RUTGERS UNIVERSITY
Department of Chemical and Biochemical Engineering

14:155:324:01 DESIGN OF SEPARATION PROCESSES (3 credits) **SPRING 2020**

Professor:

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Learning Assistants: TBD

Class Timings: Mondays and Wednesdays at 10:20-11:40 a.m.
Class Location: Pharmacy (PH)-115

See weblink below for details regarding location of PH-115 classroom.
http://rumaps.rutgers.edu/location/william-levine-hall-ernest-mario-school-of-pharmacy

Other Class Lab Locations:
Please access Microcomputer Labs (rooms B125 & D110 of SOE building) for using ASPEN-Plus simulation software required for this course. ***However, students are all ideally expected to have Aspen Plus software installed on their laptops by the end of January (if you haven't done this last semester). Details will be discussed during the Jan 22nd lecture.***

Course Description:
Application of thermodynamics and mass transfer theory to the design and analysis of chemical engineering separation processes. Example: distillation, liquid extraction, gas absorption, membrane separation and bioseparation processes. Computer software for the design and analysis of various separation processes.

Course Objectives and Outcomes: In this course, students learn how to apply knowledge of mathematics, science, and engineering to analyze and solve separations problems encountered in chemical and biochemical engineering. The course gives the student the opportunity to design single-step and multi-step separation processes, work together in multi-disciplinary/multi-functional teams, develop the ability to communicate their results effectively, and to use techniques, skills, and modern engineering tools (such as process flow simulators) necessary for engineering practice.

ABET outcomes applicable to this course
(a) an ability to apply knowledge of mathematics, science and engineering
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function in multi-disciplinary/multi-functional teams (this can be defined as a mix of biochemical and chemical engineers, or as a group of students working on a different roles of a project)

(e) an ability to identify, formulate, and solve engineering problems
(g) an ability to communicate effectively
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

TEXTBOOK (required for this course)

P. C. Wankat, Separation Process Engineering, Prentice Hall, Upper Saddle River, NJ.

Please note that the 4th edition is the latest version of this textbook but one can also use the 3rd edition, if available.

ADDITIONAL TEXTBOOKS & REFERENCE MATERIAL (not required)

J. D. Seader, E. J. Henley, D. K. Roper Separation Process Principles, 3rd ed., John Wiley & Sons, Inc., (2011).

C. J. King. Separation Processes, 2nd ed., McGraw Hill, Inc., (1980). **(pdf available freely online)**

PREREQUISITES

155:303 Transport Phenomena in Chemical Engineering I
155:307 Chemical Engineering Analysis II
155:309 Chemical Engineering Thermodynamics

SOFTWARE

Aspen Plus: This is a simulator for chemical engineering process design. This program performs material and energy balances, calculates sizes and estimates costs of equipment, and draws process flow diagrams. It has extensive thermodynamic properties database included. ***All students taking the 155:324 design course are expected to have Aspen Plus software installed on their personal laptops ideally by end of Lecture 2. This is a mandatory requirement for this course and will be needed for most homework assignments. Detailed installation instructions are provided at the end of this course outline document. Additional help for software installation can be provided by SOE Computing Services, if needed (http://ecs.rutgers.edu).*** Aspen Plus is also installed on all computers in the Microcomputer Laboratory (rooms B125, and D110). To access this program, log in to one of the computers and execute the program from the Aspen Plus icon (or from Start/Programs/AspenTech/Process Modeling V8.0/Aspen Plus/Aspen Plus V8.0) or (C:\Program Files\AspenTech\Aspen Plus V8.0\GUI\Xeq\AspenPlus.exe.

