The University of Western Ontario
Faculty of Engineering
Department of Mechanical & Materials Engineering

MME 4474A – Selected Topics in MME: Computational Biomechanics for Biomedical Applications

COURSE OUTLINE 2025-2026

Territorial Acknowledgement

The University of Western acknowledges that much of our work takes place on the traditional territory of the Anishinaabek, Haudenosaunee, Lūnaapéewak and Chonnonton Nations, on lands connected with the London Township and Sombra Treaties of 1796 and the Dish with One Spoon Covenant Wampum. This land continues to be home to diverse Indigenous Peoples (First Nations, Métis and Inuit) whom we recognize as contemporary stewards of the land and vital contributors of our society. These lands are connected with the London Township and Sombra Treaties of 1796 and the Dish with One Spoon Covenant Wampum. As a class, we respect the longstanding relationships that Indigenous Nations have to this land, as they are the original caretakers. We acknowledge historical and ongoing injustices that Indigenous Peoples (First Nations, Métis and Inuit) endure in Canada, and we accept responsibility as a public institution to contribute toward revealing and correcting miseducation as well as renewing respectful relationships with Indigenous communities through our teaching, research and community service.

Calendar Description

This is an undergraduate 4th year course suitable for MME / MSE students (with and without +BME). The objective of course is for students to achieve an advanced understanding of various computational methods applied in the field of biomechanics, and to provide hands-on experience using computational biomechanics software. Furthermore, this course aims to expose students to contemporary research literature related to the development or application of computational biomechanics techniques.

Contact Information

Course instructor:
Irene Yang, BEng (Hons I)/BMedSci, DPhil (Oxon)

Building E4, Room 128A, Victoria Hospital
800 Commissioners Rd E, London
Ontario, Canada
N6A 5W9

Extension: 53610

TEB 349
1151 Richmond Street North, London
Ontario, Canada
N6A 5B9

Extension: 88262

Email address: irene.yang@uwo.ca

Contact policy:

- Please contact the instructor via email (above) or through messages in OWL.
- If you are contacting via email, please use your Western email address. Include an academic signature with your full name, program, student ID. We encourage you to include your pronouns to facilitate respectful communication (e.g., he/him; she/her; they/them).
- Office hours: By email

- A general FAQ section on the 'forums' section of OWL will be used for students to pose course-related questions. This will ensure that all students enrolled on the course have the same information.

Teaching Assistant/s
TBC

Pre-/Anti-requisites
TBC

Prerequisites: ES1022A/B/Y, MME 1411A/B, Engineering Science 1050, MME 3360A/B. Unless you have either the prerequisites for this course or written special permission from your Dean to enroll in it, you will 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 if you are dropped from a course for failing to fulfil the necessary prerequisites.

Overview Of Course Topics
1. Introduction to Computational Biomechanics
2. Medical Imaging, Image Processing
3. Model generation
4. Material assignment
5. Biomechanical Modeling using Finite Element Analysis (FEA)
6. Model Verification and Validation
7. Applications in industry

Contact Hours
3 lecture hours, 12:30-15:30, ACEB 1420

Computing

Students will be required to use Jupyter notebook and ANSYS to complete some assignments. These programs are available in the Engineering computer labs. Students may access ANSYS from the portal https://appsanywhere.eng.uwo.ca/.

Learning Objectives/Outcomes*

The Mechanical and Materials Engineering Program has been accredited by Canadian Engineering Accreditation Board (CEAB) of Engineers Canada. Accredited programs provide the academic requirements for licensure as a professional engineer in Canada. Western Engineering has defined indicators of the twelve Graduate Attributes (GAs) that the CEAB expects graduating engineering students to demonstrate. The connections between course learning outcomes and Western Engineering's GA Indicators are identified below.
Upon successful completion of this course, students will be able to:
1. Create 3D computational models of geometric bodies as well as human anatomy from medical imaging data (KB4, ET2)

2. Use Python programming to manipulate medical image and prepare them for machine learning problems
3. Use FEA software to design, validate and conduct a finite element analysis of 3D computational models of human anatomy
4. Develop experiments to evaluate bone and tissue mechanical properties including determining loading, and boundary conditions for various activities.
5. Develop sound insight into the field of biomedical and biomechanical engineering, particularly in orthopedic surgery.

Tentative Course Outline*

1. What is biomechanics?
2. Medical imaging: X-ray imaging, Computed Tomography (CT)
3. Basic digital image processing using Python coding
4. Segmentation
    a. Traditional methods
    b. AI (CNN) methods – an overview
    c. Software: commercial and open-source platforms
5. Finite element analysis of biological structures
    a. Geometry creation
    b. Loads, fixtures and boundary conditions
    c. Material assignment

* Subject to adjustments and changes as required.

Texts/Materials

Required textbook

Required reading will be provided by the instructor when appropriate.

Please note: Any prices provided in course outlines are best estimates based on recent online prices and do not include shipping or taxes. Prices may vary between retailers.

