Department of Chemical Engineering
College of Engineering
University of the Philippines
Diliman, Quezon City

ChE 133

Heat & Mass Transfer Equipment Design

Course Description: Applications of the principles of separation and rate processes to the design of heat and mass transfer equipment.

Course Prerequisite: ChE 131

Course Credit: 3.0 units (2 h lecture, 3 h laboratory)

Program Educational Objectives (BS Chemical Engineering)
The program aims to educate students such that three to five years from graduation, they:
1. take leadership roles in their respective fields and/or effectively work in or manage a team;
2. are equipped with the extensive knowledge and relevant skills necessary to succeed in their chosen careers and to become responsive citizens;
3. are able to demonstrate strong research & innovative capability as they recognize and address opportunities and challenges in their respective spheres of influence;
4. have shown strong commitment to the ethical practice of their profession; to health, safety and environment; and service to society.

Course Outcomes
At the end of the course, the student should be able to:
1. Apply concepts of heat, mass, and simultaneous heat and mass transfer to the design of pertinent unit operations equipment
2. Determine the necessary operating conditions and design parameters from process experimental data
3. Formulate the basic design of heat and mass transfer equipment for desired process requirements
4. Identify and provide solutions to problems on heat and mass transfer equipment operations
5. Prepare and present a design project reflecting the design principles of significant unit operations equipment
6. Analyse and evaluate the efficiency of heat and mass transfer equipment

Student Outcomes Satisfied by Course Outcomes
[a] Ability to apply knowledge of mathematics and science to solve engineering problems
[c] Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards
[e] Ability to identify, formulate, and solve engineering problems
[g] Ability to communicate effectively
[k] Ability to use the techniques, skills, and modern tools for engineering practice

Course Content

Week	Objectives	Topics
1	• Revisit heat transport fundamentals • Appreciate the relevance of dimensionless ratios and empirical equations to equipment design • Appreciate the importance of the overall heat transfer coefficient • Familiarize with the various types of heat exchangers	Review of Heat Transfer Principles Overall Heat Transfer Coefficient Heat Exchanger Equipment
2	• Compute the required design parameters for a double-pipe HE	Double-Pipe Heat Exchangers

Week	Objectives	Topics
	• Compute the required design parameters for longitudinal-fin HE	Extended-Surface Heat Exchangers
3	• Understand the different types of shell-and-tube HE's, its parts and functions • Compute the required design parameters for a shell-and-tube HE • Understand and implement the procedure for the design of shell-and-tube HE	Shell-and-Tube Heat Exchanger Design and Calculations
4	• Understand the nature and mechanism of heat transfer via radiation • Evaluate view factors for certain geometries and real surfaces • Integrate radiation in obtaining the overall heat-transfer coefficient	Radiation Heat Transfer
5	• Provide basic design parameters for plate-and-frame heat exchangers • Understand the various regimes of condensation and boiling	Plate-and-Frame Heat Exchangers Heat Transfer with Phase Change: Condensation and Boiling
6	• Perform rigorous heat exchanger design using a design software	HTRI
	FIRST LONG EXAMINATION	
7	• Revisit mass transport fundamentals • Apply vapor-liquid equilibrium relations in gas absorption and desorption	Review of Mass Transfer Principles Packed Column Design Prerequisites
8	• Compute the height of a packed column needed to satisfy given process parameters • Define and apply the concept of transfer units to packed column design	Design Equation for Packed Columns Height and Number of Transfer Units (HTU and NTU) Packed Column Design
9	• Appreciate and evaluate pressure-drop limitations in packed column design • Understand the principles of fixed-bed adsorption and their application to ion-exchange processes	Pressure Drop in Packed Columns Analysis of Fixed-Bed Adsorption Ion Exchange Processes
	SECOND LONG EXAMINATION	
10	• Revisit topics in psychrometry • Calculate the required design parameters for spray chambers and cooling towers • Recognize the limitation of fogging in cooling tower design	Humidification Prerequisites Design of Spray Chambers and Cooling Towers
11	• Understand the various phenomena occurring in the drying process • Familiarize with the various types of equipment used for the drying process	Drying Fundamentals Drying Equipment
12	• Calculate the drying time required to achieve the desired moisture content based from experimental data • Calculate the required design parameters for tunnel/conveyor dryers	Drying Rate Calculations Dryer Design (Batch and Continuous)
	THIRD LONG EXAMINATION	
13	• Review colligative properties and their implications to the evaporation process • Calculate the required design parameters for single-effect evaporators	Evaporation Prerequisites Evaporator Equipment Single-Effect Evaporator Calculations
14	• Understand how multiple-effect evaporation improves steam economy • Calculate the required design parameters for multiple-effect evaporators	Steam Economy Multiple-Effect Evaporator Calculations Crystallization Mechanisms Crystallization Equipment

