

CBE 400
INTRODUCTION TO PRODUCT AND PROCESS DESIGN
FALL 2017

Lecture: MWF: 9:00am – 9:50am: 313 Towne

Recitation: M: 5:00pm – 6:30pm: 337 Towne

No Classes: 9.4 (Labor Day), 10.6 (Fall Break), 11.24 (Thanksgiving Break)

Office Hours: Scheduled before homework assignments are due (mostly Wednesdays): Rooms: to be announced
Thu., 1:30-2:30 p.m. (Holleran); TAs: to be announced

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both active in CBE 459, less active in CBE 400

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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.

Outline: **Introduction to Chemical Product Design (new-4E)**
Energy Sources (new-4E)
Engineering Ethics (new-4E)
Process Creation – Preliminary Process Synthesis (revised-4E)
Heuristics for Process Synthesis (revised-4E)
Process Simulation – ASPEN PLUS, SUPERPRO DESIGNER (revised-4E)
Synthesis of Separation Trains, Azeotropic Distillation (revised-4E)
Second Law Analysis – Thermodynamic Efficiency, Lost Work Analysis (new-4E)
Synthesis of Heat Exchanger Networks (revised-4E)
Detailed Equipment Design – including Heat-Exchanger Design
Capital Cost Estimation; Time Value of Money (revised-4E)
Product Design – Molecule and Mixture Design, Functional Products (new-4E)
Selection of Design Projects for CBE 459; Begin Work on Design Projects for CBE 459

Exams: 1 hour [First Exam] Wednesday, October 4 (9:00am – 9:50am)
1 hour [Second Exam] Friday, November 17 (9:00am – 9:50am)
2 hours [Final Exam] Friday, December 15 (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., Oct. 1, 1:00 pm – Seider home, 6 Rose Valley Rd, Rose Valley, PA; 610-566-0905; Volleyball, 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, and functional product design.
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, pharmaceutical, food, and electronic materials, manufacturing facilities, and so on.

Textbook

Attempts to cover important design subjects

Accompanies lectures – which draw attention to important subjects

Lectures help you navigate

Homework exercises often involve techniques described in textbook

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. Lectures and homework exercises try to indicate the level of detail 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 [for 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 [2016-2017 Industrial Consultants](#) have provided [projects \(2016-2017\)](#), currently being solved by 10 [design groups \(2016-2017\)](#). See the [schedule of visits](#) by the industrial consultants for Spring 2017. Also, see our recommendations for [executing the CBE 459 design project](#) in the Spring of 2017.

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 fourth edition of our textbook [Product and Process Design Principles: Synthesis, Analysis and Evaluation](#) (Seider, W. D., D.R. Lewin, J.D. Seader, S. Widgado, R. Gani, and K.M. Ng, Fourth Edition, Wiley, 2017) was published.

CBE 400 TEXTBOOK
PRODUCT AND PROCESS DESIGN PRINCIPLES

Seider, Lewin, Seader, Widagdo, Gani, Ng

Fourth Edition, Wiley, 2017

Fourth Edition has been reorganized, with several new chapters, recent financial estimates, improved spreadsheets, more complete Wiley website. It can be purchased as follows:

1. Softbound print copies (732 pages) are available from Penn bookstore for \$145 and from the Wiley website (<http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP003653.html?filter=TEXTBOOK#purchase>) for \$142. Hardbound print copies are not available.
2. Vital Source E-book (HTML with links, extensive search facilities) is available from the Penn bookstore and the Wiley website for \$64. VS E-book can be operated using a personal computer (laptop) on the Internet as well as downloaded for operation without the Internet. I will demonstrate in class.
3. Kindle E-PDF E-book (an exact copy of the softbound print copies), which contains a PDF file that runs on a personal computer (without links and extensive search facilities) can be purchased from Amazon.com for \$64.
4. E-PDF E-book (an exact copy of the softbound print copies), which contains a PDF file that runs on a personal computer (without links and extensive search facilities), has appeared. Its source and cost are unknown. Please purchase a legitimate/ethically correct copy.

Exams are open-book, open-notes. You can bring your printed book and/or laptop. Computers may be used solely to access the E-book.

W. D. Seider
Aug. 26, 2017