

RUTGERS UNIVERSITY
Department of Chemical and Biochemical Engineering

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

SPRING 2018

Professor: Dr. Shishir Chundawat
Office Location: SOE C150A
Office Phone: (848) 445-3678
Email: shishir.chundawat@rutgers.edu

Teaching Assistants: Markus Hackl (mh1158@scarletmail.rutgers.edu)

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:

Some classes might be held a couple of times during the semester in the following Microcomputer Labs (rooms C233, B125, & D110 of SOE building) for using ASPEN-Plus simulation software, if necessary.

However, students are all 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 17th 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 latest 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 C233, C241, 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, and one Aspen Plus based design 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	20%
In-class quizzes	10%
First exam (mid-term)	30%
Second exam (finals)	30%
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.***

<u>Week</u>	<u>Date</u>	<u>Location</u>	<u>Lecture Topic</u>	<u>Lecture Description</u>	<u>Assigned Reading</u>
Week 1	17-Jan	PH-115	Introduction to CBE 324	1. General discussion of separation processes	W1
Week 2	22-Jan	PH-115	Review of Basic Concepts	2. Vapor-liquid phase equilibria & Intro to Aspen-Plus Software	S2 and extra notes, W2
	24-Jan	PH-115	Review of Basic Concepts	3. Bubble-point and dew-point calculations	S4 (pp. 139-150), W2
Week 3	29-Jan	PH-115	Single Stage Distillation	4. Introduction to Flash drum distillation (binary systems)	W2
	31-Jan	PH-115	Single Stage Distillation	5. Flash drum distillation (multicomponent systems)	W2
Week 4	5-Feb	TBA	Single Stage Distillation	6. Aspen-Plus Software Exercise & In-class Quiz	Aspen Lab 1 Handout
	7-Feb	PH-115	Multi-Stage Distillation	7. Introduction to column distillation for binary systems	W3
Week 5	12-Feb	PH-115	Multi-Stage Distillation	8. Column distillation & stage-by-stage method (contd)	W3, W4
	14-Feb	PH-115	Multi-Stage Distillation	9. Column distillation & McCabe-Thiele method	W4
Week 6	19-Feb	PH-115	Multi-Stage Distillation	10. Column distillation & McCabe-Thiele method (contd)	W4
	21-Feb	PH-115	Multi-Stage Distillation	11. Introduction to multi-component column distillation	W5
Week 7	26-Feb	PH-115	Mid-term Exam Review	12. Mid-term Review & In-class Problem Solving Session	
	28-Feb	PH-115		Mid-term Exam 1	
Week 8	5-Mar	PH-115	Multi-Stage Distillation	13. Multi-component distillation & Short-cut methods (contd)	W7
	7-Mar	PH-115	Multi-Stage Distillation	14. Multi-component distillation & Rigorous methods (contd)	W6, Aspen Example
Week 9	12-Mar			Spring Break - no class	
	14-Mar			Spring Break - no class	
Week 10	19-Mar	PH-115	Multi-Stage Distillation	15. Multi-component distillation & Rigorous methods (contd)	Aspen Example
	21-Mar	PH-115	Multi-Stage Distillation	16. Staged and Packed Column Design	W10
Week 11	26-Mar	PH-115	Multi-Stage Distillation	17. Column Design (contd) and Distillation Economics	W10, W11
	28-Mar	TBA	Multi-Stage Distillation	18. In-class DSTWU/RADFRAC Aspen Simulation/Sensitivity Anal.	Aspen Lab 3
Week 12	2-Apr	TBA	Multi-Stage Distillation	19. In-class DSTWU/RADFRAC Aspen Simulation + Phillips 66 Visit	Aspen Lab 3, Visitor
	4-Apr	PH-115	Gas Absorption	20. Gas Absorption: Staged Column Operations	W12
Week 13	9-Apr	PH-115	Gas Absorption	21. Gas Absorption: Packed Column Operations	S6, W16
	11-Apr	PH-115	Liquid-Liquid Extraction	22. Liquid-Liquid Extraction: Immiscible Systems	W13
Week 14	16-Apr	PH-115	Liquid-Liquid Extraction	23. Liquid-Liquid Extraction: Partially Miscible Systems	W13
	18-Apr	PH-115	Membrane Separations	24. Membrane Separations: Gas Permeation	W17
Week 15	23-Apr	PH-115	Membrane Separations	25. Membrane Separations: Reverse Osmosis	W17
	25-Apr	PH-115	Unsteady State Operations	26. Adsorption & Chromatography + Final Exam Review Begin	W18
Week 16	30-Apr	PH-115	Special Separations Topic	27. Bioseparations; with focus on biopharmaceuticals	S1 and extra notes
	2-May	PH-115		Office Hours + Reading Day - No Class	-
Week 17	7-May	PH-115		Finals-Week Exam 2	

Aspen Plus Software Installation Instructions for Rutgers University Chemical and Biochemical Engineering Department Students

Aspen Plus can be installed on Windows PCs. Installation on Macs requires Windows emulation software. Windows 10 requires additional steps. See below for details.

