Faculty of Engineering
McMaster University
Term 1 (September - December 2017)

MECH ENG 4BB3/6BB3
Biomechanics
Revised 17 September 2017

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Lectures: Mon, Wed, Thu (10:30-11:20) — BSB 106
Tutorials: Mon (11:30-12:20) — BSB 106
Laboratories: none
Office hours: none scheduled – please send email to schedule time to meet

Course website: via *Avenue to Learn* (avenue.mcmaster.ca)

Course Objectives:
Biomechanics is the study of how physical forces interact with living systems. The aim of this course is to provide an introduction to biomechanics for engineers. It is assumed that the students will have an understanding of engineering principles including solid mechanics and fluid mechanics. The course will teach students how to apply mechanical engineering principals to biomechanical problems including cellular biomechanics, hemodynamics, the circulatory system, muscles and movement, the skeletal system, and the respiratory system.

Course Topics:
Major topics covered include:
- Cellular Biomechanics
- Hemodynamics
- The Circulatory System
- Muscles and Movement
- Skeletal Biomechanics
- Locomotion

Email Policy:
- Any emails directed to the instructor or TA should include a subject prefix of "ME 4BB3" (or "ME 6BB3").

Course Materials:

Textbook:

C.R. Ethier, C.A. Simmons *Introductory Biomechanics: From Cells to Organisms*, Cambridge University Press, 2007. ISBN: 978-0-521-84112-2

Calculator:

The McMaster Standard Calculator is the only calculator that may be used on tests or exams.

The Course Management System is Avenue to Learn (avenue.mcmaster.ca).
Students are required to check the system daily for assignment release / submission, course-related material, and posted announcements. It is also highly recommended that students forward their email from Avenue to their regular email (see *Avenue Mail* settings) to receive any important email broadcasts

Lecture Content:

Student will be expected to keep up with the lecture topics by "reading ahead" in the textbook. During class, students will be asked questions regarding content from the text. Class participation (answers) will be considered in grading (see Grading scheme, p.3)

Detailed Lecture Schedule:

	Topic	Text Reference Sections
1	**Introduction**	1.1
2	**Cellular Biomechanics** - cell structure, matrix interactions, mechanotransduction, mechanical stimulation of cells	2.1-2.9
3	**Hemodynamics** - blood rheology, large artery hemodynamics, blood flow in small vessels	3.1-3.3
4	**The Circulatory System** - the heart, pulse propagation (pressure flow relationships), capillaries and veins	4.1-4.6
5	**Muscles and Movement** - Muscle morphology and physiology, muscle modeling, whole muscle mechanics, muscle-bone interactions	8.1-8.4
6	**Skeletal Biomechanics** - Bone biomechanics, functional adaptation of bone, soft tissue biomechanics	9.1-9.10
7	**Terrestrial Locomotion** - Locomotion (jumping, walking, running), gait analysis	10.1-10.3
8	**Joint Biomechanics** - Mechanics of diarthrodial joints, injuries, and orthopaedic implants	8.4 and other

Evaluation: (* see next page for ME 6BB3 grade distribution)

Class Quizzes	10%	[10 in-class quizzes each worth 1%]
Assignments	24%	[6 assignment x 4%]
Term Tests	36%	[3 term tests x 12%]
Final Examination	30%	

The percentage marks will be converted to a final letter grade using the standard conversion scale shown in the McMaster Undergraduate Calendar.

Class quizzes: Quizzes will be held at the beginning of lectures periodically throughout the term. Each graded quiz will contribute to 1% of the total mark for the course (there will be 10 graded quizzes in all). Quizzes will be based on the material covered in the lecture. **No make-up quizzes will be given**.

Assignments: There will be 6 assignments. The first assignment will be customized (to be announced in class). The other five (5) assignments will be based on questions at the end of textbook chapters. Assignments are due one week after they are assigned. **Late assignments will be given a grade of zero**.

Term Tests: There will be three (3) term tests (see below) **to be held during Monday tutorial times (11:30-12:20)**. Books and notes are not permitted during the term tests or during the final examination. The McMaster calculator (Casio fx-991) may be used during term tests and the final examination (but will not be required). Details of the tests will be announced in class.

