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

This survey is the twenty-second in a series on undergraduate 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.

A three-page questionnaire was mailed to the chairman of each chemical engineering department in the United States and Canada in April, 1993. A follow-up letter was sent in September to those departments which had not replied. Of the 172 departments contacted, 124 replied (72%). There were 96 responses to the 1992 survey on Chemical Engineering Thermodynamics and 106 responses to the 1991 survey on Kinetics/Reactor Design.

The analysis of the responses is usually presented at the Undergraduate Free Forum at the Annual Meeting of AIChE. A copy of the analysis is mailed to each chemical engineering department submitting a completed questionnaire.

The results from this survey will be compared with the 1985 survey on Process Control as appropriate.

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 less than 15 weeks long. 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

Most departments offer one required course in process control. 73% of the departments on the semester system and 50% of the departments on the quarter system offer one course. Of the 36 departments reporting two courses, 44% offer the second course as an elective. The remainder of the results presented in this survey are for the first course.

NUMBER OF COURSES

Courses	Departments
1	88
2	36

Course Level.

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
Junior, Quarter 3	1
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 laboratory associated with the course. However, in 55 departments (44%) control experiments are carried out in the unit operations or equivalent laboratory. A list of controls experiments is included at the end of this report.

LECTURE HOURS PER WEEK
(Based on 50-minute periods)

Hours	Departments
1	12
2	71
2.5	12
3	71
>3	11
Average	2.84

LABORATORY HOURS PER WEEK
(Based on 50-minute periods)

Hours	Departments
0*	81
1	10
2	7
3	24
4	2
Average	2.42

*excluded from average

Class Sections and Enrollment.

76% of the departments offer one section of Process Control 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

Graduate Assistants

Ten departments used graduate teaching assistants in the Process Control course. For nine of these the TA's gave 10% or less of the lectures. In one case a TA gave more than 10% of the lectures.

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 Fluids, and Heat and Mass Transfer as well.

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

This section deals with several aspects of the course content. These include textbook selection, topics covered and experiments associated with the course.

Textbook.

In almost every survey conducted over the past 20 years, one textbook is used significantly more than any others. This survey 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., Wiley, New York, 1989.

Stephanopoulos, G.: Chemical Process Control., Prentice-Hall, Englewood Cliffs, 1984.

Smith, C. A. and Corripio, A. B.: Principles and Practice of Automatic Process Control., Wiley, New York, 1985.

Coughanowr, D. R.: Process Systems Analysis and Control., McGraw-Hill, New York, 1991.

Luyben, W. L.: Process Modeling, Simulation, and Control for Chemical Engineers., McGraw-Hill, New York, 1990.

TEXTBOOK SELECTION

Author(s)	Courses
Seborg, Edgar & Mellichamp	56
Stephanopoulos	24
Smith & Corripio	14
Coughanowr	13
Luyben	8
8 other texts	7

Topics Covered.

Process dynamics and modelling received the greatest amount of lecture time (28% average) followed by feedback control and tuning. Computer control systems and control system hardware received relatively little treatment.

TOPICS COVERED

Topic	Lecture time, %
Process Dynamics & Modelling	28.1
Feedback Control & Tuning	22.1
Stability & Frequency Analysis	14.3
Computer Simulation	8.9
Advanced Control Techniques	8.4
Control System Hardware	7.7
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.

SOFTWARE USAGE

Software	Departments
MATLAB	30
PICLES	16
TUTSIM	13
CC	12
DIRA	8

Acknowledgements.

I would like to thank Kenneth Thomas for his help in compiling the results of this survey.

This work is dedicated to Dr. Edwin O. Eisen who conducted the surveys for chemical engineering courses for twenty years prior to his untimely passing this year. Dr. Eisen's work in preparing this survey and in devising the format for course survey reports in general is gratefully acknowledged.

PROCESS CONTROL EXPERIMENTS

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
Furnace Control Schematic and system Identification
Mixing Tank Dynamics
Heat Exchanger Instrumentation and Control
Furnace Custom Control Strategy

University of Auburn

Two-Tank Systems
Evaporator Control
Packed Distillation
Column Control
PLC

Brigham Young University

Shell & tube heat exchanger that contains three loops is used in the lab three different times. The final lab involves the students tuning one of the 3 loops from scratch.

