RUTGERS UNIVERSITY
Department of Chemical and Biochemical Engineering

14:155:324:01 SEPARATION PROCESSES (3 credits) **SPRING 2025**

Professor/Instructor: Prof. Shishir Chundawat (Prof. C)
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Weekly Office Hours for Prof. C Timing: Thursday (4:30-5:30 pm EST, by apt)
Location: Zoom (by apt only)
https://tinyurl.com/ChundawatZoom

Teaching Assistant (TA): Mr. Ryan Murphy
Location: TBD
Email: rnm79@scarletmail.rutgers.edu

Zoom Weekly Office Hours for TA: See below for details.
Learning Assistants (LA): Kaelyn Chang (kc1228@scarletmail.rutgers.edu)

LA Weekly Study Group Hours (Tentative Study Group Slots; may change by late Jan):
Group 01: Monday, 12:10pm - 1:30pm, SERC 104 (Busch Learning Center)
Group 02: Thursday, 3:50pm - 5:10pm, (Livingston Learning Center)

Please use Google Spreadsheet link below to Signup For LA Study Groups 1 or 2.
https://docs.google.com/spreadsheets/d/1eIukmYXunXLcSL4MQK8Qv7jQscsDtJciFmuftT4XoVw/edit?usp=sharing

Class Timings: Mon and Wed at 2-3:20 pm EST
Class Location: PH-111*
**Please note that on a few occasions, if needed in emergency, the class may be held via Zoom and students will be informed ahead of time via Canvas Course Site. See weblink on canvas to join Zoom for Live Synchronous Lecture. Sign in with Rutgers Zoom Only.*

Other Class Lab Locations:
Please remotely access the SOE Microcomputer Labs (rooms B125 & D110 of SOE building) for using ASPEN-Plus simulation software required for this course. *Students are expected to have Aspen Plus software installed on their laptops by mid-Feb (if you haven't done this last semester) or access software in ECS computer labs. Details to be discussed in first lecture. Please work directly with SOE Engineering Computing Services if you need help getting access to ECS Labs (or resetting your SOE password).*

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.
Note that 5th edition is latest edition but you can use the older 3rd or 4th editions of this textbook.

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).
Note that pdf copy for this 1980 edition is 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 this 155:324 course are expected to have Aspen Plus software installed on their personal laptops ideally by end of Lecture 2 OR be able to access Aspen Software remotely using ECS computer labs. This is a mandatory requirement for this course and will be needed for some homework assignments. Detailed installation instructions are provided on the Canvas course website sub-folder titled 'Aspen Install Help' within Folder titled 'Aspen Related Course Material'. All relevant materials are lister under the Canvas course FILES section. 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 SOE microlab 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.
Detailed instructions about access to ECS (in-person) and Aspen software are given below.

Firstly, you will need access to your ECS account to be able to access software needed for this course on the ECS servers (i.e., Aspen Plus). Please note that all students registered for this class have been added by ECS to create an SOE account and you should be able to reset your password if you don't have that information or have forgotten it. See instructions below on how to proceed.

Visit ECS.RUTGERS.EDU and click on Reset Password (under Computer Lab Use) in order to reset their password to one you can remember. You can do this from your mobile devices as well as long as you are connected to SOE-Research or RUWIRELESS (it will not work from home or outside the university network) and you must be connected to the Rutgers network (use VPN for remote access). As for students who already have accounts and have forgotten their passwords they too can go to ECS.RUTGERS.EDU and reset their account password. Please note that you need to use your SoE account in order to access VLAB or download Aspen. You cannot access these resources with your regular NetID (university-wide) account. Please do not submit tickets to ECS regarding this.

Secondly, please note that DSV (EN-B125) and EIT computer labs (EN-D110) in School of Engineering have been reserved (see DSV/EIT website online for details) so that you can access the computers to work on Aspen and any other software (e.g., Thermosolver or MATLAB) required outside of regular class timings.

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 Canvas course webpage (*please contact Prof. Chundawat or the TA as soon as possible if you cannot access the Canvas course webpage contents!*). Students are requested to turn in their homework assignments and responses using Canvas (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/biweekly basis. There will be one midterm exam (including materials covered in lectures 1-10 only) and one final exam (including all lecture materials covered in the semester). *Class participation and attendance are both important to do well in this course*. The course grade will be determined as follows:

Homeworks *(+ Separations Challenge Project*)*	36%
In-class quizzes	4%
Mid-term Exam (Lectures 1-10)	25%
Final Exam (Cumulative All Lectures)	35%

**Separations Challenge Problem (Extra credit worth max 5% of total grade) may be available. Details about extra credit problem will be discussed by Prof. C with class during the semester after spring break!*

TEACHING ASSISTANTS (TA) OFFICE HOURS

TA weekly office hours timing and location will be announced in the class and posted on the Canvas website.

