

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

**ECE 4469b – Applied Control Systems**

**Course Outline 2023-24**

**Description:** The course covers analysis and development of computer-based control strategies that meet certain performance criteria. The course provides necessary insight, knowledge, and understanding needed to effectively implement a computer-based controller for either a continuous- or discrete-time industrial process. Various aspects of the problem, including parametric model identification, digital control design, z-transformation, digitizing analog controllers, e.g. PID controller, and programmable logic controllers (PLC) will be discussed. Hands-on experience using experimental modules as well as computer-based simulations using Matlab® and Simulink® are provided for “Interactive Learning” purposes.

**Academic Calendar Copy:** The course covers analytical methods for analyzing and developing control strategies for industrial processes. These include identification and empirical modeling, tuning of PID controller, digital control systems, z-transformation. PLCs are discussed. Computer based simulation modules using Matlab® and Simulink® are used. Examples from different engineering disciplines are studied.

**Contact Hours:** lectures 3 hours per week, five 3 hour labs per term

**Antirequisite:** N/A

**Prerequisites:** ECE 3331A/B, ECE 3330A/B as well as successful completion of the third year of the Engineering program.

**Co-requisite:** N/A

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.

**CEAB Academic Units:** Engineering Science 64%, Engineering Design 36%.

**Required Textbook:** N. S. Nise, Control Systems Engineering, 8th Edition, Wiley, 2019

**Recommended References:** K.J. Astrom, and B. Wittenmark, Computer-Controlled Systems, 3rd Edition, Prentice Hall, 1997.

K. Ogata, Discrete-Time Control Systems, Prentice Hall.

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

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

Notation: I Introduced, D- Developed, A Advanced

Topics and Specific Learning Objectives

1. Introduction to Control Systems

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

- a. Design control systems as in ECE 3330
- b. Create a state space model KB4

2. Programmable Logic Controllers

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

- a. Analyze a PLC program
- b. Design and implement a Ladder logic or FBD PLC program ET2, ITW2, ITW3

3. Discrete-Time Systems and the z-Transform

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

- a. Convert a continuous time system to equivalent discrete representation
- b. Convert a continuous time controller to approximately equivalent discrete implementation ET 1

4. System Analysis

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

- a. Determine stability of a system
- b. Determine controllability and observability of a system
- c. Simplify and reduce Block diagrams with state space models PA2

5. Controller Design

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

- a. Design a state feedback controller
- b. Design an state observer
- c. Design an linear quadratic regulator or optimal observer
- d. Design polynomial/classical controllers
- e. Talk intelligently about model predictive controllers at a job interview D2,D3, CS1, CS3

6. Controller Safety

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

- a. Discuss historical potential impacts on society of failed control systems
- b. Be aware of appropriate standards for control systems
- c. Design an linear quadratic regulator or optimal observer
- d. Design polynomial/classical controllers
- e. Talk intelligently about model predictive controllers at a job interview IESE1, EE1

**Evaluation**

| <b>Course Component</b> | <b>Weight</b> |
|-------------------------|---------------|
| Homework Assignments    | ungraded      |
| Laboratory              | 20%           |
| Midterm Test            | 30%           |
| Final Examination       | 50%           |

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as all laboratories must be completed. A final examination or laboratory mark < 50% will result in a final course grade of 48% or less.

**Homework Assignments:** Assignments will be given on weekly basis.

**Laboratory:** Attendance is mandatory. PLC component will be taught in laboratory and will involve hands on learning with PLC's. As such, a minimum of attendance during this portion of the course is required. **Unexcused absence will result in a maximum grade for the course of 49%.**

**Midterm Test:** 2 hour evening or weekend midterm. A one sided crib sheet (8.5"x11") with no restrictions and a 2 sided crib sheet restricted to PLC programming syntax will be permitted.

**Final Examination:** The final examination will be take place during the regular examination period. A two sided crib sheet (8.5"x11") will be permitted.

**Late Submission Policy: 10% deduction each day a lab is due. Work will not be accepted after solutions have been posted.**

## **Lab Submission via owl assignment page.**

**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 medical accommodations, see the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_medical.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf)

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

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_religious.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

**Missed Midterm Examinations:** If a student misses the midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests. The department will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

**Missed Labs.** Missed labs must be made up or otherwise dealt with by the instructor. It is the students responsibility to contact the instructor to ensure this is done. Not having this dealt with will result in a maximum grade of 48%.

**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 Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

**Use of Electronic Devices:** The use of calculators is permitted on test and exam. Any electronic device capable of wireless communication and/or displaying various file formats (e.g. pdf, mp3) is not permitted in the possession of students during the exams and midterm tests, even if turned off. Subsequently, devices such as, PDAs, smart-phones and cellular-phones may not be used as a substitute for a calculator or as a clock.

Students are permitted to use electronic devices (such as Laptops, PDAs, and smart-phones) in class for the purpose of taking notes and research related to the lecture. Students are expected to use these devices in such a manner as not to distract their peers.

Recording of Lectures:

Students are permitted to make recordings of lectures for the exclusive purpose of their own study. Students may not distribute these recordings and are expected to destroy them at the end of the semester. Students should record only the instructor and projected material unless specific permission of the speaker is given.

**Use of Personal Response Devices (“Clickers”):** Not used in this course.

**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 Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 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/services/>

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