ChE 460 – **Separation Processes II** – Fall 2018
(Tiernan Hall LECT 2; Wednesday, 6:00 - 9:05 PM)

Instructor: Professor Kamalesh K. Sirkar, 371 Tiernan Hall, 973-596-8447, sirkar@njit.edu
Office Hours: Friday, 11:30-12:30 PM, 373 Tiernan Hall (Oct 5, Tiernan LECT 2)

Description: This is the second of the two-course sequence on separations which examines methods and technologies used by chemical engineers to separate chemical solutions and particle mixtures. ChE 360 dealt with equilibrium staged processes relying primarily on thermodynamic phase equilibrium. This course will cover membrane separation processes, fixed-bed processes, crystallization processes and external force-based separations of particles as well as molecules and macromolecules involving gravity, electrical and centrifugal forces.

Prerequisites: ChE 360, ChE 370 (Heat and Mass Transfer).

Textbooks: There is no single textbook for this course. However, the two textbooks to be used almost exclusively are items (1) and (2) below. Appropriate sections from each of the four books mentioned below are identified in the schedule of lectures.

(1) I will use extensively material from my book published in 2014 by Cambridge University Press:

Kamalesh K. Sirkar, "Separation of Molecules, Macromolecules and Particles: Principles, Phenomena and Processes". (Sirkar)

(2) Christie J. Geankoplis, "Transport Processes and Separation Process Principles", 4th Ed. Prentice Hall PTR, Saddle River, NJ (2003). (Geankoplis). To be used often.

(3) J.D. Seader, E.J. Henley and D. Keith Roper, "Separation Process Principles", 3rd Ed. (2011), John Wiley & Sons, New York. (Seader et al.)

(4) Phillip C. Wankat – "Separation Process Engineering", 2nd Ed., Prentice Hall (2007). (Wankat)

If you want to learn more about membrane processes, read W.S. Winston Ho and K.K. Sirkar, "Membrane Handbook", Van Nostrand Reinhold, New York (1992); Reprinted, Kluwer Academic Publishers, Boston (2001) (now Springer Publishers). Kept in the Reserve Section of the Library. (Ho and Sirkar)

Homework: Homework problems will be provided for each separation technique/process after each topic is completed. **Unless otherwise mentioned**, the homework problem solutions have to be submitted before the next lecture begins into the box marked ChE 460 kept in the Chemical, and Materials Engineering Office. **Submission by email is not acceptable**.

There are two TAs for this course:

Generally at the end of Lectures on a given topic, home assignments will be provided; we will go over the solutions of the homework problems assigned at

the end of next lecture. Every student must submit their own homework with their own solutions. You must submit the **problem handout** along with your solutions of the problems. No copying is allowed. Homework will count for 10% of the grade (May be changed if necessary). For an Extended Design-like Problem, 3 weeks will be available for submission near the end of the course; it will count for ~5% of the grade. There will be quite a few unannounced **Quizzes** at the end or the beginning of the class; these will count for ~10% of the grade.

Policy on Exams: A compelling reason (e.g., doctor's note) is needed before a make-up is allowed. The final exam will cover the entire course.

Grading: There will be two midterm examinations each lasting 85 minutes and one final exam (lasting 150 minutes): October 10, November 28, and December 19(?), 2018. The final grade will be determined by: Midterm 1 – 20%; Midterm 2 – 20%; Final – 35%; Homework – 10%; Quiz- 10%; Larger problem solving – 5%. Course grades will be awarded on the following basis: 85+, A; 80+, B+; 75+, B; 70+, C+; 65+, C; 60+, D; 60 < F. Exams will be open books and notes.

Classroom Policy: Eating, drinking, talking with friends, using cell phone, blackberry and iPhone etc. are not allowed in the class.

NJIT Honor Code: The NJIT honor code will be followed in all issues arising.

Schedule of Lectures:

Sept 5: Syllabus, Textbooks, Schedule, Grading. General Review of Separation Processes, Description of Separation, Fluxes and Forces in Separation, Molecular Systems and Particulate Systems, Equilibrium Distribution (Sirkar, Chaps. 1, 2.1, 2.2, 2.4, 3.1-2.1/2.5, 3.3, 3.4); Introduction to Membranes (Sirkar, Chap. 3.4.2; Geankoplis, Chap. 13.1; Wankat, Chap. 16; Seader et al., Chap. 14); Dialysis and Liquid Permeation (Geankoplis, Chap. 13.2; Sirkar, Chaps. 3.1-3.2-3, 3.4-2.3, 4.3-1; Seader et al., Chap. 14.3.2,14.4).

