

BMEG 230: Biomechanics I

2024W Syllabus

COURSE INFORMATION

Instructor:	Dr. Pawel Kudzia
Email:	Pawel.kudzia@ubc.ca
Office Hours & Location:	By appointment or as posted on Canvas
Response Times:	The instructor and teaching assistants will make our best effort to respond within 24 hours (business days). We will post commonly asked questions on Canvas, Piazza or we will circulate an email.
Teaching Assistant Info:	See Canvas
<i>Pre-Requisites:</i>	Either (a) all of BMEG 101, PHYS 170 or (b) all of APSC 101, BMEG 200, PHYS 170. A sound working knowledge of calculus, statics, and basic knowledge of 2D dynamics and human anatomy and physiology is essential.

LECTURE DATES | TIMES | ROOMS

Lecture:	Tuesday 9:00am-11:00am Thursdays
Lab:	L1A: Tuesday 3:00pm-5:00pm, Wesbrook 301 L1B: Wednesday 2:00pm-4:00pm, Wesbrook 301 L1C: Thursday 11:00am-1:00pm, Wesbrook 301 L1D: Wednesday 2:00pm-4:00pm, Wesbrook 302 L1E: Thursday 4:30pm-6:30pm, Wesbrook 301
Tutorial:	T1A: Tuesday 3:00pm-5:00pm, Wesbrook 301 T1B: Wednesday 2:00pm-4:00pm, Wesbrook 301 T1C: Thursday 11:00am-1:00pm, Wesbrook 301 T1D: Wednesday 2:00pm-4:00pm, Wesbrook 302 T1E: Thursday 4:30pm-6:30pm, Wesbrook 301

COURSE DESCRIPTION

Biomechanics is the application of the principles of mechanics in the analysis of biological systems. The field of biomechanics looks at the effect of external and internal forces acting upon the human body. Biomechanics aims to study and quantify the motion of body segments and the factors that influence that movement, the deformation of biological tissues and the factors that influence these deformations, and the biological effects of localized forces. The applications of biomechanics are numerous, and it is the discipline centrally involved in things such as:

- Orthopaedic applications and devices - What are the design requirements for a knee replacement? What are the underlying mechanics causing spinal deformities?
- Joint movement, posture, and gait - What are the loads on the knee joint when walking upstairs with and without a posterior cruciate ligament? What are the forces on the lumbar spine with improper lifting technique? What are the joint angles and muscle contraction patterns characteristic of gait in children with cerebral palsy?
- Sports and sporting equipment - What advantages are there to jumping backwards in high jump? How can bicycle seat height affect muscle activation patterns and joint range of motion? Do grip tightness and ball impact location affect muscle activity and stroke mechanics in tennis?
- Prosthetics - What are the design requirements of an above the elbow arm prosthetic needed to hold a glass of water? What mechanical energy is stored and released by various foot prosthetics?
- Tissue mechanics - How does mechanical wear create damage to cartilage? How does the structure of bone affect its ability to support loads? What is the optimal design for a stent that can support the pressures and loads in the aorta?
- Injury analysis and safety equipment - How should a bicycle helmet differ from a hockey helmet and why? How does the jumping and landing technique in volleyball affect the risk of ankle ligament injuries? How does a femur fracture in a sideways fall?

Although some of these concepts are beyond the scope of this course, you will be provided with an overview of the fundamental concepts and techniques that are presently in use in this field as well as the assumptions and limitations of applying mechanics to the human body. The course is arranged in three major learning units:

1. Statics in Biomechanics
2. Dynamics in Biomechanics
3. Tissue Mechanics

LEARNING OBJECTIVES

- Identify and use the fundamental principles in mechanics and apply them to the musculo-skeletal system
- Formulate and solve relevant equations governing planar rigid-body statics and dynamics, including kinematics and kinetics, and its application to the body and human motion
- Formulate and solve the relevant equations of planar gait analysis, internal and external joint loads, and identify the purpose and limitations of forward and inverse dynamics approaches to motions analysis
- Formulate and solve relevant equations governing the elastic stresses and deformations in one-dimensional load carrying biological tissues
- Identify the basic composition, morphology and mechanical behaviors of biological tissues, such as bone, ligament, tendon, and muscles
- Describe the purpose, basic function and limitations of the equipment and sensors used to measure biomechanics
- Describe the main assumptions and limitations associated with the application of mechanics to the human body

