CHE449: Transfer Operations III (3 credits)

Course Syllabus, Fall 2020

Course Details

Instructor: Dr. Ryan Poling-Skutvik (he/him)

Email: ryanps@uri.edu. Please include [CHE 449] in your subject heading. I sort email into a specific inbox for classes and may miss your email otherwise.

Meeting Times: Tuesday and Thursdays 2:00 – 3:15 pm on Cisco Webex. Link to the meeting will be posted on Brightspace.

Office Hours: Mondays 10:00 am – 12:00 pm, Wednesdays 2:00 pm – 4:00 pm

Teaching Assistant: Joseph Sullivan josephsullivan@uri.edu. Office Hours: Fridays 10:00 am – 12:00 pm

Required Texts: The required text for this course is *Separation Process Principles: Chemical and Biochemical Operations*, 3rd or 4th ed. Seader, Henley, and Roper. Wiley 2010. The 3rd edition is perfectly acceptable (and preferred) and relatively inexpensive if purchased used. If you are struggling with the cost, please let me know and we can find a solution. Additionally, the URI library has two freely available e-resources that can supplement this class without any additional cost.

- *Transport Processes and Separation Process Principles*, 5th ed, Hersel, Lepek, and Geankoplis. Pearson 2018.
- *Separation Process Engineering*, 2nd ed. Wankat. Pearson 2006.

Course Website: All course materials will be hosted on the dedicated CHE 449 Brightspace.

Technology Requirements: Because all instruction will be conducted online, students are expected to have a personal computer with a high-speed internet access, a webcam, and a microphone. Students are expected to participate in synchronous online meetings as much as possible. If attendance or participation in these meetings will be difficult for you (such as slow internet speed at home, limited working space, or other reasons), please email me explaining your situation and we can work together to develop a plan to help you be successful in this course.

Software: This course will make use of several software programs. Each of these software programs is free to URI students and can be downloaded onto your personal computer. If you have limited access to a computer, there are resources on campus to help students with virtual learning. Please email me and we can develop a solution.

- *Required:* Microsoft Office Suite (https://web.uri.edu/its/office-365/)
- *Required*: Cisco Webex (https://web.uri.edu/its-webex/getting-started-guide/)
- *Required:* MATLAB (https://web.uri.edu/research-computing/matlab/)
- *Recommended*: LaTeX compiling software
    - Online (quick and easy): www.overleaf.com
    - Offline: MiKTeX (https://miktex.org/download) for Windows machines or MacTeX (http://www.tug.org/mactex/) for Macs
- *Recommended*: Graphic design software
    - Free: Inkscape (https://inkscape.org/)
    - Paid: Adobe Illustrator (https://www.adobe.com/products/illustrator.html)

Course Description

URI Catalog Description: (3 crs.) Theory, design, and application of separation processes with a focus on equilibrium stage operations. Integrated processes and new technologies will be examined. (Lec. 3) Pre: CHE 348 or permission of instructor.

This course will cover a selection of the many methods used by engineers to separate chemical mixtures. We encounter separation processes daily, and they represent the predominant process step in most chemical production. Although this course will focus primarily on industrial applications of chemical separations, the frameworks covered by this course can be directly applied to many burgeoning and cutting-edge applications of chemical engineering sub-disciplines, such as biochemistry, pharmaceuticals, green energy, and renewable materials.

Separation processes represent some of the most complicated components of real chemical process design and operation because of the many available options and degrees of freedom. In most applications, there will not be a "right choice" but rather a list of best practices and standards. In this course, we will apply fundamental thermodynamic and transport principles to the design of continuous and staged separation processes and discuss the limitations of theoretical assumptions and empiricism in plant design. The course will cover the following topics:

