Fall 2013

DEPARTMENT OF CHEMICAL ENGINEERING
WEST VIRGINIA UNIVERSITY

ChE 435

Chemical Process Control -
Process Dynamics, Instrumentation & Control

Tuesday, Thursday 9:30 - 10:45 a.m.

Room 401 ESB

Instructor: John W. Zondlo
Office: Room 415 ESB
Phone: 293-9366
Office Hours: Wednesday 1:00 - 3:00 or preferably by appointment. Please feel free to stop in at any time and discuss problems you are having. **If you have trouble with the material, don't wait till the end of the semester to ask for help!!!**

Recommended Text:

Process Systems Analysis and Control, D. R. Coughanowr and S. LeBlanc, Third Edition, McGraw-Hill, 2008. (This is the latest revision of an old standard text)

Reference Texts:

** Chemical Process Control, Second Edition, James R. Riggs, Ferret Publishing, Lubbock, TX, 2001. (Jim Riggs used to teach at WVU!!)

Process Control, P.C. Chau, Cambridge University Press, 2002 (Paper Back Edition)

Engineering Experimentation - Ideas, Techniques and Presentation, M.S. Ray, McGraw-Hill Book Company, 1988.

** Process Control - Designing Processes and Control Systems for Dynamic Performance, Second Edition, T.E. Marlin, McGraw Hill, 2000.

Process Dynamics, Modeling and Control, B.A. Ogunnaike and W.H. Ray, Oxford University Press, 1994.

Process Dynamics and Control, D. E. Seborg, T. F. Edgar and D. A. Mellichamp, John Wiley & Sons, 1989.

Chemical Process Control, An Introduction to Theory and Practice, G. Stephanopoulos, Prentice-Hall, 1984. (This is a very readable book)

** Process Systems Analysis and Control, D. R. Coughanowr and L. B. Koppel, First Edition, McGraw-Hill Book Company, 1965.

** Process Modeling, Simulation, and Control for Chemical Engineers, W. L. Luyben, McGraw-Hill, 1973.

Process Dynamics and Control Vol. I & II, J. M. Douglas, Prentice-Hall, 1972.

** Process Control Systems, F. G. Shinskey, McGraw-Hill, 1979.

** Principles and Practice of Automatic Process Control, C. A. Smith and A. B. Corripio, J. Wiley & Sons, Inc., 1985.

** Chemical Engineers Handbook, J. Perry (editor) Fifth Edition, 1973; Sixth Edition 1985.

** An Introduction to Process Dynamics and Control, T.W. Weber, J. Wiley, 1973.

** ISA Handbook of Control Valves, J.W. Hutchison (editor), ISA, 1971

** Instruments for Measurement and Control, Second Edition, W.G. Holzbock, Reinhold Publishing Corp., 1962.

** Measurements and Control Applications, Second Edition, J.O.Hougen, Instrument Society of America, 1979.

Feedback and Control Systems, J. DiStefano, A. Stubberud and I. Williams, Shaum's Outline Series, McGraw-Hill, 1967. (A source of many example problems)

Chemical Engineering, October 15, 1979 issue, McGraw-Hill. Entire volume dedicated to process control and instrumentation. (A good source of basic information)

Process Dynamics, Control & Protection, B. Roffel and J. E. Rijnsdorp, Ann Arbor Science, 1982.

Instrumentation for Process Measurements and Control, Third Edition, Norman A. Anderson, Chilton Co., Radnor, PA, 1980.

Experimental Methods for Engineers, Fourth Edition, J. P. Holman, McGraw-Hill, 1985.

Fundamentals of Temperature, Pressure and Flow Measurements, Third Edition, Robert P. Benedict, John Wiley & Sons, 1984.

** Books in Chemical Engineering Library

In addition to these required and reference texts, there will be class handouts illustrating special topics or detailing lecture material as needed. **You will want to obtain a large 3-ring binder to store and organize these handouts.** Also a plant trip to some local industry to view their control

systems may be arranged.

Basis for Course Grade:

Hour Exam I	= 20%
Hour Exam II	= 20%
Final Exam	= 30%
Homework	= 15%
Design & Special Projects	= 15%
	100%

Course Objectives:

"People who don't know where they're going usually wind up somewhere else."

