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DEPARTMENT OF CHEMICAL ENGINEERING
College of Engineering
University of the Philippines Diliman, Quezon City

COURSE SYLLABUS
ChemE 182 Chemical Process Dynamics and Control

A. Course Catalogue Description

1. **Course Number:** ChemE 182
2. **Course Title:** Chemical Process Dynamics and Control
3. **Course Description:** Introduction to process dynamics of simple chemical systems; objectives and performance criteria of control systems
4. **Prerequisite:** ChemE 128 Chemical Reaction Engineering
5. **Semester Offered:** First Semester
6. **Course Credit:** 3u
7. **Number of Hours:** 2h lec, 3h lab
8. **Meeting Type:** lecture, laboratory
9. **Course Goals:** To introduce process dynamics and control of chemical processes, which combine theoretical and computational approaches to illustrate how dynamic mass and heat balances govern the response of unit operations and processes to set point changes and externally induced disturbances

B. Rationale

This course covers the principles of process dynamics and control as applied to unsteady mass and energy balance in reactive and non-reactive systems. The ability to select the appropriate control device for a process equipment is an essential skill needed in the design of chemical processes.

C. Course Outline

1. **Course Outcomes (CO)**

Upon completion of the course, students must be able to:

- **CO 1.** analyze the response of chemical processes to process input changes using the concepts of material and energy balances, unit operations, chemical reaction engineering and mathematical methods to derive dynamic models of chemical processes and overall models when using different feedback controllers;
- **CO 2.** analyze the stability, performance, and robustness of feedback control systems;
- **CO 3.** evaluate other types of control strategies (feedforward, cascade, ratio control) for process units; and
- **CO 4.** identify input on process response given changes in control configurations and process parameters provided by other disciplines.

Course Outcomes and Relationship to Program Learning Objectives

<table>
<tr><th rowspan="2">Course Outcomes</th><th colspan="5">Program Learning Objectives*</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td>Analyze the response of chemical processes to process input changes using the concepts of material and energy balances, unit operations, chemical reaction engineering and mathematical methods to derive dynamic models of chemical processes and overall models when using different feedback controllers</td><td style="background:#c0c0c0"></td><td></td><td></td><td style="background:#c0c0c0"></td><td></td></tr>
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* **A** Equip students with strong technical education in chemical engineering necessary to succeed in their chosen careers and to become responsive citizens.
B Develop the students' ability to effectively communicate technical information to any audience.
C Train students to function in multidisciplinary teams, manage projects, and take leadership roles in their respective fields.
D Engage students in research, innovation, and life-long learning to identify opportunities, and address issues and challenges in their respective spheres of influence.
E Instill in students a strong commitment to the ethical practice of their profession; to health, safety, and environment; and to service to society.

2. Course Content

<table>
<tr><th rowspan="2">Lecture Topics</th><th colspan="2">No. of Hours</th></tr>
<tr><th>Lec</th><th>Lab</th></tr>
<tr><td>Introduction to process dynamics and control</td><td>2</td><td></td></tr>
<tr><td>Laplace transforms
1. Definition
2. Operations
3. Inverse Laplace transforms
4. Convolution and convolution theorem
5. Solution of linear differential equations using Laplace transforms</td><td>6</td><td>12</td></tr>
<tr><td>Long Examination 1</td><td colspan="2"></td></tr>
<tr><td>Introduction to process control
1. Theoretical models of chemical processes
2. Transfer functions
3. Dynamic behavior of first-order and second-order processes
4. Dynamic response characteristics of complicated processes
5. Development of empirical models from process data</td><td>10</td><td>15</td></tr>
<tr><td>Long Examination 2</td><td colspan="2"></td></tr>
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Lecture Topics	No. of Hours	
	Lec	Lab
Feedback controllers 1. Introduction to the different types of controllers 2. Control system instrumentation 3. Overview of control system design 4. Dynamic behavior and stability of closed-loop control system 5. PID controller design, tuning, and troubleshooting	8	12
Long Examination 3		
Other control strategies 1. Frequency response analysis 2. Control system design based on frequency response analysis 3. Feedforward, cascade and ratio control	6	9
Long Examination 4		
Design Project		
Total number of hours	**32**	**48**

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1	1	**Introduction to process dynamics and control**	What are process dynamics and how are they used in chemical engineering? What are transfer functions?	lecture	quiz
1-4	1,4	**Laplace transforms** 1. Definition 2. Operations 3. Inverse Laplace transforms 4. Convolution and convolution theorem 5. Solution of linear differential equations using Laplace transforms	How can Laplace transforms be used to solve an ODE? Why are Laplace transforms the chosen solution to the ODEs that represent a transient chemical process?	lecture, classwork	problem set
					Long Examination 1
5-9	1	**Introduction to process control** 1. Theoretical models of chemical processes 2. Transfer functions 3. Dynamic behavior of first-order and second-order processes 4. Dynamic response characteristics of complicated processes 5. Development of empirical models from process data	How are mass balance and energy balance equations used to represent the dynamics of chemical processes? How are transfer functions derived for a particular process?	lecture, classwork	problem set, quiz

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
					Long Examination 2
10-13	1,2	**Feedback controllers** 1. Introduction to the different types of controllers 2. Control system instrumentation 3. Overview of control system design 4. Dynamic behavior and stability of closed-loop control system 5. PID controller design, tuning, and troubleshooting	How do you design a feedback controller to effectively control processes and manage the safety concerns of these processes? How do we identify the type of feedback controller to use in the process?	lecture, classwork	machine exercise
					Long Examination 3
14-16	1,2,3	**Other control strategies** 1. Frequency response analysis 2. Control system design based on frequency response analysis 3. Feedforward, cascade and ratio control	Why are these other control strategies used? What are the advantages of these control strategies over feedback controllers? How do we identify the effective control strategy for a particular process?	lecture, classwork	machine exercise
					Long Examination 4
					Design Project

4. Course Requirements

1. Long examinations (4)
2. Design project
3. Machine exercises
4. Problem sets
5. Quizzes

REFERENCES:

Coughanowr, D. R. (2008). *Process Systems Analysis and Control* 3rd Ed. NY: McGraw-Hill.

Pilario, K. E. S. (2015). Nonlinear data reconciliation with gross error detection and identification for steady-state and dynamic processes (Master's thesis). University of the Philippines Diliman.

Seborg, D. E., Edgar, T. F., Mellichamp, D. A., and Doyle, F. J. III. (2016). *Process Dynamics and Control* 4th Ed. NJ: John Wiley and Sons Inc.