**`CBE 400**
**INTRODUCTION TO PRODUCT AND PROCESS DESIGN**
**FALL 2016**

Lecture: MWF: 9:00am – 9:50am: 313 Towne
Recitation: M: 5:00pm – 6:30pm: 337 Towne
No Classes: 9.5 (Labor Day), 10.7 (Fall Break), 11.25 (Thanksgiving Break)
Office Hours: Scheduled before homework assignments are due: Rooms: to be announced
Tues., 1:00-2:00 p.m. (Holleran); TAs: to be announced

**Instructors:** Prof. Warren D. Seider; 372 Towne; 215.898.7953; seider@seas.upenn.edu
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Prof. Leonard A. Fabiano; 312 Towne; 610-745-2892; lfabiano@seas.upenn.edu – both active in CBE 459, less active in CBE 400

**Teach Asst:** Jason Rossi, 1150 Vagelos; 508-212-5791; rossijas@seas.upenn.edu
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**Text:** Seider, W.D., D.R. Lewin, J.D. Seader, S. Widagdo, R. Gani, and K.M. Ng, *Product and Process Design Principles: Synthesis, Analysis, and Evaluation,* Fourth Edition, Wiley, 2017.

Lewin, D. R., et al., *Using Process Simulators in Chemical Engineering: A Multimedia Guide for the Core Curriculum*, available from Wiley web site associated with textbook.

**Outline:**
Introduction to Chemical Product Design
Energy Sources,
Engineering Ethics
Process Creation – Preliminary Process Synthesis
Heuristics for Process Synthesis
Process Simulation – ASPEN PLUS, SUPERPRO DESIGNER
Synthesis of Separation Trains, Azeotropic Distillation
Second Law Analysis – Thermodynamic Efficiency, Lost Work Analysis
Synthesis of Heat Exchanger Networks
Detailed Equipment Design – including Heat-Exchanger Design
Capital Cost Estimation; Time Value of Money
Product Design – Molecule and Mixture Design, Home Hemodialysis Device
Selection of Design Projects for CBE 459; Begin Work on Design Projects for CBE 459

**Exams:**

| | |
|---|---|
| 1 hour [ First Exam ] | Wednesday, October 5 (9:00am – 10:00am) |
| 1 hour [ Second Exam ] | Friday, November 18 (9:00am – 10:00am) |
| 2 hours [ Final Exam ] | Tuesday, December 20 (9:00am – 11:00am) |

**Homework:** Average for all homework = 1 exam grade; All assignments must be submitted.

**Web Sites:** For the latest information concerning CBE 400, access the Product and Process Design Web Page (www.seas.upenn.edu/~seider/design.html). Also, see the Canvas website to obtain the latest homework assignments and course announcements.

**Fall Picnic:** Sun., Sept. 18, 1:00 pm – Seider home, 6 Rose Valley Rd, Rose Valley, PA; 610-566-0905; Volley ball, basketball, croquet, badminton; Short walk from Moylan-Rose Valley Station; Sign-up with Denice Gorte.

**Course Learning Objectives:**

After completing this course, students will:

1. have been introduced to the strategy of product design involving basic chemicals, devices, functional, and formulated chemical products.

2. be able to carry out process synthesis using heuristics and process simulation methods.

3. have carried out several process simulations using ASPEN PLUS and SUPERPRO DESIGNER.

4. have learned to synthesize distillation trains for nearly-ideal mixtures, and have been introduced to the synthesis of distillation trains for azeotropic mixtures.

5. be able to carry out second-law analysis; that is, calculate the lost work and thermodynamic efficiency for a chemical process.

6. be able to carry out heat integration of process flowsheets.

7. be able to design a heat exchanger

8. be able to size and estimate the costs for distillation complexes, heat exchangers, pumps, compressors, expanders, and other kinds of equipment, using many cost equations.

9. have been introduced to the design of molecule and mixture chemical products.

10. have been assigned a CBE 459 product/process design project, and through solution of many homework exercises, be prepared to carry out the design effectively.

## CONSIDERATIONS IN DESIGN COURSES

**Prior Courses**

| | **New Concepts in Design Courses** |
|---|---|
| Material and Energy Balances | Few |
| Thermodynamics | Few |
| Fluid Mechanics | Few |
| Heat and Mass Transfer | Few |
| Separations | Few |
| Reactor Design | In Parallel |
| Process Control | In Parallel |

**Design Course Emphasis**

How to design a chemical product/process using these concepts

How to identify the important alternatives – how to select the best (optimize)

Like painting a painting, composing a symphony – using the basics

How to work in a team to design a product/process

Prepares you for work as a chemical engineer – in industry and government labs – less in patent offices, medical facilities, food manufacturing, etc.

**Textbook**

Attempts to cover important design subjects

Often accompanies lectures – which draw attention to important subjects

Lectures help you navigate

Difficult to use book easily without attending lectures

Homework exercises often involve techniques described in textbook

Learn to use the extensive index

Warning – for some subjects, has more detail than you need

For example, Chapter 16 – for some designs, too much detail for selecting and sizing equipment – important only when needed

On your design projects, industrial consultants often help you navigate.

# Chemical Product and Process Design Courses

## Overview

For over 70 years, the Department of Chemical and Biomolecular Engineering has offered a two-course sequence in product and process design. The Fall course, CBE 400, is a lecture course that introduces the basics of product and process design. The Spring course, CBE 459, has been devoted entirely to the solution of design problems in groups of two, three, or four students. Timely problems are provided mostly by consultants from the local chemical industry who visit the University on Tuesday afternoons to assist the students throughout the Spring semester.

For a description of the courses, see Capstone Chemical Product and Process Design Courses: Industry and Faculty Interactions, an article prepared for the Capstone Design Conference, University of Illinois, May 31-June 2, 2012. Also, see the course syllabus for CBE 400 and CBE 459, the list of Reserve Books in the Rosengarten Reserve Room, Ground Floor of the Van Pelt Library, and a website that provides special assistance for CBE 400-459 students provided by the Librarians.

## Student Design Projects

The 2015-2016 Industrial Consultants have provided projects (2015-2016), currently being solved by 11 design groups (2015-2016). See the schedule of visits by the industrial consultants for Spring 2016. Also, see our recommendations for executing the CBE 459 design project in the Spring of 2016.

Since 1978, the Melvin C. Molstad Prize has been awarded annually to the most outstanding design group in the senior class. Also, since 2000, three of our best design groups have competed in the Engineering Alumni Design Competition.

## Teaching Tool Development

During the summer of 1994, work was begun to create a multimedia module to teach the basics of the simulation of chemical processes using the ASPEN PLUS and HYSYS simulators. An article entitled "An Interactive Approach to Teaching Steady-state Simulation of Chemical Processes" was prepared for the *Computer Application in Engineering Education* journal.

From 1996-2000, the two courses were upgraded in cooperation with colleagues at Princeton and Lehigh Universities and funded by the NSF Combined Research-Curriculum Development Program. For an overview of the changes, see the Project Description. Also, see the paper entitled "Experiences in Team-Teaching a Process Design Course Covering Steady-state Synthesis, Optimization, and Control."

Recently, the third edition of our textbook *Product and Process Design Principles: Synthesis, Analysis and Evaluation* (Seider, W. D., J. D. Seader, D. R. Lewin and S. Widagdo, Third Edition, Wiley, 2009) was published. You can access the multimedia module from the Instructor or Student Companion websites. Click on using Process Simulators in Chemical Engineering Software. Also, you can obtain 71 design problem statements. Click on PDF Files, then Appendix II.pdf