

## MME 4450A – Control Systems: Theory and Practice

### COURSE OUTLINE 2019-2020

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**CALENDAR DESCRIPTION:** Modern Control techniques for solving vibration and control problems associated with practical mechanical systems. The emphasis of the course is on the concepts, applications and numerical simulations to aid Power-train dynamics, Hardware-in-the-loop (HIL) simulations and communications via Control Area Network (CAN).

**COURSE INFORMATION:**

|             |                                 |
|-------------|---------------------------------|
| Instructor: | Professor Samuel F. Asokanathan |
|             | Email: sasokant@uwo.ca          |
| Lectures:   | Tue 11:30 – 1:30 pm ACEB1420    |
|             | Wed 3:30 - 4:30 pm ACEB1420     |
| Tutorials:  | Wed 4:30 - 6:30 pm ACEB1420     |

**CONSULTATION HOURS:** By email appointment.

**PREREQUISITES:** MME 3350b or ECE 3330a

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. 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.

**ACCREDITATION UNITS:** Engineering Science = 85%, Engineering Design = 15%

**TOPICS:**

1. System description in State-space, simulation of time response using MATLAB and SIMULINK: Rigid-body, Spring-Mass, Electromechanical, Power-train components, Hydraulic, and Pneumatic Systems.
2. Controller and Observer design via Full state feedback; Controllability and Observability; Pole placement design; Ackermann's formula.
3. Introduction to optimal control; Linear Quadratic Regulator and Kalman Filter.
4. Pole placement and optimal control and observer design via MATLAB.
5. Computer implementation of digital compensators; Tustin's method, direct and cascade realizations .
6. Linearization and controller design via Gain scheduling.
7. Practical case studies and implementations include Semi-active / fully-active automotive suspension systems, Inertial Stabilization and control and other Multi-input multi-output mechanical/electro-mechanical/electro-hydraulic systems, Hardware-in-the-loop (HIL) simulations, Communications via Control Area Network (CAN).

**LEARNING OUTCOMES:** On completion of this course students will be able to understand and work with practical control problems that arise in automotive, aerospace and power-generation industries. The students will also be able to design model-based controllers using computer-aided tools available within MATLAB/SIMULINK environment as well understand the implementation issues for performing HIL simulations and using CAN bus for communications with the controllers.

**CONTACT HOURS:** 3 lecture hours, 2 tutorial hours, half course

**RECOMMENDED TEXT:** G. F. Franklin, J.D. Powell and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 7th Edition, 2014, Prentice Hall, New Jersey ISBN 978-0133496598

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- REFERENCES:** B. Friedland *Control System Design: An Introduction to State Space Methods*, 2005, Dover Publications, ISBN-13: 978-0486442785
- K J Astrom and B Wittenmark *Computer-Controlled Systems: Theory and Design*, 3<sup>rd</sup> edition, 2011, Dover Publications, ISBN-13: 978-0486486130
- UNITS:** S.I.
- EXAMINATIONS AND QUIZZES:** Mid-term and Final Examination
- EVALUATION:** All examinations will be **LIMITED OPEN BOOK. ONE PAGE (double sided) hand-written, self-prepared sheet allowed.**
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| Assignment 1: Due week of Sept 30  | 3.75% |
| Assignment 2: Due week of Oct 14   | 3.75% |
| Assignment 3: Due week of Nov 4  | 3.75% |
| Assignment 4: Due week of Nov 25   | 3.75% |
| Mid-term Exam (2 hours): Week of Oct 21  | 20%   |
| Group Assignment / Presentation: Due Week of Nov 25  | 15%   |
| The group assignment: Practical case studies of Controller Design, simulation and Implementation for Mechanical Systems (Three students per group) |       |
| Final Examination (3 hours)  | 50%   |
| During U/G examination period  |       |
- If a minimum of 50% is not obtained on the final examination, the student cannot receive a mark greater than 48%.
- Assignments will provide minimal (but sufficient) experience to master each aspect of the course. Marks will be deducted for late submissions of assignments.
- 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 the improper use of English. Additionally, poorly written work with the exception of final examinations 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 or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.
- CHEATING:** University policy states that cheating, including plagiarism, is a scholastic offense. 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. (see Scholastic Offence Policy in the Western Academic Calendar).
- SSD:** *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 Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.*
- NOTE:** The above topics and outline are subject to adjustments and changes as needed. Students who have failed an Engineering course (ie.<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.

**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 link [here](#).

**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](#)  
[Absences Due to Illness](#)  
[Academic Accommodations for Students with Disabilities](#)  
[Academic Accommodations for Religious or Holy Days](#)  
[Course Withdrawals](#)  
[Examinations](#)  
[Scheduling of Term Assignments](#)  
[Scholastic Offences](#)  
[Student Medical Certificate](#)  
[Engineering Academic Regulations](#)

**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.

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| <b><u>Add Deadlines:</u></b> | 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   |

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| <b><u>Drop Deadlines:</u></b> | 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:**

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| Undergraduate Services Office                                    | SEB 2097 Phone: 519-661-2130  | E-mail: <a href="mailto:engugrad@uwo.ca">engugrad@uwo.ca</a>                 |
| Chemical & Green Process Engineering                             | TEB 477 Phone: 519-661-2131   | E-mail: <a href="mailto:cbeugrad@uwo.ca">cbeugrad@uwo.ca</a>                 |
| Civil Engineering:   | SEB 3005 Phone: 519-661-2139  | E-mail: <a href="mailto:civil@uwo.ca">civil@uwo.ca</a>                       |
| Computer, Electrical, Mechatronic Systems & Software Engineering | TEB 279 Phone: 519-661-3758   | E-mail: <a href="mailto:eceugrad@uwo.ca">eceugrad@uwo.ca</a>                 |
| Integrated Engineering   | ACEB 2410 Phone: 519-661-6725 | E-mail: <a href="mailto:engceli@uwo.ca">engceli@uwo.ca</a>                   |
| Mechanical Engineering   | SEB 3002 Phone: 519-661-4122  | E-mail: <a href="mailto:mmeundergraduate@uwo.ca">mmeundergraduate@uwo.ca</a> |

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