ChE 182

Chemical Process Dynamics and Control

Course Description: Introduction to process dynamics of simple chemical systems; objectives & stability criteria of control systems.

Course Prerequisites: ChE 125, ChE 133, ChE 134

Course Credit: 3.0 units (2 h lecture, 3 h laboratory)

Program Educational Objectives (BS Chemical Engineering)
The program aims to educate students such that three to five years from graduation, they:

1. take leadership roles in their respective fields and/or effectively work in or manage a team;
2. are equipped with the extensive knowledge and relevant skills necessary to succeed in their chosen careers and to become responsive citizens;
3. are able to demonstrate strong research & innovative capability as they recognize and address opportunities and challenges in their respective spheres of influence;
4. have shown strong commitment to the ethical practice of their profession; to health, safety and environment; and service to society.

Course Outcomes
At the end of the course, the student should be able to:
At the end of this course, the students should be able to:

1. Apply the concepts of material and energy balances, unit operations, chemical reaction engineering and mathematical methods to:
    a. Derive and simulate dynamic models of chemical processes,
    b. Solve for and analyze the response of chemical processes to process input changes,
    c. Derive the overall model of a control system using different feedback controllers;
2. Design and analyze the stability, performance, and robustness of feedback control systems;
3. Use MATLAB and Aspen HYSYS Dynamics as computational tools to design, simulate, and analyze the behavior and stability of processes and control systems; and
4. Familiarize with common instrumentation such as valves, controllers, and sensors found in the industry, as well as their principles of operation.

Student Outcomes Satisfied by Course Outcomes

[a] Ability to apply knowledge of mathematics and science to solve engineering problems
[c] Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards
[e] Ability to identify, formulate, and solve engineering problems
[j] Knowledge of contemporary issues
[k] Ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

Course Content

WEEK	LECTURE CLASS	LABORATORY CLASS
Week 1	Lecture 1: Introduction to Process Dynamics • Overview of Dynamic Models • Deviation form of Dynamic Models • Introduction to Dynamic Simulation	Laplace Transforms: • Review of Laplace Transforms • Laplace Transforms of ODEs • Laplace Transforms of Input Signals
Week 2	Lecture 2: Process Dynamic Modelling • Dynamic Models of Selected Processes • Linearization of Dynamic Models • Transfer Functions (TF) & State-space (SS) Models	Process Dynamic Modelling & Simulation: • Written Exercise • SIMULINK Tutorial
Week 3	Lecture 3: Dynamic Behavior of Low-order Processes • First-order Processes • Second-order Processes • Time Delay	Dynamic Behavior of Low-order Processes: • Written Exercise • Machine Exercise: SIMULINK
Week 4	Lecture 4: Dynamic Behavior of Higher-order Processes • Pole-zero Plots • Approximation of Higher-order Process • Stability of Processes	Dynamic Behavior of Higher-order Processes • Written Exercise • Machine Exercise: SIMULINK
Week 5	**LONG EXAM 1**	
Week 6	Lecture 5: Introduction to Process Control • Basic Process Control System (BPCS) • Control Strategies: Feedback, Feedforward, Ratio, Split-range, Cascade Control	Lecture 6: Industrial Instrumentation & Control • Industrial Valves and Sensors for Flow, Level, Temperature, Pressure, and Concentration • Plant-wide Control: DCS and PLC
Week 7	Lecture 7: Basic Control Theory • PID Controllers • Servo-Regulator Theory • Direct-acting vs. Reverse-acting	Basic Control Theory: • Written Exercise • Machine Exercise System Identification: • Wet Lab Exercise
Week 8	Lecture 8: Closed-loop Control Systems • Feedback Control Loops • Cascade Control Loops • Multi-loops (Optional)	Closed-loop Control Systems: • Written Exercise • Machine Exercise: SIMULINK P and PI Temperature Control: • Wet Lab Exercise
Week 9	Lecture 9: Stability of Feedback Control Loops • Stability Criteria • Root-Locus Diagrams	Stability of Feedback Control Loops: • Written Exercise • Machine Exercise: SIMULINK & SISOTOOL
Week 10	**LONG EXAM 2**	
Week 11	Lecture 10: PID Controller Tuning • Direct Synthesis & Internal Model Control • Tuning Relations from Continuous Cycling • Robustness vs. Aggressiveness	PID Controller Tuning: • Written Exercise • Machine Exercise: SIMULINK & SISOTOOL
Week 12	Lecture 11: Frequency Response Analysis (FRA) • Amplitude Ratio and Phase Shift • Bode & Nyquist Plots • PID Controller Tuning using FRA • Bode & Nyquist Stability Criteria	Frequency Response Analysis: • Written Exercise • Machine Exercise: SIMULINK & SISOTOOL
Week 13	Lecture 12: Process Monitoring: SPC • Review of Statistics	Statistical Process Control (SPC): • Written Exercise

WEEK	LECTURE CLASS	LABORATORY CLASS
	• Nature of Errors in Process Data • Quality Control Charts	• Machine Exercise
Week 14	**LONG EXAM 3**	
Week 15	Lecture 13: Aspen HYSYS Dynamics • HYSYS Tutorial • Dynamic Simulation of Control Systems	Design Project: • Consultation
Week 16	**DESIGN PROJECT SUBMISSION**	

Course Assessment

Long Examinations	60%
Exercises and Quizzes	20%
Design Project	20%

Course Policies

1. There will be 3 long exams (LE). There will be NO MAKE-UP LE; you will get a zero score for the missed exam regardless of the reason.
2. NO COMPREHENSIVE EXAM will be given in this course.
3. Quizzes (QIZ) are given during the lecture session. MISSED QIZ will be given a grade of zero.
4. Machine, Written, and Wet Lab Exercises (EX) given during the laboratory session shall be submitted at the end of the period. MISSED EX will be given a grade of zero.
5. Attendance will be checked. A student who is absent for more than 3 lecture sessions or 3 laboratory sessions will be given a grade of 5.0 if he/she does not drop before the official day of dropping. A student's attendance shall only be credited in the section he/she is enrolled in.
6. A design project (PROJ) shall be submitted at the end of the course. Details on the project will be discussed later in the course.
7. Grievances will be entertained three days (3) after the results are returned or announced. All grievances (for whatever reason) will not affect the grades if it is raised after the 3 day grace period.
8. The instructor reserves the right to make changes to the syllabus when deemed necessary.

Grading System

1.00	1.25	1.50	1.75	2.00	2.25	2.5	2.75	3.00	5.00
[92,100]	[88,92)	[84,88)	[80,84)	[76,80)	[72,76)	[68,72)	[64,68)	[60,64)	[0,60)

List of Instructors

Dr. Jose Muñoz
Prof. Karl Ezra Pilario
Prof. Ralph Villa
Prof. Miguel Francisco Remolona

References

1. Seborg, D., Edgar, T., and Mellichamp, D., **2004**. *Process Dynamics and Control.* 3rd ed. Hoboken, NJ: Wiley.
2. Romagnoli & Palazoglu, **2016**. *Introduction to Process Control.* 2nd Ed. CRC Press.
3. Bequette, B.W., **2003**. *Process Control Modeling, Design, and Simulation.* New Jersey: Pearson Ed. Inc.
4. Coughanowr, D. and Koppel,L.,**1965**. *Process Systems Analysis and Control.* New York, NY: Mc-Graw-Hill.
5. Marlin, T., **2000**. *Process Control.* 2nd Ed. Boston, MA: Mc Graw-Hill.
6. Ogunnaike, B. A. and Ray, W. H., **1994**. *Process Dynamics, Modeling, and Control.* New York, NY: Oxford Univ. Press.