announced. In this lab, the instructor or TA will present a tutorial or an overview to the weekly assignment to assist students to solve problems given in the assignment. One assignment will involve using a software package and may be held in a computer lab. More details will be given prior to this assignment due date.

Examinations: Midterm Test and Final Examination

- Both the midterm test and final examination will be closed book (closed notes). While the final examination will cover the entire course material, more emphasis will be given to parts that were not included in the midterm test.
- Use of calculators [HP 48G+ or equivalent/less complex] with no relevant data and program in memory will be allowed.
- Exam times will be posted on the course OWL when available. Students needing to make travel arrangements are advised to book a travel date after the end of the examination period. No makeup exams will be given to accommodate travel!

COURSE MATERIAL

Course Slide: will be provided for each lecture and posted on the course OWL before the start of the lecture.

OPTIONAL COURSE READINGS

1. Y. C. Fung, Biomechanics, Mechanical Properties of Living Tissues, Second Edition, Springer, 1993
2. V. C. Mow and R Huiskes, Basic Orthopaedic Biomechanics and Mechanobiology, Third Edition, Lippincott Williams & Wilkins, 2005
3. C. R. Ethier and C. A. Simmons, Introductory Biomechanics *From Cells to Organisms*, Cambridge University Press, 2007
4. R.M. Alexander, Animal Mechanics, Second Editon, Blackwell Scientific Publications, 1983
5. Y. C. Fung, N. Perrone and M. Anliker (editors), Biomechanics, Its Foundations and Objectives, Prentice Hall Inc., 1972

GENERAL INFORMATION

Professionalism & Privacy:

Western students are expected to follow the Student Code of Conduct. Please also note that all course materials created by the instructor(s) are copyrighted and cannot be sold/shared

How to Be Successful in this Class:

Students enrolled in this class should understand the level of autonomy and self-discipline required to be successful.

1. Invest in a planner or application to keep track of your courses. Populate all your deadlines at the start of the term and schedule time at the start of each week to get organized and manage your time
2. Make it a daily habit to log onto OWL to ensure you have seen everything posted to help you succeed in this class
3. Be an active participant. Take notes as you go through the lesson material. Keeping handwritten notes or even notes on a regular Word document will help you learn more effectively than just listening to your instructor

4. Connect with others. Try forming a study group and try meeting online (or in person if deemed safe) on weekly basis for study and peer support
5. Do not be afraid to ask questions. If you are struggling with a topic, check the online discussion boards or contact your instructor and or teaching assistant
6. Reward yourself for successes. It seems easier to motivate ourselves knowing that there is something waiting for us at the end of the task

Western Academic Policies and Statements

Absence from Course Commitments:
Please refer to relevant policies of the School of Graduate and Postdoctoral Studies and your graduate program.

Accommodation for Religious Holidays:
Please refer to relevant policies of the School of Graduate and Postdoctoral Studies and your graduate program.

Special Examinations:
Please refer to relevant policies of the School of Graduate and Postdoctoral Studies and your graduate program.

Academic Offenses:
"Scholastic offences are taken seriously, and students are directed here to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence. Also, please refer to relevant policies of the School of Graduate and Postdoctoral Studies and your graduate program.

Accessibility Statement:
Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Accessible Education (AE) at 661-2111 x 82147 for any specific question regarding an accommodation or review The policy on Accommodation for Students with Disabilities. Also, please refer to relevant policies of the School of Graduate and Postdoctoral Studies and your graduate program.

Correspondence Statement:
The centrally administered **e-mail account** provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner. You can read about the privacy and security of the UWO email accounts here.

Turnitin and other similarity review software:
All assignments will be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. Students will be able

to view their results before the final submission. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between Western University and Turnitin.com.

More Academic Policies and Statements

Cell Phone and Electronic Device Policy (for in-person tests and exams if applicable):
The Schulich School of Medicine & Dentistry is committed to ensuring that testing and evaluation are undertaken fairly across all our departments and programs. For all tests and exams, it is the policy of the School that any electronic devices, i.e., cell phones, tablets, cameras, or iPod are strictly prohibited. These devices MUST be left either at home or with the student's bag/jacket at the front of the room and MUST NOT be at the test/exam desk or in the individual's pocket. Any student found with one of these prohibited devices will receive a grade of zero on the test or exam. Non-programmable calculators are only allowed when indicated by the instructor. The program is not responsible for stolen/lost or broken devices.

Copyright and Audio/Video Recording Statement:
Course material produced by faculty is copyrighted and to reproduce this material for any purposes other than your own educational use contravenes Canadian Copyright Laws. You must always ask permission to record another individual and you should never share or distribute recordings.

Rounding of Marks Statement:
Across the Basic Medical Sciences Undergraduate Education programs, we strive to maintain high standards that reflect the effort that both students and faculty put into the teaching and learning experience during this course. All students will be treated equally and evaluated based only on their actual achievement. ***Final grades*** on this course, irrespective of the number of decimal places used in marking individual assignments and tests, will be calculated to one decimal place and rounded to the nearest integer, e.g., 74.4 becomes 74, and 74.5 becomes 75.

Support Services:
The following links provide information about support services at Western University.

School of Graduate and Postdoctoral Studies

Appeal Procedures

Registrarial Services

Student Development Services

Student Health Services