**Western University**
***Department of Mechanical & Materials Engineering***

# MME 4450A – Control Systems: Theory and Practice

## COURSE OUTLINE 2022-2023

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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:***

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| Instructor: | Professor Samuel F. Asokanthan |
| | Email: sasokant@uwo.ca |
| | Office: SEB 2059A |
| Lectures: | Mon 10:30 – 11:30 am SH 3307 |
| | Wed 1:30 - 2:30 pm SEB 2094 |
| | Thurs 8:30 - 9:30 am SEB 1059 |
| Tutorials: | Fri 12:30 am - 2:30 pm SEB 1056 |

***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*, 8th Edition, 2018, Prentice Hall, New Jersey ISBN 978-0133496598

***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*, 3rd 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: Tentative due date 3 Oct | 3.75% |
| Assignment 2: Tentative due date 24 Oct | 3.75% |
| Assignment 3: Tentative due date 14 Nov | 3.75% |
| Assignment 4: Tentative due date 5 Dec | 3.75% |
| Mid-term Exam (2 hours): Week of Oct 24 | 20% |
| Group Assignment / Presentation: Due Week of Nov 29 | 15% |

The group assignment: Practical case studies of Controller Design, simulation and Implementation for Mechanical Systems (Two students per group)

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| Final Examination (3 hours) During U/G examination period | 50% |

If a minimum of 50% is not obtained on the final examination, the student cannot receive a mark greater than 48% (However, special consideration may be given to those who participate well in the in-class and project activities)

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).

***ACCESSIBILITY:*** Students with disabilities work with Accessible Education (formerly SSD) which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The accommodation policy can be found here: Academic Accommodation for Students with Disabilities.

***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.