Western University  
Faculty of Engineering  
Department of Electrical and Computer Engineering

ECE 4455A/B: Biomedical Systems Analysis  
Course Outline 2019-20

**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, cardiovascular, and neuromuscular 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  
Consultation hours: To be announced

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

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

**Prerequisites:** (ECE 2233A/B or MSE 2233A/B) and ECE 3330A/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. Recommended references will be placed on reserve at Taylor Library and posted to the course OWL site.

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

<table>
<thead>
<tr>
<th>Knowledge Base</th>
<th>2/2</th>
<th>Use of Engineering Tools</th>
<th>3/2</th>
<th>Impact on Society and the Environment</th>
<th>2/2</th>
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</thead>
<tbody>
<tr>
<td>Problem Analysis</td>
<td>3/2</td>
<td>Individual and Team Work</td>
<td></td>
<td>Ethics and Equity</td>
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<tr>
<td>Design</td>
<td></td>
<td>Professionalism</td>
<td></td>
<td>Life-Long Learning</td>
<td>3/3</td>
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Notation: \( x/y \), where \( x \) is the cognitive level (1: Remember, 2: Understand, 3: Apply) at which the attribute is assessed and \( y \) is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.
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. **Respiratory Regulation and Diagnosis of Unstable Periodic Breathing**
   At the end of this section, students will be able to:
   
   a. Understand the biophysical processes that may lead to instability of respiratory regulation.
   
   b. Determine whether a newly proposed data analysis method provides more or different information than established engineering problem analysis techniques.
   
   c. Use MATLAB’s Control Systems Toolbox to determine the relative stability of a closed-loop system with feedback delays.

5. **Neuromuscular Control and Upper-Limb Neural Prosthetics**
   At the end of this section, students will be able to:
   
   a. Understand how the hand’s trajectory during a reaching motion is encoded by the neural activity of the motor cortex.
   
   b. Employ a stochastic computational model to analyze the behaviour of a complex physiological system.
   
   c. Identify and evaluate ethical issues arising from the development of expensive or invasive medical devices.
Evaluation

<table>
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<tr>
<th>Course Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Homework Assignments</td>
<td>45%</td>
</tr>
<tr>
<td>Minute Papers</td>
<td>5%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>50%</td>
</tr>
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To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as an average mark of 50% on the homework assignments. A final examination or average homework mark < 50% will result in a final course grade of 48% or less.

**Homework Assignments:** The course will include four 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.

Each homework assignment consists of two parts: short-answer questions about background knowledge relevant to the case study and a computational investigation of issues raised by the case using the MATLAB systems models. The MATLAB investigation components of the assignments will each include one or two lecture sessions devoted to use and discussion of the MATLAB systems models. Students should bring a laptop, tablet, or other device with MATLAB installed to these class sessions. **Students must be present for and participate in these in-class discussions to receive credit for the MATLAB investigation component of a homework assignment.** A schedule of the in-class MATLAB investigations 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 in-class discussions to have an opportunity to submit minute papers.** A schedule of in-class ethics discussions will be posted on OWL at the beginning of the term.

**Final Examination:** A three-hour limited-open-book final exam will be scheduled during the regular Winter term examination period in April. The exam will focus on an assigned biomedical engineering or physiology journal article to be distributed via OWL no later than March 20. Calculator usage, including the use of programmable calculators, is permitted during the exam. A copy of the assigned article will be provided with the exam. Students may also bring one single-sided 8½ inch by 11 inch sheet of handwritten notes to refer to during the exam. No other written or electronic aids are permitted.

**Late Submission Policies:**
The first part of each homework assignment (short-answer questions) will be due 15 minutes before the start of the corresponding MATLAB investigation classroom session. Late submissions of short-answer responses will not be accepted because the purpose of those questions is to prepare students to participate in the classroom portion of the MATLAB investigation.

The second part of each homework assignment (results of the MATLAB investigation) will be accepted without penalty until the end of a grace period lasting 24 hours after the posted due date.
MATLAB investigations submitted more than 24 hours late will receive no credit unless alternate arrangements are agreed to in advance by the instructor.

