18 APR 2018 CC/ 28 MAY 2018 UC

DEPARTMENT OF CHEMICAL ENGINEERING
College of Engineering
University of the Philippines Diliman, Quezon City

COURSE SYLLABUS
ChemE 132 Separation Processes I

A. Course Catalogue Description

1. **Course Number:** ChemE 132
2. **Course Title:** Separation Processes I
3. **Course Description:** Fundamentals of mass transfer; separation processes based on equilibrium and mass transfer rate; applications of equilibrium-based and rate-based principles in equipment design
4. **Prerequisites:** ChemE 123 Chemical Engineering Thermodynamics II and ChemE 130 Process Fluid Systems
5. **Semester Offered:** First Semester
6. **Course Credit:** 4u
7. **Number of Hours:** 4h
8. **Meeting Type:** lecture
9. **Course Goals:** To introduce the concept of mass transfer and to apply the principles of mass transfer and phase equilibrium in the rate-based and equilibrium-based design of mass transfer equipment

B. Rationale

This course discusses how chemical engineers can apply the key concepts of mass transfer and phase equilibrium to the design of continuous and stagewise separation process systems.

C. Course Outline

1. **Course Outcomes (CO)**

Upon completion of the course, students must be able to:

- **CO 1.** develop appropriate mathematical models for mass transfer mechanism by selecting relevant mechanisms and initial and boundary conditions;
- **CO 2.** explain general separation techniques and how mass and energy balances and phase equilibria play an important role in these processes;
- **CO 3.** apply mass and energy balances around different equilibrium stage configurations using graphical and numerical methods;
- **CO 4.** simulate computer-aided analyses of a multistage, multicomponent system;
- **CO 5.** apply concepts of mass transfer to the design of pertinent unit operations equipment; and
- **CO 6.** conduct design projects based on the desired process requirements, design principles, and solutions to operating problems and limitations of significant unit operations equipment.

Course Outcomes and Relationship to Program Learning Objectives

Course Outcomes	Program Learning Objectives*				
	A	B	C	D	E
Develop appropriate mathematical models for mass transfer mechanism by selecting relevant mechanisms and initial and boundary conditions					
Explain general separation techniques and how mass and energy balances and phase equilibria play an important role in these processes					
Apply mass and energy balances around different equilibrium stage configurations using graphical and numerical methods					
Simulate computer-aided analyses of a multistage, multicomponent system					
Apply concepts of mass transfer to the design of pertinent unit operations equipment					
Conduct design projects based on the desired process requirements, design principles, and solutions to operating problems and limitations of significant unit operations equipment					

* **A** Equip students with strong technical education in chemical engineering necessary to succeed in their chosen careers and to become responsive citizens.
B Develop the students' ability to effectively communicate technical information to any audience.
C Train students to function in multidisciplinary teams, manage projects, and take leadership roles in their respective fields.
D Engage students in research, innovation, and life-long learning to identify opportunities, and address issues and challenges in their respective spheres of influence.
E Instill in students a strong commitment to the ethical practice of their profession; to health, safety, and environment; and to service to society.

2. Course Content

Lecture Topics	No. of Hours
Principles of mass transfer 1. Steady-state, ordinary molecular diffusion 2. Diffusion coefficients (diffusivities) 3. Steady- and unsteady-state mass transfer through stationary media 4. Mass transfer in laminar flow 5. Mass transfer in turbulent flow 6. Models for mass transfer in fluids with a fluid-fluid interface 7. Two-film theory and overall mass transfer coefficients 8. Molecular mass transfer in terms of other driving forces	16
Long Examination 1	

Lecture Topics	No. of Hours
Introduction to separation processes 1. Equilibrium-based approach 2. Rate-based approach	2
Leaching and washing 1. Solid-liquid systems 2. Equipment for leaching 3. Equilibrium-stage model for leaching and washing 4. Rate-based model for leaching	6
Liquid-liquid extraction with ternary systems 1. Ternary liquid-liquid systems 2. Equipment for solvent extraction 3. General design considerations 4. Hunter-Nash graphical equilibrium stage method 5. Maloney-Schubert graphical equilibrium stage method	8
Long Examination 2	
Absorption and stripping of dilute mixtures 1. Gas-liquid systems 2. Equipment for vapor-liquid separations 3. General design considerations 4. Graphical and algebraic method for determining the number of stages 5. Stage efficiency and column height for tray columns 6. Flooding, column diameter, pressure drop, and mass transfer for tray columns	12
Long Examination 3	
Distillation of binary mixtures 1. Binary vapor-liquid systems 2. Equipment and design considerations 3. McCabe-Thiele graphical method for tray towers 4. Estimation of stage efficiency for distillation 5. Column and reflux-drum diameters	12
Batch distillation 1. Differential distillation 2. Binary batch rectification	4
Approximate methods for multicomponent, multistage separations 1. Fenske-Underwood-Gilliland (FUG) method 2. Kremser Group method	4
Long Examination 4	
Total number of hours	**64**

