

**Western University
Faculty of Engineering
Artificial Intelligence Systems Engineering Program**

AISE 3350A – Cyber-Physical Systems Theory

Course Outline Fall 2025

COURSE DESCRIPTION: Cyber-Physical systems (CPS) are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. CPSs are complex systems with the integration of computation, communication, and control (3C). In this course, the students are introduced to the fundamentals of CPSs, including the architecture of CPS, modelling in the continuous time domain, and the interface between physical (continuous) and cyber (discrete) worlds. Basis of control theory, sensors and actuators, will be introduced.

This course explores the foundational principles of cyber-physical systems with an emphasis on AI techniques for enhancing system intelligence, adaptability, and autonomy. Topics include the integration of machine learning algorithms into CPS, data-driven modeling, perception, and decision-making in real-time, as well as methods for ensuring safety, robustness, and efficiency in complex environments. Applications span areas like autonomous vehicles, smart cities, and robotics.

ACADEMIC CALENDAR:

https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_030974_1&SelectedCalendar=Live&ArchiveID=

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PREREQUISITES: Numerical and Mathematic Methods 2270A/B, [Numerical and Mathematical Methods 2276A/B](#) or [Numerical and Mathematical Methods 2277A/B](#), Physics 1302A/B or [Physics 1402A/B](#).

COREQUISITES: DS3000

ANTIREQUISITES: The former ECE 3350A/B.

CEAB ACADEMIC UNITS: Engineering Science 25%, Engineering Design 75%

CONTACT HOURS:

LECTURE: 3 hours weekly
LAB: 2 hour labs 5 times per term

RECOMMENDED/REQUIRED TEXT: None. Students are expected to have backgrounds in formal logic, circuits, programming, mathematical modelling, dynamic system, differential equations, linear algebra, and calculus.

RECOMMENDED/ REQUIRED SOFTWARE: Matlab/Simulink, Python/Jupyter Notebook/Google Colab

RECOMMENDED RESOURCES/REFERENCES:

N. Nise, "Control Systems Engineering", 8th (or 7th) edition, Wiley, ISBN: 978-1-119-47422-7

D.G. Manolakis and V.K. Ingle, "Applied Digital Signal Processing", Cambridge University Press, ISBN: 9780511835261

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

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

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: Cyber-Physical Systems refers to the integration of computation with physical processes. Often, communication is an integral part of the integration. This course will cover the mathematics needed to model them. Students will learn about the use of continuous systems, discrete systems, and hybrid systems for modelling CPSs, with modest use of communication, sensing and actuation.

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. Introduction to Cyber-Physical Systems(CPS) • Architecture of Cyber-Physical world, including analog, digital, and cyber-systems. • Examples of CPS • Concept of software At the end of this section, students will be able to: • Understand the components of CPS, how they are interconnected, and the significance of CPS in modern society • Discuss intelligently about requirements for CPSs, such as real-time and fault tolerance • Discuss the significance of historical figures and their contributions to CPS	KB4 IN3, CS3, IE1, LL2 EE4
2. Modelling of systems in continuous time • State-space models • Transfer functions • Frequency response • Stability • Feedback At the end of this section, students will be able to • Understand the basics of how to use mathematical principles to model physical systems and phenomena • Understand how to evaluate the performance of these systems • Capable of mathematical skills including modelling, differentiation and integration, and solving algebraic and differential equations	KB1 KB2 KB1

3. Interface between Physical and Cyber Worlds • Sensors and actuators • Sampling, A/D and D/A conversion • Principles of data collection • Notion of information and control At the end of this section, students will be able to • Understand the basic types of sensors and actuators and how to model and evaluate them mathematically • Understand how to convert a continuous (analog) signal and its discrete (digital) counterpart and vice versa, and the limitations of these techniques • Assemble a given CPS • Program a CPS to achieve a certain task • Evaluate and compare different CPS designs	IN3 CS1 ET2 D3
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EVALUATION:

Name	% Worth	CEAB GAs ASSESSED
Assignments	10%	ET,IE,KB
Labs (Total = 4)	20%	KB,ITW,IN
Project	35%	ET,IN,DE,ITW,CS,LL,PR
Final Examination	35%	KB,CS,LL,EE

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.

Homework Assignments: Assignments are posted on the course online portal. It should be noted that assignments are not only used as a means of student's assessment in the course, but also to provide information that complements the learning experience and enriches the study outcome. Student must use Assignments as a tool for evaluating their knowledge and understanding of each topic.

For each assignment, students are expected to submit the assignment by the deadline listed. Should illness or extenuating circumstances arise, students are permitted to submit up to 72 hours past the deadline without academic penalty. Should students submit their assessment beyond 72 hours past the deadline, a late penalty of 10% per day will be subtracted from the assessed grade.

Please note that because the submission deadline for homework assignments already includes flexibility in the form of 72 hour submission window, the instructor reserves the right to deny academic consideration for assignments which are submitted following the end of the period of flexibility.

LABORATORIES: The schedule for laboratory exercises will be posted on the course online portal. All lab exercises are to be completed in person during the allocated laboratory time. It is mandatory for the students to complete all lab exercises. Students will work in groups of 2-3. Equipment required for the labs will be provided.

Attendance at all laboratory sessions is mandatory. Absence from any session, or a portion of a session, without permission will result in a zero assigned to the corresponding laboratory report. The teaching assistants will sign your lab report as testimony to your attendance. Students who arrive 20 min after the scheduled lab time without a legitimate reason, leave the lab early without permission from the teaching assistant, or miss the lab without a legitimate reason will receive a zero for the corresponding laboratory assignment. Students who miss a lab with academic consideration are required to contact the course instructor within x days for further instructions. Failure to do so will result in a zero mark for that lab.

A minimum average of 60% across all laboratory exercises is required to pass the course.

PROJECT: A group project with flexible format will be completed in which student will perform critical analysis and design and implementation of a CPS. The details of the project, including requirements, grading specifications, and due date, will be distributed on the course online portal. Lab reports are expected to be submitted in digital form to the course online portal. Please note that because the submission deadline for Project already includes flexibility in the form of 72 hour submission window, the instructor reserves the right to deny academic consideration for assignments which are submitted following the end of the period of flexibility.

FINAL EXAMINATION: The final exam will take place during the regular examination period. The final exam will be three 3 hours long, closed book, with 2-pages of notes allowed. Only simple, nonprogrammable calculators are allowed.

To obtain a passing grade in the course, a mark of 60% or more must be achieved on the final examination. 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.

This course employs flexible deadlines for assignments. The assignment deadlines can be found above in the course outline. For each assignment, students are expected to submit the assignment by the deadline listed. Should illness or extenuating circumstances arise, students are permitted to submit their assignment up to 72 hours past the deadline without academic penalty. Should students submit their assessment beyond 72 hours past the deadline, a late penalty of 10% per day will be subtracted from the assessed grade. As flexible deadlines are used in this course, requests for academic consideration will not be granted. If you have a long-term academic consideration or an accommodation for disability that allows greater flexibility than provided here, please reach out to your instructor at least one week prior to the posted deadline.

All deliverables will be penalized by 10% of the available marks per day for late submission. Deliverables submitted more than 5 days late will not be accepted.

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>