Western University
Faculty of Engineering
Electrical and Computer Engineering Program

ECE 4455A/B – Biomedical Systems Analysis

Course Outline Fall/Winter 2025-26

COURSE DESCRIPTION: An introduction to biomedical engineering organized around applications of linear and control systems analysis to the dynamics of physiological systems and their responses to diagnostic and therapeutic interventions. Emphasis will be placed on respiratory and cardiovascular physiology and interactions of those systems with medical devices. Numerical models will be used to investigate these topics.

ACADEMIC CALENDAR:
https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_018088_1&SelectedCalendar=Live&ArchiveID=

PREREQUISITES: (CBE 2221A/B or ECE 2233A/B or (MME 3374A/B or the former ECE 3374A/B) or MSE 2233A/B) and (CBE 3310A/B or ECE 3330A/B or MME 3350A/B)

Unless you have either the requisites 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.

ANTIREQUISITE: MEDBIO 4455A/B

CEAB ACADEMIC UNITS: Engineering Science 75%, Natural Science 25%

INSTRUCTOR INFORMATION:

CONTACT HOURS: One hour lectures occur three times weekly

RECOMMENDED/REQUIRED TEXT: No required textbook.

REQUIRED SOFTWARE: A recent version of MATLAB including the Control Systems Toolbox.

RECOMMENDED RESOURCES/REFERENCES: Recommended and required references are posted on the course OWL site.

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

Knowledge Base	D	Engineering Tools	D	Impact on Society	**D**
Problem Analysis	A	Individual & Teamwork		Ethics and Equity	
Investigation	D	Communication	**A**	Economics and Project Management	
Design		Professionalism		Life-Long Learning	D

Notation: x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

Rating: I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e. g. no review).

COURSE MATERIALS: Weekly content will be available on the course OWL site.

UNITS: SI

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES:

The following table summarizes the course learning outcomes along with CEAB Graduate Attribute Indicators (GAIs). The GAIs in bold indicate ones to be measured and reported annually.

Course Topics and Specific Learning Outcomes	**CEAB Graduate Attributes Indicators**
1. Introduction to Biomedical Modeling	
At the end of this section, students will be able to:	
a. Formulate analogies among engineering models of electrical, solid mechanical, fluid mechanical, and chemical diffusion systems.	KB3
b. Represent a simple physiological system using a lumped-parameter engineering systems model.	PA1
2. Cardiac Electrophysiology and Implantable Cardioverter Defibrillators	
At the end of this section, students will be able to:	
a. Understand the engineering considerations used to specify the stimulus waveform produced by an implantable defibrillator.	KB3, KB4
b. Demonstrate the use of a linear time-invariant biomedical systems model to optimize key design parameters for a medical device.	PA2, PA3, I3, ET2, CS3
c. Identify and evaluate ethical issues arising from biomedical device innovation.	**IESE1**
d. Develop and apply their own strategies for critical evaluation of scientific and engineering publications.	LL2 (taught but not assessed)

3. Cardiovascular Mechanics and Left Ventricular Assist Devices At the end of this section, students will be able to:	
a. Understand the engineering science principles governing hemodynamic interactions between the cardiovascular system and a left ventricular assist device.	KB3, KB4
b. Apply Euler's method for numerical analysis of a time-varying system.	PA2, PA3
c. Employ a biomedical systems model to analyze physiological interactions between a patient and a medical device.	I3, ET2, CS3
4. Respiratory Mechanics and Mechanical Ventilation At the end of this section, students will be able to:	
a. Understand the fluid mechanical properties of the respiratory system that determine pulmonary airflow.	KB3, KB4
b. Investigate whether questionable methodological choices affect the conclusions of a biomedical engineering research study.	PA2, PA3, CS3
c. Interpret computational results obtained from a time-domain hybrid system model with a switching controller.	I3, ET2
d. Identify and evaluate ethical and safety issues arising from scenarios that require allocation of scarce medical resources.	**IESE1**
5. Respiratory Regulation and Prevention of Unstable Periodic Breathing At the end of this section, students will be able to:	
a. Understand the application of control systems principles to analysis of respiratory regulation.	KB3, KB4
b. Use MATLAB's Control Systems Toolbox to determine the relative stability of a closed-loop system with feedback delays.	I3, ET2
c. Employ a biomedical systems model to evaluate a patient's response to a therapeutic intervention.	PA2, PA3, I3, **CS3**

