DOC. NO. 131

SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE: PROCESS CONTROL

CODE NO. PPE 344-5 **SEMESTER:** V

PROGRAM: ENVIRONMENTAL ENG./PULP & PAPER/WATER RESOURCES

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DATE: DECEMBER 1994 **PREVIOUS OUTLINE DATED:** DECEMBER 1991

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DATE

PROCESS CONTROL — PPE 344-5

COURSE NAME — **CODE NO.**

TOTAL CREDIT HOURS: 80

PREREQUISITE(S): HYD220 HYDRAULICS

I. PHILOSOPHY/GOALS:

The course is designed to provide theoretical and practical knowledge of the fundamentals of process control systems. Particular emphasis is placed upon the functioning of the various components, including measuring devices and transducers, transmitters, controllers, and final control elements.

II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will be able to:

1. Describe applications of process control and recognize the basic control types.
2. Identify the functions of the components of a control loop and explain the difference between an open loop and a closed loop control using block diagrams.
3. Define and apply the principles of hydrostatics and fluid mechanics, and to use these concepts in appropriate applications.
4. Identify the characteristics and applications of various pressure measuring elements.
5. Select and apply a variety of pressure and level measuring devices.
6. Describe the function of a transmitter.
7. Describe the hardware used in pneumatic to electric and electric to pneumatic switching.
8. Explain the operation of an on-off control loop.
9. Describe the general characteristics and operation of the proportional control mode.
10. Define the purpose of and explain the operation of a control valve, identify control valve components, and select and specify control valves for various processes.

PROCESS CONTROL PPE 344-5

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III. TOPICS TO BE COVERED:

	TOPICS	**HOURS**
1.	Process Control Applications	3
2.	Control Loop Components	3
3.	Open and Closed Loop Control	3
4.	Principles and Applications of Hydrostatics and Fluid Mechanics - Hydrostatics - Pressure Measuring Scales - Fluid Mechanics	
5.	Characteristics and Applications of Pressure and Level Measuring Devices	
6.	Transmitter Function and Input/Output Calculations	3
1.	On/Off Control - The On/Off Control Mode - Error and Switching Cycle Time	6
3.	Proportional Control - The Proportional Control Mode - Controller Output Calculations	
3.	Control Valve Characteristics and Applications.	
		36
	Laboratory Exercises	16
	Interim Test/Final Examination	5
	Review	3

PROCESS CONTROL | PPE 344-5

.COURSE NAME | **CODE NO.**

IV. LEARNING ACTIVITIES	**REQUIRED RESOURCES**
A. LECTURES	
1.0 OVERVIEW OF AUTOMATIC CONTROL	MODULE I OVERVIEW OF AUTOMATIC CONTROL
Upon successful completion of this unit the student will be able to:	Read pp. 1-24 Complete Self-Test Questions 1 to 9.
1.1 Explain the purpose of automatic control.	INTRODUCTION TO PROCESS CONTROL Read Part 1; Section 1 Principles of Operation pp. 4-10
1.2 Describe some applications of control projects.	
1.3 Recognize the basic control types.	
2.0 HYDROSTATICS	
Upon successful completion of this unit the student will be able to:	MODULE 2 HYDROSTATICS Read pp. 1-18 Complete Self-Test Questions 1 to 7.
2.1 Define weight, mass, weight-density and specific gravity and to use these concepts in appropriate applications.	INTRODUCTION TO PROCESS CONTROL Read Part III, Section 4 General Information pp. 19-20
2.2 Calculate liquid pressure at any given depth.	
2.3 Demonstrate the use of Pascal's Law.	

PROCESS CONTROL | PPE 344-5

ZOURSE NAME | **CODE NO.**

IV. LEARNING ACTIVITIES	**REQUIRED RESOURCES**
3.0 PRESSURE MEASURING SCALES	
Upon successful completion of this unit the student will be able to:	MODULE 3 PRESSURE MEASURING SCALES
3.1 Define and differentiate between differential, atmospheric, absolute and gauge pressures.	Read pp. 1-13 Complete Self-Test Questions 1 to 8.
3.2 Use instrumentation to measure pressures.	INTRODUCTION TO PROCESS CONTROL Read Part III, Section 5 Direct-Measurement Hardware pp. 21-33
4.0 FLUID MECHANICS	
Upon successful completion of this unit the student will be able to:	MODULE 4 FLUID MECHANICS
4.1 Determine the flow pattern in a closed conduit.	Read pp. 1-19 Complete Self-Test Questions 8, 12 and 13 to 18.
4.2 Calculate velocities at any point of the pipe.	Read pp. 22-32 Complete Self-Test Questions 19 to 22.
4.3 Solve problems to find pressures, velocities and elevations in a fluid using Bernoulli's Law.	Read pp. 34-46 Complete Self-Test questions 26 to 36.
4.4 Calculate Reynold's No. for a given flow situation.	INTRODUCTION TO PROCESS CONTROL Read Part II; Section 6. Pneumatic Transmission Hardware pp. 34-47