University of British Columbia

Liquid Level Control

Bucknell University

Modelling 1st order systems, Linearized 1st order, Second order.
Frequency Response & Tuning
Drill sessions on Laplace and root locus.

University of Calgary

1) Behavior of Tanks in Series
2) Simulation of Heat Exchanger
3) Head Control of Tanks in Series
4) Heat Exchanger Temperature Control

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
Flow Control
Temperature Control
Cascade Control

Christian Brothers University

Single Tank Level Control
Two-Tank Level Control
Heat Exchanger Temp. Control
Pipe Flow Control
Working on Distillation Control

Clarkson University

Liquid Level Control

Colorado School of Mines

Dynamics of an Interacting Tank System
Control of an Interacting Tank System

University of Connecticut

Operation of a Bubble Cap Distillation Column
Pneumatic Control of a Heating Tank
Computer Control of Heating Tanks

University of Dayton

Liquid Level Control
Temperature & Liquid Level Control
PH Control
Heat Exchanger Control
Pressure Control

Drexel University

Solutions of differential equations by analog computer
Solutions of differential equations by digital computer
Dynamics of nonlinear liquid-level system
Control valves
Stability of closed-loop systems
Controller Tuning
Operation and tuning of control system using a commercial microprocessor-based system

University of Florida

Simulation of a two tank level control system
Tuning a single-loop PID controller
Tuning a multiloop PID control system
control of a distillation column using a Rosemount RS3 industrial computer.

University of South Florida

Controller Tuning
Programmable Logic Controllers

Georgia Tech

The Dynamics of Tanks in a Series
The Dynamics of Thermocouples
PID Control of a Heated Bar
Multivariable Control of a Mixing Tank
Distillation Control
Control of pH

University of Houston

Level control in a tank

Illinois Institute of Technology

1. Dynamic development for a heat exchanger - Reaction curve and statistical methods.
2. Feedback control of a heat exchanger, PI, IMC, direct synthesis

University of Iowa

1. Computer Simulation of Process
2. Dynamic Response of 2 Tank System
3. Dynamic Response of Heated Stirred Tank
4. Computer Control & Tuning of Heat Exchanger
5. Computer Control & Tuning of 3 Tank Level Control

University of Kansas

1. Level Control
2. Distillation Control

Data Acquisition On:

1. Fluid Flow
2. Heat Exchange
3. Transient Heat Exchange
4. Distillation

Lakehead University

Course 1:
Review of Hardware & Controller Tuning
Cascade Control
Course 2:
Flow/Level Trainer
Second Order Servomotor Position Control
First Order & Deadtime Air Temperature Control
Autodynamics Simulator & Tuning Rules
Logic Control of Pinball Machine

Lamar University

1. Atlantic Process Simulator
2. Ph Computer Control
3. Analog Liquid Level, Flow, Temp. Control
4. PID Tutorial
5. Valve Sizing/Selection

Lehigh University

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

Louisiana State University

Testing of nonlinear process-gain
Linear process dynamics - first-order, second-order noninteractive, 2nd-order interactive
Feedback control - tuning P,PI,PID
Ratio control of steam heater
Feed forward control of steam heater - static/dynamic
(Open-ended) multivariable control of a blending tank.

University of Maine

PID tuning of interactive tank level process
Digital FB, FFd, & Cascade cont. of shell & tube heat exch. using PC as controller (unit ops lab)
Pulse test identification of process

Manhattan College

1. Liquid Level Control
2. Heat Exchanger Computer Control

University of Maryland

Equipment Introduction
First Order System Response
Flow Meter Calibration
Frequency Response
Level Control

University of Mass. Lowell

1. Dynamics of a Surge Tank System
2. Dynamics of a Mixing Process
3. Liquid Level Control
4. Temperature control of a Heat Exchanger
5. Flow Characteristics and Dynamics of Control Valves

MIT

Temperature & Level Control of a Stirred Tank

McGill University

1. Process Reaction Curve
2. Controller Tuning

University of Minnesota

1. Computer Aided Process Identification
2. Computer Control of Level and Temperature in a Tank
3. Computer Control of pH

University of Missouri-Columbia

Computer Control of a Distillation Column
Liquid Level Control

Mississippi State University

Liquid Level
Heat Exchanger Control
Distillation Control
Advanced Control Using Pyroluminescent Regulometer

