CHEN 425
Process Integration, Simulation and Economics

Lecture hours: TR 9:35 – 10:25 a.m.
Lab hours: W 4:00 – 7:00 p.m.

Instructor: Mahmoud El-Halwagi, Professor and Holder of the McFerrin Professorship
Office: 230 Brown
Office hours: TR 10:30 – 12:30 p.m. (also any time I am at my office or via appointment)
Phone: 845-3484
E-mail: El-Halwagi@tamu.edu
Web Page: Departmental Secure Site: http://chesec.tamu.edu/classes/el-halwagi/425/
This site will be used to communicate as needed. Students should check frequently.

Textbooks:

Additional References:

Course Content: Engineering Design - 3 credits (100%).

Prerequisites: Senior level in chemical engineering or approval of instructor

Skill Prerequisites: You are expected to have the ability to:
- Perform calculations for mass and energy balances
- Write relationships for first and second laws of thermodynamics
- Apply key laws of heat transfer, fluid mechanics, and mass transfer
• Use computer software for numerical solution of nonlinear algebraic equations

**Objectives:** CHEN 425 is the first course in a two-course sequence involving the synthesis, integration, simulation, and design of chemical engineering processes. This is a three-hour course which is intended to introduce students to the fundamentals and applications of process design. In particular, the course presents systematic process-integration tools for the synthesis, development, and screening of potential process flowsheets. The course also reinforces equipment design of common process equipment. Practical problems are used as examples. These problems cover general classes of topics in the areas of mass integration, heat-integration, separation processes and environmentally-benign and inherently-safe designs. The course also introduces the students to the principles of process economics including evaluation of fixed and operating costs, depreciation, and profitability analysis. The lab portion of the class provides the students with working experience and applications on computer-aided simulation of chemical-engineering systems.

**Course Learning Outcomes:**

By the end of the course, the students should be able to perform the following:

1. Evaluate overall mass targets (fresh usage, waste discharge, yield, etc.) for a given process
2. Manipulate design and operating variables to optimize process performance
3. Synthesize direct-recycle networks
4. Screen and synthesize networks of mass exchangers
5. Evaluate targets for minimum heating and cooling utilities
6. Screen and select mass and heat utilities
7. Use ASPEN Plus to simulate various scenarios of units and groups of units. Also, use simulation to analyze process performance, identify opportunities, troubleshoot problems, and recommend changes
8. Use ICARUS to evaluate process economics
9. Apply different techniques to estimate fixed cost, operating cost, and profitability criteria.
10. Apply economic principles to assess the design of a project
11. Develop basic schedules for project management
12. Work effectively in teams and play different roles (team leader, process engineer, and consultant). Prepare a professional design report.

**Policies and Procedures:**

**Grading:** Homework (10%), Two unannounced (pop) quizzes (10%), Simulation workshops (15%), Simulation exam (10%), Midterm exam (15%), Final exam (30%), Project (10%)

**Attendance:** Class attendance is important for this course (also, remember, there are unannounced quizzes). A student with a documented excused absence will be
allowed to make up missed work in accordance with the Student Rules. The rules of excused absence can be found at http://student-rules.tamu.edu/rule7.htm. It is the student’s responsibility to provide to the instructor satisfactory evidence of excused absence.

**Email:** class updates and frequent announcements regarding class meetings, homework, and exams will be transmitted via email. You are responsible for checking your Neo email account on a regular basis.

**Disabled Students:** The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B118 of Cain Hall or call 845-1637.

**Academic Integrity:** “An Aggie does not lie, cheat, or steal or tolerate those that do” is the lead statement of the Aggie Honor Code. Please refer to the Honor Council Rules and Procedures on the web at: [http://www.tamu.edu/aggiehonor](http://www.tamu.edu/aggiehonor).

**Topics Summary:**

**Lecture Topics:**

I. **Introduction to Process Design** (Week 1)
   1. Process synthesis
   2. Process analysis and simulation
   3. Detailed equipment design
   4. Process integration
   5. Process optimization

II. **Global Analysis of Mass and Energy Flows** (Week 2)
   1. Mass-energy matrix of a process
   2. Breadth analysis vs. detailed equipment design

III. **Mass Integration** (Weeks 3-6)
   1. Detailed design and costing of stagewise and continuous mass exchange equipment
   2. Thermodynamic, design, and economic-optimization aspects of mass-exchange operations
   3. Screening of candidate separation processes using mass pinch analysis
   4. Tradeoffs between fixed and operating costs
   5. Targeting of process performance
   6. Allocation, segregation, mixing, and direct reuse/recycle
   7. Stream interception
   8. Visualization tools
   9. Algebraic techniques
10. Pollution prevention

IV. Energy Integration (Week 7)
1. Detailed design and costing of heat exchangers and energy conversion equipment
2. Global flow of energy in a process
3. Thermal pinch analysis
4. Optimization of heating and cooling utilities as well as combined heat and power

V. Process Economics (Weeks 8 – 13)
1. Evaluation of equipment cost, fixed capital investment
2. Time-value of money
3. Annuity
4. Depreciation
5. Profitability analysis
6. Net present value
7. Discounted cashflow return on investment
8. Economic evaluation and screening of projects

VI. Introduction to Project Management (Week 14)
1. Hierarchy of project objectives, assignments, tasks, and sub-tasks
2. Developing a project schedule through a network diagram
3. Critical path analysis
4. Gantt charts

Simulation Lab
The lab covers various workshops using ASPEN Plus. These include the following topics (each topic corresponds to one week in the lab):
- Overview of ASPEN Plus
- Property selection in ASPEN
- Simulation of compressors
- Flash columns
- Distillation I
- Distillation II
- Multi-unit simulation
- Wastewater treatment
- Heat exchange
- Simulating flowsheets with recycle
- Sensitivity analysis
- Design specifications
- Handling hydrocarbon blends
- Cost evaluation using ICARUS.

Project: Term project on process simulation, integration, and economic evaluation.
**Relationship of course to ChE program outcomes**

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