1. To obtain a thorough understanding of the fundamental principles of dynamic systems both from a theoretical as well as a physical viewpoint and perform related calculations.
   -- First, second and higher-order systems
   -- Closed-loop analysis
   -- Dead time

2. To learn about the basic components of a control loop and the function of each.
   -- Closed-loop feedback control

3. To understand a 3-mode feedback controller by performing calculations on:
   -- Modes of control
   -- Methods of controller tuning
   -- Stability of a control loop

4. To gain an appreciation for the basic measurements and instrumentation commonly found in the chemical process environment.
   -- Various process measurements in the Chemical Plant
   -- Variety of sensors
   -- Control valve operation and sizing

5. To integrate topics in this course to plant design and safety as well as plant operations.

6. To have fun learning about Process Control!

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Department of Chemical Engineering
West Virginia University

ChE 435 - Chemical Process Control
Process Dynamics, Instrumentation and Control

COURSE OUTLINE

TEXT: Process Systems Analysis and Control, D. R. Coughanowr and S. LeBlanc, Third Edition, McGraw-Hill, 2008.

A. PRACTICE — Chapter in text

I. Introduction to Process Control — Chapter 1

- a. Need for Process Control
- b. Control Systems
  - i) Components of a Control System
  - ii) Control Strategies
  - iii) Terminology
  - iv) Control Loop Diagrams
  - v) Problems with Chemical Process Control

II. Instrumentation and Hardware — See class handouts

- a. Important Measurement Characteristics
- b. P&ID Specifications
- c. Types of Measurements
  - i) Temperature
  - ii) Pressure
  - iii) Liquid Level and Density
  - iv) Flow Rate
  - v) Concentration
- d. Control Valves — Chapter 19
  - i) Valve Types & Selection
  - ii) Valve Sizing
- e. Transducers and Converters
  - i) Pneumatic to Electronic
  - ii) Analog to Digital
- f. Specifying and Ordering Hardware

B. THEORY

III.	Process Dynamics and Analysis		
	a.	Laplace Transforms	Chapter 2
	b.	Transfer Functions	
	c.	First-Order Systems	Chapters 3
		i) Examples of first-order systems	
		ii) Response of first-order systems	
		iii) Characteristics of first-order systems	
	d.	Second-Order Systems	Chapter 3
		i) Examples of second-order systems	
		ii) Response of second-order systems	
		iii) Characteristics of second-order systems	
	e.	Higher-order Systems	Chapter 3
		i) Examples of higher-order systems	
		ii) Response of higher-order systems	
	f.	Dead Time	Chapter 3
IV.	Controllers		
	a.	Function and Operation	Chapter 5
	b.	Modes of Control	
	c.	Controller Tuning Methods	Chapter 6
		i) Closed-loop Methods	& Class
		ii) Open-loop Methods	Notes
	d.	Control Strategies Revisited	Chapters 6 & 10
		i) Process characteristics	
		ii) Common control loops	
		iii) Things to look for	
		iv) Control objectives	
V.	Feedback Control Systems		
	a.	Controllers - Transfer function	Chapter 5
	b.	Block Diagrams	
	c.	Closed-Loop Analysis	Chapters 5 & 6
		i) Transfer functions	
		ii) Closed-loop responses	
	d.	Stability	Chapter 7
	e.	Dead Time Revisited	Chapter 3

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Instructions for Homework Problems

1. Paper: Use standard 8 1/2" x 11" paper. Write on one side only. Do not use spiral bound notebook paper.

2. References: All data not given in the problem statement must be referenced. Example: McCabe, W. L., and J. C. Smith. Unit Operations of Chemical Engineering, 3rd ed., McGraw-Hill, New York, 1978, pp. 279-285.

3. Final Answer: Box the final answer.

4. Intermediate answers: Underlined with a single line all intermediate answers.

5. Arrangement of problems:

   a. Given: all data given in the original statement of the problem.

   b. Required: answer sought (if more than one, list separately).

   c. Solution: all calculations arranged chronologically.

*6. **Due Date: 1 week after problems are handed out whether this is stated explicitly or not. Late work will not be accepted without the instructor's permission.**

7. Submission:

   a. If an assignment consists of more than one page, it must be stapled and handed in FLAT (not folded).

   b. Record in the upper right corner of each page

      (1) Name
      (2) Course number
      (3) Date due
      (4) Problem number and page

   c. Each problem should begin on a new page.

   d. **Please make your work neat and legible**.