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 122 Chemical Engineering Thermodynamics I

A. Course Catalogue Description

1. **Course Number:** ChemE 122
2. **Course Title:** Chemical Engineering Thermodynamics I
3. **Course Description:** Application of the first and second laws of thermodynamics to closed and open systems; thermodynamic properties of fluids; power cycles, refrigeration, and liquefaction processes
4. **Prerequisite:** ChemE 102 Chemical Engineering Process Analysis II and ChemE 105 Mathematical Methods in Chemical Engineering I
5. **Corequisite:** Math 23 Elementary Analysis III
6. **Semester Offered:** First Semester
7. **Course Credit:** 3u
8. **Number of Hours:** 3h
9. **Meeting Type:** lecture
10. **Course Goals:** To introduce the First and Second Laws of Thermodynamics to analyze and describe fluid systems in different chemical engineering processes

B. Rationale

This course discusses how chemical engineers apply the First and Second Laws of Thermodynamics in the analysis of open and closed chemical systems. It also covers the thermodynamic properties of process fluids encountered in industrial operations, such as steam, air and refrigerants.

C. Course Outline

1. **Course Outcomes (CO)**

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

   CO 1. solve energy balance equations for closed and open systems;
   CO 2. calculate volumetric properties for ideal gas and real fluids;
   CO 3. apply the derived thermodynamic property relations for enthalpy and entropy in calculating property values and changes; and
   CO 4. perform thermodynamic analysis of power generation and refrigeration systems (entropy generation, ideal work, lost work, thermal efficiency or coefficient of performance, and thermodynamic efficiency).

Course Outcomes and Relationship to Program Learning Objectives

Course Outcomes	Program Learning Objectives*				
	A	B	C	D	E
Solve energy balance equations for closed and open systems					
Calculate volumetric properties for ideal gas and real fluids					
Apply the derived thermodynamic property relations for enthalpy and entropy in calculating property values and changes					
Perform thermodynamic analysis of power generation and refrigeration systems (entropy generation, ideal work, lost work, thermal efficiency or coefficient of performance, and thermodynamic efficiency)					

* **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 of fundamental concepts 1. Scope of thermodynamics 2. Dimensions and units 3. Force, temperature, pressure 4. Work, energy, heat	3
The First Law and other basic concepts 1. Joule's Experiment 2. Internal energy 3. The First Law of Thermodynamics 4. Energy balance for closed systems 5. Thermodynamic state and state functions 6. Equilibrium and the phase rule 7. The reversible process 8. Constant-volume and constant-pressure processes 9. Enthalpy and heat capacity 10. Mass and energy balance for open systems	6

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Lecture Topics	No. of Hours
Volumetric properties of fluids 1. P-V-T behavior of pure substances 2. Virial equations of state 3. The ideal gas 4. Applications of the virial equations 5. Cubic equations of state 6. Generalized correlations for gases 7. Generalized correlations for liquids	6
Long Examination 1	
Heat effects 1. Sensible heat 2. Latent heat of pure substances 3. Heat of reaction (standard heat of reaction, formation, combustion) 4. Temperature dependence of ΔH 5. Heat effects of industrial reactions	3
The Second Law of Thermodynamics 1. Statements of the Second Law 2. Heat engines 3. The Carnot Cycle 4. Thermodynamic temperature scales 5. Entropy 6. Entropy changes of an ideal gas 7. Mathematical statement of the Second Law 8. Entropy balance for open systems 9. Calculations of ideal work 10. Lost work 11. The Third Law of Thermodynamics 12. Entropy from the microscopic viewpoint	9
Long Examination 2	
Thermodynamic properties of fluids 1. Property relations for homogeneous phases 2. Residual properties 3. Residual properties by equations of state 4. Two-phase systems 5. Thermodynamic diagrams 6. Tables of thermodynamic properties 7. Generalized property correlations for gases	6
Application of thermodynamics to flow processes 1. Duct flow of compressible fluids 2. Turbines (expanders) 3. Compression	3
Long Examination 3	
Production of power from heat 1. The steam power plant 2. Internal-combustion engines 3. Jet engines and rocket engines	6

