

**CBE 4000**  
**INTRODUCTION TO PRODUCT AND PROCESS DESIGN**  
**FALL 2022**

**Lecture:** MWF: 10:15am – 11:15am / 311 Towne  
**Recitation:** M: 5:15pm – 6:45pm / 311 Towne  
**No Classes:** 09.05 (Labor Day), 10.07 (Fall Break), and 11.25 (Thanksgiving Break)  
**Office Hours:** TBA

**Instructors:** **Prof. Warren D. Seider** 372 Towne / 215-898-7953 / [seider@seas.upenn.edu](mailto:seider@seas.upenn.edu)  
**Dr. Sean P. Holleran** 354 Towne / 215-898-9879 / [seanholl@seas.upenn.edu](mailto:seanholl@seas.upenn.edu)  
**\*Prof. Bruce M. Vrana** 312 Towne / 302-690-0032 / [vrana@seas.upenn.edu](mailto:vrana@seas.upenn.edu)  
**\*Prof. Leonard A. Fabiano** 312 Towne / 610-745-2892 / [lfabiano@seas.upenn.edu](mailto:lfabiano@seas.upenn.edu)  
(\* ) = both active in CBE 4590, less active in CBE 4000

**Teach Asst:** Mitchell Daneker / [mdaneker@seas.upenn.edu](mailto:mdaneker@seas.upenn.edu)  
Monika Ramini / [mramini@seas.upenn.edu](mailto:mramini@seas.upenn.edu)

**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.

**Multimedia** Seider, W.D., D.R. Lewin, J.D. Seader, C. Novak, and A. Kishun,  
*Using Process Simulators in Chemical Engineering,*  
available free through UPenn CETS – <https://www.seas.upenn.edu/~cbe400/aspenn/>

**Outline:** **Introduction to Chemical Product Design** (new-4E) / Chap 1  
**Process Creation – Preliminary Process Synthesis** (revised-4E) / Chap 2  
**Heuristics for Process Synthesis** (revised-4E) / Chap 6  
**Process Simulation – ASPEN PLUS** (revised-4E) / Chap 7  
**Synthesis of Separation Trains, Azeotropic Distillation** (revised-4E) / Chap 9  
**Second Law Analysis – Thermo Efficiency, Lost Work Analysis** (new-4E) / Chap 10  
**Synthesis of Heat Exchanger Networks** (revised-4E) / Chap 11  
**Detailed Equipment Design – including HX Design** (revised-4E) / Chap 12, 13  
**Capital Cost Estimation; Time Value of Money** (revised-4E) / Chap 17  
**Profitability Analysis** (revised-4E) / Chap 17  
**Selection of Design Projects for CBE 4590; Begin on Design Projects for CBE 4590**

**Exams:** First Midterm Exam (25%) PM Session on Monday October 10  
Second Midterm Exam (25%) PM Session on Monday November 14  
Final Exam (40%) TBA (will update when available)

**Homework:** All assignments must be submitted. Homework will be graded (10%) – solutions will be evaluated by the TAs and returned to the students. Students are responsible for concepts.

**Fall Picnic:** Saturday [ September 10 or September 17 or September 24 ]

## Course Learning Objectives:

After completing this course, students will:

1. have been introduced briefly to the strategy of chemical product design.
2. be able to carry out process synthesis using heuristics and process simulation methods.
3. have carried out several process simulations using ASPEN PLUS.
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. be able to carry out a profitability analysis for a chemical process design.
10. for students not participating in an interdisciplinary senior design (ISD) project, have been assigned a CBE4590 product/process design project, and through solution of many homework exercises, be prepared to carry out the design effectively.

## 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 4000, is a lecture course that introduces the basics of product and process design. The Spring course, CBE 4590, 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 4000](#) and for [CBE 4590](#), the list of [Reserve Books](#), and a website that provides special assistance for CBE 4000 and 4590 students provided by the [Librarians](#).

### Student Design Projects

The [2021-2022 Industrial Consultants](#) have provided [projects \(2021-2022\)](#), currently being solved by 9 [design groups \(2021-2022\)](#). See the [schedule of visits](#) by the industrial consultants for Spring 2022. Also, see our recommendations for [executing the CBE 4590 design project](#) in the Spring of 2022.

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](#). CBE 4590 design project reports are stored in the [Penn library system](#).

### 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 4000 TEXTBOOK**  
**PRODUCT AND PROCESS DESIGN PRINCIPLES**

**Seider, Lewin, Seader, Widagdo, Gani, Ng**

**Fourth Edition, Wiley, 2017**

We will be using the Fourth Edition of *Product and Process Design Principles*, which has been reorganized, with several new chapters, recent financial estimates, improved spreadsheets, and a more complete Wiley website. In CBE 4000 and 4590, we will be emphasizing Chapters 1-3, 6, 7, 9-14, 16, and 17. The book can be purchased as follows:

1. Vital Source E-book (HTML with links, extensive search facilities) is available from the Penn Bookstore and the Wiley website for \$96.

<https://www.wiley.com/en-us/Product+and+Process+Design+Principles%3A+Synthesis%2C+Analysis+and+Evaluation%2C+4th+Edition-p-9781119475262>

The VS E-book can be operated using a personal computer (laptop) on the Internet as well as downloaded for operation without the Internet. It contains 90 video clips (~10-min lectures) in Chapters 2, 6, 9, 11, 16, and 17. Rental copies are available for \$33 (120 days) and \$38 (150 days).

2. Softbound print copies (784 pages) are available from the Penn Bookstore and from the Wiley website for \$125.95. Rental copies are available from Wiley for \$40 (130 days).

<https://www.wiley.com/en-us/Product+and+Process+Design+Principles%3A+Synthesis%2C+Analysis+and+Evaluation%2C+4th+Edition-p-9781119475262>

Hardbound print copies for the fourth edition are not available. Also, video clips are not available with softbound print copies.

3. 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 **illegally**. Please don't use it. Note – the sites distributing the PDF are often from dubious international websites that have been known to distribute viruses.

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  
August 31, 2022