Montana State University

Response of Thermocouples
Response of pH Electrode
Control Valve Hysteresis
Introduction to VC-ONLINE
Control of a Heat Exchanger
Control of a CSTR Reactor
Introduction to VC-Signal
Relative Gain Analysis of Distillation Column
Control of Distillation Column
Experiment Performed on a PC

University of Nebraska

First-Order Dynamics: Pressure, Level, Temp., Analog simulation
Transfer Functions & Frequency Response: Heat Exchanger, Analog Simulation
Control(Feedback) & Stability: Pressure, Analog Simulation

University of New Brunswick

Control Level in a Tank

University of New Hampshire

Control Valve Calibration
Determination of Time Constants
Controller Tuning by Cohen-Coon
Controller Tuning Using Frequency Response
Data-Acquisition Hardware and Software

University of New Haven

Dynamic Model for Tanks in Series
Process Identification and Controller Tuning
Development of Dynamic Simulation Program
Addition of PI Control to Dynamic Simulation Program
Dynamic/Control Simulation using PICLES
Control Hardware Demonstrations

New Jersey Institute of Technology

Liquid Level Control
Process Identification/Frequency Response
Temperature Control

New Mexico State University

1. Determination of the valve coefficients for the holding tanks via dynamic height vs. time measurements
2. Comparison of theoretical and experimental results for a step change in the manipulated flow rate
3. Comparison of theoretical and experimental results for the feedback loop using appropriate tuning parameters for PID controller.
4. "In-the-field" tuning of controller to improve performance of theoretical tuning parameters.

State University of N.Y. at Buffalo

Familiarization with Computer Controller
Calibration of Computer Controller
Liquid Level Tank Dynamics
Air Pressure Dynamics of Tanks

North Carolina A&T

1. Dynamics and Control of a Thermal Process
2. Coupled Tank Liquid Level System
3. pH Control
4. Liquid Level Control for a Distillation Column
5. Flow Control

University of North Dakota

1. Dynamics of First Order Systems
2. Feedback Control Tuning

Northwestern University

1. Calibration of level control system, introduction to Program CC, & use of Laplace transforms to solve an engineering problem.
2. Dynamic responses of first-order systems.
3. Dynamic responses of second-order and third-order systems.
4. Introduction to controlled systems and control system hardware.
5. Dynamic responses of systems with feedback control.
6. Stability analysis and design of feedback control systems.
7. Analysis of frequency responses using Program CC.
8. Control system design using frequency response techniques.

Technical University of Nova Scotia

Level Control
Temp. Control
Level & Temp. Control
Pressure Control

Ohio University

Calibration of Controller
Dynamics of Steam-Jacketed Kettle
Process Reaction Curve for Three Element System
Computer Control of Steam-Jacketed Kettle
Control by the Methods of Ziegler-Nichols and Cohen-Coon
Computer Simulation for Distillation

University of Oklahoma

Liquid Level Control
Cascade Temperature Control

University of Western Ontario

Computer Control & Interfacing of:
CSTR
Heat Exchanger
Heat Transfer
Cooling Tower
Fluid Transport
Level Tank

University of Ottawa

Process Control for a Tank Cooler

University of Puerto Rico
1. Temperature Control
2. 1st & 2nd Order Level Control

Queen's University
Concentration Control in a Stirred Tank

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
4. Steady-state absorption column
5. Dynamic absorption column
6. Predator-prey (limit cycle) system
7. Eigenvalue/eigenvector analysis, phase plane plots for linear systems
8. Phase-plane analysis for nonlinear systems
9. Bioreactor models, phase-plane and stability analysis
10. Modeling, transfer function analysis and step responses
Course 2:
0. Simulink tutorial
1. Modeling and simulation of a heated mixing tank
2. PID control of the heated mixing tank
3. Internal model control of a system with inverse response and deadtime
4. IMC-based PID control of a bioreactor under open-loop stable and unstable conditions
5. Ziegler-Nichols
6. Frequency Response
7. MVSISO control of distillation columns

University of Rhode Island
A/D and D/A with Microcomputer
Controlling Level of Tank
Controlling Temperature
Dynamics of Heat Transfer

Rochester University
Distillation Column Control
Residence Times in Stirred Tanks
Temperature, Pressure, Flow & Concentration
Measurement Methods
Temperature Control Experiment
Heat Transfer in a Jacketed CSTR

Saskatchewan University
Data Acquisition
Feedback Control of a Surge Tank
Transfer Function
Feedforward & Feedback Control of a Stirred Tank Heater

South Dakota School of Mines & Tech.
Characterization of Feedback Control Elements
Characterization of a Process Controller
Control of Liquid Level in a Tank
Control Valve Characteristics

Stanford University
Process Dynamics: Step change to three tanks in series
Process Control: PID control of three tanks in series

Stevens Institute of Technology
Open-loop response of a liquid-level process.
Tuning of conventional feedback controllers.
Closed loop control and stability analysis of a "mystery" process.