- Introduction and classification of separation processes (Chap. 1)
- Review of thermodynamics of mixtures (Chap. 2)
- Review of mass transfer principles, including diffusivity, Fick's law of diffusion, and calculation of mass transfer coefficients (Chap. 3)
- Absorption and stripping of dilute mixtures through graphical and analytical methods (Chap. 6)
- Binary distillation (Chap. 7)
- Designing trayed and packed columns based on empirical data (Chap. 7)
- Equilibrium-based models for membrane separations (Chap. 14)
- Equilibrium-based models for adsorption, ion exchange, and chromatography (Chap. 15)
- Liquid-liquid extraction (Chap. 8)

Course Learning Objectives

By the end of this course, you should be able to do the following:

1. Explain the role of separation operations in an industrial chemical process
2. Define key vocabulary used in describing separation processes
3. Identify equipment types for many common industrial separation processes and their applications
4. Explain how each of the following systems work: partial condenser, partial reboiler, flash tank, absorber, stripper, distillation column, liquid-liquid extractor, membrane separator, adsorber, ion exchanger, chromatographic separator, and solid-liquid extractor
5. Calculate mass transfer rates using Fick's law and other empirical relationships
6. Design and size columns for absorption and stripping of dilute mixtures and distillation of binary mixtures graphically and analytically
7. Calculate mass transfer rates in various types of membrane separators
8. Design, size, and describe the operation of a fixed-bed adsorber

Course Schedule

Below is a tentative schedule for this course. Given the online environment and potential for significant disruptions this semester as we continue to deal with this on-going pandemic, we may need to significantly revise this schedule throughout the semester.

Week	Day	Date	Topic / SHR Section	Due
1	Th	09/10	Introduction to Separations	
2	Tu	09/15	Classification of Separations 1.0-1.6	Pre. Exam.
2	Th	09/17	Separation factors, sequences, design heuristics 1.7, 1.8, 1.10	
3	Tu	09/22	Thermodynamics and Mass Transfer Review 2.0-2.3, 3.0, 3.1.0, 3.1.1, 3.1.3, 3.1.4, 3.2.0, 3.2.1, 3.2.2, 3.2.5, 3.3.0, 3.3.1, 3.3.2, 3.3.3, 3.5.0, 3.5.2, 3.7.0, 3.7.1	
3	Th	09/24	Introduction to Flash Tanks and Single Stage Equilibrium	HW #1
4	Tu	09/29	Phase Diagrams and Sections 4.0, 4.2, 4.4	
4	Th	10/01	Absorption and Stripping	HW #2
5	Tu	10/06	Trayed and packed columns, Graphical Method Sections 6.0-6.3	
5	Th	10/08	Algebraic Method 6.4, 6.5.1, 6.5.4	
6	Tu	10/13	Review and Test Prep	HW #3
6	Th	10/15	Midterm (Take home, Due Friday at 11:59 pm)	
7	Tu	10/20	Flooding and column calculations Sections 6.6.1, 6.6.3, 6.7, 6.8.1-6.8.2	
7	Th	10/22	Introduction to distillation	HW #4
8	Tu	10/27	Distillation design and McCabe-Thiele. Sections 7.0-7.2	
8	Th	10/29	Sections 7.3.0-7.3.2, 7.3.4, 7.3.7, 7.3.9, 7.4.3, 7.5, 7.6.1	
9	Th	11/05	Introduce Membranes	HW #5
10	Tu	11/10	Sections 14.0-14.2, 14.3.1, 14.3.2	
10	Th	11/12	Membranes	HW #6
11	Tu	11/17	Sections 14.3.4, 14.3.6, 14.3.8, 14.4, 14.6, 14.7	
11	Th	11/19	Adsorption	HW #7
12	Tu	11/24	Sections 15.1.1-3, 15.2.1, 15.3.2, 15.3.5, 15.5.2, 15.5.3	
13	Tu	12/01	Introduce Liquid-Liquid Extraction	HW #8
13	Th	12/03	Sections 8.1.1-8.1.3, 8.2.1, 8.3.1-8.3.3	
14	Tu	12/08	Summarize, Review and Q&A	HW #9
14	Th	12/10	Q&A, Assign Final Exam (Take home)	
15	??	??	Finals Week	Final

Grading

Your final grade will be calculated based on the following weights:

Homework	20%
Participation	20%
Midterm exam	30%
Final exam	30%

Grading Scale

Final letter grades will be assigned based on the following grading scale. I reserve the right to grade on a curve and to adjust the weight of each grading category based on class performance and any unexpected changes (e.g. schedule).

