Western Engineering

Western University
Faculty of Engineering
Artificial Intelligence Systems Engineering Program

AISE 4450A – Data Driven Control of Cyber-Physical Systems

Course Outline Fall/Winter 2026

COURSE DESCRIPTION: In this course, modern control methods for cyber-physical systems with an emphasis on data-driven approaches are introduced. Topics include continuous- and discrete-time linear and nonlinear systems, state-space modeling, control and estimation, system identification, and adaptive control. Advanced data-driven methods such as model predictive control with machine learning, neural network control, and extremum seeking control are also covered. Laboratories focus on practical applications, including inverted pendulum simulations and experiments, controllability and observability analysis, state feedback and observer design, system identification, adaptive control, neural network-based control, model predictive control, and extremum seeking.

ACADEMIC CALENDAR:
https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_030978_1&SelectedCalendar=Live&ArchiveID=

The course covers: 1) State-space control of systems using data processing algorithms. System identification. Adaptive control algorithms; 2) Use of ML in data-driven control of real-world cyber-physical systems.

PRE OR COREQUISITES: AISE 3010A/B, AISE 3351A/B (or the former ECE 3351A/B), Data Science 3000A/B

ANTIREQUISITES: the former ECE 4450A/B

CEAB ACADEMIC UNITS:

INSTRUCTOR INFORMATION:

Instructor:
Office:
Phone:
Email:

CONTACT HOURS: Timetable information is available at https://draftmyschedule.uwo.ca/.

LECTURES:

LAB:

RECOMMENDED REFERENCE: Brunton, S. L., & Kutz, J. N. (2022). *Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control* (2nd ed.). Cambridge: Cambridge University Press

RECOMMENDED/ REQUIRED SOFTWARE: MATLAB/Simulink and/or Python

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

Knowledge Base	A	Engineering Tools	A	Impact on Society	
Problem Analysis	D	Individual & Teamwork		Ethics and Equity	
Investigation		Communication	A	Economics and Project Mgmt.	
Design		Professionalism		Life-Long Learning	

Notation: x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

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

COURSE MATERIALS: Weekly content and guides for the laboratories will be available on the course OWL site. The material for this course will be taught in both lectures and labs; therefore, it is imperative that you attend each lecture and lab.

UNITS: SI

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES:

The following table summarizes the course learning outcomes along with CEAB GAIs where the GAIs in bold indicate ones to be measured and reported annually.

Course Topics and Specific Learning Outcomes	CEAB Graduate Attribute Indicators
1. Systems: continuous-time vs. discrete-time, nonlinear vs. linear At the end of this section, students will be able to: a. Describe basic properties and mathematical models of continuous-time and discrete-time systems b. Distinguish between linear and nonlinear systems c. Describe basic properties of linear time-invariant systems **2. State space approach to control and estimation** At the end of this section, students will be able to: a. Describe a linear time-invariant system in the form of a state space model. b. Convert state space model of an LTI system into its transfer function and vice versa. c. Define the notion of controllability and determine if a given LTI system is controllable. d. Define the notion of observability and determine if a given LTI system is observable. e. For a given controllable LTI system, design an optimal linear-quadratic regulator f. For a given controllable/observable LTI system, design an optimal full state estimator, and implement linear-quadratic Gaussian control **3. System Identification** At the end of this section, students will be able to: a. For a given LTI system, implement basic algorithms for identification of a model using data-driven techniques **4. Adaptive control** At the end of this section, students will be able to: a. For a given LTI system, implement basic adaptive control algorithms **5. Data-driven control: MPC, neural network control, extremum seeking control** At the end of this section, students will be able to: a. For a given LTI system, Implement basic model predictive control algorithms b. For a given LTI system, implement basic neural network control algorithms c. For a given LTI system, implement an adaptive extremum seeking control algorithm	

EVALUATION:

Name	% Worth	Assigned	Due Date	CEAB GAs ASSESSED
Labs (Total = 9)	40%			
Quizzes (Total = 2)	20%			
Final Examination	40%			

Note that the dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, clarity and neatness.

COURSE POLICIES: All work submitted must be of professional quality in the requested format. Material that is handed in dirty, illegible, disorganized, or in an unapproved format will be returned to the student for resubmission and the late submission penalty will take effect. An additional penalty of 10% may be deducted for poor grammar, incoherence, or lack of flow in the written reports.

LABORATORIES: There will be 9 laboratory sessions. Specific schedule will be announced. Attendance at all laboratory sessions is mandatory. Students who miss a lab with academic consideration are required to contact the course instructor within 3 days for further instructions. Failure to do so will result in a zero mark for that lab. Reports must be written individually and submitted electronically through OWL before the deadline indicated in the laboratory manual and/or course website.

A minimum average of 50% across all laboratory exercises is required to pass the course.

QUIZZES: There will be two 1-hour quizzes that will take place on October 22nd and November 26th, respectively, during the regularly scheduled lecture hours. The quizzes are closed book. Necessary equations are provided. No programmable calculators are allowed.