Syracuse University
1. Calibration
2. System Modeling
3. PID Control
4. Level & Temperature Control
5. Advanced Control

Tennessee Technological University
1. Draining of Tanks
2. Mixing in Tanks System
3. Tuning of a Thermal System

University of Texas-Austin
1. Liquid Level Dynamics
2. PID Controller Tuning of Heat Transfer Expt.
3. Computer Control of Distillation Column

Texas A&M
1. APT Programs for Sequential Control
2. First Order Responses
3. Open Loop Reaction Curve Fitting
4. Feedback Control of Two Serial First Order Lags
5. Open Loop Heat Exchanger Testing
6. Closed Loop Heat Exchanger Control
7. PI and PID Control of Four Serial Lags
8. Cascade Control of Four Serial Lags

Texas A&I
Ht. Exp.
Level Exp.
Distillation Simulation

Texas Tech
Calibration of RTD & Orifice
Valve Characteristics
Steam/Water Shell-and-Tube Dynamics
SISO Feedback Controls Options & Tuning
Feedforward Control
Hot/Cold Mixing for RGA - Good and Bad Pairing

Toledo University
Process Dynamics Modeling I & II
System Identification
Control of Double Pipe Heat Exchanger
Control of 2 Stirred Tanks in Series

Toronto University
1. Modelling of a Stirred Tank Heater using Step Response Data
2. Modelling of a STH Using Statistical Identification
3. Feedback Control of a STH

Tri-State University
1. Unsteady State Dynamics With Tank Drainage
2. Behavior of First and Second Order Systems
3. CSTR's in Series
4. Proportional Control
5. PID Control
6. Computer Simulation

The University of Tulsa
Digital Control of Level in Tank

Tuskegee University, Al
Manual Control
Automatic On/Off Control
Proportional Control
Calibration of a Rotameter
Control Valve Characteristics
Controller Characteristics

Vanderbilt
Heat Exchange Control

Villanova
Complex Control & Dynamics
Computer Control

Virginia Tech
1. Flowing Water
2. Temperature of Slowing, Heated Gas
3. 4th-order op-amp system
4. Dow's Pyroluminescent Regulometer

Washington University, St. Louis
Level Control
Pressure Control
Temp & Level Control
Dynamics of Heated Rod
Dynamics of Packed Bed
Hot Air Blower

University of Washington
Level Control & Dynamics
Plant-Wide Control

Waterloo University
Level Controller
CSTR Heater

Wayne State University
Valve Dynamics
Flow Control

West Virginia University
1. Control of a Heat Exchanger
2. Control of Air Pressure in a Tank

West Virginia Tech
Tuning of Liquid Level Controller
Cascade Control of pH
Feedforward Heat Exchanger Temp.Control

University of Wisconsin
Simulation Workshop
Water Tank Systems Response
Tuning of Level Controller
Feedback, Feedforward, Cascade
One of Several:
Polymerization Reactor
Distillation Column
Packed Bed Reactor

Youngstown State University
Interacting and Non-Interacting Tanks
Proportional, Integral, Derivative Controller
Dynamics of Stirred Tank System

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 this course (Jr., Sr.)?	_______	_______
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?	_______	_______
8. What was the total student enrollment in all sections taught in 1992-93?	_______	_______
9. Is this course required or elective	__RE__	__RE__

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?

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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 this course (Jr., Sr.)?	______	______
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?	______	______
8. What was the total student enrollment in all sections taught in 1992-93?	______	______
9. Is this course required or elective	__RE__	__RE__

(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. ______ ______

14. Method of instruction:

Formal lectures	______	______
Self-Paced	______	______
Both	______	______

How many hours lecture are scheduled each week, (based on 50 minute periods). ______ ______

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?

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?

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.