# BMEN 611

# Computational Modeling in Biomechanics

# Spring 2020-21

## 1. Course Administration

Instructor: Dr. Jason Amatoury
Office: RGB-413
Phone: x3497
Email: jason.amatoury@aub.edu.lb
Virtual office: https://aub.webex.com/meet/ja106
Office hours: TBA or by email appointment

## 2. Course Description [3 credits]

This course is open to engineering, science and medical students wanting a glimpse into the world of computational finite element modeling and simulation to investigate and solve biomedical problems. Students will take a journey through the processes involved in producing a computational finite element model in the biomedical field; starting at construction of model geometry from medical imaging data (CT/MRI), through to model creation, simulation and visualization using finite element analysis software (ANSYS Workbench). Students will also be exposed to a selection of experimental lab techniques in biomechanics and physiology to acquire data required for model development and validation. In pursuit of developing an appreciation for the areas covered, the course will incorporate a mix of theory, demonstrations, practice, real-world modeling applications and research seminars. In addition to skills gained in modeling and basic experimentation, the course will inherently provide students with an opportunity to enhance vital skills in scientific writing and oral communication.

Note: While fundamental concepts in mechanics and the finite element method will be discussed, the course is geared towards applied modeling methods in the biomedical field utilizing sophisticated software tools. A student who finds themselves interested in finite element modeling can subsequently pursue courses that comprehensively deal with the underlying theory.

## 3. Course Schedule and Delivery

**Time:** MW 14:00-15:15

**Delivery:** Online via WebEx (unless specified otherwise during the semester) + virtual labs

## 4. Prerequisites

- Open to graduate and senior undergraduate students. Instructor consent is required.
- Desirable: basic knowledge of anatomy/physiology; knowledge of solid mechanics or mechanics of materials (the fundamentals required for the course will be covered)

## 5. Course Material

- Lecture notes and other selected material will be made available via Moodle
- There is no required textbook for the course; useful references will be provided.

## 6. Course Learning Outcomes

By the end of this course, students should be able to:

- Describe fundamental principles and concepts in computational modeling in biomechanics and experimentation
- Develop a geometric model from medical imaging data
- Develop a biomedical computational finite element model
- Perform computational simulations and apply data visualization techniques
- Critique computational models in terms of applicability and limitations

## 7. Course Topics *(subject to change)*

Note that topics, their order and indicated time may vary. Sections from parts 3 and 4, in particular, will be interlaced with our discussions of model development (part 2).

1. **Introduction to modeling in biomedical engineering and biomechanics** (1-2 weeks)
2. **The computational finite element modeling process in biomechanics** (9 weeks)
    a) Modeling Geometry (2 weeks)
        - Overview of medical imaging.
        - Image processing, segmentation and reconstruction (using Simpleware software or similar)
    b) *Fundamentals/concepts of mechanics and the finite element method (2-3 weeks)*
    c) Finite element model creation (3 weeks)
        - Mesh creation
        - Boundary and load conditions
        - Material properties and modeling
    d) Model simulation and post-processing
    e) Optimization and sensitivity analysis
    f) Model prediction and validation
3. **Experimental lab techniques and modeling** (2-3 weeks)
    a) Tools/experiments to acquire real-world data for model development and validation
    b) Experimental physiological modeling as a tool for computational modeling

4. **Real world topics and modeling applications** (2-3 weeks)

## 8. Student Assessment *(subject to change)*

| | |
|---|---|
| **Major Project** | **50%** |
| **Assignments/Labs *(+ Short Quizzes)*** | **35%** |
| **"Turning the table" (TTT)<br>(flipped classroom assessment)** | **10%** |
| **Class participation** | **5%** |

## 9. Moodle and Course Communication

You are expected to check for updates on the course Moodle page and your email on a daily basis. Announcements, course handouts, recorded sessions, assignments and other resources will be shared via Moodle.

## 10. Technology

A notebook or desktop computer with a working internet connection is required for this course. Your device must have a webcam, a microphone, and speakers. Note that you may be asked to turn on your webcam during online classes (and for proctoring of exams, if applicable).

A virtual machine (VM) has been setup to allow you to access required course software applications from home. Instructions for VM access are available on the Moodle page.

## 11. Course Evaluation

Student feedback helps to continually shape and refine BME graduate courses. This can be in the form of direct communication with the course instructor or anonymously via AUB's Office of Institutional Research & Assessment (OIRA) on-line evaluations. You are highly encouraged to provide honest course evaluations and offer any additional comments/suggestions. Feedback provided will be important in improving the course for future students.

## 12. Academic Integrity

Any act of cheating and plagiarism will not be tolerated. Please refer to the student handbook on plagiarism for more information.

## 13. Academic Accessibility

AUB strives to make learning experiences as accessible as possible. If you anticipate or experience academic barriers due to a disability (including mental health, chronic or temporary medical conditions), please inform me immediately so that we can privately discuss options. In order to help establish reasonable accommodations and facilitate a smooth accommodations process, you are encouraged to contact the Accessible Education Office: accessibility@aub.edu.lb; +961-1-350000, x3246; West Hall, 314.

## 14. Title IX, Non-Discrimination, and Anti-Harassment at AUB

AUB is committed to facilitating a learning environment that is free of all forms of prohibited discrimination. The University's non-discrimination policy and Title IX apply to, and protect, all students, faculty, and staff. Under Title IX, discrimination based on sex and gender, including sexual harassment, is prohibited. If you think you have experienced discrimination or harassment, including sexual misconduct, we encourage you to tell someone promptly. If you speak to a faculty or staff member about an issue such as harassment, sexual violence, or discrimination, the information will be kept as private as possible, however, faculty and designated staff are required to bring it to the attention of the University's Title IX Coordinator. Faculty can refer you to fully confidential resources, and you can find information and contacts at www.aub.edu.lb/titleix.
To report an incident, contact the University's Title IX Coordinator Mitra Taukat 01-350000 ext. 2514, titleix@aub.edu.lb, or a Deputy Title IX Coordinator (www.aub.edu.lb/titleix-people).
Reports may be submitted anonymously (or not) online through EthicsPoint at www.aub.ethicspoint.com.

***By signing up for this course, you confirm that you have read and accepted the terms and provisions of AUB's Privacy Statement.***