Sept 12: Dialysis and Liquid Permeation (Seader et al., Chap. 14.4; Geankoplis, Chap. 13.2; Sirkar, 4.3-1, 8.1-7). Pressure-driven Membrane Processes: Ultrafiltration (Geankoplis, Chap. 13.11; Sirkar, Chap. 3.4-2.3, Chaps. 6.3-3.2, 6.4-2.1; Seader et al., p. 539-561).

Sept 19: Ultrafiltration (Sirkar, Chaps. 6.4-2.1, 7.2-1.3; Seader et al., p. 539-561; Wankat, Chap. 16.5); Reverse Osmosis (Geankoplis, Chaps. 13.9/13.10; Sirkar, Chaps. 3.4-2.1, 4.3-4, 6.3-3.3; Seader et al., p.530-533).

Sept 26: Reverse Osmosis (Geankoplis, Chap. 13.9/13.10; Sirkar, Chaps. 6.3-3.3, 7.2-1.2; Wankat, Chap. 16.4; Seader et al., p. 530-533); Microfiltration (Geankoplis, Chap. 13.12; Sirkar, Chap. 6.3-3.1; Seader et al., p. 530-546).

| | |
|---|---|
| Oct 3: | Microfiltration (Sirkar, Chap. 7.2-1.4), Cake Filtration (Geankoplis, Chap. 14.2; Sirkar, Chaps. 6.3-3.1, 7.2-1.5; Seader et al., p. 509-513, 787-790). |
| Oct 10: | Gas Permeation<br>(Geankoplis, Chap. 13.3, 13.4, 13.5; Sirkar, Chaps. 3.3-7.3, 3.4-2.2, 4.3-3, 6.3-3.5, 6.4-2.2; Seader et al., Chap. 14). |
| | **Mid-term (Exam 1).** |
| Oct 17: | Gas Permeation (Continued)<br>(Geankoplis, Chap. 13.3, 13.4, 13.5; Sirkar, Chaps. 3.3-7.3, 3.4-2.2, 4.3-3, 6.3-3.5, 6.4-2.2; Seader et al., Chap. 14). |
| Oct 24: | Gas Permeation (Geankoplis, Chaps. 13.5 to 13.8; Sirkar, Chaps. 6.4-2.2, 7.2-1.1; Seader et al., p. 517-523).<br>Fixed Bed Processes (Geankoplis, Chaps. 12.1, 12.2, 12.3, 12.4; Sirkar, Chaps: 3.3-7.6, 3.4-1.4, 4.1-5, 4.1-6, 7.1-1; Wankat, Chap. 17; Seader et al., Chap. 15). |
| Oct 31: | Fixed Bed Processes (Geankoplis, 12.3, 12.4; Sirkar, Chaps. 7.1-1, 7.1-2, 7.1-5, 7.1-6; Wankat, Chap. 17; Seader et al., Chap. 15). |
| Nov 7: | Fixed Bed Processes (continued from Oct 31).<br>Crystallization (Seader et al., Chap. 17; Geankoplis, Chaps. 12.11, 12.12; Sirkar, Chaps. 2.4-1, 3.3-7.5, 3.4-1.3, 4.1-4, 6.2-3, 6.4-1). |
| Nov 14: | Crystallization (continued).<br>Mechanical Separations/External Force Fields, Gravitational and Centrifugal Force Fields (Geankoplis, Chaps. 14.3, 14.4; Sirkar, Chaps. 3.1-2, 3.3-3, 4.2-1.1, 4.2-1.2, 4.2-3; Seader et al., Chap. 19) |
| Nov 28: | Mechanical Separations/External Force Fields (continued). |
| | **Mid-term (Exam 2).** |
| Dec 5: | Centrifugal Force Field-based Separations (Geankoplis, Chap. 14.4; Sirkar, Chaps. 6.3-1.3, 7.3-2; Seader et al., p. 800-802 ). |
| Dec 12: | Gravitational Force Field-based Separations (Geankoplis, Chap. 14.3; Sirkar, Chaps. 4.2-3, 6.3-1.1, 7.3-3; Seader et al., p. 781-782)<br>Electrical Force Field-based Separations (Sirkar, Chaps. 4.2-2, 6.3-1.2, 7.3-1; Seader et al., Chap. 15.8). |
| Dec 19 (?): | Final Exam. |