Department of Chemical and Biochemical Engineering

CBE:3117 Separations
August 21 - December 15, 2023

Instructor: **David Rethwisch (4138 SC; 335-1413)**
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Office Hours: 9:30-10:30 am Tuesday

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Textbook: Wankat, Phillip W., **Separation Process Engineering**, 4th Ed., Prentice-Hall (2017).

Class: Flipped Class
Lectures online in ICON (UICapture)
Problem Solving Session TR 11:00am-12:15pm, 134 Trowbridge Hall
Group Study – TR 6:00-8:00 pm, 2040 SC

Course Description:

Separations is designed to introduce the concepts and applications of equilibrium and nonequilibrium separations. These principles, along with the thermodynamic phase equilibrium relationships, are applied to equipment design for separation processes in the chemical, biochemical, and petroleum industries. This course will draw heavily from required prerequisite courses including CBE:2105 Process Calculations and CBE:3105 Chemical Engineering Thermodynamics. The chief objective of this course is to apply the foundations of mass transfer separations to the solution of problems of interest to the chemical engineer.

We will examine the idealized case of equilibrium separations. We will also consider the case where equilibrium is not attained, i.e., cases where diffusional limitations become important. We will develop mass transfer relations further and consider the application of this information for the measurement or estimation of necessary design parameters such as mass transfer coefficients, and the use of these parameters to design membrane separation units, distillation columns, scrubbers, etc.

Specific course goals are as follows:

1. By the end of the course, the student will develop a clear understanding of common separation mechanisms (relative volatility, liquid/liquid partitioning, liquid/membrane partitioning, size selective filtration, etc.) and the merits and disadvantages of each.

2. By the end of the course, the student will be able to perform calculations for equilibrium-staged separations systems including energy and material balances and to use these calculations to design membrane separation units, distillation columns, scrubbers, leaching units, etc.

3. By the end of the course, the student will have had opportunities to further his or her professional development through using modern computer tools and completing work as part of a team.

Flipped Course Structure:

Separations will be taught as a flipped course. The lecture content is in ICON using UICapture videos that are in ca. 7-15 minute segments, typically 4-6 segments per "lecture." The lecture videos should be viewed before attending class/problem solving session. Attendance will be taken and work collected for each problem-solving session. There will also be homework, some of this will be done in the problem-solving sessions.

Exam Schedule:

There will be 2 two-hour midterm exams and a two-hour final exam. The midterm exams will be held at an arranged time in the evening (see below) and will usually comprise three problems based on the indicated material. The final exam will be comprehensive, covering the whole course with particular emphasis placed on the material since the second midterm.

Midterm exams (open book)	6:30-8:30 pm in 3655 SC; Tuesday, October 10
	6:30-8:30 pm in 3655 SC; Tuesday, November 7
Final Exam (open book)	5:30-7:30 pm in 3655 SC; Thursday, December 14

Grading:

The distribution of points for grading is:

2 midterm exams	50%
Final Exam	25%
Problem Session Participation	10%
Homework & Project	15%
TOTAL	100%

Attendance at the problem-solving sessions (TILE classes) is mandatory. You are allowed to miss two problem solving-sessions with no penalty.

Homework will be due in the ICON drop box on their due date (see schedule below and in ICON) at 11:59 pm. Late homework will not be accepted. To facilitate grading please be sure your scan is legible, not too high of resolution, and in one document. Uploads of multiple documents makes it more difficult to grade. Similarly, very high-resolution documents take significant time to upload and grade in ICON. Answers to the homework problems will be posted on the course site after the homework is due.

Collaboration Policy:

Discussion of homework problems with other students in the class and/or working in groups is encouraged. In industry chemists and engineers are generally expected to work as a team. This is a good way to develop that team concept, and to learn from each other, thereby putting in fewer hours on homework. Feel free to work together; however, direct copying of an assignment in part or in total is not allowed. Direct copying of answers from websites such as CHEGG and Coursehero.com is an academic ethics violation. College regulations recommend that a zero be given in all homework assignments if this policy is violated. Cheating on any exam will result in an "F" in the course.

