Medical Biophysics 3330F/9530A/BME 9529A
HUMAN BIOMECHANICS WITH BIOMEDICAL APPLICATIONS

1. Course Information

Medical Biophysics 9530A/BME9529A - Human Biomechanics with Biomedical Applications: The mechanical properties of biological structures and fluids in relation to function: deformability, strength, and visco-elasticity of hard and soft tissues, modes of loading and failure. Special topics include mechanics of synovial joints, mechanics of hearing, and mechanics of orthopedic implants and joint replacement.

Lectures:
- Tuesdays: 11:30 am – 12:30 am / NCB - 296
- Thursdays: 11:30 am – 1:30 pm / NCB - 296

Tutorial / Laboratory:
- Fridays: 3:30 pm – 5:30 pm / MSB-190

Prerequisites:
Prerequisite(s): 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.

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.

2. Instructor and TA Information

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<tr>
<th>Instructors and TAs</th>
<th>Email</th>
<th>Office</th>
<th>Phone</th>
<th>Office Hours</th>
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<tbody>
<tr>
<td>Instructor:</td>
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<tr>
<td>Dr. Abbas Samani</td>
<td><a href="mailto:asamani@uwo.ca">asamani@uwo.ca</a></td>
<td>MSB402</td>
<td>82723</td>
<td>Mon. 12:30 pm – 2:30 pm or by appointment</td>
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<tr>
<td>TAs:</td>
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<tr>
<td>Elham Karami</td>
<td><a href="mailto:ekarami@uwo.ca">ekarami@uwo.ca</a></td>
<td>MSB 416</td>
<td>86135</td>
<td>TBD</td>
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3. Course Syllabus

**Expected Learning Outcomes:** By the end of the course, students will be able to demonstrate broad understanding of the principles of tissue mechanics. They will demonstrate how to apply these principles in developing specific diagnostic and therapeutic methods. The students will achieve these abilities through solving problem assignments, tutorials and computer labs.

**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. We restricted the focus in this course to human mechanical aspects of biology and biophysics. Our intent is to learn about the true mechanical behaviour of tissues and materials, 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 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. To complement the basic mechanics laws and analytical solutions presented in the course, we introduce the Finite Element Method (FEM), a numerical technique to solve complex differential equations, especially ones arising in clinical applications. 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 structures. Another objective is to provide exposure to more advanced tools such as FEM software (ABAQUS) to solve complex biomechanics problems.

**Approach** - Weekly notes should provide a framework for following the lecture presentations. From time to time supplementary text material will be suggested for amplification, and the course OWL will be used as a means of enhancing communication between instructors and students in the course. Problem assignments are an integral part of the course; they will be marked promptly and discussed in the tutorials. There will be about 7 assignments throughout the course. I invite you to work in groups for the assignments (submitting one assignment per group). Up to two students may submit one assignment, provided that each student has contributed significantly to the assignment. Group assignments promote sharing of ideas and improve learning for students of varied talent and academic background. The problem lab offers an opportunity to work on the assignments with a teaching assistant or lecturer who is available to answer questions. Our role as tutors is to facilitate learning without short-cutting the thinking process.

**Course Topics**

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<table>
<thead>
<tr>
<th>3 Lecture hr</th>
<th>1. Introduction to Biomechanics</th>
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<tr>
<td>(a) Objectives, learning outcomes and course structure</td>
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<tr>
<td>(b) History and applications</td>
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### 2. Biological Tissue Structure

1 Lecture hr

### 3. Introduction to Statics

2 Lecture hrs
(a) Free body diagram
(b) Static equilibrium equations

### 4. Elasticity and the Biology of Tissue

5 Lecture hrs
(a) Building blocks of animal tissues
(b) Elasticity and pure elastic structures
  - Hooke’s law (1D and 2D)
(c) Non-linear elastic materials
(d) Elasticity of biological tissues
  - Bone, tendon, ligament, skin and blood vessels
  - Composite materials

### 5. Soft Tissue Elasticity Measurement

5 Lecture hrs
(a) Measurement of ex vivo soft tissue specimens by direct and indirect methods
(b) Measurement of soft tissues in vivo using elastography (strain imaging and elastic modulus imaging)

### 6. Tissue Nonlinearity, Viscosity and Viscoelasticity

4 Lecture hrs
(a) Tissue nonlinear behavior: source and modeling
(b) Combination of elasticity and viscosity in biological materials
(c) Creep and stress relaxation, spring and dashpot idealizations

### 7. Midterm Review

1 review lecture hr

### Midterm TEST (100 min.)

- **On Friday, October 21st at 3:30 pm – 5:30 pm (Location TBD)**
- **Covered materials up to and including Soft Tissue Elasticity Measurement are required for this test.**

### 8. Mechanics of Joints

5 Lecture hrs
(a) Joints with limited movement
(b) Synovial joints - lubrication of synovial joints and the combination of articular cartilage and synovial fluid
(c) Temporomandibular Joint mechanics

### 9. Bone Mechanics and Bone Fractures

4 lecture hrs
(a) Introduction: Bone mechanical properties and density
(b) Hard tissue mechanics: Ultimate strength in compression, tension and shear
(c) Bending and torsion
(d) Strength of irregular structures (bone)
  - stress concentration in brittle versus ductile materials
  - consequence of geometry for strength in bending
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10. Finite Element Method (FEM)  
3 lecture hrs / Lab  
(a) Introduction: Theory and practical issues  
(b) Hard tissue and bone mechanics using FEM  
- Lecture will be held in the VERC Lab (M150)  
- Tutorial will be held in the VERC Lab (M150)  

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11. Special Topics  
3 lecture hrs  
(a) Mechanical Challenges in Replacement Joints  
  - Hip replacement  
  - Knee replacement  
(b) Middle ear Biomechanics  

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12. Review  
1 lecture hr  

FINAL EXAM  
Exam Period: December 10-21, 2016  

4. Course Materials  
   Course Notes: Helper notes will be provided for each lecture. Previously used texts are either out of print or not sufficiently comprehensive for this course.  