HOMEWORK AND GRADING POLICY

Homework problems and quizzes will be assigned, collected, and graded on a regular basis during the semester. All homeworks will be posted on the Sakai course webpage (*please contact Prof. Chundawat or the TA as soon as possible if you cannot access the Sakai course webpage contents!*). Students are requested to turn in their homework assignments in-class (and not by email or using Sakai, unless specifically instructed otherwise). Homework solutions will be briefly discussed in class the following week (and/or during office hours). No late homeworks will be accepted (dates/deadlines will be announced in class on a weekly basis). There are going to be several quizzes held in class throughout the semester on a weekly basis. There will be one midterm exam, one final exam, one Aspen Plus based design project, and separations focused lab project as well. *Class participation and attendance are both important to do well in this course*. The course grade will be determined as follows:

Homeworks	15%
In-class quizzes	5%
First exam (mid-term)	30%
Second exam (finals)	30%
Separations lab project	10%
Aspen design project	10%

TEACHING ASSISTANTS (TA) OFFICE HOURS

TA weekly office hours timing and location will be announced in the class and posted on the Sakai course website by lecture 2.

LEARNING ASSISTANTS (LA) STUDY GROUPS

LA's will be holding four weekly study groups for this course. Interested students are requested to enroll for one study group following instructions posted on the Sakai course website. Limited slots are available for weekly LA study groups. Study group meeting times and location will be finalized by end of Jan.

ACADEMIC INTEGRITY

Students are expected to familiarize themselves with and adhere to the University policy on academic integrity at: http://academicintegrity.rutgers.edu/policy-on-academic-integrity.

It is understood that a student's name on any individual homework assignment, quiz, or exam indicates that he/she neither gave nor received unauthorized aid. On individual homework assignments, *authorized* aid includes discussing: 1) interpretation of the problem statement, 2) concepts involved in the problem, 3) approaches for solving the problem. Anything beyond this constitutes unauthorized aid and violates the academic integrity policy.

A student's name on a group assignment indicates that he/she contributed to the assignment. Quizzes and exams are tests of individual performance. The student is not permitted to obtain assistance from any other person (or persons) during quizzes or exams. The student must adhere strictly to the instructions provided by the professor regarding what is permissible to be used during the exam. Use of lecture notes, computers, laptops, and cell phones without prior authorization of instructor is **PROHIBITED** during exams.

Students caught cheating on homeworks, quizzes, projects, or exams will be reported to the undergraduate program director for disciplinary action in accord with the university policy on academic integrity!

COURSE MATERIAL COPYRIGHT

All course material posted on the Sakai course website is copyrighted and may not be posted on any other web site at or outside of Rutgers without permission from the course instructor. Noncompliance with this policy will be treated as a violation of the Code of Student Conduct and will be referred to the Office of Student Conduct for action.

COURSE OUTLINE & SCHEDULE

The course will follow closely the contents of the required textbook by Wankat (W). Some chapters will not be covered. Additional reading will be assigned from other textbooks like Seader (S), which maybe posted on the Sakai course website. Required reading of chapters from either textbook will be indicated in the course

outline below (e.g., Chapter 1 from Wankat's book and Seader's book will be designated as W1 and S1, respectively). Partially complete lecture slides by Prof. Chundawat will be available to the students as pdf files on the Sakai web site. **Students will be expected to complete lecture notes in class.** Additional material may be distributed as handouts in-class. A week-by-week schedule of the course, lecture topics, textbook reading assignments and relevant lecture description is given below *(please follow announcements on the Sakai course webpage for any changes to the following schedule!).* ***Students are advised to complete reading all assignments prior to attending the lecture to keep up with the class and do well on quizzes/exams.***