LECTURES

Lectures will consist of a combination of traditional lectures and flipped classroom style lectures. The flipped classroom style will require students to prepare before the class, typically by completing a short reading. Preparation materials will be available on Canvas prior to class. Students should prepare beforehand to participate in activities including solving problems and group work. The in-class activities will be real-world applications of biomechanics. These activities will be submitted but not graded (these questions are open ended and complex; they will not be assessed on correct/incorrect solutions but will serve as evidence of the engagement of you and your group in the task). Those working on the activity should sign their name as a record of course engagement. If you miss a lecture that has an in-class activity, you may submit your copy of the work to the instructor for a record of engagement. To perform these complex activities, and get the most out of the course, you should prepare ahead of time and participate to the fullest.

ASSIGNMENTS

There will be several assignments through the term that will allow you to work individually on further learning and applying the course concepts.

ASSIGNED READINGS

To prepare for the learning units and to better engage in the flipped classroom lectures, you will be assigned some small pre-class readings.

TUTORIALS

Tutorials will offer some example problems and further explanation of complex material, as well as extra time to work on assignments and the course project with TAs available to help. Tutorials are designed to be conducted in-person. If you cannot attend a tutorial, please contact the TA well in advance (if possible) to arrange an alternative (you may be able to attend another tutorial section, but the tutorial space has capacity limits, so you need to arrange this before with the TAs).

LABORATORIES

The field of biomechanics is heavily driven by laboratory research and industrial testing methods and a knowledge of various biomechanical techniques and equipment is valuable; thus, we will have six laboratories where you will gain some hands-on experience with testing methods, computational methods, equipment, and experimental protocols. You will work in groups and submit a laboratory report as a group, which is due two weeks following your assigned laboratory session (you will get a bonus 2% on the lab report if you pass it in within one week of your lab). Laboratories are designed to be conducted in-person. If you cannot attend a laboratory, please contact the TA well in advance (if possible) to arrange an alternative (you may be able to attend another laboratory section, but the laboratory space has capacity limits, so you need to arrange this before with the TAs).

PROJECT

The course will consist of a project that will be conducted in groups and will be due at end of the course. The aim of the project is to provide the opportunity to apply concepts learned throughout the course and gain a deeper understanding on a specific topic in biomechanics. A

final design solution will be due at the end of the term; however, a physical prototype will not be required for the design project. You will have opportunities through the term to get feedback on your work, we suggest you use these deadlines to ensure you are progressing on the project. You will be given time to work with your group on the project during the tutorials, where TAs will be able to guide you and help with design methods. If more time is needed, you should coordinate meeting times with your team that works for you. When you submit a project deliverable, your team is expected to outline how each person contributed to the task. We can help support you in setting up an effective method of team communication (such as MS Teams).

ASSESSMENTS

The course is divided into three major learning units (statics in biomechanics, dynamics in biomechanics, tissue mechanics). Each unit will require some preparation, such as short-assigned readings. Followed by some lecture and in-class activities. Tutorials, laboratories, and assignments are designed to build on, and practice, your knowledge of the unit. Each unit builds upon the next, so it is in your best interest to keep up on the material. Your comprehension of the material covered will be evaluated with both a midterm exam and a final exam.

PARTICIPATION

Participation is important for your progress in this course as a great deal of learning will happen in the classroom, tutorials, laboratories, and group work. There is no direct course mark for participation; however, if your grade is borderline (i.e., a 79% and you are arguing for an 80%) your participation throughout the course (such group work that has been handed in) will factor into this. You should also be aware that your peer-evaluation scores by your project group members will reflect your engagement with your project work through the whole term.

PEER EVALUATION: Students will be asked to conduct peer-evaluations of their project group members throughout the semester. This evaluation, along with justifications for the assigned scores, will be made at the end of the term and will only be visible to the instructor. A multiplier on the project grade will be applied based on the peer evaluation scores (this grade will either raise or lower your own team mark relative to the team average).

DISCUSSION BOARDS

Piazza will be used for offline discussions of course related material. This should be used for questions regarding course assignments, labs, readings, etc. Students should feel free to have discussions and answer each other's questions if appropriate. The instructor and TAs will monitor the board and answer questions that are directed at us. Please allow for a reasonable response time. We will try our best to respond within 24 hours of the post (weekends may take longer). If your matter is urgent or personal, or your question is unanswered after a couple of days, please email us.

STUDENT EVALUATION

The grading scheme was determined with your help on the first day of class. The following course elements will be used for evaluation for the course grade.

