COURSE DESCRIPTION, GOALS AND OUTCOME WORKSHEET

Course: ChE 184A Design of Chemical Processes

Instructor: Michael F. Doherty, Professor Chemical Engineering

2001-02 Catalog Course Description:
Credits: 3 Hours: 2 Lectures per week
Prerequisites: Chemical Engineering 110A-B; 120A-B-C; 140A; and 152A. Not open to students who have completed Engineering 100 or Chemical Engineering 181.
Application of chemical engineering principles to plant design. Spreadsheeting and flowsheeting methods. Engineering cost principles and economic aspects.

Texts, References, & Software: "Conceptual Design of Chemical Processes," J. M. Douglas, McGraw Hill (1988).
"Conceptual Design of Distillation Systems w/CD," M. F. Doherty and M. F. Malone, McGraw Hill Publishing (2001).
Excel spreadsheet software, Microsoft Corp.
HYSYS steady-state simulation software, Hyprotech Limited.

Course Objectives:

1. The major objective is to understand how to invent chemical process flowsheets, how to generate and develop process alternatives, and how to evaluate and screen them quickly.

2. Understand the structure, macro-economics, and supply chains of the US chemical process industries.

3. Understand and apply basic economic principles, especially discounted cash flow calculations and internal rate of return.

4. Understand the relationship between reaction chemistry (selectivity, reversible side-reactions, etc) and flowsheet structure at the input/output level.

5. Understand and apply overall stoichiometric mole balances for complex chemistries to the input/output structure of a flowsheet, and to generate the corresponding economic potential of a project.

6. Be able to synthesize and design reactor sub-systems, to develop the recycle structure(s), and perform recycle material and energy balances for process flowsheets.

7. Be able to synthesize and design separation sub-systems in the context of the total flowsheet. To understand, develop, and evaluate process alternatives.

8. Be able to simulate the steady-state behavior of process flowsheets at each level of process development.

Topics Covered (include approximate number of hours for each topic):

Each lecture in the following schedule is 75 minutes long with one recitation class every two lectures. Recitation time is used to (1) work on example problems to reinforce concepts covered in lectures, (2) answer student questions, and (3) learn how to use design software tools.

<table>
<tr><th><u>Lecture #</u></th><th><u>Topics</u></th></tr>
<tr><td>1-2</td><td>Chapter 1: The Nature of Process Synthesis and Analysis
• introduction and general overview of process synthesis and conceptual design.
• overview of the US chemical process industries</td></tr>
<tr><td>3-5</td><td>Chapter 2: Engineering Economics
• cost information required
• estimating capital and operating costs
• time value of money
• discounted cash flow and internal rate of return</td></tr>
<tr><td>6</td><td>Chapter 4: Input Information
• overview of Douglas's hierarchical design procedure, and description of the levels
• relationship between reaction chemistry (selectivity, reversible side-reactions, etc) and flowsheet structure
• data requirements</td></tr>
<tr><td>7-8</td><td>Chapter 5: Input-Output Structure of Flowsheets
• decisions for the input-output structure
• overall molar balances and design variables
• economic potential
• examples: HDA process, MTBE process, butane alkylation
• process alternatives</td></tr>
<tr><td>9-14</td><td>Chapter 6: Reactor System and Recycle Structure
• decisions that determine reactor system
• decisions that determine recycle structure
• reactor design
• reactor heat effects
• reaction equilibrium limitations & opportunities
• recycle material balances
• compressor design
• design variables
• capital and operating costs for reactors and compressors
• economic potential
• examples: HDA and MTBE processes with & without recycle of equilibrium by-products
• HYSYS simulations with recycles closed for propylene glycol process, HDA process, MTBE process, butane alkylation process</td></tr>
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15-20	Chapter 7: Separation System Chapters 2, 3, 4, 6, 7 (Doherty & Malone) • general structure of the separation system • vapor recovery systems • liquid separation systems • distillation sequences for ideal mixtures • review of flash calculations & application to HDA process • design of liquid separation systems for ideal mixtures • HYSYS simulations of complete flowsheets

Laboratory Projects (specify amount of time allowed for each):
This course does not include laboratory experiments.

Design Project (specify amount of time allowed for each):
The course includes a design project for the production of a chemical in a continuous process. The students are expected to invent the process and implement Douglas's Hierarchical Design Procedure to the end of Level 3. That is, they are expected to make all the decisions needed to develop the Input-Output structure, the Reactor and Recycle Structure, and to calculate the economic potential as a function of the key design variables. A Hysys simulation of the optimal base-case design (with all recycle loops closed) is required. Students work in teams of 2, and submit a written report and also give an oral presentation. (Time expected to complete project, 30-50 hours).

The Relation between the Course Objectives and the ChE Program Outcomes

Course Objectives	**Relevant to which ChE Program Outcomes**	**Course activity**	**Material to be collected to verify course objective or program outcome**
1	PO3, PO5, PO6	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 7 on the attached student self-evaluation survey.
2	PO3	Lectures, quiz on this specific topic	(1) Samples of quiz. (2) Question 1on the attached student self-evaluation survey.
3	PO3, PO6	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 2 on the attached student self-evaluation survey.
4	PO3	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 3 on the attached student self-evaluation survey.

5	PO3	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 3 on the attached student self-evaluation survey.
6	PO3, PO5	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 4 on the attached student self-evaluation survey.
7	PO3, PO5	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 5 on the attached student self-evaluation survey.
8	PO3, PO5	Lectures, recitations, homework, exam, and design project	(1) Samples of homeworks, exams, and design projects. (2) Question 6 on the attached student self-evaluation survey.

Chemical Engineering Department Outcomes:

Upon graduation, graduates of the ChE program at UCSB are expected to have:

PO1. [**Fundamentals**] the fundamental knowledge of mathematics, computing, science, and engineering needed to practice chemical engineering and the ability to apply this knowledge to identify, formulate, and solve chemical engineering problems.

PO2. [**Laboratory**] the ability to design and conduct experiments and to analyze and interpret data.

PO3. [**Design**] the ability to design a system, component, or process to meet desired specifications. Ability to use modern engineering tools necessary for chemical engineering practice.

PO4. [**Advanced Training**] beyond the basic fundamentals in at least one area of chemical engineering as preparation for a continuing process of lifelong learning.

PO5. [**Teamwork/Communication**] the ability to function productively in multidisciplinary teams working towards common goals; the ability to communicate effectively through written reports and oral presentations.

PO6. [**Engineering & Society**] the broad education necessary to understand the impact of engineering solutions in a global/societal context; a knowledge of contemporary issues; an understanding of professional and ethical responsibility; a recognition of the need for and the ability to engage in lifelong learning.