155:427 CHEMICAL & BIOCHEMICAL ENGINEERING DESIGN AND ECONOMICS I
FALL 2014 (3 credits)

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                          email: anwesha@scarletmail.rutgers.edu

Grader: Mr. Subodh Karkala                  SOE, room C137            Tel: (848) 445-2203
                          email: anwesha@scarletmail.rutgers.edu

Class time: MW 1:40 – 3:00 p.m.        Location: SEC 210

Office hours: Mondays 3-5 PM (Dr. Ramachandran), C-216
                       Wednesdays, 3-5PM (Ms. Chaudhury), C-137

Course description
Chemical engineering fundamentals are integrated in the design and operations of chemical and biochemical plants. In this course, we give a thorough analysis of the steps involved in the design and economic evaluation of chemical and biochemical processes. We elaborate on the economic considerations involved in the design, construction, and operation of chemical plants, such as investment costs, production costs, depreciation, and profitability analysis.

This course includes a thorough discussion of safety considerations involved in the design of chemical and biochemical processes. We present several cases of chemical plant accidents from the extensive collection published by the US Chemical Safety Board (CSB). We include a HAZOP analysis case study.

The class is divided into design teams of 5 students each, and are assigned a major design project. They first conduct a literature survey related to their project and are required to make a Powerpoint presentation of their findings. The detailed design and economic evaluation of their project forms their major task during the Spring semester design course (155:428 Chemical & Biochemical Engineering Design & Economics II).

Course objectives

• This is the first of two capstone courses, which utilize the fundamentals of chemical engineering (material balances, energy balances, transport phenomena, thermodynamics, kinetics, separations, unit operations, control, and safety) in the design and operation of chemical plants.

• The course introduces the concepts and methods of plant design, optimization and economic evaluation: planning, cost estimation, fixed capital investments, working capital, production costs, depreciation, rate of return, profitability analysis, discounted cash flow analysis.

• Raises awareness of the students to the concepts of supply and demand of raw materials, commodity, and specialty chemicals.

• Introduces the students to the available computational tools for process flow design and economic evaluation.

• Stresses the importance of professional ethics, honesty, and integrity.
ABET outcomes applicable to this course

| (a) an ability to apply knowledge of mathematics, science and engineering |
| (c) an ability to design a system, component, or process to meet desired needs |
| (d) an ability to function in multi-disciplinary/multi-functional teams (this can be defined as a mix of biochemical and chemical engineers, or as a group of students working on a different roles of a project) |
| (e) an ability to identify, formulate, and solve engineering problems |
| (f) an understanding of professional and ethical responsibility |
| (g) an ability to communicate effectively |
| (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context |
| (i) a recognition of the need for, and an ability to engage in life-long learning |
| (j) a knowledge of contemporary issues |
| (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice |

Textbooks (required)


Computer Software

Matlab (www.app.s.rutgers.edu), (C-233 Microlab)
Aspen (C233 – Microlab)
Excel (MS Office)

Prerequisites

155:303 Transport Phenomena I
155:304 Transport Phenomena II
155:324 Design of Separation Processes

Assessment: Homework and grading policy

| Homework assignments | 20% |
| Quizzes | 20% |
| Midterm | 25% |
| Design project presentation & report | 30% |
| Attendance | 5% |
| | 100% |

Homeworks will be collected on due dates and will be graded. Late homeworks will be penalized for lateness. Any homeworks that are not submitted will receive the grade of zero. Quizzes will be conducted weekly every Wed (starting from the week of Sep 15)

Class participation and attendance are important.
**Academic Integrity**

Students are expected to familiarize themselves with and adhere to the University policy on academic integrity at: [http://academicintegrity.rutgers.edu/policy-on-academic-integrity](http://academicintegrity.rutgers.edu/policy-on-academic-integrity).

