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 133 Separation Processes II

A. Course Catalogue Description

1. **Course Number:** ChemE 133
2. **Course Title:** Separation Processes II
3. **Course Description:** Principles and equipment design of simultaneous heat and mass transfer; humidification, drying, crystallization, sorption, and membrane separation technologies; emerging separation process technologies
4. **Prerequisites:** ChemE 131 Thermal Systems and ChemE 132 Separation Processes I
5. **Semester Offered:** Second Semester
6. **Course Credit:** 3u
7. **Number of Hours:** 3h
8. **Meeting Type:** lecture
9. **Course Goals:** To introduce the concept of simultaneous heat and mass transfer to the design of an energy-driven unit operation equipment

B. Rationale

This course discusses how chemical engineers can apply the key concepts of simultaneous heat and mass transfer to the basic and advanced design of unit operations in which heat is applied/removed to induce separation of material components, such as drying, crystallization and humidification.

C. Course Outline

1. **Course Outcomes (CO)**

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

   CO 1. demonstrate a good understanding of the mechanism and mathematics governing simultaneous heat and mass transfer;

   CO 2. interpret the solutions of the derived appropriate mathematical equations arising from the analysis of simultaneous heat and mass transfer in the context of chemical engineering practice;

   CO 3. use computer software for the solution of simultaneous heat and mass transfer problems;

   CO 4. perform equipment design calculations for humidification, drying of solids, crystallization, adsorption, ion exchange, chromatography, and electrophoresis; and

   CO 5. report on emerging separation technologies and current research trends on simultaneous and heat mass transfer.

Course Outcomes and Relationship to Program Learning Objectives

Course Outcomes	Program Learning Objectives*				
	A	B	C	D	E
Demonstrate a good understanding of the mechanism and mathematics governing simultaneous heat and mass transfer	■	■			
Interpret the solutions of the derived appropriate mathematical equations arising from the analysis of simultaneous heat and mass transfer in the context of chemical engineering practice	■	■			
Use computer software for the solution of simultaneous heat and mass transfer problems	■			■	
Perform equipment design calculations for humidification, drying of solids, crystallization, adsorption, ion exchange, chromatography, and electrophoresis	■				
Report on emerging separation technologies and current research trends on simultaneous and heat mass transfer	■	■		■	■

* **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
Introduction to simultaneous heat and mass transfer	3
Humidification operations 1. Psychrometry and humidity chart 2. Wet-bulb temperature and humidity measurement 3. Equipment for humidification operations 4. Theory and principles of humidification 5. Process calculation of humidification processes 6. Design and application of humidification equipment	9
Long Examination 1	
Drying of solids 1. Equipment for drying 2. Equilibrium moisture content of materials 3. Drying rates and drying curves	9

Lecture Topics	No. of Hours
4. Calculation methods for constant-rate and falling-rate drying periods 5. Design of batch and continuous drying processes 6. Transport principles and application of freeze drying	
Crystallization 1. Crystal geometry 2. Thermodynamic, kinetic, and mass transfer considerations 3. Equipment for solution crystallization 4. Mixed-suspension, mixed-product-removal (MSMPR) crystallization model 5. Precipitation, evaporative, and melt crystallization	6
Long Examination 2	
Adsorption 1. Sorbent materials and adsorption applications 2. Equilibrium, kinetic, and transport considerations 3. Equipment for sorption operations 4. Principles and design equations of adsorption 5. Equipment design for fixed-bed adsorption columns 6. Continuous countercurrent adsorption and regeneration 7. Ion-exchange processes and application	9
Sorption technologies 1. Membrane materials, modules, and transport 2. Dialysis and electrodialysis 3. Reverse osmosis, gas permeation, and pervaporation 4. Electrophoresis	6
Long Examination 3	
Emerging technologies 1. Membrane separation 2. Supercritical fluid extraction 3. Bioseparation 4. Reactive separation	6
Oral Presentation	
Total number of hours	**48**

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1	1	**Introduction to simultaneous heat and mass transfer**	What are the equations that govern simultaneous heat and mass transfer?	lecture, classwork	seatwork
2-4	2,3,4	**Humidification operations** 1. Psychrometry and humidity chart 2. Wet-bulb temperature and humidity measurement 3. Equipment for humidification operations	What is psychrometry? How is the psychrometric chart used in determining humidity?	lecture, classwork	homework, seatwork

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		4. Theory and principles of humidification 5. Process calculation of humidification processes 6. Design and application of humidification equipment	How are the principles of heat transfer and mass transfer applied to the design of humidifiers, dehumidifiers, and cooling towers?		homework, seatwork
					Long Examination 1
5-7	2,3,4	**Drying of solids** 1. Equipment for drying 2. Equilibrium moisture content of materials 3. Drying rates and drying curves 4. Calculation methods for constant-rate and falling-rate drying periods 5. Design of batch and continuous drying processes 6. Transport principles and application of freeze drying	What are the different stages of drying? How are the principles of heat transfer and mass transfer applied to the design of different types of dryers? What are the heat and mass transfer principles applied in a freeze dryer?	lecture, classwork	homework, seatwork
8-9	2,3,4	**Crystallization** 1. Crystal geometry 2. Thermodynamic, kinetic, and mass transfer considerations 3. Equipment for solution crystallization 4. Mixed-suspension, mixed-product-removal (MSMPR) crystallization model 5. Precipitation, evaporative, and melt crystallization	What are the different mechanisms of crystallization? What are the equations that describe the kinetics of crystallization? How are the principles of heat transfer and mass transfer applied to the design of crystallizers?	lecture, classwork	homework, seatwork
					Long Examination 2

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
10-12	2,3,4	**Adsorption** 1. Sorbent materials and adsorption applications 2. Equilibrium, kinetic, and transport considerations 3. Equipment for sorption operations 4. Principles and design equations of adsorption 5. Equipment design for fixed-bed adsorption columns 6. Continuous countercurrent adsorption and regeneration 7. Ion-exchange processes and application	What are the different mechanisms of adsorption? What are the equations that describe the kinetics of adsorption? How are the principles of heat transfer, mass transfer and equilibrium applied to the design of adsorbers? What are the applications of ion-exchange processes?	lecture, classwork	homework, seatwork
13-14	2,3,4	**Sorption technologies** 1. Membrane materials, modules, and transport 2. Dialysis and electrodialysis 3. Reverse osmosis, gas permeation, and pervaporation 4. Electrophoresis	How are the principles of heat transfer and mass transfer applied to the design of membrane equipment, chromatograms, and electrophoretic devices?	lecture, classwork	homework, seatwork
					Long Examination 3
15-16	1,5	**Emerging technologies** 1. Membrane separation 2. Supercritical fluid extraction 3. Bioseparation 4. Reactive separation	What are the latest advancements in separation technology? What are the current research trends in simultaneous mass and heat transfer?	oral presentation	oral report

4. Course Requirements

1. Long examinations (3)
2. Homework
3. Seatwork
4. Oral presentation

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Welty, J.R., Wicks, C.E., Wilson, R.E., Rorrer, G.L. (2008). *Fundamentals of Momentum, Heat, and Mass Transfer*. NJ: John Wiley and Sons, Inc.