

**ChBE 4505/4525 Chemical Process Design/Biochemical Process Design  
Basic Curriculum and Learning Outcomes.**

**Credit:** 3-0-3

**Instructor:** Matthew J. Realff

**Textbook:** *Product & Process Design Principles*, Third Edition, Wiley 2009. W.D. Seider, J.D. Seader, D.R. Lewin, S. Widagdo,

**Catalog Description:** Principles of flowsheet synthesis and economic analysis and optimization. A complete design on a chemical process will be undertaken, including concepts of unit operations, design, economics, and safety.

**Prerequisites:** Transport Phen. II (ChBE 3210), Kinetics & Reactor Design (ChBE 4300), and separation processes (ChBE 3225). A minimum grade of C is required in all three courses. Process safety course (ChBE 4515) is a co-requisite, it may be taken simultaneously with the process design.

**Objectives:** To enable students to synthesize their previous course work in the context of a significant problem-solving task, a process design. To teach students basic concepts in process design; bounding, searching over discrete and continuous alternatives, targeting, tradeoffs. To teach students basic skills in process design; economic evaluation, sizing and costing of process units, process simulation, basic optimization. To create a situation where the students must operate in diverse teams of mixed ability.

**Learning Outcomes:** By the end of this course, a student should be able to:

1. Be knowledgeable about the kinds of design decisions that challenge process design teams. (Student Outcomes: a, c, d, e, f, g, h, i, k)
2. Understand the key steps in carrying out the design of a chemical process. (Student Outcomes: a, b, c, e).
3. Be aware of the many kinds of environmental issues and safety considerations in process design. (Student Outcomes: f, g, h, i, j)
4. Appreciate the importance of maintaining high ethical principles in process design. (Student Outcomes: f, g, h, i, j)
5. Understand process simulators and be able to use them in process creation, equipment sizing and costing, profitability analysis, and optimization. (Student Outcomes: a, b, c, e, k)
6. Understand the importance of selecting reaction paths that do not involve toxic or hazardous chemicals, and when unavoidable, to reduce their presence by shortening residence times and reducing storage. (Student Outcomes: a, b, c, e, f, j, k)

7. Be able to distribute the chemicals, when designing a process flowsheet, to account for the presence of inert species, to purge species that would otherwise accumulate to unacceptable levels, to achieve high selectivity to the desired products, and to accomplish reactions and separations in the same vessel when possible.( Student Outcomes: a, e, k)
8. Be able to apply heuristics in selecting chemical reactors or reactor trains, and in selecting separation processes to separate liquids, vapors, vapor-liquid mixtures, and vapor-liquid-solid mixtures. (Student Outcomes: a, e, k)
9. Be familiar with the most widely used industrial separations and their basis for separation.( Student Outcomes: a, e, k)
10. Understand how distillation columns are sequenced and how to apply heuristics to narrow the search for a near optimal sequence.( Student Outcomes: a, e, k)
11. Be able to determine the second law efficiency of a process and pinpoint the major areas of inefficiency (lost work).( Student Outcomes: a, e, k)
12. Understand the concepts and application of heat and power integration to minimize energy requirements for chemical process plants.( Student Outcomes: a, e, k)

### **Topical Outline**

1. Profit upper bound analysis
2. Sizing and costing of units such as reactors, distillation columns and other auxiliary units.
3. Economic evaluation of process designs, applications of
  - a) net present value
  - b) time value of money
  - c) discount rate of return.
4. Tradeoffs in design of reactor separator systems.
  - a) Separation system location relative to reactor
  - b) Recycle to extinction
5. Targeting
  - a) heat exchanger network design – pinch analysis
6. Optimization
  - a) linear programming models
  - b) mixed integer programming models
  - c) non-linear models
  - d) Decision Making Under Uncertainty