Using Aspen requires an active internet connection to connect to the license server from a campus location. Off-campus access requires the use of virtual private network (VPN) software.

0. Install windows software on your Macbook – see separate instructions below.

I. Obtain Aspen Software

1. If you have been provided with a thumb drive, insert thumb drive into USB port.
2. If you don't have a thumb drive:
 - a) Go to the following url:
https://drive.google.com/file/d/0B-7Ot_2vxq9QMHRsYnV3RVE5eEU/view
 - b) Click on **Download**, and then **Download anyway**
 - c) The downloaded file may have the extension **.cdr**. In that case, rename the file and change the extension to **.iso**.
 - d) Install any ISO reader from the internet. (Recommended program : **PowerISO** - <http://www.poweriso.com/download.php>)
 - e) Open the downloaded file in PowerISO and extract all the contents to a folder

II. Install Aspen Software

1. Open and launch **Setup.exe**
2. Click install **AspenOne products**.
3. Read the agreement, Click "**I accept**" and then **Next**
4. From the list, select the following components, and then click **Next**
Process Modeling (Aspen Plus)
5. Feel free to install other components if interested, but we will not use them in class.
6. In the License Server box, type **ecswinserv.engr.rutgers.edu** and then click **Add Server**, then click **Next**.
Make sure you type the IP address exactly and that you **do not copy any spaces** at the end of the address if you are copying and pasting
7. Click **Install Now**. It is normal for installation to take 10 minutes or more
8. Once complete, click **Finish** and then **Close**. You should then reboot **your computer**.

III. Windows 10 Instructions (fixes database configuration error – REQUIRED)

1. Download SQL Server 2012
<https://www.microsoft.com/en-us/download/details.aspx?id=29062>
2. Launch **Setup**
3. Select **New SQL Server stand-alone installation**
4. In the **Instance Configuration**, select **Default Instance**
5. Click **Install**
6. Run **Database Tester - Aspen Properties** from Aspen Properties V8.6
7. Click **Start**
8. Click **Restore databases directly**
If you see the **APV86**, **FACTV86**, and **NISTV86** entries in the Database Access Settings, your configuration is correct.

II. Run Aspen Software

1. If running from an on-campus location, skip to step 3. Otherwise go to step 2.
2. Run VPN software – see separate instructions.
3. To run Aspen, launch **Aspen Plus V8.6**. Click **register later** when prompted.
4. The first time you launch Aspen Plus, there will be a database restoring step. This is normal.

How to get Windows operation system software (XP, 7 or 8) & Burn it onto a DVD

1. go to :
 - a. Windows 10 Download: <https://www.microsoft.com/en-us/software-download/windows10>
 - b. Windows 8.1 Download: <https://www.microsoft.com/en-us/software-download/windows8>
 - c. Windows 7 Download: <https://www.microsoft.com/en-us/software-download/windows7>
 - d. If you are on a Rutgers Network go to [\\cbe-nas.rutgers.edu\ktarabok](https://cbe-nas.rutgers.edu/ktarabok) and you can download any of the iso's. If prompted for a username and password, you can put anything in. The folder is publicly viewable so authentication is not required. Instructions on connecting to a network share via a Mac (<https://support.apple.com/en-us/HT204445>)
2. Complete the purchase/download to get the iso file.
3. Once you have the iso file you can burn it to a DVD or use UNetbootin to make a bootable usb drive: <https://unetbootin.github.io/>

How to install Windows OS using Bootcamp on Mac OSX?

Carefully read page 3-11 of this official guide from Apple on how to install windows using bootcamp: (Pay attention to all steps)

http://manuals.info.apple.com/MANUALS/1000/MA1583/en_US/boot_camp_install-setup_10.7.pdf

You may have a different version of boot camp. Please if the above link does not work for you particular computer, please use google search of the help search on the apple page to get the instructions for your computer.

Once you finish installation Windows, start it and install any necessary updates via Windows Update,

Proceed to Aspen plus installation instruction (as described earlier).