The University of Western Ontario
Faculty of Engineering

DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

CBE 4420/CBE 9424 – Digital Process Control

Course Outline 2025-2026

The course covers some advanced topics in process control in Digital environment and Model Predictive Control (MPC). An introduction to the fundamental concepts in process dynamics and control is provided depending on the background of the participating students. Digital process control theory using z-transformation is covered and the design of digital and linear model predictive control will be discussed. The course will make use of Matlab and Simulink environment. The derivation of the unconstrained linear model predictive control will be covered in detail, followed by the use of Matlab/Simulink MPC toolbox. The implementation of the control systems in the LabView environment will be discussed.

The general outcome of the course is to enable the students to:

- Develop dynamic models for lumped-parameter systems, stagewise processes and distributed-parameter systems and simulate the resulting dynamic models in Matlab/Simulink environment.
- Develop computational skills to analyse the feedback control systems in a variety of configurations
- Implementation of feedback controller in the LabView environment
- Develop tools for testing stability of the feedback control systems in the s-domain, and z-domain
- Develop various deterministic digital controllers for the linear time-invariant (LTI) systems in the z-domain.
- Develop the unconstrained model predictive control (MPC) algorithms.
- Design and implement digital MPC controllers in the Matlab/Simulink environment

Prerequisites:
An introductory course in Process Dynamics and Control
Graduate Student Status or permission of the department

Corequisites:
None

Antirequisites: None

Contact Hours:
3 lecture hours per week, 0.5 course.

Instructor:
Dr. S. Rohani (TEB 479) E.mail srohani@uwo.ca

Teaching Assistant:
Johana Angelica Guerrero Amaya
Email: jguerre7@uwo.ca

Recommended Text
S. Rohani, Coulson and Richardson Chemical Engineering, Vol 3B: Process Control, Fourth Edition, IChem E, Elsevier, 2017.

Reference Texts:
Seborg, Edgar, Mellichamp, Doyle. "Process Dynamics and Control", 3rd Edition, Wiley, 2011.
MPC toolbox of Matlab/Simulink

Units:
SI and British units will be used

Learning Objectives

- Students will be able to develop non-linear dynamic models of chemical processes based on material and energy balances
- Students will become proficient in solving ordinary differential equations using Matlab and Simulink
- Students will be able to set up simple feedback control loops using PID controllers
- Students will analyze the stability of the feedback control systems
- Students will be able to implement controllers using LabView and NI-DAQ systems
- Students will be able to analyze and design digital controllers in the z-domain
  - Note: this learning objective aligns with and is selected for the assessment of the Graduate Attribute Knowledge Base (**KB2 and KB3, LEVEL: Advanced**): Demonstrate competence in engineering fundamentals and specialized engineering knowledge appropriate to engineering discipline.
- Students will use MATLAB/SIMULINK to implement and test out controllers
- Students will be able to design unconstrained and constrained model predictive controllers in the Matlab/Simulink environment
  - Note: this learning objective aligns with and is selected for the assessment of the Graduate Attribute Design (**DE1 and DE2, LEVEL: Advanced**): Demonstrate ability to frame a complex, open-ended process control design problem.
- Students will use Matlab/Simulink MPC toolbox to design and implement controllers
  - Note: this learning objective aligns with and is selected for the assessment of the Graduate Attribute Engineering Tools (**ET1 and ET2, LEVEL: Advanced**): Demonstrate ability to identify and select appropriate engineering tool(s) and resources.

SECTION 1 Introduction to Process Dynamics and Control (Chapters 1, 2, 4 and 5 of Textbook)…….

1. Hardware instruments for the implementation of control systems……………..……………
2. Linear dynamic modeling in the s-plane and linear state-space modeling....………………
3. Closed loop transfer function……………………………………………………………..
4. Concept of stability………………………………………………………………………….
5. Design of feedback and feedforward controller in the s-domain……………………………

SECTION 2 Theoretical Process Dynamic Modeling (Chapter 3 of Textbook) ....

1. Detailed theoretical dynamic modeling...

Evaluation:
The Computer Process Control Laboratory has a number of processes interfaced to real time computers. A series of goals will be set for the group and a comprehensive project report will be used to assess the group and individual performance. Simulation projects using Matlab + Simulink are also available.

The final course mark will be determined as follows:	**CBE 4420 students**	**CBE 9424 students**
Assignments	15%	10%
Term Project	0%	10%
Midterm Examination	35%	30%
Final Examination	50%	50%

Examination will be open book, open notes, and open power point presentations. You may bring in a laptop computer in the exam, to run Matlab and Simulink simulations. NO emailing or website searches will be allowed during the exams.

Academic considerations

In this course, your written assignments have a no-questions-asked 2-day grace period. This means that you can submit any of these assignments up to 2 days past the posted deadline without penalty. As such, requests for academic consideration for assignments will be denied.

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 the 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 or laboratory periods in any course, will be reported to the Associate Chair (Graduate), after due warning has been given. On the recommendation of the Department concerned, and with permission of the Associate Chair,

appropriate action will be taken, with the possibility of course failure.

Cheating:
University policy states that cheating is a scholastic offense. The commission of a scholastic offense is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

Plagiarism:
University policy states that plagiarism is a scholastic offense. Plagiarism is defined as appropriating and passing off writings or ideas of another person's as one's own. Penalties may include failure or automatic withdrawal from the course.

Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

For further information on plagiarism, consult the Scholastic Offence Policy in the Western Academic Calendar.

Sickness and Other Problems:
Students should immediately consult with the instructor or Associate Chair (Graduate) if they have any problems that could affect their performance in the course. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE
Western is committed to working to end gender-based and sexual violence on campus and in our community and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you can connect with a case manager or set up an appointment (support@uwo.ca).

Provisional Guidance for the use of Generative AI in Graduate Studies

With ongoing advancements in artificial intelligence (AI), the School of Graduate and Postdoctoral Studies recognizes the need for guidance on the ethical and responsible use of generative AI technologies in graduate work.
The considerations for using generative AI in graduate work are based on five principles described below and align with the guidance on generative AI use for Western University. For a description of generative AI, please see 'What is AI?' at ai.uwo.ca.

Notice:
Students are responsible for regularly checking their email and notices posted on Instructors' doors.

Consultation:
Office hours will be posted. Individual consultation may be arranged by appointment with the instructor.

Accreditation Unit (AU) Content:

Engineering Science	=	60%
Engineering Design	=	40%

June/2024