Evaluation

Assessment Type	Material Covered	Tentative Due Date	Weight
In-class mini quizzes	Questions will be revealed to students at the beginning of the class, starting from the first week. Each quiz will contain technical questions based on material covered previously.	*Assigned bi-weekly in-class Due in class*	**20%**
Homework Assignments (three)	Students will use several commercial applications for developing 3D anatomical models from medical imaging data (MIMICS), creating sophisticated musculoskeletal biomechanical models, and developing / solving structural finite element models of human anatomic systems (Ansys).		**30%**
	Assignment 1	*Assigned Week 2 Due Week 4*	*10%*

	"Python coding assignment: basic image processing using Python & understanding basic machine learning – an exercise"		
	Assignment 2 *"Creating 3D anatomical model using MIMICS, SolidWorks (if required)"*	*Assigned Week 4* *Due Week 6*	*10%*
	Assignment 3 *"Finite element analysis of a biomedical model exercise"*	*Assigned Week 7* *Due Week 9*	*10%*
Course Project	Work in teams of 2-3, students will design and complete a project to analyze a biomedical model and use the computational techniques taught in this class to tailor the model as required for the engineering problem, assign appropriate material properties (e.g. cortical and cancellous bone), apply a force and assess model response using computational software e.g. FEA.		**50%**
	Proposal, incl. literature review and methods (describing modelling techniques)	*Due Week 6*	*15%*
	Project presentation to class	*Due Week 13*	*15%*
	Project final report	*Due Week 14*	*20%*

Policies

The following course-specific policies will be strictly enforced throughout the course:

- In-class mini quizzes
  - Quizzes are delivered through: Microsoft Quiz – an online form.
  - Questions are based on content presented in lectures from the previous week.
  - Quiz questions will only be released in class each week.
  - Quizzes will be timed; quiz responses will be due at the end of the timed quiz time. Late submissions will not be accepted and will be given a grade of 0.
  - The lowest quiz mark across the term will be dropped.
  - If a minimum of 50% is not obtained on term work (in class weekly quizzes, assignments 1, 2, 3), the student will fail the course irrespective of the mark obtained in the final group project.
- Assignments
  - Students are expected to use the allocated lab rooms to complete the assignments.
  - Students may attend the laboratory session anytime that suits them.
  - Assignments must be submitted individually.
  - Assignments will be due as allocated. No late submissions will be accepted.
  - If a minimum of 50% is not obtained on term work (in class weekly quizzes, assignments 1, 2, 3), the student will fail the course irrespective of the mark obtained in the final group project.
- Group project
  - Teams must be formed by Week 4. After this time, team members are locked and can no longer be altered.
  - It is expected that groups will self-delegate for the various aspects of the project, including problem identification, CAD (if applicable), FEA analysis, and report generation.

- Students who do not choose a team will be assigned to one.
- SolidWorks will be used for the design drawings and layouts, if applicable.
- ANSYS must be used for the FEA.
- While the default assumption is that everyone contributes equally to the team effort and that everyone should therefore receive the same mark for the common team submission, if it is deemed by the course instructor or the teaching assistants that individual contributions to the team effort are not equitably shared by the team members, individual adjustment of the marks may occur, with allocation at the discretion of the instructor and teaching assistants.
- All students must be present at the group presentation day (Week 13). Failure to turn up without academic consideration will see an immediate individual deduction of 50% of the group presentation score achieved (assuming that there has been equal contribution to other group project components. If not, individual contribution across the group project will first be determined, in addition to the 50% reduction the group presentation score).
- Late submissions (proposal/project report) will be penalized 20% per day, after 3 days students will receive a grade of 0.

Generally, students are required to contact the course instructor for any other concerns that are not covered by the non-exhaustive list of circumstances above.

Intellectual Property

This course contains the intellectual property of the instructor, TA, and/or the University of Western. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof).
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides).
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, labs, tests/final exams, whichever applicable); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

The material provided in this course is designed to enhance student learning. The lecture notes and online lecture videos are copyrighted to the instructor and legally protected. You are not permitted under any circumstances to share the course materials on any other website, online forums/ with students taking the same/similar courses in subsequent terms/years. Recording of any sessions delivered on the course without the permission from the instructor is prohibited. In many cases, instructors might be happy to allow distribution of certain materials if permission is sought. Posting and sharing the copyrighted course content without expressed permission from the owner is considered a violation of intellectual property rights and academic integrity and could be subjected to legal actions. Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online.

Attendance

Students on this course are expected to attend scheduled classes and any other appointments scheduled/agreed to ensure the best chance for the student to successfully complete the course. Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods will be reported to the Dean (after a warning has been given). On the recommendation of the

department concerned, and with the permission of the Dean, the student may not be allowed to take part in the major group project component of the course.

Conduct/Class Demeanor
The instructor is committed to providing a respectful learning environment for all students involved in this course. This is a collective responsibility of the instructor and students, and therefore students enrolled in this course agree to abide by this criterion. This includes arriving at lectures on time and acting in a professional manner during class.