	Evaluation Method	Percentage of Final Grade
Individual Work	Assignments <i>Total of 5 assignments</i>	15
	Midterm Exams x 2	20
	Final Exam	25
Group Work	Project <i>Deliverables through the term, final report graded</i>	20
	Laboratories <i>Five laboratories, each with reports</i>	20
TOTAL		100%

A multiplier on the project grade might be applied based on the peer evaluation scores for the project (this grade will either raise or lower your own team mark relative to the team average). Note that if there is clear evidence of little to no engagement in the group project, you are at risk of failing the project portion of the course.

The lab group work grade is not adjusted based on peer evaluation scores but may be adjusted due to evidence of lack of contribution (i.e., if there is clear evidence you did not engage or participate in a particular lab, you can get a lower grade than your group received for that lab, including receiving a zero).

I reserve the right to make slight adjustments to your mark based on your participation in the course. For instance, I will collect group class activities and project/laboratory reports, and if you're consistently contributing, then this would factor into whether you may get a small bump in a borderline grade (i.e., if you're on the border between a B or a B+). This adjustment will only be slight and will be at my discretion.

Bonus points: There will be opportunities for bonus points, e.g., 1% will be given to the top 10 students that provide the best answers on Piazza.

REGRADE REQUESTS

Requests for re-graded assignments, reports, and tests fall into two categories:

- (1) A belief that there is some typo/clerical error in the work - please direct requests to the instructor or teaching assistants (preferably whomever marked your assignment/report/test) to correct.
- (2) A substantive request for an assignment/report/test to be reassessed - please generate a short (<1pg) memo detailing the specific areas of concern, citing the rubric wherever possible and submit it to the course instructor.

LATE POLICY

LATE WORK

10% will be deducted from the mark of any work submitted late for each day after the submission deadline unless an exemption has been granted. Work will not be accepted for marks after in-class discussions have occurred and/or the solutions have been posted. Please note that we recognize that you may have a lot of stress in your life under current circumstances. If you find yourself having major difficulties in this course (e.g., making deadlines), please talk to one of the instructional team as soon as you can, and we can discuss solutions and provide support to you.

COURSE MATERIALS

The course material will mostly be covered by the following text: Fundamentals of Biomechanics. (4th or any edition) Nihat Özkaya, Margareta Nordin, David Goldsheyder, Dawn Leger, Springer, 2017 [online @ UBC library]. It is recommended that students supplement the course lectures with readings from this text. The underlying mechanical principles to the course (without the biomechanics applications) can also be found in a general mechanics text. Some recommendations of texts include the Mechanics Map Digital Textbook (open source, <http://mechanicsmap.psu.edu>) and Mechanics of Materials by Hibbeler (2005, available online through UBC library). These texts are not required; however, they are valuable supplemental texts. Good resources for anatomy, that are freely available at UBC, are [Clinical Anatomy](#), [Acland's Video Atlas of Anatomy](#), and [AnatomyTV](#). The first chapter of Clinically Oriented Anatomy by Moore, Dalley, Agur (2018) will be available online via course reserves. Throughout the term, there may be some required and suggested readings from other sources. These will be posted for your access on Canvas. Canvas will also be used to post lectures, assignments, recommended/suggested readings, supplemental material, etc. It will also be used to communicate important deadlines and reminders.

Students must be able to access the course content online via Canvas. You will be expected to document and submit your work electronically (this might include scanning, photographing, and/or taking videos). The laboratories and course project require specialized software, such as Matlab and Solidworks. Accommodations may be made if you do not have sufficient computer specifications for either software. Please speak to the instructor or TAs as early as possible in the term so other options can be pursued. Note: do not leave it to the last minute to verify software as accommodations may be impossible on short notice.

COURSE SCHEDULE

SCHEDULE (APPROXIMATE **)

The following topics will be covered, subject to course progress. The relevant textbook chapters for each week are as indicated.

