**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 147 Chemical Engineering Plant Design**

## A. Course Catalogue Description

1. **Course Number:** ChemE 147
2. **Course Title:** Chemical Engineering Plant Design
3. **Course Description:** Application of chemical engineering principles to the design of an industrial processing plant; design of waste treatment and pollution management facilities
4. **Prerequisite:** ChemE 146 Chemical Process Development and Simulation and ChemE 151 Introduction to Health, Safety, and Environment
5. **Semester Offered:** Second Semester
6. **Course Credit:** 3u
7. **Number of Hours:** 1h lec, 6h lab
8. **Meeting Type:** lecture, laboratory
9. **Course Goals:** To discuss the development of a designed chemical process into a full chemical plant design report, including auxiliary processes such as utilities and waste treatment, incorporating sound health, safety and environmental design considerations

## B. Rationale

This course is the culmination of all the topics covered in the other design courses in chemical engineering. In this course, the chemical plant process is designed for a particular objective (e.g., production of fuel from biomass conversion) with the intent of establishing optimum operational parameters based on physical and thermodynamic limitations as well as economic, health, safety, and environmental considerations.

## C. Course Outline

### 1. Course Outcomes (CO)

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

- **CO 1.** assess previously developed market feasibility study and process design development reports;
- **CO 2.** design equipment in the plant (process and utility/auxiliary) with due consideration of industry-accepted standards;
- **CO 3.** optimize the design of major plant equipment;
- **CO 4.** prepare preliminary piping and instrumentation diagrams (P&ID), and equipment and piping layouts;
- **CO 5.** formulate process control schemes for the main process and other critical equipment;
- **CO 6.** design pollution control and waste treatment systems;

**CO 7.** perform a process hazard analysis (PHA); and
**CO 8.** communicate the results of the design project in a written plant design report and an effective oral presentation.

**Course Outcomes and Relationship to Program Learning Objectives**

| Course Outcomes | Program Learning Objectives* | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Assess previously developed market feasibility study and process design development reports | | ■ | ■ | | |
| Design equipment in the plant (process and utility/auxiliary) with due consideration of industry-accepted standards | ■ | ■ | ■ | | ■ |
| Optimize the design of major plant equipment | ■ | ■ | ■ | ■ | |
| Prepare preliminary piping and instrumentation diagrams (P&ID), and equipment and piping layouts | ■ | ■ | ■ | | |
| Formulate process control schemes for the main process and other critical equipment | ■ | ■ | ■ | | ■ |
| Design pollution control and waste treatment systems | | ■ | ■ | | ■ |
| Perform a process hazard analysis (PHA) | | ■ | ■ | ■ | ■ |
| Communicate the results of the design project in a written plant design report and an effective oral presentation | ■ | ■ | | ■ | |

* **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

| Topics | No. of Hours | |
|---|---|---|
| | Lec | Lab |
| **Introduction to chemical plant design and equipment design preliminaries**<br>1. Design objectives<br>2. Important operating conditions<br>3. General design considerations<br>4. Design methodology | 1 | 6 |
| **Introduction to piping and instrumentation diagrams (P&ID)** | 1 | 6 |
| **Hazards and operability (HAZOP) reviews** | 1 | 6 |

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| Topics | No. of Hours | |
|---|---|---|
| | Lec | Lab |
| **Equipment design procedure and costing: reactors and heat transfer equipment** | 1 | 6 |
| **Equipment design procedure and costing: separation equipment** | 1 | 6 |
| **Design of reactors and component separation equipment**<br>1. Summary of mass and energy balances<br>2. Equipment specifications<br>3. Component specifications<br>4. Process control scheme | 2 | 12 |
| **Design of other major equipment (utilities, heat exchangers, phase separators)**<br>1. Summary of mass and energy balances<br>2. Equipment specifications<br>3. Component specifications<br>4. Process control scheme | 2 | 12 |
| **Assessment of waste streams and emissions sources, design of waste management/treatment systems and pollution control processes, and costing if these systems**<br>1. Wastewater treatment processes<br>a. Primary treatment<br>b. Secondary treatment (if applicable)<br>c. Tertiary treatment (if applicable)<br>i. Disinfection<br>ii. Nutrient removal<br>2. Air pollution control<br>a. Gaseous contaminant control<br>b. Particulate matter control<br>3. Solid waste management (storage, transport, treatment, and disposal) | 2 | 12 |
| **Utilities and materials handling equipment – type, size, specifications**<br>1. Type and size<br>2. Specifications | 2 | 12 |
| **Plant layout and preliminary piping design** | 1 | 6 |
| **Cost and profitability analysis**<br>1. Capital cost and product cost<br>2. Profitability analysis | 1 | 6 |
| **Optimization/sensitivity analysis**<br>1. Breakeven capacity<br>2. Sensitivity analysis | 1 | 6 |
| HAZOP Review | | |
| Long Examination | | |
| Final Plant Design Report | | |
| Oral Presentation | | |
| **Total number of hours** | **16** | **96** |