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1-4	1,5	**Principles of mass transfer** 1. Steady-state, ordinary molecular diffusion 2. Diffusion coefficients (diffusivities)	What are the different mechanisms of mass transfer?	lecture, classwork	quiz/seatwork

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		3. Steady- and unsteady-state mass transfer through stationary media 4. Mass transfer in laminar flow 5. Mass transfer in turbulent flow 6. Models for mass transfer in fluids with a fluid-fluid interface 7. Two-film theory and overall mass transfer coefficients 8. Molecular mass transfer in terms of other driving forces	What are the different cases of diffusion? How are mass transfer coefficients determined?		seatwork
					Long Examination 1
5	2,3	**Introduction to separation processes** 1. Equilibrium-based approach 2. Rate-based approach	What is an equilibrium stage? How is a phase diagram generated from thermodynamic data? How is percent recovery measured in a multistage unit for different phase equilibria?	lecture, classwork	seatwork
5-6	2,3,5	**Leaching and washing** 1. Solid-liquid systems 2. Equipment for leaching 3. Equilibrium-stage model for leaching and washing 4. Rate-based model for leaching	How are the principles of mass transfer and phase equilibrium applied to design a leaching extraction unit?	lecture, classwork	problem set
7-8	2,3 4,5	**Liquid-liquid extraction with ternary systems** 1. Ternary liquid-liquid systems 2. Equipment for solvent extraction 3. General design considerations 4. Hunter-Nash graphical equilibrium stage method 5. Maloney-Schubert graphical equilibrium stage method	What are the cases of liquid miscibility? How are the Hunter-Nash method and the Maloney-Schubert method used to design a liquid extraction unit?	lecture, classwork	problem set
					Long Examination 2

18 APR 2018 CC/ 28 MAY 2018 UC

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
9-11	2,3 5,6	**Absorption and stripping of dilute mixtures** 1. Gas-liquid systems 2. Equipment for vapor-liquid separations 3. General design considerations 4. Graphical and algebraic method for determining the number of stages 5. Stage efficiency and column height for tray columns 6. Flooding, column diameter, pressure drop, and mass transfer for tray columns	How are the principles of mass transfer and phase equilibrium applied to determine the number of stages and height of an absorption column?	lecture, classwork	homework
					Long Examination 3
					Design Project 1
12-14	2,3,5	**Distillation of binary mixtures** 1. Binary vapor-liquid systems 2. Equipment and design considerations 3. McCabe-Thiele graphical method for tray towers 4. Estimation of stage efficiency for distillation 5. Column and reflux-drum diameters	How are the principles of interphase mass transfer and phase equilibrium applied to determine the required number of stages and height of distillation column?	lecture, classwork	seatwork
15	2,3 4,5	**Batch distillation** 1. Differential distillation 2. Binary batch rectification	How are the principles of mass transfer and phase equilibrium applied to design a still pot?	lecture, classwork	problem set
16	2,3,4 5,6	**Approximate methods for multicomponent, multistage separations** 1. Fenske-Underwood-Gilliland (FUG) method 2. Kremser Group method	How are the principles of phase equilibrium applied to determine the required number of stages and height of distillation column processing streams with 3 or more components?	lecture, classwork	seatwork
					Long Examination 4
					Design Project 2

4. Course Requirements

1. Long examinations (4)
2. Design projects (2)
3. Seatwork
4. Problem sets

REFERENCES:

Bird, R. B., Stewart, W. E., Lightfoot, E. N., and Klingenberg, D. J. (2014). *Introductory Transport Phenomena*. NJ: John Wiley and Sons Inc.

Dy, T. R. N. (2013). Water hyacinth-derived biopolyols for polyurethane production using crude glycerine as liquefaction solvent (Master's thesis). University of the Philippines Diliman.

Geankoplis, C. J., Hersel, A. H., and Lepek, D. H. (2018). *Transport Processes and Separation Process Principles* 5th Ed. London, UK: Pearson Higher Education.

McCabe, W.L., Smith, J.C. and Harriott, P. (2005). *Unit Operations of Chemical Engineering* 7th Ed., Singapore: McGraw-Hill.

Seader, J.D., Henley, E.J., and Roper, D.K. (2016). *Separation Process Principles* 4th Ed. NJ: John Wiley and Sons Inc.

Towler, G. and Sinnott, R. (2012). *Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design* 2nd Ed. Oxford, UK: Butterworth-Heinemann.

Welty, J.R., et al. (2008). *Fundamentals of Momentum, Heat, and Mass Transfer*. NJ: John Wiley and Sons, Inc.