Term Test I: Monday, October 02, ~~7:00 PM – 8:30 PM DSB AB102~~ 11:30-12:20 T13 Rm. 123
Term Test II: Monday, November 06, ~~7:00 PM – 8:30 PM DSB AB102~~ 11:30-12:20 T13 Rm. 123
Term Test III: Monday, November 27, ~~7:00 PM – 8:30 PM DSB AB102~~ 11:30-12:20 T13 Rm. 123

Final Exam: A 2.5 hour final exam will be held in December (date to be determined). The final exam must be written otherwise a final grade of 'F' will be awarded with the notation DNW (Did Not Write). Final exam details are set by the Registrar. The instructor reserves the right to choose the format (i.e., written or oral) of any deferred exam in this course.

MSAF:
Should a student need to use the McMaster Student Absence Form (MSAF) for an assignment or midterm, there will be no supplemental offered. The value of that deliverable to your overall grade will be added to the final examination weighting.

Mechanical Engineering 6BB3

For graduate students enrolled in ME 6BB3 the following are additional course requirements and modified grading scheme. The purpose of these additional elements is to encourage the graduate student to develop skills for writing, presentation, and critical literature review in the multidisciplinary field of biomechanics.

Evaluation:

Class Quizzes	10%	[10 in-class quizzes each worth 1%]
Assignments	0%	[no problem assignments]
Review paper:	16%	
Presentation:	8%	
Term Tests:	36%	[3 term tests x 12%]
Final Examination:	30%	

Assignments:
Graduate students are not required to complete the six assignments required for ME 4BB3.

Review Paper and Presentation:
Graduate students will write one review paper (approximately 8-10 pages double spaced plus references) on selected topics from the areas of 1) cell mechanics, 2) cardiovascular mechanics, 3) injury mechanics, 4) implant design, 5) spinal disorders, 6) osteoporosis, 7) osteoarthritis, or 8) tissue engineering. Students are also welcome to write on a topic of their choosing with permission from the instructor. Students will be required to perform the review of the current literature related to their topics of interest. The students will also give a presentation (10 minutes) on their selected review topic (time and location to be determined). The graduate students will be guided through their seminars/reports by additional meetings with the instructor.

Term tests and final exam:
Complete term test details are provided on the previous page.

Learning Outcomes:
Upon successful completion of the course, the student will be expected to have demonstrated the ability to:

1. Compare techniques for measuring the mechanical properties of cells and illustrate the key operating principles of these techniques.
2. Illustrate key characteristics of red blood cell behaviour that affect the viscosity of blood.
3. Derive the relationship between pressure and volume in the heart at key phases of the cardiac cycle.
4. Analyze the contributions of different muscles to a prescribed loading condition and determine the joint reaction force based on these muscle forces.
5. Assess the effect that skeletal loading plays in the mechanical properties of cortical and trabecular bone and analyze mechanisms of injury and treatment that can cause these mechanical properties to be altered.
6. Develop and mathematically solve rudimentary lumped parameter model to explain viscoelastic behaviours of musculoskeletal tissues.
7. Illustrate how joint reaction forces are calculated based on data collected during walking and/or running activities and determine the key parameters that must be measured.

Mapping to Graduate Attributes:

Graduate Attribute		***Learning Outcomes***
A01 – A Knowledge Base for Engineers		
1.02	Competence in Natural Sciences	1-7
1.04	Competence in Specialized Engineering Knowledge	1-7
A02 – Problem Analysis		
2.01	Demonstrates an ability to identify reasonable assumptions (including identification of uncertainties and imprecise information) that could or should be made before a solution path is proposed.	1,6,7
A03 – Investigation		
3.02	Selects appropriate model and methods and identifies assumptions and constraints.	1,5,6,7
3.03	Estimates outcomes, uncertainties and determines appropriate data to collect.	1,2,5,6,7

Policy Reminders: Students are reminded of the following Policies, which could be relevant to activities in this course.

Adverse Discrimination: The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

Academic Integrity (Ethics and Dishonesty) Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at: http://www.mcmaster.ca/senate/academic/ac_integrity.htm

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work
3. Copying or using unauthorized aids in tests and examinations.

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.