   Supplemental Information:  
2. V. C. Mow and R Huiskes, Basic Orthopaedic Biomechanics and Mechanobiology, Third Edition, Lippincott Williams & Wilkins, 2005  

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.
5. Evaluation:

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<th>MedBio 9530A / BME 9529A</th>
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<tr>
<td>Midterm I</td>
<td>20%</td>
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<tr>
<td>Assignments</td>
<td>40%</td>
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<tr>
<td>Project</td>
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6. Laboratories/Tutorials:
This course involves a problem solving / tutorial lab session every week. 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 will be held in the VERC computer lab. More details will be given prior to this assignment due date.

7. Make-up Policy
   **Midterm test and project:**
   If you are unable to meet a course requirement due to illness or other serious circumstances, you must contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved by the instructor.

   For UWO Policy on Accommodation for Medical Illness, see:
   [http://counselling.ssc.uwo.ca/procedures/medical_accommodation.html](http://counselling.ssc.uwo.ca/procedures/medical_accommodation.html).

   **Assignments:**
   If you are unable to submit an assignment due illness or other serious circumstances, you must contact your instructor immediately. If accommodation is approved, while the student is encouraged to solve the assignment, his/her submitted assignments will be reweighted in order to compensate for the missed assignment’s mark.

8. Western Policies

   **Attendance Policy:**
   All classes, laboratories, and tutorials are mandatory, unless otherwise stated. Any student who, in the opinion of the course instructor is absent too frequently from class or laboratory periods in any course, will receive a failing grade after due warning has been given in writing from the course instructor and Graduate Chair.

   **Cheating and Plagiarism Policy:**
   Students are encouraged to work together, but each student must take total responsibility for his/her submitted work. Students must write their laboratory reports and final projects in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic
offence is attended by academic penalties which might include expulsion from the program. If a student is caught cheating, there will be no second warning.

All written reports and projects may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All reports will be included as source documents on 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 the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

See the School of Graduate and Postdoctoral Studies Scholastic Offence Policy: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

Use of Electronic Devices Policy:
No electronic devices (e.g., cell phones, MP3 players) may be used during lectures or examinations. The use of non-programmable calculators is permitted during examinations; programmable calculators are prohibited during examinations.

OWL Internet/Bulletin Board Policy:
It is the student’s responsibility to read the course website posted on Western’s on-line learning management system, OWL (https://owl.uwo.ca). This includes the course bulletin board and all information and/or assignments posted about the course. If the student fails to act on information that has been posted on the course site and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

Request for Assignments Extensions:
Students are advised to inform the course instructor as soon as possible regarding an extension for assignment submissions due to medical reasons or other compassionate reasons. Extensions will only be granted by the course instructor at his/her discretion.

Absence Due to Medical Illness:
Students must familiarize themselves with the Policy on Accommodation for Medical Illness: http://counselling.ssc.uwo.ca/procedures/medical_accommodation.html. If you are unable to meet a course requirement due to illness or other serious or compassionate circumstances, you must provide valid medical or other supporting documentation to the course co-ordinator immediately. It is the student's responsibility to make alternative arrangements with the co-ordinator to complete missing course requirements.

A student requiring academic accommodation due to illness, should use the Student Medical Certificate: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf

When visiting an off-campus medical facility or request a Record's Release Form for visits to Student Health Services. The release form will allow the course co-ordinator to
confirm with Student Health Services that a student’s absence from regular attendance or inability to meet scheduled course commitments is due to medical reasons. The nature of the illness will not be divulged by Student Health Services.

**Graduate Students’ Mental Health and Physical Wellness:**
As part of a successful graduate student experience at Western, students are encouraged to make their health and wellness a priority. Western provides several on campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. For example, to support physical activity, all students, as part of their registration, receive membership in Western’s Campus Recreation Centre: [http://www.uwo.ca/campus_life/athletics.html](http://www.uwo.ca/campus_life/athletics.html)

All facets of extracurricular campus life in which graduate students can participate are available on this URL: [http://www.uwo.ca/campus_life/arts_culture.html](http://www.uwo.ca/campus_life/arts_culture.html)

Information regarding health and wellness-related services available to students may be found at [http://www.health.uwo.ca](http://www.health.uwo.ca). Students seeking help regarding mental health concerns are advised to speak to someone in whom they feel comfortable confiding, such as their graduate supervisor, their program director (Graduate Chair), or other relevant administrators in their unit. Campus mental health resources may be found at: [http://www.health.uwo.ca/mental_health/resources.html](http://www.health.uwo.ca/mental_health/resources.html)

**Accessibility to the Course and Course Materials:**
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 Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.