EVALUATION:

Name	**% Weight**	**Assigned**	**Due Date**	**CEAB GAs ASSESSED**
Homework Assignments (total 3)	35%	Sept. 29 Oct. 23 Nov. 17	Oct. 6 Oct. 31 Nov. 24	PA2, PA3, I3, ET2, ET3, CS3
Quizzes (total 4)	20%	Sept. 23 Oct. 17 Nov. 11 Dec. 2	Sept. 26 Oct. 22 Nov. 14 Dec. 5	KB3, KB4
Minute Papers (total 2)	5%	Oct. 6 Nov. 20	Oct. 6 Nov. 20	**IESE1**

Final Project	40%	Dec. 1	Dec. 15	KB3, KB4, PA2, PA3, I3, ET2, **CS3**

Note that the dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, and clarity.

COURSE POLICIES:

Homework Assignments: Three case-based homework assignments will require students to critique assigned readings from biomedical engineering or physiology journals and investigate the behaviour of relevant systems models implemented in MATLAB. The readings and MATLAB models will be distributed via OWL. Homework assignments must be submitted electronically to the course OWL site.

For each assignment, one to two lecture sessions will be devoted to use and discussion of the MATLAB systems models. Students are expected to bring a laptop, tablet, or other device with MATLAB installed and available for their use during these sessions. A schedule of the MATLAB class sessions will be posted on OWL at the beginning of the term.

Quizzes: Four quizzes consisting of multiple-choice and fill-in-the-blank questions will assess students' understanding of background knowledge concepts relevant to the case studies. These quizzes will be administered asynchronously via OWL. Each quiz will be available to students for at least 72 hours. Each quiz may be submitted twice; the higher mark will be recorded. A schedule of quiz deadlines will be posted on OWL at the beginning of the term.

Minute Papers: Two lecture sessions will be devoted to class discussions of ethical issues related to selected case studies. At the end of those discussions, students will complete "minute papers", which are brief written responses to the class discussions. **Students must be present for these discussions to have an opportunity to submit minute papers.** A schedule of ethics discussions will be posted on OWL at the beginning of the term.

Final Project: A final project will be due on **December 15**. The project will focus on the assigned journal article and MATLAB investigation for the fourth case study. The MATLAB code and instructions for the project will be available to students for at least two weeks prior to the due date.

Late Submission Policies: Advise the instructor if you are having problems completing an assignment on time *prior* to the due date of the assignment and be prepared to submit an Academic Consideration Request and provide documentation, if requested by the instructor, at:

https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html

If you are granted an extension, establish a due date with the instructor. The approval of the Chair of your Department is not required if assignments are completed prior to the last day of classes. Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

All assessments will be due at 11:59 pm on their due date unless otherwise specified.

Should illness or extenuating circumstances arise, **homework assignments will be accepted without penalty until the end of a grace period lasting 72 hours after the posted due date**. Homework assignments submitted more than 72 hours late will receive no credit unless alternate arrangements are agreed to *in advance* by the instructor.

Please note that because the submission deadline for homework assignments includes flexibility in the form of a 72-hour grace period, the instructor reserves the right to deny academic consideration for assignments that are submitted following the end of the period of flexibility.

The OWL quiz tool will not permit late submission of quizzes.

Minute papers will be completed during class sessions and must be submitted at the end of that class period. Late submissions of minute papers will not be accepted.

If a student submits an absence self-report or receives an accommodation **for a missed quiz or minute paper, the weight of that assessment will be transferred to the final project.**

For this course the following assessment has been designated as requiring supporting documentation: Final Project, due on December 15.

Please note that the Final Project is considered to be central to the learning objectives for this course. Accordingly, students seeking academic consideration for this assessment will be required to provide formal supporting documentation. Students who are granted academic consideration for this assessment will be provided with the opportunity to submit their project at a later deadline.

ATTENDANCE: Attendance is strongly recommended for all lectures.