PROCESS CONTROL | PPE 344-5

.COURSE NAME | **CODE NO.**

IV. LEARNING ACTIVITIES	**REQUIRED RESOURCES**
5.0 ON-OFF CONTROL	
Upon successful completion of this unit the student will be able to:	MODULE 5 ON-OFF CONTROL Read pp. 1-27 Read Self-Test Questions 1 to 6.
5.1 Explain the operation of a simple on-off control loop.	INTRODUCTION TO PROCESS CONTROL Read Part III; Section 7 Recording and Indicating Hardware pp. 48-51
5.2 Calculate the speed of response from the capacitance of and the net input into a process loop.	
5.3 Calculate "error" and "switching cycle time" for loops having differential gap and delayed response.	
6.0 PROPORTIONAL CONTROL	
Upon successful completion of this unit the student will be able to:	MODULE 6 PROPORTIONAL CONTROL Read pp 1-26 Complete Self-Test Questions 1 to 4.
6.1 Describe the general characteristics of the proportional control mode.	INTRODUCTION TO PROCESS CONTROL Read Part III; Section 9 Controllers and Alarms pp. 57-65
6.2 Express, in mathematical form, the operation of the proportional control mode.	
6.3 Calculate the output of a proportional controller depending on "gain" and "error".	Read Part IV; Section 11 Using a Loop Diagram pp. 75-76
6.4 Make a graphical representation of the controller-output calculation.	Read Part IV; Section 13 Loop Tuning pp. 83-84

PROCESS CONTROL | PPE 344-5

..COURSE NAME | **CODE NO.**

IV. LEARNING ACTIVITIES | **REQUIRED RESOURCES**

7.0 CONTROL VALUES

Upon successful completion of this unit the student will be able to:

MODULE 7 CONTROL VALVES

Read pp. 1-45
Complete Self-Test Questions 1 to 8.

7.1 Define the purpose of and explain the operations of a control valve.

INTRODUCTION TO PROCESS CONTROL

7.2 Identify control valve components and use control valve terminology and nomenclature correctly.

Read Part II; Control Valves and Positioners pp. 66-74

7.3 Calculate to flow through a control valve.

LABORATORY EXERCISES

Upon successful completion of these laboratory exercises, the student will be able to:

No. 1; Calibrate a Differential Pressure Transmitter (DPT) that may be used for the measurement of flow, level or pressure.

LABORATORY EXERCISE NO. 1

Calibration of a Differential Pressure Transmitter

No. 2; Perform flow measurements using an orifice plate and flange taps.

LABORATORY EXERCISE NO. 2

Flow Versus differential Pressure for an Orifice Plate

No. 3; Perform a calibration check on a DPT and measure the level of fluid in a tank using a DPT.

LABORATORY EXERCISE NO. 3

Level Measurement of an Open Tank

PROCESS CONTROL PPE 344-5

:OURSE NAME **CODE NO.**

IV. LEARNING ACTIVITIES	**REQUIRED RESOURCES**
No. 4; Determine the response characteristics of an electronic and/or a pneumatic DPT.	LABORATORY EXERCISE NO. 4 Pressure Transmitter Response Check
No.5; Select and install the necessary instruments/equipment for a simple feedback control loop for a flow process.	LABORATORY EXERCISE NO. 5 Flow Process Control Loop Hook-Up
No. 6; Select and install the necessary instruments/equipment for a simple feedback control loop for a level process.	LABORATORY EXERCISE NO. 6 Level Process Control Loop Hook-Up
No. 7; Select and install the necessary instruments/equipment for a simple feedback control loop for a pressure process.	LABORATORY EXERCISE NO. 7 Pressure Process Control Loop Hook-Up
No. 8; Operate the flow process and describe the automatic flow control loop action.	LABORATORY EXERCISE NO. 8 Operating the Flow Process Loop
No. 9; Operate the level process and describe the automatic level control loop action.	LABORATORY EXERCISE NO. 9 Operating the Pressure Process Loop
No. 10; Operate the pressure process and describe the automatic pressure control loop action.	
OPTIONAL	
No.11; Use standard process instrumentation and analyze the effects of set point and gain changes (upsets) and using the observed information, determine the optimum settings required to time the controller.	LABORATORY EXERCISE NO. 11 Ultimate Period Timing of a Flow Process

PROCESS CONTROL PPE 344-5

ZOURSE NAME **CODE NO.**

V. METHOD OF ASSESSMENT: **GRADING:**

Assignments/Laboratory Exercises	25%	A+	90-100%
Interim Test	25%	A	80- 89%
Quiz Tests	15%	B	70-79%
Final Examination	35%	C	60-69%

A passing grade will be based on a minimum composite grading of 60%. Students obtaining a composite grading of 55% to 59% may be allowed to complete a supplementary examination.

VI. REQUIRED STUDENT RESOURCES:

PPE344 - Proces Control Lab Manual - Campus Shop

VII. **ADDITIONAL RESOURCE MATERIALS AVAILABLE IN THE COLLEGE LIBRARY BOOK SECTION:**

Introduction to Process Control, Publication 105B by The Foxboro Company.

Process Measurement Fundamentals, Vol. 1; by T.E. Collis, E.M. Eacho, ^J.P. Jerald, and M.K. Reardon; General Physics Corporation.

Process Control Fundamentals; by Quintech Division of Lab-Volt.

Instrumentation, Third Edition; by F.W. Kirk and N.R. Rimboi. American Technical Publishers, Inc.

Automation and Instrumentation, AWWA Manual M2, Second Edition, American Water Works Society.

Process Instrumentation and Control Systems - Manual of Practice No. OM-6 Water Pollution Control Federation.

VIII. **SPECIAL NOTES**

Students with special needs (e.g. physical limitations, visual impairments, hearing impairments, learning disabilities) are encouraged to discuss required accommodations confidentially with the instructor.

Your instructor reserves the right to modify the course as he/she deems necessary to meet the needs of students.