It is understood that a student’s name on any individual homework assignment, quiz, or exam indicates that he/she neither gave nor received unauthorized aid. On individual homework assignments, *authorized* aid includes discussing: 1) interpretation of the problem statement, 2) concepts involved in the problem, 3) approaches for solving the problem. Anything beyond this constitutes unauthorized aid and violates the academic integrity policy.

A student’s name on a group assignment indicates that he/she contributed to the assignment.

Quizzes and exams are tests of individual performance. The student is not permitted to obtain assistance from any other person (or persons) during quizzes or exams. The student must adhere strictly to the instructions provided by the professor regarding what is permissible to be used during the exam. The exams in this course will be closed-book / closed-notes. One 8.5 \times 11 sheet of paper (written on both sides) with formulas, equations, and methods, may be allowed. Use of calculators is allowed. Use of computers, laptops, and cell phones is PROHIBITED during exams.

Disciplinary actions for academic misconduct will be in accord with the University policy on academic integrity.

**Course Outline (subject to change and modifications)**

<table>
<thead>
<tr>
<th>Week</th>
<th>Subject</th>
<th>Reading Assignment</th>
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| 1, 2 | Introduction to plant design and economic evaluation  
General design considerations  
Process design development  
Design basis | Ch. 1 (P, T & W)  
PowerPoint slides  
Ch. 2 (P, T & W)  
Ch. 3 (P, T & W)  
PowerPoint slides |
| 3 | Essential flowsheet diagrams  
Block flow diagrams (BFD)  
Process flow diagrams (PFD)  
Equipment descriptions and standard notation  
Piping and instrumentation diagrams (P&ID)  
Site plans and plant layout diagrams | Ch. 4 (P, T, & W)  
PowerPoint slides  
PowerPoint slides  
PowerPoint slides  
PowerPoint slides |
| | Computer-aided design | Ch. 5 (P, T, & W)  
PowerPoint slides |
| 4 | Analysis of cost estimation  
Cash flow  
Capital investments  
Fixed capital and working capital  
Types of capital cost estimates  
Direct and indirect costs  
Cost indexes; Cost scaling factors  
Ratio factors | Ch. 6 (P, T & W)  
PowerPoint slides |
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Topic</th>
<th>Subtopics</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Production Costs</td>
<td>Raw materials; Utilities; Operation costs; Overhead expenses; Fixed charges; Administrative and marketing expenses</td>
<td>Ch. 6 (P, T &amp; W) PowerPoint slides</td>
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<td>6</td>
<td>Interest and Investment Costs</td>
<td>Time value of money; Simple, compound, continuous interest; Present worth, future worth</td>
<td>Ch. 7 (P, T &amp; W) PowerPoint slides</td>
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<td>Taxes and Insurance</td>
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<td>Ch. 7 (P, T &amp; W) PowerPoint slides</td>
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<td>Depreciation Methods</td>
<td>Straight-line method, declining-balance method, Modified Accelerated Cost Recovery System (MACRS)</td>
<td>Ch. 7 (P, T &amp; W) PowerPoint slides</td>
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<tr>
<td>6</td>
<td>Profitability Analysis</td>
<td>Rate of return on investment; Discounted cash flow rate of return; Net present worth; Payout period</td>
<td>Ch. 8 (P, T &amp; W) PowerPoint slides</td>
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<td>7-8</td>
<td>Optimum Design &amp; Design Strategy</td>
<td>Optimization</td>
<td>PowerPoint slides</td>
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<td>9-10</td>
<td>Safety in Design</td>
<td>Principles of chemical systems safety; Process safety management; Safety and Chemical Engineering Education (SACHE); US Chemical Safety Board (CSB); Histories of several significant chemical disasters</td>
<td>Ch. 2 (P, T &amp; W) Handouts PowerPoint slides Videos on CSB</td>
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<tr>
<td>11</td>
<td>Assignment of design projects</td>
<td>Assignment of literature surveys; Discussion of midterm examination</td>
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<tr>
<td>11</td>
<td>Midterm examination</td>
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<tr>
<td>12-14</td>
<td>Student presentations of design projects</td>
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