Week	Date	Location	Lecture Topic	Lecture Description	Lecture #	Assigned Reading
Week 1	22-Jan	PH-115	Introduction to CBE 324	1. General discussion of separation processes and term projects	1	W1
Week 2	27-Jan	PH-115	Review of Basic Concepts	2. Vapor-liquid phase equilibria & Intro to Aspen-Plus Software	2	S2 and extra notes, W2
	29-Jan	PH-115	Review of Basic Concepts	3. Bubble-point and dew-point calculations	3	S4 (pp. 139-150), W2
Week 3	3-Feb	PH-115	Single Stage Distillation	4. Introduction to Flash drum distillation (binary systems)	4	W2
	5-Feb	PH-115	Single Stage Distillation	5. Flash drum distillation (multicomponent systems)	5	W2
Week 4	10-Feb	TBA	Single Stage Distillation	6. Aspen-Plus Software Exercise & In-class Quiz	6	Aspen Lab 1 Handout
	12-Feb	PH-115	Multi-Stage Distillation	7. Introduction to column distillation for binary systems	7	W3
Week 5	17-Feb	PH-115	Multi-Stage Distillation	8. Column distillation & stage-by-stage method (contd)	8	W3, W4
	19-Feb	PH-115	Multi-Stage Distillation	9. Column distillation & McCabe-Thiele method	9	W4
Week 6	24-Feb	PH-115	Multi-Stage Distillation	10. Column distillation & McCabe-Thiele method (contd)	10	W4
	26-Feb	PH-115	Special Separations Topic	27. Bioseparations; with focus on biopharmaceuticals	11	W5
Week 7	2-Mar	PH-115	Mid-term Exam Review	12. Mid-term Review & In-class Problem Solving Session	12	
	4-Mar	PH-115		**Mid-term Exam 1**		
Week 8	9-Mar	PH-115	Multi-Stage Distillation	11. Introduction to multi-component column distillation	13	W7
	11-Mar	PH-115	Multi-Stage Distillation	13. Multi-component distillation & Short-cut methods (contd)	14	W6, Aspen Example
Week 9	14-Mar			**Spring Break - no class**		
	22-Mar			**Spring Break - no class**		
Week 10	23-Mar	PH-115	Multi-Stage Distillation	14. Multi-component distillation & Rigorous methods (contd)	15	Aspen Example/Lab 3
	25-Mar	PH-115	Multi-Stage Distillation	15. Multi-component distillation & Rigorous methods (contd)	16	W10/Aspen/Lab 3
Week 11	30-Mar	PH-115	Multi-Stage Distillation	16. Staged and Packed Column Design	17	W10, W11
	1-Apr	TBA	Multi-Stage Distillation	17. Column Design (contd) and Distillation Economics	18	Aspen Lab 3
Week 12	6-Apr	TBA	Multi-Stage Distillation	18. In-class DSTWU/RADFRAC Aspen Simulation/Sensitivity Anal.	19	Aspen Lab 3, Visitor
	8-Apr	PH-115	Multi-Stage Distillation	19. In-class DSTWU/RADFRAC Aspen Simulation	20	W12
Week 13	13-Apr	PH-115	Gas Absorption	20. Gas Absorption: Staged Column Operations	21	S6, W16
	15-Apr	PH-115	Gas Absorption	21. Gas Absorption: Packed Column Operations	22	W13
Week 14	20-Apr	PH-115	Liquid-Liquid Extraction	22. Liquid-Liquid Extraction: Immiscible Systems	23	W13
	22-Apr	PH-115	Liquid-Liquid Extraction	23. Liquid-Liquid Extraction: Partially Miscible Systems	24	W17
Week 15	27-Apr	PH-115	Membrane Separations	24. Membrane Separations: Gas Permeation	25	W17
	29-Apr	PH-115	Membrane Separations	25. Membrane Separations: Reverse Osmosis	26	W18
Week 16	4-May	PH-115	Unsteady State Operations	26. Adsorption & Chromatography + Final Exam Review Begin	27	S1 and extra notes
	6-May	PH-115		**Office Hours + Reading Day - No Class**		-
Week 17	11-May	PH-115		**Finals-Week Exam 2**		
TBA or "to be announced" in class						
PH-115 is located inside William Levine Hall-Ernest Mario School of Pharmacy Building (see weblink below for details)						
http://rumaps.rutgers.edu/location/william-levine-hall-ernest-mario-school-of-pharmacy						