Minute papers will be handwritten in class 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

**Use of Electronic Devices:** Students may use laptop or tablet computers during 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. Calculator use is permitted during examinations; students using programmable calculators must clear the device’s memory at the beginning of exams. No other electronic devices (e.g., cell phones, MP3 players) may be used during lectures or examinations.

**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 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/, for a complete list of options about how to obtain help.
INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

NEW: Requests for Academic Consideration using the Self-Reported Absence Form

If you experience an unexpected illness or injury or an extenuating circumstance (48 hours or less) that is sufficiently severe to temporarily render you unable to meet academic requirements (e.g., attending lectures or labs, writing tests or midterm exams, completing and submitting assignments, participating in presentations) you should self-declare using the online Self-Reported Absence portal. This option should be used in situations where you expect to resume academic responsibilities within 48 hours or less.

Each student will be allowed a maximum of two self-reported absences between September and April and one self-reported absence between May and August. Self-reporting may not be used for final exams or assessments (e.g. midterm exams, tests, reports, presentations, or essays) worth more than 30% of any given course.

For full instructions about the Self-Reporting System refer to the Academic Calendar:
http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=32&SelectedCalendar=Live&ArchiveID=#SubHeading_322

A. GENERAL REGULATIONS & PROCEDURES (other than self-reported absences)

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.

3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.

5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. TERM/MIDTERM TESTS (other than self-reported absences)

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.

2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.

3. Be prepared to provide supporting documentation to the Department Chair and/or the Undergraduate Services Office (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. N.B. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.
C. **FINAL EXAMINATIONS (cannot be self-reported)**

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

**PLEASE NOTE:** It is the student's responsibility to check the date, time and location of the Special Examination.

D. **LATE ASSIGNMENTS**

1. Advise the instructor if you are having problems completing the assignment on time (prior to the due date of the assignment).
2. Be prepared to provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
   ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

E. **SHORT ABSENCES**

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. **EXTENDED ABSENCES**

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

G. **DOCUMENTATION**

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, you must provide the doctor with a Student Medical Certificate to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information:** severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.

**In Case of Serious Illness of a Family Member:** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**In Case of a Death:** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**For Other Extenuating Circumstances:** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

**Note:** Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).
H. **ACADEMIC CONCERNS**

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

2. You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

**Calendar References:** Check these regulations in your 2019 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

**Self-Reporting Absences:**
http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=322&SelectedCalendar=Live&ArchiveID=#SubHeading_322

**Absences Due to Illness:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_12

**Academic Accommodations for Students with Disabilities:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10

**Academic Accommodations for Religious or Holy Days:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16

**Course Withdrawals:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75

**Examinations:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=#SubHeading_78

**Scheduling of Term Assignments:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78

**Scholastic Offences:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20

**Student Medical Certificate:**
https://www.eng.uwo.ca/files/undergraduate/forms/smc.pdf

**Engineering Academic Regulations:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

**Note:** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

**Add Deadlines:**
- First term half course (i.e. “A” or “F”)  
  September 13, 2019
- Full courses and full-year half course (i.e. “E”, “Y” or no suffix)  
  September 13, 2019
- Second term half course (i.e. “B” or “G”)  
  January 14, 2020

**Drop Deadlines:**
- First term half course (i.e. “A” or “F”)  
  November 12, 2019
- Full courses and full-year half courses (i.e. “E”, “Y” or no suffix)  
  November 30, 2019
- Second term half or second term full course (i.e. “B” or “G”)  
  March 7, 2020

**Contact Information:**
- Undergraduate Services Office: SEB 2097 Phone: 519-661-2130 E-mail: engugrad@uwo.ca
- Chemical & Green Process Engineering: TEB 477 Phone: 519-661-2131 E-mail: cbeugrad@uwo.ca
- Civil Engineering: SEB 3005 Phone: 519-661-2139 E-mail: civil@uwo.ca
- Computer, Electrical, Mechatronic Systems & Software Engineering TEB 279 Phone: 519-661-3758 E-mail: eceugrad@uwo.ca
- Integrated Engineering ACEB 2410 Phone: 519-661-6725 E-mail: engceli@uwo.ca
- Mechanical Engineering: SEB 3002 Phone: 519-661-4122 E-mail: mmengineering@uwo.ca

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