CBE:3117 Separations
Course Outline - - Fall 2023

Lecture		Date	Topic(s)	Reading		Homework
1	T	Aug 22	Introduction; Physical Bases of Separations Example: Extraction of Phenol from Wastewater – single stage	Ch. 1 Notes, L1-3		
			Thermo Equilibrium Review – In Panopto (UICapture) Videos	Smith Van Ness		
2	R	Aug 24	Flash (Equilibrium) Distillation Vapor-Liquid Equilibrium Mass and Energy Balances	Ch. 2.1-2.4 L 15-19		
3	T	Aug 29	Flash (Equilibrium) Distillation Vapor-Liquid Equilibrium Mass and Energy Balances	Ch. 2.1-2.4 9.1-9.4 L 20-27		HW 1 (Ch. 1)
4	R	Aug 31	Flash (Equilibrium) Distillation Batch Distillation	Ch. 2.1-2.4, L 28-34		HW 1 resubmit Sep 2
5	T	Sept 5	Batch Distillation Introduction to Multistage (Column) Distillation	Ch. 9.1-9.4 L 34b-35		HW 2 (Ch. 2)
6	R	Sept 7	Multistage Distillation	Ch. 3.1-3.4 L 36a-38		HW 2 resubmit Sep 9
7	T	Sept 12	Multistage Distillation	Ch. 4 L 39-46		HW 3 (Ch. 3, 9)
8	R	Sept 14	Multistage Distillation Tray Designs	Ch. 4, 10 L 47-51b		HW 3 resubmit Sep 16
9	T	Sept 19	Multistage Distillation	Ch. 4 L 52-59		HW 4 (Ch. 4)
10	R	Sept 21	Multistage Distillation Efficiency Gilliland Equation	Ch. 4 Ch. 7 L 60-62		HW 4 resubmit Sep 23

11	T	Sept 26	Multicomponent Distillation	Ch. 5-6 L 64-69b		HW 5 (Ch. 5-6)
12	R	Sept 28	Review for Exam 1; Azeotropic Distillation	Ch. 8.0-8.2 L 70a-c		HW 5 resubmit Sept 30
13	T	Oct 3	Solid-Liquid Extraction (Leaching)	Ch. 14 L 124-131		
14	R	Oct 5	Solid-Liquid Extraction	L 132-143		HW 6 (Ch. 8 & 14)
15	T	Oct 10	Exam Day – No Lecture			
	T	Oct 10	**Exam 1 evening 6:30 pm (3655 SC)**			3655 SC
16	R	Oct 12	Solid-Liquid Extraction Liquid-Liquid Extraction – Equipment Miscible solvent phase diagrams	Ch. 13 L 144-149		HW 6 resubmit Oct 14
17	T	Oct 17	Liquid-Liquid Extraction	L 150-156		HW 7 (Ch. 14)
18	R	Oct 19	Liquid-Liquid Extraction	L 156-158a, 2a-4		HW 7 resubmit Oct 21
19	T	Oct 24	Liquid-Liquid Extraction– example	L 4b-6, 160- 161		HW 8 (Ch. 13, 14)
20	R	Oct 26	Liquid-Liquid Extraction Supercritical fluids Gas-Liquid Absorber or Stripper	Ch. 12 L 163-171		HW 8 resubmit Oct 28
21	T	Oct 31	Gas-Liquid Absorber or Stripper Mass Transfer Coefficients	L 172-175		HW 9 (Ch. 13)
22	R	Nov 2	Gas-Liquid Absorber or Stripper Review for Exam 2	L 175b- 177a		HW 9 resubmit Nov 4
23	T	Nov 7	Exam Prep – No Lecture			
	T	Nov 7	**Exam 2 evening 6:30 pm**			3655 SC
24	R	Nov 9	Gas-Liquid Absorber or Stripper Heat effects Multicomponent absorption	Ch. 16 L 177-178c, Ex1-7		
25	T	Nov 14	Adsorption (solid-gas or solid-liquid)	Ch. 19 L 179-181		HW 10 (Ch. 12, 16)

26	R	Nov 16	Adsorption Ion Exchange Affinity Chromatography	L 182-185		HW 10 resubmit Nov 18
		Nov 18-26	**Thanksgiving Break**			
27	T	Nov 28	Aspen discussion Adsorption Stirred Contactor Continuous packed-bed separation analysis	L 186-191		HW 11 (Ch. 19)
28	R	Nov 30	Adsorption Continuous packed-bed separation analysis (cont.)	L 191-196		HW 11 resubmit Dec 2 Aspen Project Dec 2
29	T	Dec 5	Membranes Gas Separation Isotopic Separations	Ch. 18 L 197-201		HW 12 (Ch. 18 & 19)
30	R	Dec 7	Membranes Hemodialysis Reverse Osmosis Review for Final Exam	L 202-205, Review A-E		HW 12 resubmit Dec 9
		Dec 14	**Final Exam evening 5:30-6:30 pm**			3655 SC
			Extra Material (not included in Exam – Teaser for Biochemical Separations course)			
31			Biochemical Separations Imposed Potential Separations Electrophoresis Isoelectric Focusing Ultracentrifugation Precipitation	L 206-217		