Week	Topics Covered	Textbook Section
1	Introduction, anatomy review, introduction to project	Clinically Oriented Anatomy by Moore, Dalley, Agur, Ch 1
2	Statics review, free body diagrams, statics in biomechanics, upper body biomechanics	Ozkaya Ch 2, 3, 4, and 5.1 – 5.6
3	Mechanics of spine/lower extremity, review statics, intro to kinematics methods/equipment	Ozkaya 5.7 – 5.10
4	Rotational kinematics, head/neck injury, angle conventions	Ozkaya Ch 6 and 7, Ch 9.1-9.9
5	Relative kinematics and review for midterm	Ozkaya Ch 9.10-9.11
6	Midterm, linear kinetics, occupant protection/seatbelts	Ozkaya Ch 8 and 11.1-11.6
7	Angular kinetics and inverse dynamics	Ozkaya Ch 10, 11.8-11.10
8	EMG, gait, modelling, optimization	
9	Power, energy harvesting, more dynamics	Ozkaya 8.11
10	Dynamics review, no class 10 th	
11	Tissue composition and morphology, mechanics of bone loading and examples	Ch 12 and 13 and 15.7
12	Bone bending, shear, torsion, mechanical properties of ligaments, tendon and muscle	Ozkaya 14.11-14.13
13	Mechanical properties of cartilage, osteoarthritis, mechanics of prosthetics, tissue mechanics review	Ozkaya 15
14	Project pitches and course review	

COURSE POLICIES

ATTENDANCE

Although in-person attendance is not mandatory, course engagement is very important for your progress in this course as a great deal of learning will happen with the in-class activities, tutorials, laboratories, and group work. There is no course mark for attendance; however, if your grade is borderline (i.e., a 79% and you are arguing for 80%) your engagement throughout the course (such group work that has been handed in) will factor into this.

The course involves group work; thus, you are expected to meet with your group (at a time that works for all members) to complete the tasks assigned. You are expected to communicate with your group members if you cannot attend meetings. Remember that you will be graded by your peers on your involvement in group work so a lack of engagement could affect your group grades.

ACCOMMODATIONS AND CONCESSIONS

Concessions will be made for assessments (assignments, labs, midterms, etc.) when the grounds for academic concession (<http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,329,0,0>) have

been met. These can include things such as medical circumstances, conflicting responsibilities, and compassionate grounds. Please discuss possible concessions with your instructor as soon as possible in addition to filling out the following form:

<https://academicservices.engineering.ubc.ca/form-request-for-academic-concession-in-term-work/>

Please contact the Center for Accessibility as early as possible for disability-related accommodations (<https://students.ubc.ca/about-student-services/centre-for-accessibility>).

Accommodations and concessions that may be made available include exemptions from an activity/deliverable, shifting the weight of a missed activity to another portion of the grading scheme, adjusting expectations for the activity (including teamwork if necessary), or submitting an alternate deliverable (e.g., a recorded video).

SPECIAL CIRCUMSTANCES DUE TO COVID-19

We are committed to providing an engaging and academically rigorous learning experience for you. We are living in uncertain times, and it is difficult to predict what the physical and mental health consequences of the COVID-19 pandemic will be for both students and faculty. **If you are ill, please let us (and your team) know as soon as possible so we can plan for accommodations.** If one of the instructors or teaching assistants becomes ill, we have overlapping expertise and will rearrange as needed to best support you - please be patient with us should this happen.

We expect you to abide by the current UBC and Provincial Health policies.

STAY HOME WHEN YOU'RE FEELING SICK

Do not attend in-person class activities if you are feeling sick - but do let us know as soon as possible so we can excuse attendance and arrange alternatives. Coming in sick is a violation of the student code of conduct and you may be asked to leave if you are showing viral-like symptoms. Your (and our) health is paramount - you can catch up with your team later.

Further information about UBC's COVID-19 policies can be found at <https://covid19.ubc.ca/>.

UBC POLICY ACADEMIC INTEGRITY

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

For more information, see: <http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,286,0,0>

ACADEMIC CONCESSION

The University is committed to supporting students in their academic pursuits. Students may request academic concession in circumstances that may adversely affect their attendance or performance in a course or program. Students who intend to, or who as a result of circumstance must, request academic concession must notify their instructor, dean, or director as specified in the [link](#) below.

<http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,48,0,0>

Students seeking academic concession due to absence from the final exam for any reason must apply to Engineering Student Services (ESS) within 72 hours of the missed exam. This is a standard practice for all final examinations at UBC.

For more information, see: <http://students.engineering.ubc.ca/enrolment/faq/>

STATEMENT ON UNIVERSITY'S VALUES AND POLICIES

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious, spiritual and cultural observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available here: senate.ubc.ca/policies-resources-support-student-success.

LAND ACKNOWLEDGMENT

This course is held on the UBC Point Grey (Vancouver) campus, which sits on the traditional, ancestral, unceded territory of the x^wməθk^wəyəm (Musqueam) First Nation.