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 131 Thermal Systems

A. Course Catalogue Description

1. **Course Number:** ChemE 131
2. **Course Title:** Thermal Systems
3. **Course Description:** Fundamentals of heat transfer; application to design of heat transfer equipment
4. **Prerequisite:** ChemE 106 Mathematical Methods in Chemical Engineering II
5. **Corequisite:** ChemE 130 Process Fluid Systems
6. **Semester Offered:** Second Semester
7. **Course Credit:** 3u
8. **Number of Hours:** 3h
9. **Meeting Type:** lecture
10. **Course Goals:** To introduce the concept of heat transfer, and to apply the principles of energy balance in the design of heat transfer equipment

B. Rationale

This course focuses on the principles of heat transfer and overall energy balance as well as how chemical engineers apply these concepts to the analysis and design of heat exchangers, boilers, condensers, evaporators, and other essential thermal equipment in an industrial process.

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 heat transfer;
- **CO 2.** formulate appropriate mathematical equations arising from the analysis of heat transfer, and interpret the results in the context of chemical engineering practices;
- **CO 3.** demonstrate the ability to use computer software for the solution of combined heat and momentum transfer problems;
- **CO 4.** compose the thermal design of heat exchangers, condensers, boilers and evaporator equipment that comply with specifications from the process objectives; and
- **CO 5.** design a heat transfer equipment that provides a solution to a specific engineering problem.

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 heat transfer					
Formulate appropriate mathematical equations arising from the analysis of heat transfer, and interpret the results in the context of chemical engineering practices					
Demonstrate the ability to use computer software for the solution of combined heat and momentum transfer problems					
Compose the thermal design of heat exchangers, condensers, boilers and evaporator equipment that comply with specifications from the process objectives					
Design a heat transfer equipment that provides a solution to a specific engineering problem					

* **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 and review 1. Energy balances 2. Dimensional analysis 3. Introduction to heat transfer	1.5
Conductive heat transfer 1. Shell energy balances 2. Differential equations of energy 3. Thermal conductivity	6
Convective heat transfer 1. Natural and forced convection 2. Temperature profiles of fluids in laminar and turbulent flow 3. Heat transfer coefficient	7.5
Long Examination 1	
Radiative heat transfer 1. Radiative fundamentals 2. Combined heat transfer calculations 3. View factor calculations	4.5

Lecture Topics	No. of Hours
Overall energy balance 1. Interphase heat transfer 2. Overall heat transfer coefficient	4.5
Long Examination 2	
Overview of heat exchangers	1.5
Design of heat exchangers without phase change 1. Design considerations for heat exchangers 2. Double-pipe heat exchangers 3. Shell-and-tube heat exchangers 4. Extended-surface heat exchangers 5. Plate heat exchangers 6. Transfer unit and effectiveness	10.5
Long Examination 3	
Design of heat exchangers with phase change 1. Condensation and boiling phenomena 2. Condenser design considerations 3. Reboiler design considerations	6
Design of evaporators 1. Review of colligative properties 2. Overview of evaporator equipment 3. Single-effect evaporator calculations 4. Multiple-effect evaporator calculations	6
Long Examination 4	
Design Project	
Total number of hours	**48**

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1	2	**Introduction and review** 1. Energy balances 2. Dimensional analysis 3. Introduction to heat transfer	How are energy balance calculations performed for open and closed systems?	lecture, classwork	seatwork/ problem set
1-3	1,2	**Conductive heat transfer** 1. Shell energy balances 2. Differential equations of energy 3. Thermal conductivity	What is Fourier's law of conduction? How is conductive heat transfer modelled using differential equations? How does the material of construction affect how much heat is transferred?	lecture, classwork	seatwork/ problem set
3-5	1,2	**Convective heat transfer** 1. Natural and forced convection 2. Temperature profiles of fluids in laminar and turbulent flow	How does heat transfer through natural and forced convection? How does temperature vary in laminar and turbulent flows in fluid conduits?	lecture, classwork	seatwork/ problem set

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Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		3. Heat transfer coefficient	How is the heat transfer coefficient calculated based on specified process conditions?		seatwork
					Long Examination 1
6-7	1,2	**Radiative heat transfer** 1. Radiative fundamentals 2. Combined heat transfer calculations 3. View factor calculations	How does temperature and type of material affect the amount of heat transferred through radiation?	lecture, classwork	seatwork/ problem set
7-8	1,2	**Overall energy balance** 1. Interphase heat transfer 2. Overall heat transfer coefficient	How is the overall heat transfer calculated based on the types of heat transfer involved?	lecture, classwork	seatwork/ problem set
					Long Examination 2
9	1,2	**Overview of heat exchangers**	What are the types of heat exchangers and how do they operate?	lecture, classwork	seatwork/ problem set
9-12	3,4,5	**Design of heat exchangers without phase change** 1. Design considerations for heat exchangers 2. Double-pipe heat exchangers 3. Shell-and-tube heat exchangers 4. Extended-surface heat exchangers 5. Plate heat exchangers 6. Transfer unit and effectiveness	How are the principles of heat transfer and momentum transfer applied to the design of a heat exchanger without phase change?	lecture, classwork	seatwork/ problem set
					Long Examination 3
13-14	3,4,5	**Design of heat exchangers with phase change** 1. Condensation and boiling phenomena 2. Condenser design considerations 3. Reboiler design considerations	How are the principles of heat transfer and momentum transfer applied to the design of a heat exchanger with phase change?	lecture, classwork	seatwork/ problem set
15-16	3,4,5	**Design of evaporators** 1. Review of colligative properties 2. Overview of evaporator equipment	How are the principles of heat transfer and momentum transfer applied to the design of an evaporator?	lecture, classwork	seatwork/ problem set

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		3. Single-effect evaporator calculations 4. Multiple-effect evaporator calculations			seatwork/ problem set
					Long Examination 4
					Design Project

4. Course Requirements

1. Long examinations (4)
2. Design project
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.

Cao, E. (2010). *Heat Transfer in Process Engineering*. NY: McGraw-Hill Companies, Inc.

De Castro, L. T. (2015). Optimization of TEC-cooled closed-end oscillating heat pipe charged with degassed, deionized water (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., NY: McGraw-Hill Companies, Inc.

Serth, R. W. and Lestina, T. (2014). *Process Heat Transfer: Principles, Applications and Rules of Thumb* 2nd Ed. MA: Academic Press.

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.