$94 \leq$ A ≤ 100
$90 \leq$ A- < 94
$87 \leq$ B+ < 90
$83 \leq$ B < 87
$80 \leq$ B- < 83
$77 \leq$ C+ < 80
$73 \leq$ C < 77
$70 \leq$ C- < 73
$67 \leq$ D+ < 70
$60 \leq$ D < 67
F < 60

Homework

Homework is assigned to help you master the course material. Because this course counts for 3 credits, I am designing homework and projects to take you approximately 6 hours per week to complete. Completed homework assignments **will not** be graded in the traditional sense. You will be asked to verify that you have completed each problem set by the beginning of class (usually Thursdays) on Brightspace and to indicate to me how many hours it took you to complete. This data will have no bearing on your grade but is for my records to improve how I teach and assign homework. During synchronous meetings (again, usually on Thursdays), I will ask individual students to present their answers and work to a given problem to the class or in small breakout sessions. These presentations will serve to help you present and defend your assumptions and work, which are fundamental to effective engineering communication. Grades will be based on attempts at the problem but will not be based on if you achieve the correct answer. For homework, I mostly care about **how** you approach problems rather than if you can fully solve them. After all, homework is a learning exercise.

Participation

A significant portion of our synchronous meetings will be targeted to critically thinking about problems and working through examples. Based on these exercises, I will be calling on students during our meetings to stimulate discussion. This participation is not about getting the "correct" answer but about your willingness to think critically about engineering problems and to justify your best guess.

Exams

There will be one midterm and one final exam for this class. These will be take-home, open book exams. For these exams, you may print the exam if you have access to a printer, or simply write your answers on blank paper. You will then upload photos or scans of your work to Brightspace for grading.

Office Hours

I will be holding regular office hours during the week to help you with questions about material covered in class, in required readings, or with homework questions. These office hours will be open meetings on Webex where you can join at any time. Attendance at these office hours is completely optional but can be very helpful to understand the material and get specific questions asked. To incentivize participation, you will receive a bonus of 0.5 percentage points on your final grade for each week in which you attend at least one session of office hours, up to a total of 3 percentage points in a semester (i.e. raise an 80% to an 83%). This bonus credit can also be earned by attending the TA office hours.

Additional Policies

Attendance

As currently planned, this course will be offered fully online for the semester. Attendance is strongly encouraged but I recognize that it may not be feasible for some people at all times. If you know that you will miss a meeting, please email me at ryanps@uri.edu before the scheduled meeting time.

Accommodations for special needs

Your access in this course is important. Please send me your Disability Services for Students (DSS) accommodation letter early in the semester so that we have adequate time to discuss and arrange your approved academic accommodations. If you have not yet established services through DSS, please contact them to engage in a confidential conversation about the process for requesting reasonable accommodations in the classroom.

Academic honesty and integrity

Academic dishonesty, such as plagiarism and cheating, will not be tolerated and will result in immediate disciplinary actions. This includes but not limited to presenting someone else's work in class or on assignments, using unapproved resources during exams, distributing test questions to other students, or communicating with other students during exams. If you have any doubt about what constitutes plagiarism, visit the following websites: the URI Student Handbook, and Sections 8.27.10 – 8.27.21 of the University Manual.

Anti-Bias and Diversity

This class exists as a welcoming environment for **all** students regardless of race, gender, sexual orientation, age, or socioeconomic background. Students are expected to treat faculty and fellow classmates with dignity and respect. If you experience any action that makes you feel unwelcome or unsafe, please let me know and you are additionally encouraged to submit a report to the URI Bias Response Team at www.uri.edu/brt.