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## 3. Course Coverage

| Week | CO | TOPIC | ESSENTIAL/ KEY QUESTIONS | Suggested Teaching and Learning Activities | Suggested Assessment Tools |
|---|---|---|---|---|---|
| 1 | 1 | **Introduction to chemical plant design and equipment design preliminaries**<br>1. Design objectives<br>2. Important operating conditions<br>3. General design considerations<br>4. Design methodology | What are the general considerations in preparing a chemical plant design? | lecture, laboratory consultations | group and individual evaluation |
| 2 | 4,5,8 | **Introduction to piping and instrumentation diagrams (P&ID)** | What is a P&ID?<br>What are the important information that are included into a P&ID? | lecture, laboratory consultations | group and individual evaluation |
| 3 | 7,8 | **Introduction to hazards and operability (HAZOP) reviews** | What is a HAZOP and how is it conducted for a proposed chemical plant process? | lecture, laboratory consultations | group and individual evaluation |
| 4 | 2,8 | **Equipment design procedure and costing: reactors and heat transfer equipment** | What are the general considerations in designing a chemical reactor? a heat exchanger? a boiler? a condenser? | lecture, laboratory consultations | group and individual evaluation |
| 5 | 2,8 | **Equipment design procedure and costing: separation equipment** | What are the general considerations in designing unit operation equipment? | lecture, classwork, laboratory consultations | group and individual evaluation |
| 6-7 | 3,5,8 | **Design of reactors and component separation equipment**<br>1. Summary of mass and energy balances<br>2. Equipment specifications<br>3. Component specifications<br>4. Process control scheme | What are the contents of a technical specification sheet? | lecture, laboratory consultations | group and individual evaluation |

| Week | CO | TOPIC | ESSENTIAL/ KEY QUESTIONS | Suggested Teaching and Learning Activities | Suggested Assessment Tools |
|---|---|---|---|---|---|
| 8-9 | 3,5,8 | **Design of other major equipment (utilities, heat exchangers, phase separators)**<br>1. Summary of mass and energy balances<br>2. Equipment specifications<br>3. Component specifications<br>4. Process control scheme | What are the contents of a technical specification sheet? | lecture, laboratory consultations | group and individual evaluation |
| 10-11 | 3,6,8 | **Assessment of waste streams and emissions sources, design of waste management/ treatment systems and pollution control processes, and costing if these systems**<br>1. Wastewater treatment processes<br>a. Primary treatment<br>b. Secondary treatment (if applicable)<br>c. Tertiary treatment (if applicable)<br>i. Disinfection<br>ii. Nutrient removal<br>2. Air pollution control<br>a. Gaseous contaminant control<br>b. Particulate matter control<br>3. Solid waste management (storage, transport, treatment, and disposal) | What are the general considerations for designing waste treatment processes as part of a chemical plant design? | lecture, laboratory consultations | group and individual evaluation |
| 12-13 | 2,8 | **Utilities and materials handling equipment – type, size, specifications**<br>1. Type and size<br>2. Specifications | What are the general considerations for designing/specifying utilities and materials handling equipment as part of a chemical plant design? | lecture, laboratory consultations | group and individual evaluation |
| 14 | 4,8 | **Plant layout and preliminary piping design** | What are the general considerations for developing plant and equipment layouts? | lecture, laboratory consultations | group and individual evaluation |

| Week | CO | TOPIC | ESSENTIAL/ KEY QUESTIONS | Suggested Teaching and Learning Activities | Suggested Assessment Tools |
|---|---|---|---|---|---|
| 15 | 8 | **Cost and profitability analysis**<br>1. Capital cost and product cost<br>2. Profitability analysis | What are the additional considerations in performing cost and profitability analysis for plant design? | lecture, laboratory consultations | group and individual evaluation |
| 16 | 8 | **Optimization/sensitivity analysis**<br>1. Breakeven capacity<br>2. Sensitivity analysis | What are the additional considerations in performing optimization and sensitivity analysis for plant design? | lecture, laboratory consultations | group and individual evaluation |
| | | | | | HAZOP Review |
| | | | | | Long Examination |
| | | | | | Final Plant Design Report |
| | | | | | Oral Presentation |

## 4. Course Requirements

1. Final plant design report
2. Oral presentation of plant design
3. Group evaluation
4. Individual evaluation
5. Journal writeup of plant design
6. HAZOP review
7. Long examination

**REFERENCES:**

Cruz, A. J., Marquez, R., and Zurbano, F. J. (2014). Green petrochemical: integrated 1,3-butadiene and hydrogen production from ethanol via tantalum-promoted bifunctional catalysis (Plant design report). University of the Philippines Diliman.

Del Rosario, K., Pe Benito, I. P., and Syling, T. S. (2016). Dimethy ether production from synthesis gas on a CuO-Zuo-$Al_2O_3$-γ$Al_2O_3$ catalyst (Plant design report). University of the Philippines Diliman.

Sullivan, W. G., Wicks, E. M., and Koelling, C. P. (2014). *Engineering Economy* 16th Ed. London, UK: Pearson Education, Ltd.

Towler, G. and Sinnott, R. (2013). *Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design* 2nd Ed. NY: Elsevier.