CHEM ENG 4E03
Digital Computer Process Control

Course outline, Fall 2022

Lecture schedule

- 12:30pm–1:20pm on Mondays
- 1:30pm–2:20pm on Tuesdays
- 12:30pm–1:20pm on Thursdays

Lectures will be in-person in BSB 138 by default, but we may switch to Teams in an emergency.

Instructor

Dr. Kamil A. Khan (`kamilkhan@mcmaster.ca`)

Office: JHE 202
Teams ID: `khank11`
Office hours TBA

Teaching assistants

- Daniela Dering (`deringdd@mcmaster.ca`)
- Lloyd MacKinnon (`mackila2@mcmaster.ca`)

Office hours TBA

Description

This course aims to address the design and analysis of discrete–time control laws that are predominantly model-based and suitable for implementation on digital computers, and to provide a broad foundation for further independent or graduate study in process control. Material covered will include:

- continuous– and discrete–time dynamic models,

- statistical empirical identification of process models,
- analysis of discrete-time systems and design of digital control systems, including *model predictive control*, a widely used advanced control strategy in the chemical process industry.

Control algorithms will be implemented and their performance evaluated through state-of-the-art simulation software. The course material will be relevant to engineering practice.

Prerequisites

The only formal prerequisite for this class is CHEMENG 3P04 (Process Control). The world of process control beyond 3P04 is heavily rooted in mathematics, and this class will involve linear algebra and vector calculus.

Format

The course will consist of in-person lectures. Masking is encouraged. The course material will be supplemented by regular assignments that will include the use of computer-aided tools.

All critical communication about deadlines etc. will be posted as "announcements" in Avenue. Please check the course's Avenue page daily for announcements.

Final grade breakdown

	% of final grade
Assignments	25
Midterm exam #1	20
Midterm exam #2	20
Final exam	35

Assignments

There will be 5 or 6 assignments throughout the semester. Your lowest-scoring assignment will not count toward your final grade. Some assignment problems will involve implementation in MATLAB or Simulink.

Assignments must be submitted in a certain way. Please refer to the Assignment Policy (posted in Avenue) for details regarding submission, grading, and collaboration.

Course notes

Posted to Avenue as `.pdf` files, typically a week before the relevant lectures.

Further reading

These textbooks on process control are available in Thode, and are not necessary but may be helpful:

1. Bequette, B.W., Process Control. *Modeling, Design and Simulation*, Prentice-Hall, 2003.
2. Brosilow, C. and B. Joseph, *Techniques of Model-Based Control*, Prentice-Hall, 2002.
3. Maciejowski, J.M., *Predictive Control with Constraints*, Prentice Hall, 2002.
4. Marlin, T.E., *Process Control: Designing Processes and Control Systems for Dynamic Performance*, 2nd Edn., 2000. Tom Marlin has made this book freely available at http://pc-textbook.mcmaster.ca.
5. Ogunnaike, B. and H. Ray, *Process Dynamics, Modeling, and Control*, Oxford University Press, London, 1994
6. Seborg, D., T. Edgar, and D. Mellichamp, *Process Dynamics and Control*, Wiley, New York, 1989

Policy reminders

Academic integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, such as:

- the grade of zero on an assignment,
- loss of credit (noted on the transcript as: "Grade of F assigned for academic dishonesty") and/or
- suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information about the various types of academic dishonesty, please refer to the Academic Integrity Policy linked in the sidebar of `http://www.mcmaster.ca/academicintegrity`.

The following list illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

Course changes

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

Provisional course outline

[Approximate numbers of lectures in square brackets]

0. Introduction [1]

1. Linearity [2]

2. Dynamic models [3]

    - Components of dynamic models
    - Continuous–time representations
    - Linearization
    - Discrete–time representations
    - Continuous-to-discrete translation

3. Frequency domain analysis [4]

    - Laplace transforms and transfer functions
    - z–transforms and pulse transfer functions
    - Open-loop stability and dynamic response

4. Model identification [5]

    - Components of optimization problems
    - Quadratic functions of many variables
    - Least-squares formulation for model identification
    - Handling deadtime
    - Input test signal and data pre-processing

5. Feedback control for continuous– and discrete–time models [8]

    - Closed-loop transfer functions
    - Closed-loop stability and internal stability
    - Controller design by direct synthesis

6. More about dynamic models [4]

    - Manipulating ODE models
    - Differential-algebraic equations (DAEs)

7. Model Predictive Control (MPC) [9]

    - Formulation
    - Implementation
    - Closed–loop properties