LEARNING ASSISTANTS (LA) STUDY GROUPS

The LA will be holding 4 weekly study groups (90 mins each) for this course. Interested students are requested to enroll for the study group following instructions posted on the canvas course website. Limited slots are available for weekly LA study groups. Study group meeting times and location will be finalized by end of Jan. Sign up online using link below.
https://docs.google.com/spreadsheets/d/1eIukmYXunXLcSL4MQK8Qv7jQscsDtJciFmuftT4XoVw/edit?usp=sharing

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, 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 Canvas 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 Canvas 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 Canvas web site. **Students will be expected to complete lecture notes in class.** Additional material may be distributed as pdf handouts in-class during the lecture (or made accessible via Canvas). 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 Canvas 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 No. and Description	Assigned Reading
Week 1	22-Jan	PH-111	Introduction to CBE 324	1. General discussion of separation processes	W1
Week 2	27-Jan	PH-111	Review of Basic Concepts	2. Vapor-liquid phase equilibria & Intro to Aspen-Plus Software	S2 and extra notes, W2
	29-Jan	PH-111	Review of Basic Concepts	3. Bubble-point and dew-point calculations	S4 (pp. 139-150), W2
Week 3	3-Feb	PH-111	Single Stage Distillation	4. Introduction to Flash drum distillation (binary systems)	W2
	5-Feb	PH-111	Single Stage Distillation	5. Flash drum distillation (multicomponent systems)	W2
Week 4	10-Feb	PH-111*	Single Stage Distillation	6. Aspen-Plus Software Exercise & In-class Quiz	Aspen Lab 1 Handout
	12-Feb	PH-111	Multi-Stage Distillation	7. Introduction to column distillation for binary systems	W3
Week 5	17-Feb	PH-111	Multi-Stage Distillation	8. Column distillation & stage-by-stage method (contd)	W3, W4
	19-Feb	PH-111	Multi-Stage Distillation	9. Column distillation & McCabe-Thiele method	W4
Week 6	24-Feb	PH-111	Multi-Stage Distillation	10. Column distillation & McCabe-Thiele method (contd)	W4
	26-Feb	PH-111	Multi-Stage Distillation	11. Introduction to multi-component column distillation	W5
Week 7	3-Mar	PH-111	Mid-term Exam Review	12. Mid-term Review & In-class Problem Solving Session	
	5-Mar	PH-111	**Exam 1 (Mid-term; Lectures 1-10)**		
Week 8	10-Mar	PH-111	Multi-Stage Distillation	13. Multi-component distillation & Short-cut methods (contd)	W6, Aspen Lab 3 extra
	12-Mar	PH-111	Multi-Stage Distillation	14. Staged and Packed Column Design	W10
Week 9	17-Mar		**Spring Break - no class**		
	19-Mar		**Spring Break - no class**		
Week 10	24-Mar	PH-111	Multi-Stage Distillation	15. Column Design (contd) and Distillation Economics	W10, W11
	26-Mar	PH-111*	Multi-Stage Distillation	16. Demo of Aspen based Distillation Column Discussion	Aspen Lab 3
Week 11	31-Mar	PH-111	Gas Absorption	17. Gas Absorption: Staged Column Operations	Aspen Lab 3, Visitor
	2-Apr	PH-111	Gas Absorption	18. Gas Absorption: Packed Column Operations	W12
Week 12	7-Apr	PH-111	Liquid-Liquid Extraction	19. Liquid-Liquid Extraction: Immiscible Systems	S6, W16
	9-Apr	PH-111	Liquid-Liquid Extraction	20. Liquid-Liquid Extraction: Partially Miscible Systems	W13
Week 13	14-Apr	PH-111	Crystallization	21. Crystallization - Core Principles	W17, 18
	16-Apr	PH-111	Crystallization	22. Crystallization - Application in Pharma Industry	W17, 18
Week 14	21-Apr	PH-111	Membrane Separations	23. Membrane Separations: Gas Permeation	W13
	23-Apr	PH-111	Membrane Separations	24. Membrane Separations: Reverse Osmosis	W17
Week 15	28-Apr	PH-111	Adsorption	25. Adsorption and Ion Exchange	W18
	30-Apr	PH-111	Bioseparations	26. Bioseparations - Relevance to Biotech/Pharma Industry	S1 and extra notes
Week 16	25-Apr	PH-111	Bioseparations	27. Protein Chromatography Application in Pharma Industry	
	5-May	PH-111	Final Exam Review	28. Final Review & In-class Problem Solving Session	
Week 17	7-May		**Reading Day - no class**		
	12-May	TBA*	**Exam 2 (Final; Cumulative Lectures 1-27)**		
***TBA or "to be announced" in class or via canvas course website if Zoom lecture schedule or location changes**					
PH-111 is located inside Pharmacy Building Room 111 (see weblink below for details)					
https://dcs.rutgers.edu/classrooms/pharmacy-room-111					

Tips for Online Canvas Homework Submission:

- **Include your name on the top right of the first page of your document**
- **Box or highlight the final results for each problem to make it easier for grading**
- **Be sure to check the units for the final results**
- **Clearly describe and show your work. For example, mention the use of a graphing calculator or Mathematica/Matlab to solve an equation, if it has not been solved analytically on paper.**
- **Aspen results can be added as screenshots to your document, but make sure it is clearly referenced to a particular problem/question and the result is highlighted (for example, results from the stream table)**
- **Matlab/Mathematica code should be added at the end of the PDF file**
- **Upload your homework as a single PDF file (use camscanner or similar for easy conversion of images to PDF) but also remember to enter all quantitative results in the respective HW/quiz response section on canvas as well**
- **Responses entered on canvas will be auto-graded in some cases so its important students pay particular close attendtion to their work before entering responses online.**