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

1. Course Information
   Medical Biophysics 3330F/9530A and BME9529A - Human Biomechanics with Biomedical Applications: 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, mechanics of hearing, and mechanics of orthopedic implants and joint replacement.

   Lectures:
   Tuesdays 11:30 am – 12:30 am / UC-1225
   Thursdays 11:30 am – 1:30 pm / UC-1225

   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>Office</th>
<th>Office Hours</th>
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<tr>
<td>Instructor:</td>
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<tr>
<td>Dr. Abbas Samani</td>
<td>MSB402</td>
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<td>TAs:</td>
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<td>• Sergio Dempsey</td>
<td>TEB 206</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. 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.

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<th>Learning Outcomes</th>
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<tr>
<td>Knowledge Base</td>
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<td>Interdisciplinarity</td>
<td>2/1</td>
<td>2/2</td>
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<td>Communication Skills</td>
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<td>Life-long Learning</td>
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<td>Creative Thinking</td>
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<td>Professionalism</td>
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Notation: x/y, where x is the cognitive level (1: Remember/Understand, 2: Apply/Analyze, 3: Evaluate/Create) at which the attribute is assessed and y is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.

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 the instructor and students in the course.

Problem assignments are an integral part of the course; they will be marked soon after submission 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. **Student contribution may be assessed by randomly inviting a few students who submitted group assignments to describe their**
solutions. Failing to demonstrate basic understanding of assignment solutions may lead to academic penalties. 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 the instructor who is available to answer questions. Our role as tutors is to facilitate learning without short-cutting the thinking process.

**Course Topics**

A. Samani

1. **Introduction to Biomechanics**
   2 Lecture hr
   (a) Objectives, learning outcomes and course structure
   (b) History and applications

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2. **Biological Tissue Structure**
   1 Lecture hr

A. Samani

3. **Introduction to Statics**
   2 Lecture hrs
   (a) Free body diagram
   (b) Static equilibrium equations

A. Samani

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

A. Samani

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)

A. Samani

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

A. Samani

7. **Midterm Review**
   1 review lecture hr

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**Midterm TEST (100 min.)** tentatively scheduled on Friday, October 19th in (TBD)

A. Samani

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

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4 lecture hrs  

9. Bone Mechanics and Bone Fractures  
(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

A. Samani  

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)

A. Samani  
3 lecture hrs  

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

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1 lecture hr  

12. Review

FINAL EXAM  
Exam Period: December 10-21, 2018

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
5. Evaluation:

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<th>Medical Biophysics 3330F</th>
<th>MedBio 9530A / BME 9529A</th>
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<tr>
<td>Midterm I</td>
<td>20%</td>
<td>15%</td>
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<tr>
<td>Final Examination</td>
<td>50%</td>
<td>30%</td>
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<tr>
<td>Assignments (~7)</td>
<td>25%</td>
<td>25%</td>
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<tr>
<td>Project / term paper *</td>
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<td>Participation **</td>
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* The project for graduate students involves in-depth literature review and presentation of a relevant Biomechanics related topic.
** Student participation will be evaluated based on class attendance as well as active participation in the lecture and lab sessions. An example of active participation is to answer questions posed by the instructor or TAs in the class.

IMPORTANT NOTES:
- To obtain a passing grade in the course a mark of 50% or more must be achieved in the final examination. A final examination mark <50% will result in a final course grade of 48% or less.
- Graduate students may have some different assignments and/or exam questions.
- Assignments can be done in groups of 2 students. In this case, each pair of students has to submit only one assignment and each student will receive identical mark.
- Assignment grades will be posted regularly on the class OWL site. Any errors, or appeals to your scores, must be reported to your instructor within two weeks of their initial posting.

6. 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 will be held in the VERC computer lab. More details will be given prior to this assignment due date.

7. Examinations: Midterms and Final
- 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!

Accommodations for Religious Holidays
When scheduling unavoidably conflicts with religious holidays which a) require an absence from the University or b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate department chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

A student who, for either of the situations outlined in paragraph one above (a or b), is unable to write examinations and term tests on a Sabbath or Holy Day in a particular term shall give notice of this fact in writing to his or her Dean as early as possible, but not later than November 15 for mid-year examinations and March 1 for final examinations, i.e., approximately two weeks after the posting of the mid-year and final examination schedule respectively. In the case of mid-term tests, such notification is to be given in writing to the instructor within 48 hours of the announcement of the date of the mid-term test. If a Special Examination is offered as an alternative means to satisfy the academic requirements, the instructor(s) in the case of mid-term tests and the dean in the case of mid-year and Spring final examinations will arrange for special examination(s) to be written at another time. In the case of mid-year and Spring final examinations, the accommodation must occur no later than one month after the end of the examination period involved. It is mandatory that students seeking accommodations under this policy give notification before the deadlines and that the Faculty accommodate these requests.

For purposes of this policy, the University has approved a list of dates which are recognized religious holidays which require members of those religions to be absent from the University; this list is updated annually and is available at Departmental, Deans' and Faculty advising offices.

8. Make-up Policy

A. Absence for medical illness:
Western requires documentation from the medical community for students who require academic accommodation due to medical illness. Students are required to have their physician or health care provider fill out a Student Medical Certificate.

If you require this documentation from Student Health Services:

- The request for medical certificate should be made during the initial visit with the SHS physician or nurse practitioner.
- The fee for having this form completed is $20. You may pick up the completed form and make your payment in the Accounts Office (Room 19) at SHS.
Medical certificates will only be considered for students who are seriously affected by illness and cannot reasonably be expected to meet their academic responsibilities.

Special Examinations
A Special Examination is any examination other than the regular examination, and it may be offered only with the permission of the course coordinator and the Medical Biophysics Graduate Chair. Permission to write a Special Examination may be given on the basis of compassionate or medical grounds with appropriate supporting documents. If a student fails to write a scheduled Special Examination, permission to write another Special Examination will be granted only with the permission of the Graduate Chair in exceptional circumstances and with appropriate supporting documents.

9. Cheating (Scholastic Offenses)
   Cheating
   Scholastic offenses are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offense, at the following Web site:
   http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf
   Plagiarism
   Students must write their essays and assignments 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. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).
   All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. 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 The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

10. Internet and Electronic Mail:
    Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca) and making themselves aware of any information that is posted about the course.

11. Accessibility:
    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 519-661-2111 ext. 82147 for any specific question regarding an accommodation.
12. **Support Services:**

   Student Development Centre, [http://www.sdc.uwo.ca/](http://www.sdc.uwo.ca/)

   USC Student Support Services, [http://westernusc.ca/services/](http://westernusc.ca/services/)

   Students who are in emotional/mental distress should refer to Mental Health @ Western, [http://www.health.uwo.ca/mental_health/](http://www.health.uwo.ca/mental_health/), for a complete list of options about how to obtain help.

13. **Classroom Conduct**
   Disruptive behaviour will not be tolerated in class. Please respect the rights of your classmates to benefit from the lecture by limiting your conversations to those essential to the class. Students who persist in loud or rude behaviour will be asked to leave and may have their clicker codes disabled for an extended period.

14. **Complaints and Suggestions**
   If you have a concern about something, please let us know. We rely on your feedback. Please contact initially the person most directly concerned; this will usually be your instructor. If that is not satisfactory, or if there is something more general bothering you, talk it over with the Medical Biophysics Department Graduate Chair.

15. **Contacting Us**
   The simplest way to contact the instructor or TAs outside of the lectures is via e-mail using your UWO e-mail account.