SYLLABUS FOR CHEMICAL ENGINEERING SEPARATIONS
Fall Semester, 2012

Class: Chemical Engineering Separations, # 32-4040
Meets T, W, and Fr from 1 - 1:50 PM (Ricketts 203)

Textbook: Seader, Henley and Roper, Separation Process Principles, 3rd Edition, John Wiley and Sons, Inc. 2011.

Instructor: Steven M. Cramer, William Weightman Walker Professor, Department of Chemical and Biological Engineering, 3211 Biotechnology and Interdisciplinary Studies Building, ext. 6198, crames@rpi.edu

Teaching Assistants: Siddharth Parimal and Bill Keller, 3216 BT, ext. 4275, kellew@rpi.edu
Office Hours: 11:30 to 1 on Tuesday (Cramer) and 11-1 on Wednesday (TA) in Ricketts lounge.

Course Objectives: Although separations have been an integral part of chemical engineering education for many years, the recent emergence of industries such as biotechnology and nanotechnology have significantly increased the demand for chemical engineers well schooled in the fundamentals of separation processes. The objective of this senior course is to familiarize the chemical engineering students with the fundamental principles of Separation Processes. We will examine both equilibrium controlled separation processes as well as separation processes that involve both mass transport and equilibrium considerations. In order to probe the key concepts in depth, the course will focus primarily on distillation, absorption and membranes. However throughout the course, a wide variety of separation processes will be brought to the student's attention to broaden the discussion. In particular, examples from biotechnology will be used to illustrate key concepts. In addition to teaching the fundamental principles involved in these unit operations, the course will also introduce the students to specific subtleties associated with a wide variety of separation processes both old and new. In class problems will be used throughout the course to deepen the students' understanding of the material. Computer instruction will be employed throughout the course to illustrate important characteristics of these separation systems. In addition, Aspen will be employed to solve complex distillation problems. The specific topics that will be covered in the course are described below.

Course Learning Outcomes:
Students who complete this course will be able to:

1) fully understand key concepts of separation processes including equilibrium stages, reflux, countercurrent contacting, limiting cases, efficiency and mass transport effects.
2) model and solve problems related to flash distillation, liquid-liquid extraction, batch distillation, cascades, simple and complex binary distillation systems and absorption in packed towers.

3) understand the basic principles of various membrane processes.

Grading: There will be two exams and a final exam. Detailed homework sets will be assigned once per week. Student groups consisting of no more than three students per group will complete each homework assignment. Homework is worth 10 % of the grade (Homework assignments will also include computer problems using software to simulate various separation processes). The final exam is worth 35 % and the two exams are worth a total of 55 % of the grade.

Academic Integrity: In this class, all assignments that are turned in for a grade must represent the students' own work. While working in groups, each student should truly contribute to the groups effort.

CHEMICAL ENGINEERING SEPARATIONS (Course Outline)

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Equilibrium Based Separation Processes

Classes of Separation Processes Chapter 1
VLE, Relative volatility, Maximum and minimum Boiling Point Azeotropes (Section 4.2, 4.3)
Flash Distillation, bubble point and dew point (Section 4.4)
Ternary Liquid-Liquid Systems (Section 4.5)
Differential Batch Distillation (Section 13.1)
Cascades: Single Stage, Multiple-Contact Stages (Co-current, counter current, cross-current) (Section 5.1, 5.3, 5.4, 5.5, 5.6)
Distillation Systems and Equipment Chapter 6.1
Binary Distillation (Sections 7.1, 7.2)
McCabe Thiele Technique: Operating lines for enriching and stripping sections; q lines for the feed, counting off stages, optimum feed location, limiting cases of total reflux and minimum reflux

Exam 1

Binary distillation continued: multiple feed/sidestreams, partial condenser, overall and Murphree efficiencies
Estimation of Stage Efficiency (Section 7.3)

Separation Processes that Involve Mass Transport and Equilibrium considerations

Absorption in Packed Towers (Chapter 6):
Graphical Equilibrium Stage Method for Trayed Towers (Section 6.3)
Algebraic Method for Determining the Number of Stages (Section 6.4)
Rate Based Method for Packed Columns (Section 6.7)
Packed-Column Efficiency, Capacity and Pressure Drop (Section 6.8)
Concentrated Solutions in Packed Columns (Section 6.9)

Exam 2

ASPEN Module for solving complex distillation problems
Membrane Separation Processes (Chapter 14 and other sources)

Final Exam