English
In accordance with Senate Academic policy on English proficiency, any work presented in this course that is deemed by the instructor to show a lack of proficiency in English and is, therefore, unacceptable for academic credit may be penalized. If resubmission of the work is permitted, it may be graded with marks deducted for poor English, penalized up to 10%, and/or late submission. Extremely poor written work may be returned to the student without grading, and the student will receive a grade of 0.

Absences
If a student is facing any barriers that may affect their academic performance on the course, it is the student's responsibility to familiarize themselves with the coursework requirements and deadlines, identify potential conflicts/barriers, and to notify the course instructor as soon as possible so that appropriate action can be taken to accommodate reasonable requests for absences. If a suitable arrangement cannot be reached between the student and instructor, the student should consult the appropriate Department Chair (or delegate) and, if necessary, the student's Dean (or delegate). As outlined in the academic considerations for absences, absences due to unforeseen situation beyond one's control that negatively affected academic performance e.g. due to illness/medical concerns, compassionate, religious (see accommodation for Religious Holidays), varsity, class/exam conflicts, accessible education, clubs and teams may be considered. Failure to notify the instructor or the Associate Chair for undergraduate studies within a reasonable time will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is the responsibility of the student and may be valuable when asking for accommodation due to illness.

Appeals
Students who believe that a decision that has been made is unfair/unreasonable may have grounds for appeal. If students are unsure whether they have sufficient grounds for appeal, students are advised to contact the Office of the Ombudsperson for further advice. This course is governed by Western University's undergraduate academic appeals policy. Students are directed to review this policy.

Cheating, Plagiarism/Academic Offences
Academic integrity is an essential component of learning activities. Members of the Western University community are expected to promote honesty, trust, fairness, respect and responsibility. Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence.

Cheating: Some examples of cheating include e.g. providing someone else answers during a test, looking at another person's test, carrying (even without use)/consulting a 'cheat sheet' (a page of information) during a closed book test/exam.
Plagiarism: Students must ensure that they understand what plagiarism is. Students must use their own ideas and work in all submissions made to this course. If students have taken another person's ideas/work, this must be acknowledging by placing words in quotation marks, or citing the original source, even when paraphrasing into their own words, otherwise this is still considered plagiarism. Students who have failed an Engineering course (i.e. <50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years, as this is considered self-plagiarism.
Cheating and plagiarism are considered serious academic offences that will not be tolerated. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. Students caught cheating will not be offered a second warning. Cheating/plagiarism offences may include expulsion from the program.
Artificial Intelligence (AI): Students should be aware of the potential benefits and limitations of using AI as a tool for learning and research. AI systems can provide helpful information or suggestions, but they are not always reliable or accurate. Students should critically evaluate the sources, methods, and outputs of AI systems. Students must be aware that generative AI is based on input from other human authors, and therefore, may contain inaccuracies (e.g. fabricate facts, inaccurately express ideas, and is known to falsify references to other work), reflect biases. To ensure equal opportunity and preservation of academic integrity, students are NOT permitted to submit any course deliverable that has been generated by AI systems e.g. ChatGPT, Bing Chat, Claude, Google Bard, or any other automated assistance. All work must be the work of the student. This includes using AI to directly generate text for the report, code for the projects, or using AI to complete any other project tasks. Using AI in this way undermines the student's ability to develop critical thinking, writing, or research skills that are essential for academic success. As the legal/copyright status of generative AI inputs and outputs remains unclear, in this course, students are accountable for the content and accuracy of all submitted work. Students are directed to review Western's AI policy. Violations of this policy will be treated as an academic offence.

Gender-Based and Sexual Violence
Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website. To connect with a case manager or set up an appointment, please contact support@uwo.ca. Students who are in emotional/mental distress should refer to Mental Health@Western for a complete list of options about how to obtain help.

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 Accessible Education, for any specific question regarding an accommodations that may be required.

Important Links

Administrative

- Western Academic Calendar
  - Academic Rights and Responsibilities
  - Academic Consideration for Medical Illness
  - Accommodation For Religious Holidays
  - Scheduling of Assignments, Tests, Examinations
- Forms for Engineering students
- Engineering - progression requirements and academic regulations
- Office of the Registrar
  - Important Dates and Deadlines

Student support services

- University Student Council (USC) - Student Support Services
- Health/Wellness:
  - Crisis Support Resources: 24/7 crisis supports in the community. For on campus student crisis support, please visit the Crisis Clinic located at Thames Hall Room 2170 (level 2) or call 519-661-3030 to book an appointment. The Crisis Clinic operates between 11:00 am - 4:30 pm.
  - Western University's health and wellness services: wellness appointments, counselling support, groups care & workshops, peer-to-peer support, sexual violence support, wellness events.
    - Mental health support: professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, mental health counselling.
  - Undergraduate engineering student wellness: Engineering wellness counsellor, workshop series, resources, events.