FACULTY OF ENGINEERING POLICIES:
Students must familiarize themselves with the undergraduate course policies of the Faculty of Engineering, which are provided on the following pages:

Western Engineering

Faculty of Engineering Policies and Procedures-Undergraduate

Absence/Late Accommodation Policy

Students must familiarize themselves with the University Policy on Academic Consideration – Undergraduate Students in First Entry Programs posted on the Academic Calendar:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration_Sep24.pdf
This policy does not apply to requests for Academic Consideration submitted for attempted or completed work, whether online or in person. The policy also does not apply to students experiencing longer-term impacts on their academic responsibilities. These students should consult Accessible Education.

Students missing a test/assignment/lab or examination will report the absence by submitting Academic Consideration Request form through STUDENT ABSENCE PORTAL.

- All requests for Academic Consideration must be made within 48 hours after the assessment date or submission deadline. Academic consideration may include extension of deadlines, waiver of attendance requirements for classes/labs/tutorials, or re-weighting of course requirements.
- An instructor may deny academic consideration for any assessment that is not required in the calculation of the final grade (e.g., "8 of 10 quizzes"). Assessment flexibility must be indicated on the course outline.
- An instructor may deny academic consideration relating to the timeframe submission of work where there is already flexibility in the submission timeframe (e.g., 72-hour submission window). This assessment flexibility must be indicated on the course outline.
- All Academic Consideration requests must include supporting documentation; however, recognizing that formal documentation may not be available in some extenuating circumstances, the policy allows students to make one Academic Consideration request without supporting documentation per course. Some assessments are excluded from this policy. Please refer to the course outline to determine if documentation is required.
- Requests without supporting documentation are limited to one per term per course.
- Please note that examinations scheduled during official examination periods always require official supporting documentation.
- If a student mistakenly submits their one allowed Academic Consideration request without supporting documentation for the assessments listed above that do not require academic consideration, the request cannot be recalled and reapplied. This privilege is forfeited.

An undocumented absence is only valid for a 24-hour period, from midnight on the day specified to midnight of the following day. An appropriate use of an undocumented absence would be for an in-class assessment that takes place that day. Where the time given to complete the assessment is longer than 24 hours, an undocumented absence will not cover a student for the full time given to complete the assessment, and flexibility considerations in submitting the assessment will override the undocumented absence.

NOTE: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).
It is the student's responsibility to check the date, time and location of the Special Examination.

Religious Accommodation

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.

Academic Integrity

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.

Please visit Academic Integrity Western Engineering for more information.

Academic Offences

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from theuniversity.
Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know

Students must write their reports, 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. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on 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). Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Faculty of Engineering AI Policy

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. Please refer to the course outline for the GenAI policy related to each course.

GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

Accessibility

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the Accessibility Western University for information on accessibility-related resources available at Western. Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit Academic Support & Engagement -Academic Accommodation.

Inclusivity, Diversity, and Respect

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the Office of Equity, Diversity and Inclusion.

Health and Well-Being

Health & Wellness Services – Students - Offers appointment-based medical clinic for all registered part-time and full-time students.

Mental Health Support - Provides 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, change-oriented psychotherapy.

Crisis Support - For immediate assistant, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click here.

Gender-Based Violence and Survivor Support - "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: https://www.uwo.ca/health/student_support/survivor_support/gethelp.html to connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts

Engineering Undergraduate Services	SEB 2097	engugrad@uwo.ca
Department of Electrical and Computer Engineering	TEB 279	eceugrad@uwo.ca
Office of the Registrar/Student Central	WSSB 1120	519-661-2100

Important Links

- WESTERN ACADEMICCALENDAR
- ACADEMIC RIGHTS AND RESPONSIBILITIES
- ENGINEERING PROGRESSION REQUIREMENTS AND ACADEMIC REGULATIONS
- UNIVERSITY STUDENTS' COUNCIL (USC) - SERVICES
- IMPORTANT DATES AND DEADLINES
- ACADEMIC CONSIDERATION FOR MEDICAL ILLNESS - UNDERGRADUATE STUDENTS
- ACCOMMODATIONS FOR RELIGIOUS HOLIDAYS
- SCHEDULING OF ASSIGNMENTS, TESTS, AND EXAMINATIONS
- STUDENT FORMS
- OFFICE OF THE REGISTRAR
- RETENTION OF ELECTRONIC VERSION OF COURSE OUTLINES (SYLLABI)
- ACADEMIC APPEALS
- STUDENT ABSENCEPORTAL