Lecture Topics	No. of Hours
Refrigeration and liquefaction 1. The Carnot Refrigerator 2. The vapor-compression cycle 3. The choice of refrigerant 4. Absorption refrigeration 5. The heat pump 6. Liquefaction processes	3
Thermodynamic analysis of flow processes	3
Long Examination 4	
Final Examination	
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 and review of fundamental concepts** 1. Scope of thermodynamics 2. Dimensions and units 3. Force, temperature, pressure 4. Work, energy, heat	What are the different thermodynamic quantities and their units?	lecture, classwork	problem set/quiz
2-3	1	**The First Law and other basic concepts** 1. Joule's Experiment 2. Internal energy 3. The First Law of Thermodynamics 4. Energy balance for closed systems 5. Thermodynamic state and state functions 6. Equilibrium and the phase rule 7. The reversible process 8. Constant-volume and constant-pressure processes 9. Enthalpy and heat capacity 10. Mass and energy balance for open systems	How can the First Law be used to perform energy balance calculations for closed and open systems undergoing steady state or transient processes? What is a reversible process, and how does it relate to thermodynamic efficiency?	lecture, classwork	problem set/quiz

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
4-5	2	**Volumetric properties of fluids** 1. P-V-T behavior of pure substances 2. Virial equations of state 3. The ideal gas 4. Applications of the virial equations 5. Cubic equations of state 6. Generalized correlations for gases 7. Generalized correlations for liquids	What is the compressibility factor? What are the different equations of states and correlations that describe the P-V-T relationship for a pure fluid? What is the acentric factor?	lecture, classwork	problem set/quiz
					Long Examination 1
6	1	**Heat effects** 1. Sensible heat 2. Latent heat of pure substances 3. Heat of reaction (standard heat of reaction, formation, combustion) 4. Temperature dependence of ΔH 5. Heat effects of industrial reactions	What are the different heat effects associated with different thermodynamic processes in chemical engineering?	lecture, classwork	problem set/quiz
7-9	3	**The Second Law of Thermodynamics** 1. Statements of the Second Law 2. Heat engines 3. The Carnot Cycle 4. Thermodynamic temperature scales 5. Entropy 6. Entropy changes of an ideal gas 7. Mathematical statement of the Second Law 8. Entropy balance for open systems 9. Calculations of ideal work 10. Lost work 11. The Third Law of Thermodynamics 12. Entropy from the microscopic viewpoint	What is the Second Law of Thermodynamics? How can the Second Law be used to perform entropy balance calculations to determine efficiency? What is the Carnot Cycle?	lecture, classwork	problem set/quiz

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Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
					Long Examination 2
10-11	2,3	**Thermodynamic properties of fluids** 1. Property relations for homogeneous phases 2. Residual properties 3. Residual properties by equations of state 4. Two-phase systems 5. Thermodynamic diagrams 6. Tables of thermodynamic properties 7. Generalized property correlations for gases	What are the different thermodynamic variables to define energy, and how are they related to S, T, V and P? How are thermodynamic variables represented in diagrams, tables and correlations?	lecture, classwork	problem set/quiz
12	2,4	**Application of thermodynamics to flow processes** 1. Duct flow of compressible fluids 2. Turbines (expanders) 3. Compression	How can thermodynamics be used to define flow processes involving compressible fluids?	lecture, classwork	problem set/quiz
					Long Examination 3
13-14	3,4	**Production of power from heat** 1. The steam power plant 2. Internal-combustion engines 3. Jet engines and rocket engines	What are the different power cycles? How can mass, energy and entropy balance calculations be performed for different power cycles?	lecture, classwork	problem set/quiz
15	3,4	**Refrigeration and liquefaction** 1. The Carnot Refrigerator 2. The vapor-compression cycle 3. The choice of refrigerant 4. The heat pump 5. Liquefaction processes	What are the different refrigeration cycles? How can mass, energy and entropy balance calculations be performed for different power cycles?	lecture, classwork	problem set/quiz
16	4	**Thermodynamic analysis of flow processes**	How can thermodynamic efficiencies be calculated for different thermodynamic cycles?	lecture, classwork	problem set/quiz
					Long Examination 4
					Final Examination

4. Course Requirements

1. Long examinations (4)
2. Final examination
3. Problem sets
4. Quizzes

REFERENCES:

De Castro, L. T. (2015). Optimization of TEC-cooled closed-end oscillating heat pipe charged with degassed, deionized water. A master's thesis. University of the Philippines Diliman.

Sandler, S.I. (2017). *Chemical, Biochemical and Engineering Thermodynamics* 5th Ed. NJ: John Wiley and Sons, Inc.

Smith, J. M., Van Ness, H. C. and Abbott, M. M. (2018). *Introduction to Chemical Engineering Thermodynamics* 8th Ed. NY: McGraw-Hill Co., Inc.