FINAL EXAMINATION: The final exam will take place during the regular examination period. The final exam will be three hours long, closed book. Only simple, nonprogrammable calculators are allowed. To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination. A final examination mark < 50% will result in a final course grade of 48% or less. If the above conditions are not met, your final grade cannot be greater than 48%. Students who have failed this course (i.e., final average < 50%) must repeat all components of the course.

LATE SUBMISSION POLICY: Advise the instructor if you are having problems completing the assignment on time prior to the due date of the assignment and be prepared to submit an

Academic Consideration Request and provide documentation if requested by the instructor at: https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html
If you are granted an extension, establish a due date with the instructor. The approval of the Chair of your Department is not required if assignments are completed prior to the last day of classes. 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.

ATTENDANCE: Attendance is mandatory for all lectures and labs.

FACULTY OF ENGINEERING POLICIES:
Students must familiarize themselves with the policies of the Faculty of Engineering
https://www.eng.uwo.ca/electrical//pdf/2025-UG-Policy-and-Procedures.pdf

Faculty of Engineering Policies and Procedures-Undergraduate

Absence/Late Accommodation Policy

Students must familiarize themselves with the University Policy on Academic Consideration – Undergraduate Students in First Entry Programs posted on the Academic Calendar:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration_Sep24.pdf
This policy does not apply to requests for Academic Consideration submitted for attempted or completed work, whether online or in person. The policy also does not apply to students experiencing longer-term impacts on their academic responsibilities. These students should consult Accessible Education.

Students missing a test/assignment/lab or examination will report the absence by submitting Academic Consideration Request form through STUDENT ABSENCE PORTAL.

- All requests for Academic Consideration must be made within 48 hours after the assessment date or submission deadline. Academic consideration may include extension of deadlines, waiver of attendance requirements for classes/labs/tutorials, or re-weighting of course requirements.
- An instructor may deny academic consideration for any assessment that is not required in the calculation of the final grade (e.g., "8 of 10 quizzes"). Assessment flexibility must be indicated on the course outline.
- An instructor may deny academic consideration relating to the timeframe submission of work where there is already flexibility in the submission timeframe (e.g., 72-hour submission window). This assessment flexibility must be indicated on the course outline.
- All Academic Consideration requests must include supporting documentation; however, recognizing that formal documentation may not be available in some extenuating circumstances, the policy allows students to make one Academic Consideration request without supporting documentation per course. Some assessments are excluded from

this policy. Please refer to the course outline to determine if documentation isrequired.

- Requests without supporting documentation are limited to one per term per course.
- Please note that examinations scheduled during official examination periods always require official supporting documentation.
- If a student mistakenly submits their one allowed Academic Consideration request without supporting documentation for the assessments listed above that do not require academic consideration, the request cannot be recalled and reapplied. This privilege is forfeited.

An undocumented absence is only valid for a 24-hour period, from midnight on the day specified to midnight of the following day. An appropriate use of an undocumented absence would be for an in-class assessment that takes place that day. Where the time given to complete the assessment is longer than 24 hours, an undocumented absence will not cover a student for the full time given to complete the assessment, and flexibility considerations in submitting the assessment will override the undocumented absence.

NOTE: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

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

Religious Accommodation

When scheduling unavoidably conflicts with religious holidays, which (a) require an absence from the University or
(b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate Department Chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

Academic Integrity

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.

Please visit Academic Integrity Western Engineering for more information

Academic Offences

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from theuniversity.
Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know

Students must write their reports, 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

Faculty of Engineering AI Policy

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. Please refer to the course outline for the GenAI policy related to each course.

GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

Accessibility

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the Accessibility Western University for information on accessibility-related resources available at Western.
Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit Academic Support & Engagement -Academic Accommodation.

Inclusivity, Diversity, and Respect

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the Office of Equity, Diversity and Inclusion.

I. Health and Well-Being

Health & Wellness Services – Students - Offers appointment-based medical clinic for all registered part-time and full-time students.

Mental Health Support - Provides professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, change-oriented psychotherapy.
Crisis Support - For immediate assistant, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click here.
Gender-Based Violence and Survivor Support - "Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website: https://www.uwo.ca/health/student_support/survivor_support/gethelp.html To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts

Engineering Undergraduate Services
Department of Electrical and Computer Engineering
Office of the Registrar/Student Central

Important Links

- WESTERN ACADEMICCALENDAR
- ACADEMIC RIGHTS AND RESPONSIBILITIES
- ENGINEERING PROGRESSION REQUIREMENTS AND ACADEMIC REGULATIONS
- UNIVERSITY STUDENTS' COUNCIL (USC) - SERVICES
- IMPORTANT DATES AND DEADLINES
- ACADEMIC CONSIDERATION FOR MEDICAL ILLNESS - UNDERGRADUATE STUDENTS
- ACCOMMODATIONS FOR RELIGIOUS HOLIDAYS
- SCHEDULING OF ASSIGNMENTS, TESTS, AND EXAMINATIONS
- STUDENT FORMS
- OFFICE OF THE REGISTRAR
- RETENTION OF ELECTRONIC VERSION OF COURSE OUTLINES (SYLLABI)
- ACADEMIC APPEALS
- STUDENT ABSENCEPORTAL