THE TEACHING OF UNDERGRADUATE PROCESS CONTROL

A Survey Prepared by the

Chemical Engineering Education Projects Committee

American Institute of Chemical Engineers

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INTRODUCTION

chemical engineering courses that began in 1971. Each survey

attempts to present the current text materials, course credits, curriculum placement, student enrollments, topical content and special features of one of about ten standard chemical engineering courses. The first cycle began with Mass and Energy Balances in 1971 and ended with Chemical Engineering Electives in 1980. The second cycle began with Mass and Energy Balances in 1981 and ended with Chemical Engineering Electives in 1989. The third cycle began with Mass and Energy Balances in 1990. This 1993 survey on Process Control is the fourth survey of the third cycle.

I. COURSE MECHANICS

This section of the report summarizes administrative factors. These include student enrollments and the time allocated to the course.

Course Length.

About 19% of the departments responding operate on the quarter system. The quarter lasts just over 10 weeks while the semester is [illegible]. Both time periods exclude final examinations periods.

COURSE LENGTH
(Quarter Basis)

Length	Departments
9 weeks	1
10 weeks	20
11 weeks	1
12 weeks	1
Average	10.1 weeks

COURSE LENGTH
(Semester Basis)

Length	Departments
12 weeks	3
13 weeks	15
14 weeks	33
15 weeks	36
16 weeks	11
18 weeks	1
Average	14.4 weeks

NUMBER OF COURSES

Courses	Departments
1	88
2	36

The Process Control course is usually taught at the senior level. Within the senior year, there is a slight preference for the second semester and the second quarter.

COURSE LEVEL
(Semester Basis)

Semester	Courses
Sophomore, Semester 1	1
Junior, Semester 1	8
Junior, Semester 2	19
Senior, Semester 1	33
Senior, Semester 2	36

(Quarter Basis)

Quarter	Courses
Junior, Quarter 1	2
Junior, Quarter 2	3
Senior, Quarter 1	7
Senior, Quarter 2	9
Senior, Quarter 3	2

There was a downward trend in the course level for the first process control course. The current survey indicates nearly twice the number of departments offering the course below the senior level as in 1985 or 1975.

COURSE LEVEL

Courses, %

	1993	1985	1975
Sophomore	1	--	--
Junior	27	15	13
Senior	72	85	87

Class Sessions.

In 71% of the departments process control meets for three hours lecture per week. In 65% of the departments there is no

Class Sections and Enrollment.

[redacted]

annually. 19% offer two sections. One-half of the sections have enrollments of 30 students or less. The average enrollment per section is 41.

NUMBER OF SECTIONS
(1992-93)

Sections	Departments
1	94
2	23
3	3
4+	4

COURSE ENROLLMENT
(1992-93)

Enrollment	Courses
1 - 10	9
11 - 20	21
21 - 30	29
31 - 40	26
41 - 50	8
51 - 60	3
61 - 80	6
81 - 100	8
100+	8
Average	41

II. BACKGROUND

This section examines the technical background of students enrolled in Process control.

Prerequisites.

The typical position of Process Control in the first or second semester of the senior year is reflected in the courses students have taken during their junior year. Nearly all students have taken Differential Equations and Calculus, and most have had

[redacted]

PREVIOUS COURSES

Course	Departments
Differential Equations	119
Calculus	108
Fluid Flow	87
Heat Transfer	84
Mass Transfer	72

Other courses listed as prerequisites included Kinetics & Reactor Engineering, Thermodynamics, Mass & Energy Balances, and Numerical Methods.

III. COURSE CONTENT

Textbook.

[redacted]

was no exception. The new text by Seborg, Edgar and Mellichamp was used in 54 courses (44%). Stephanopoulos' text was used in 24 courses (19%). Eight other texts were used in 42 courses.

TEXTBOOKS

Seborg, D. E., Edgar, T. F., Mellichamp, D. A.: Process Dynamics and Control.,

TOPICS COVERED

Topic	Lecture time, %
Process Dynamics & Modelling	28.1
Feedback Control & Tuning	22.1
Stability & Frequency Analysis	14.[illegible]
[illegible]	[illegible]
Advanced Control Techniques	8.4
[illegible]	[illegible]
Computer Control Systems	4.8
Other	5.7

Software Usage.

A large number of software packages were used to support the Process Control course, ranging from FORTRAN to MATLAB. MATLAB was the most frequent package reported for use with the course [illegible]

SOFTWARE USAGE

Software	Departments

University of Alabama

Course 1: Determination of Time Constants and Fitting FOPDT Model to Step-Response Data.
Course 2: Modeling and Digital Control of a Heat Exchanger.

University of South Alabama

Programmable Controllers/Ladder Logic
Calibration of Transmitters
Process Reaction Curves
Level Control in Multi-tank System
Level and Temperature Control

Self-Tuning Controllers

University of Alberta

Course 1:
1.Introductory Process Control - Step testing and empirical model derivation.
2. Feedback (PID) Control of a Pilot-Scale Process.
Course 2:

1. Process Model Identification and Verification.
2. Comparison of Feedback (PID) Control & Smith Predictor Control of a Process With Time-delay

Arizona State University

TDC 3000 System Overview
A/B Mixing Reactor Operation and Control 1st Order Systems Response Analysis

University of California, Berkeley

1. Heat Exch. F.B. & Gain Scheduling
2. Catalytic Fixed-Bed Reactor,F.B. & Auctioneering
3. Distillation Overhead System
4. Level F.B. & Cascade
5. Fired Heater F.B. & Gain Scheduling
SIMULATIONS
6. Continuous Blending F.B. & F.F.
7. Production Rate/Inventory control
8. Distillation col. override control
PROJECTS
1. Autothermal Reactor
2. Distillation Preheat
3. Steam Utility
4. Reaction/Separation Process
5. 4 Oil Filters Coordination

UCLA

Level control is prepared for unit operations.

