ChE 524 – Winter 2023

PROCESS CONTROL LABORATORY

Important Notice: **the experiments are conducted by groups of 3 students each. Please notice, one student from each group must be physically present in the lab. Thus, each group must make sure that one member of the group can attend each time. The same group member or different group members may attend each of the experiments in person and this will have no impact on the final grade of the group.**

Course description:

Experiments on process dynamics, control and simulation of processes. Time constant; step and frequency response; controller tuning; multivariable control strategies; model predictive control. Implementation using simulation systems, mainframe computer control, microcomputers.

Instructor: Hector Budman

Office: E6 3012, x36980

email: hbudman@uwaterloo.ca, Webex address: https://uwaterloo.webex.com/meet/hbudman

Office hours: tbd in Webex: https://uwaterloo.webex.com/meet/hbudman

Teaching Assistant: Mohammad Aghaee Foroushani

Office: E6 3118

email: Mohammad Aghaee Foroushani maghaeef@uwaterloo.ca

Course Timetable:

Tutorial Session: Tuesday 3-3:50 pm E6-4022, 1hour lecture per week on material relevant to the experiments to be posted online as narrated PowerPoint and corresponding video file.

Laboratories: **the experiments are conducted by groups of 3 students each. Please notice one student from each group must be physically present in the lab. Thus, each group must make sure that one member of the group can attend each time. The same group member or different group members may attend the labs and this will have no**

impact on the final grade of the group.

- Tuesday 4-6:50 pm in DWE-1514/1519.
- Thursday 4-6:50 pm in DWE-1514/1519.

Important Dates:

Laboratories start on the week of January 16, 2023

Reading Week: February 20-24, 2023 (Tutorial and Labs cancelled)

Laboratories are scheduled to end of March, 2023

Short Quiz: Thursday, March tbd, 2023, E6-4022, during tutorial time.

Grading:

Final Laboratory Reports	80 %
Short Quiz	20 %

The Laboratory reports and the short quiz will be marked by the teaching assistant and the course instructor.

Textbook:

Seborg, D.E., Edgar T.F. and Mellichamp, D.A. *Process Dynamics and Control,* John Wiley & Sons, Inc., Second Edition, 2004

Lecture Topics:

- Traditional Methods for System Identification in Process control.
- Model Predictive Control, MPC.
- Internal Model Control, IMC
- Digital Sampling, Filtering and Control (z-transform).

Laboratories:

- Double Heat Exchanger experiment (DPHE).
- Continuous Stirred Tank Heater experiment (CSTH).
- Multivariable Control Unit (MVCU)

Each experiment consists of two sessions.

Read the following sections of the textbook:

First Session

- CSTH : Sections: 5.1, 5.2, 6.1, 6.2, 6.3, 7.1 and 7.2.
- DPHE: Sections: 5.1, 5.3, 6.2, 6.3, 6.5, 7.1, 7.2, 18.1 and 18.2
- MVCU: Sections 8.1, 8.3, 8.5, 11.4, 12.3 and 12.4

Second Session

- CSTH: Sections 8.1, 8.3, 8.5, 11.4, 12.3 and 12.4
- DPHE: 20.1, 20.2, 20.3, 20.4 and 20.7
- MVCU: Sections 18.1, 18.2 and 18.4

1st session CSTH: Identify the model in open loop

2nd session CSTH: Implement SISO controller based on open loop model.

1st session DPHE: Identify the models in open loop

2nd session DPHE: Implement MIMO Model Predictive Controller (MPC)

1st session MVCU: Identify models in open loop. Determine physical limitations of controller gains.

2nd session MVCU: Implement and test SISO controllers in closed-loop and with interaction.

Be prepared to give a five minute presentation followed by discussion of the results obtained from the first session.

Important: Bring a flash memory to the lab sessions to download your data and results. **Final Laboratory Report**

Reports are due at the end of the term. The report should follow standard lab reporting format and should contain sections such as:

- Pertinent theory *(*1 page maximum).
- Experimental procedure if not outlined in manual, otherwise only list deviations from the specified procedure.
- System identification and Modelling
    - Results, not intended for in depth discussion, but should include:
        - Detailed modelling methodology for each "unique" case.
        - Model parameters obtained for each case.
        - Graphical summary of remaining modelling, clearly showing relevant information (i.e. data and models on the same plot for easy comparison)
    - Discussion of modelling and interpretation of results.
- Control Testing
    - Results
        - Theoretical versus actual, same rules for plotting
    - Discussion
        - Explain discrepancies if possible
        - Evaluate controller qualitatively and quantitatively
        - Discuss actual versus theoretical performance with regard for "real world" implications.
- Conclusions
    - Discuss with focus on proposed objectives from preliminary report
    - Unattained objectives ARE NOT penalized, but poor discussion it is.

Marking scheme for lab reports

- Intro and formalities 5%
- Clarity of writing 5%
- Graphs and plots 10%
- Other formatting 5%
- System Identification and Modelling (Write-up and validity of modelling session) 25%
- Controller testing (Write-up and explanations for second session) 25%
- Conclusions and recommendations 25%

Preliminary laboratory schedule (to be confirmed)

TBD

Classroom Responsibilities:
http://www.eng.uwaterloo.ca/- ugoffice/course responsibilities.html

Academic Integrity, Grievance, Discipline, Appeals and Note for Students with Disabilities: see www.uwaterloo.ca/accountability/documents/courseoutlinestmts.pdf
the text for this web site is listed below:

Institutional-required statements for undergraduate course outlines approved by Senate Undergraduate Council, April 14, 2009

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may pave grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing academic offenses and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the undergraduate associate dean. For information on categories of offenses and types of penalties, students should refer to Policy 71, Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check guidelines for the Assessment of Penalties,
http://www.adm. uwaterloo .ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals, http://www.adm. uwaterloo .ca/infosec/Policies/po licy72 .htm.

Note for students with disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.