Week	Objectives	Topics
	• Understand how crystallization phenomena occur, as well as the various equipment used in crystallization	
15	• Apply the ILAR method in computing the amount of each phase at equilibrium • Predict product crystal size distributions from given process parameters	Crystallization Phase Diagrams Crystal Size Distribution Calculations
FOURTH LONG EXAM **CASE STUDY PRESENTATION: FINALS WEEK**		

Course Assessment

Long Examinations (4)	50%
Design Project	20%
Case Study	10%
Homework, Problem Sets	10%
Class Work	10%

Course Policies

1. **Long Examinations**
   a. There will be four long examinations for this course.
   b. All exam papers must be written legibly in black/blue ink; otherwise, the student forfeits his/her right to seek any correction for his/her paper. Solutions written in pencil will not be considered.
   c. Each student must submit at least 10 sheets of yellow paper, with only their **name, student number and section** written at the top-right portion **at least one working day before the long exam date**. Additional answer sheets may be brought for use during long exams provided that they present it for inspection. Failure to comply shall be an equivalent to a **ten (10) point deduction** for that particular long exam.
   d. Students shall be given **one week** after the release of exam results to seek corrections. **All grievances (for whatever reason) will not be considered if it is raised after the one-week grace period.**
   e. A student who misses an exam must submit an official excuse slip to the instructor **as soon as possible (e.g. prior to the next exam)**; otherwise, a score of zero will be given for the missed exam. **Only one missed long exam is allowed,** provided that the excuse is valid, and the student must take a **comprehensive exam** as remedial.
2. **Design Project**
   a. Groups of three students shall carry out the detailed design of a process unit with multiple heat and mass transfer equipment.
   b. All group members must be able to explain their work when asked by the instructor during consultation sessions.
   c. A ring-bound copy of the final design report is to be submitted, as well as an e-copy (burned in a CD) of the report and the program files used in the project.
3. **Case Study**
   The same design project group shall present a case study of specific heat/mass transfer equipment and its application to a particular industry (chemicals manufacturing food, etc.). They shall also create an excel spreadsheet that can be used to perform basic sizing of the assigned equipment. A detailed documentation on how to use the spreadsheet as well as the pertinent formulas references used should also be submitted.
4. **Homework and Classwork**
   a. Problem sets will be done in pairs. Late submissions shall not be accepted for whatever reason.
   b. Quizzes may be given at any point during class.
   c. There is no remedial for any missed problem set or quiz.
   d. Extra points are awarded to students presenting their solution in class.
5. **Other Matters**
   a. Students are encouraged to actively participate in discussions and are expected to have read (or at least browsed over) the suggested readings prior to class.
   b. University rules on absences/cheating/dropping/LOA shall apply.

c. The instructor reserves the right to make changes in class policies when deemed necessary.

Grading System

1.00	1.25	1.50	1.75	2.00	2.25	2.5	2.75	3.00	5.00
[92,100]	[88,92)	[84,88)	[80,84)	[76,80)	[72,76)	[68,72)	[64,68)	[60,64)	[0,60)

List of Instructors

Dr. Terence Tumolva
Prof. Jhud Mikhail Aberilla
Prof. Julie Anne del Rosario
Engr. Myron Alcanzare
Engr. Marlon Mopon, Jr.
Engr. Aldren Ribalde
Mr. John Andrew Kane Jovellana

References

1. Foust, A.S., Wenzel, L.A., Clump, C.W., Maus, L., Andersen, L.B. (1980). *Principles of Unit Operations.* 2nd Ed. Singapore: John Wiley and Sons.
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4. TEMA. (1999). *Standards of the Tubular Exchanger Manufacturers Association.* 8th Ed. USA: TEMA.
5. McCabe, W.L., Smith, J.C. and Harriott, P. (2001). *Unit Operations of Chemical Engineering.* 6th Ed. Singapore: McGraw-Hill.
6. Geankoplis, C.J. (2003). *Transport Processes and Separation Process Principles (Includes Unit Operations).* 4th Ed. USA: Prentice-Hall.
7. Green, D.W. and Perry, R. H., (Eds.) (2008). *Perry's Chemical Engineers' Handbook.* 8th Ed. USA: McGraw-Hill.
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