Department of Chemical & Materials Engineering

2015 Fall - CHE 446 - Process Dynamics and Control

- **Course Instructor**

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- **Teaching Assistants**

Kevin Arulmaran arulmara@ualberta.ca (TA) Tianrui An ta1@ualberta.ca (TA)

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- **Lab Instructor**

Khushaal Popli popli@ualberta.ca

- **Schedule**

Lecture	Tuesday, Thursday	9:30am - 10:50am	CSC B 2
Seminar 1	Thursday	8:30am - 9:20am	ETLC E2 005
Seminar 2	Friday	3:00pm - 3:50pm	ETLC E2 005

- **Required Textbook**

Seborg, Edgar, Mellichamp and Doyle, Process Dynamics and Control (3rd Edition), Wiley, 2011. ISBN: 978-0-470-12867-1

- **Labs**

Laboratory exercises consist of experiments and computer simulation laboratories. Hands-on experimental laboratories will complement the lectures to illustrate the basic concepts of feedback control and controller design techniques. The main software platform used for this course will be MATLAB and SIMULINK, including the Control System Toolbox. Lab schedules will be distributed separately.

- **Course Description**

Process dynamics is concerned with the study of transient and steady-state behavior of processes. Process control is concerned with the "control" or "manipulation" of process behaviour so that the process operates close to the desired operating point even in the presence of inevitable upsets and disturbances. Process control plays a central role in the efficient and trouble-free operation of modern processing plants. This course will introduce the concepts of systems modeling, transient response analysis and feedback control. At the end of this course, students will be able to:

- Model and simulate the behaviour of 1st, 2nd and higher order dynamical systems.
- Design and tune feedback and feedforward controllers and obtain a hands-on experience in doing this via simulation and experimentally on pilot-scale processes.
- Configure and analyze control loops for stability and performance.

- **Course Outline**

1. Introduction to process control

Classify process variables, Control & instrumentation diagram, Control configurations, control block diagram

2. Theoretical modeling

Modeling principle, balance equations, Modeling procedure, Mass balance modeling example Energy balance modeling example, Degree of freedom analysis, Linear models and deviation variables, Linearization of nonlinear models

3. Laplace Transform, Transfer Function

Laplace Transform, Determine transient response, Transfer function, Properties of transfer function

4. Dynamic response analysis

Standard inputs functions, Response of 1st, 2nd order system, Zeros & poles of transfer function, Zeros-poles analysis, process with time delays, approximate higher order transfer function, develop empirical process model, Fitting models using step tests

5. Feedback control and PID controller

Feedback control, On-off controller, PID controllers, Closed-loop transfer function, Response of closed-loop control system, Issues of PID controllers (offset, proportional & derivative kick), Issues of PID controllers (integral windup), Implementation issue of PID (digital PID), General Expression of feedback control loop

6. Stability analysis

Stability of feedback control system, closed loop stability, Routh's test, root-locus method

7. Design & tuning PID controller

Performance criteria controllers design & tuning, Direct synthesis method, IMC based method Integral error criteria based tuning method, open loop tuning (Ziegler-Nichols, Cohen-Coon), Closed loop tuning (continuous cycling, relay auto)

8. Frequency response analysis

Sinusoidal forcing for a 1st order process, amplitude ratio, phase angle, Bode diagram, 2nd order system, process zero, integrator, differentiator, time delay, Bode Stability Criterion, Phase Margin, Gain Margin, Controller design with frequency response analysis

9. Advanced control strategies

Feedforward control, Cascade control, Time delay compensation

- **Course Webpage**

All handouts, assignments and other pertinent information will be posted on UofA's eClass portal.

- **Grading**

Assignments (>5)	15%	Lab Reports (~5)	25%
Midterm Exam (1)	20%	Final Exam (1)	40%

Unless you have an acceptable excuse, there will be a penalty on late assignments (including lab reports):

- Late by 24 hours or less, the grade will be reduced by 25%
- Late by more than 24 hours, a zero grade will be assigned

- **Plagiarism, Cheating, Misrepresentation of Facts and Participation in an Offence**

See the Message from the Office of the Dean, Faculty of Engineering in eClass.