University of California, Santa Barbara

Process: Stirred Tank Heating System
Controller Design: Level Control System
Controller Tuning
Feedforward - Feedback Control

California State University at Long Beach

Liquid Level Control

Drexel University

Solutions of differential equations by analog computer
Solutions of differential equations by digital computer

Lamar University

1. Atlantic Process Simulator
2. Ph Computer Control

Controller Tuning
Operation and tuning of control system using a

Lehigh University

Interacting Temp. and Level
Identification - step, ATU, sinewave, PRBS

University of Florida

Simulation of a two tank level control system
Tuning a single-loop PID controller
Tuning a multiloop PID control system

Louisiana State University

Testing of nonlinear process-gain

Mississippi State University
Liquid Level
Heat Exchanger Control

State University of N.Y. at Buffalo
Familiarization with Computer Controller

Advanced Control Using Pyroluminescent Regulometer

Air Pressure Dynamics of Tanks

Montana State University
Response of Thermocouples
Response of pH Electrode

North Carolina A&T
1. Dynamics and Control of a Thermal Process

Introduction to VC-ONLINE
Control of a Heat Exchanger
Control of a CSTR Reactor
Introduction to VC-Signal

4. Liquid Level Control for a Distillation Column
5. Flow Control

University of North Dakota

University of Puerto Rico

1. Temperature Control

Stanford University

Process Dynamics: Step change to three tanks in

Process Control: PID control of three tanks in series

Queen's University

Concentration Control in a Stirred Tank

Stevens Institute of Technology

Open-loop response of a liquid-level process.
Tuning of conventional feedback controllers.

Rensselaer Polytechnic Institute

Course 1:

1. Introduction to MATLAB
2. Iterative Solution of the van der Waal's equation of state
3. The logistic equation

Closed loop control and stability analysis of a "mystery" process.

Syracuse University

1. Calibration

4. Steady-state absorption column
5. Dynamic absorption column

2. System Modeling
3. PID Control

3. CSTR's in Series

Tuning of Level Controller

QUESTIONNAIRE ON THE TEACHING OF

UNDERGRADUATE PROCESS CONTROL

PROCESS CONTROL

UNIVERSITY_____INSTRUCTOR_____

Course No. TEXT (AUTHOR, TITLE) (Circle chapters covered)

1._____
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

2._____
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

1. What are the two main strengths of each textbook above?

2. What are the two main weaknesses of each textbook above?

3. Is your school on the semester or the quarter system?
(Circle one:) Semester Quarter

4. How many weeks of class (excluding final exams) are there in your semester/quarter? _____weeks.

	Course No. 1	Course No. 2
5. In which year do most students take		

[redacted]

6. In which semester/quarter) do most students take this course (1,2,3)?	_____	_____
7. How many sections of the course were offered in 1992-93?	_____	_____

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1. What are the two main strengths of each textbook above?

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3. Is your school on the semester or the quarter system?
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4. How many weeks of class (excluding final exams) are there in your semester/quarter? _____ weeks.

(circle 1)

Please list the prerequisite courses for Process Control	Course No. 1	Course No. 2
Calculus		
Differential Equations	_____	_____
Heat Transfer	_____	_____
Mass Transfer	_____	_____
Fluid Flow	_____	_____
Other _____	_____	_____
Other _____	_____	_____

11. How many hours laboratory are scheduled specifically for this course each week? _____ _____

12. If the process control course has no laboratory component, are process control experiments used in the Unit Operations Laboratory or equivalent? _____ _____

13. What computer software is used specifically in this course. _____ _____

15. Do graduate teaching assistants any lectures in this course? (yes/no) _____ _____

16. If the answer to the above is yes, about what percent (to the did TA's give? _____ _____

17. About what per cent of the lecture time (to the nearest 5%) is devoted to the following topics?

Process Dynamics & Modelling _____ _____

Computer simulation _____ _____

Control system hardware _____ _____

Feedback control & tuning

Computer control systems _____ _____

Advanced control techniques _____ _____

Stability & frequency analysis. _____ _____

18. How many major tests, excluding exams, are given in the course? _____ _____

19. Please list abbreviated titles of experiments related to this course.

15. Do graduate teaching assistants any lectures in this course? (yes/no) _____ _____

16. If the answer to the above is yes, about what percent (to the nearest 10%) of the lectures did TA's give? _____ _____

17. About what per cent of the lecture time (to the nearest 5%) is devoted to the following topics?

Computer simulation _____ _____

Control system hardware _____ _____

Feedback control & tuning _____ _____

Computer control systems _____ _____

Advanced control techniques _____ _____

Stability & frequency analysis. _____ _____

18. How many major tests, excluding exams, are given in the course? _____ _____

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