

**Western University**  
**Faculty of Engineering**  
**Department of Electrical and Computer Engineering**

**ECE 4455A/B: Biomedical Systems Analysis**

**Course Outline 2020-21**

**Description/Academic Calendar Copy:** 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.

**Instructor:** Dr. James Lacefield, P.Eng.  
ACEB 2405D, 519-661-2111 ext. 84303, [jlacefie@uwo.ca](mailto:jlacefie@uwo.ca)  
Consultation hours: To be announced

**Contact Hours:** 3 lecture hours, 0.5 course.

**Antirequisite:** MEDBIO 4455A/B.

**Prerequisites:** (ECE 2208A/B or ECE 2233A/B or ECE 3374A/B or MSE 2233A/B) and (CBE 3310A/B or ECE 3330A/B or MME 3350A/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 in the event that you are dropped from a course for failing to have the necessary prerequisites.

**CEAB Academic Units:** Engineering Science 75%, Natural Science 25%.

**Required Textbook:** No required textbook. Required and recommended references will be posted to the course OWL site.

**General Learning Objectives (CEAB Graduate Attributes)**

Knowledge Base	<b>D</b>	Use of Engineering Tools	<b>D</b>	Impact on Society and the Environment	<b>D</b>
Problem Analysis	<b>A</b>	Individual and Team Work		Ethics and Equity	
Investigation	<b>D</b>	Communication Skills	<b>A</b>	Economics and Project Management	
Design		Professionalism		Life-Long Learning	<b>D</b>

**I** (introduce): The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. **D** (develop): 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 (apply):** It is expected that the student can apply the knowledge without prompting (e.g., no review).]

## **Topics and Specific Learning Objectives**

### **1. Cardiac Electrophysiology and Implantable Cardioverter Defibrillators**

At the end of this section, students will be able to:

- a.** Understand the electrophysiological mechanism by which an external electrical stimulus terminates an episode of ventricular fibrillation.
- b.** Demonstrate the use of a biomedical systems model to inform the design of a medical device.
- c.** Identify and evaluate ethical issues arising from the use of biomedical systems models to make decisions about public health or safety risks.

### **2. Cardiovascular Mechanics and Left Ventricular Assist Devices**

At the end of this section, students will be able to:

- a.** Understand hemodynamic interactions between the cardiovascular system and a left ventricular assist device.
- b.** Employ a biomedical systems model to tune a control algorithm for a medical device.
- c.** Apply Euler's method for numerical analysis of a nonlinear time-varying system.

### **3. Respiratory Mechanics and Noninvasive 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.
- b.** Investigate whether questionable methodological choices affect the conclusions of a biomedical engineering research study.
- c.** Interpret computational results obtained from a time-domain hybrid system model.

### **4. Extending Mechanical Ventilation Resources During a COVID-19 Emergency**

At the end of this section, students will be able to:

- a.** Analyze the effects of patient characteristics on ventilatory support when two patients share a mechanical ventilator.
- b.** Modify an existing biomedical systems model to analyze a new clinical challenge.
- c.** Identify and evaluate ethical and safety issues arising from scenarios that require allocation of scarce medical resources.

## Evaluation

Course Component	Weight
Homework Assignments	45%
Quizzes	20%
Minute Papers	5%
Take-Home Final Examination	30%

**Homework Assignments:** The course will include three case-based homework assignments that 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.

The MATLAB investigation components of the assignments will each include two synchronous (live) lecture sessions devoted to use and discussion of the MATLAB systems models. Students may attend these sessions in person or remotely. Students should have a laptop, tablet, or other device with MATLAB installed and available for their use during these sessions. A schedule of the MATLAB investigation sessions will be posted on OWL at the beginning of the term.

**Quizzes:** The course will include four quizzes consisting of multiple-choice and fill-in-the-blank questions testing 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, either in person or remotely, to have an opportunity to submit minute papers.** A schedule of ethics discussions will be posted on OWL at the beginning of the term.

**Take-Home Final Examination:** A take-home final exam will be scheduled during the regular Fall term examination period in December. The exam will focus on an assigned journal article and MATLAB investigation for the final case study. The take-home exam will be available to students for at least 72 hours.

**Online Activities:** Students are expected to participate in nine synchronous (live) class sessions that will occur approximately weekly during the scheduled lecture hours. Students may attend these sessions in person or remotely. A schedule of synchronous sessions will be posted on OWL at the beginning of the term. Students will be offered an opportunity to choose a day of the week to attend.

The instructor's office hours will also be held as synchronous remote meetings.

During two weeks of the term, the synchronous lecture sessions will include the minute paper assessments described above. Students attending those sessions remotely will be expected to submit their minute papers electronically via the OWL Assignments tool immediately after the session ends.

Remote synchronous sessions will be hosted on Zoom. Students choosing to participate remotely should have access to a stable internet connection suitable for video conferencing and a computer equipped with a camera and a microphone. Students must log into synchronous Zoom sessions using their uwo.ca login. Students should have their camera turned on throughout a synchronous session and their microphone muted unless they are invited to speak.

**Recording Online Activities:** All synchronous lecture sessions for this course will be recorded by the instructor. The data captured during these recordings may include your image, voice recordings, chat logs, and personal identifiers (*i.e.*, name displayed on the screen). The instructor's recordings will be used for educational purposes related to this course and may be disclosed to other individuals participating in the course for their private or group study purposes. All recorded lecture sessions will remain within the course OWL site. Please contact the instructor if you have any concerns related to session recordings. Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

**Late Submission Policies:** All assessments will be due at 11:55 pm Eastern (London, Ontario) time on their due date unless otherwise specified.

Homework assignments will be accepted without penalty until the end of a grace period lasting 24 hours after the posted due date. Homework assignments submitted more than 24 hours late will receive no credit unless alternate arrangements are agreed to *in advance* by the instructor.

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

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

**Use of English:** In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Attendance:** Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

**Absence Due to Illness or Other Circumstances:** Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning academic accommodations for absences, see the relevant section of the Academic Calendar:

[www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_12](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_12)

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Calendar:

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_16](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16)

**Cheating and Plagiarism:** Students must write their 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 Calendar:

[www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_20](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20)

**Use of Electronic Devices:** Students may use laptop or tablet computers during in-person lectures *only* to access the course OWL site or other information relevant to the course material or to run MATLAB during in-class computational investigations. No other electronic devices (e.g., cell phones, MP3 players) may be used during lectures.

**Policy on Repeating All Components of a Course:** Students who are required to repeat an Engineering course 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 by the student for grading in subsequent years.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western e-mail and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course.

**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 Student Accessibility Services (SAS) at 519-661-2147 or [ssd@uwo.ca](mailto:ssd@uwo.ca) for any specific question regarding an accommodation.

**Support Services:** Office of the Registrar, <http://www.registrar.uwo.ca/>  
Student Development Centre, <http://www.sdc.uwo.ca/>  
Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>  
USC Student Support Services, <http://westernusc.ca/your-services/>

Students who are in emotional/mental distress should refer to Mental Wellbeing @ Western, [https://www.uwo.ca/health/mental\\_wellbeing/](https://www.uwo.ca/health/mental_wellbeing/), for a complete list of options about how to obtain help.