# ChE161.2: Process Evaluation and Chemical Systems Design II

Prof. Okorafor and Prof. Davis

## Spring 2016 Syllabus

*Class meeting times:*

Mondays 1:00 PM - 2:50 PM in room 104 / room 101
Tuesdays 2:00 - 3:50 PM in room 105 / room 101

*Course overview:*

This is the capstone design course; students are required to work in groups to site, design, and cost a chemical plant and give a quantitative conclusion about its overall economic value. The course is project-based; it requires the completion of two process designs, an ethylene production process and one of two possible final projects.

For the ethylene project, students will work in groups of three to four (3-4) assigned by the instructor. Each group is assigned a different mix of raw materials (propane, butane, or ethane/propane at a 3:1/1:3 ratio), different amounts of ethane recycle, and different properties of generated superheated steam. The students are expected to design and cost the following pieces of equipment: cracking furnace, quench tower, multi-stage compressor, demethanizer, deethanizer, ethylene/ethane splitter, depropanizer, propylene/propane splitter, debutanizer, heat exchangers, flash towers, and pumps. Other assignments include: a steam balance calculation, implications of "green engineering" to the process, and consideration of safety procedures. The strategy employed has the instructor manually outline the design of the plant in class to demonstrate how an engineer-driven design is carried out, while the students use simulation software to visualize their design. Each group will submit a written report describing their process flow diagram and the calculations they did to create it. The ethylene plant capacity will be 700 metric tons per day of 99.95% purity with a stream factor of 8400 operating hours/year.

For the second project, the students will remain in the same groups. This project will be similar to the first one, but there will be limited in-class instruction and each group will present on their progress four times and have three formal meetings. There will be two different projects assigned; one for creating stem cells at scale and one for making carbon-taxed linear low density polyethylene (LLDPE) from the ethylene in the first project. The groups who have a more complete, efficient, and economical design for the first project will be assigned the stem cell project.

*Prerequisites and other requirements:*

The prerequisite for this course is ChE 161.1: Process Evaluation and Design I. The course has an optional textbook: <u>Analysis, Synthesis, and Design of Chemical Processes</u> by Turton, Bailie, Whiting and Shaeiwitz ($4^{th}$ ed.) ISBN# 0132618125, $98 (used) @ Amazon.com. You should purchase it (or another chemical engineering design textbook) and use it as your primary reference for performing your technical design and writing your memos, reports, and presentations. You will need access to a computer with a spreadsheet program and either AspenPro or Pro/II to do your two design projects.

*Groups:*

The group assignments and corresponding feed compositions, recycle rates of ethane to the cracking unit, generated steam pressures in psig, and generated steam temperatures in $^{o}$F for project 1 are below:

| **Group** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| Feed | 75E/25P | 100P | 100B | 25E/75P | 100P | 100B |
| Recycle | 50% | 100% | 100% | 100% | 75% | 50% |
| Steam P | 1600 | 1600 | 1750 | 1750 | 1650 | 1500 |
| Steam T | 950 | 800 | 875 | 900 | 850 | 750 |
| | Tiffany | Kenny | Shoshana | Alexa | Steven | Mitch |
| | Shlomo | Justin | Jamie | Stephanie | Ray | Alexander |
| | Chae | Matt K. | Arielle | Chris | Matt F. | Devora |
| | | Josephine | Anthony | Hyunjun | Ashmera | |
| Project 2 | S | L | S | L | S | L |

You are REQUIRED to submit a group member evaluation form for each team member you have during the semester. The evaluation form will be available to print out on Moodle.

*Memos, Meetings, and Project Presentations:*

There will be three memos, two project written reports, four project presentations, three meetings, and no exams in this class. The memos will be summaries of what you communicate to your “supervisor” in meetings and are usually a follow-up on that weeks’ part of the design. They should be one page long, formatted correctly (e.g. dated, addressed, signed by each group member), and may include relevant appendices. The written reports should be detailed technical descriptions of your processes, with emphasis on the economics, environmental impact, and safety of your designs. A rubric for such reports can be found in your design textbooks. Your presentations should be concise oral descriptions of the current state of your plant design; they should focus on the aspects of your design your group focused on in the past week. These presentations should be formal and business attire and demeanor are required.

This is a four contact hour class, so we expect that you will each spend about 8 hours per week outside of class on project 1. For project 2, we expect that you will spend about 12 hours per week on work for this class. Additionally, we expect **weekly invoices** from each group with the number of hours spent on the project for that week **itemized for each group member**.

*Attendance and Grading Policy:*

Attendance in class for meetings and presentations is mandatory. Please E-mail Professor Davis well before class time if you cannot attend. There will be no make-up or extra credit work associated with this class. Please ensure that you hand in your assignments on time. All assignments must be completed for a passing grade in the class. Grading is as follows:

| | **Proj 1 Report** | **Memos** | **Meetings** | **Presentations** | **Proj 2 Report** |
|---|---|---|---|---|---|
| **% of grade** | 10 | 9 | 9 | 36 | 36 |

Each group will be assigned a grade for each of their written submissions for project 2 (memos and final report), their four oral presentations, and the three meetings. Those grades will be combined to determine the group's grade for project 2. These project 2 grades (90% of the raw score) may be adjusted based on group member evaluations and individual presentations in order to encourage equal participation by all group members on all assignments. Letter grades will be determined at the end of the semester using each student's raw score from above, the average raw score for the class, and the instructors' discretion. Additionally, each group is required to submit a brief write-up of their project for the end of the year show.

*Sequence of topics and class schedule:*

Below is the schedule for classes for the rest of the semester. I will have you sign up for specific meeting / presentation times. Assignment due dates are indicated in the right-most column.

| Week | Class # | Day | Date | Topic(s) | Due |
|---|---|---|---|---|---|
| 7 | 12 | Tues | 3/1 | Last class for Project 1 – Project 1 report due | Project 1 |
| 8 | 13 | Mon | 3/7 | Introduction to project 2 – All groups | |
| 8 | 14 | Tues | 3/8 | Kick-off discussion – All groups | |
| 9 | X | Mon | 3/14 | **NO CLASS** – Spring Break | |
| 9 | X | Tues | 3/15 | **NO CLASS** – Spring Break | |
| 10 | 15 | Mon | 3/21 | Meeting 1: Basis for study I | |
| 10 | 16 | Tues | 3/22 | Meeting 1: Basis for study II | |
| 11 | 17 | Mon | 3/28 | Presentation 1: BFD and cost estimates – I | |
| 11 | 18 | Tues | 3/29 | Presentation 1: BFD and cost estimates – II | Memo 1 |
| 12 | 19 | Mon | 4/4 | Meeting 2: Reactor systems – I | |
| 12 | 20 | Tues | 4/5 | Meeting 2: Reactor systems – II | |
| 13 | 21 | Mon | 4/11 | Presentation 2: Separation systems – I | |
| 13 | 22 | Tues | 4/12 | Presentation 2: Separation systems – II | Memo 2 |
| 14 | 23 | Mon | 4/18 | Meeting 3: Heat integration and full PFD – I | |
| 14 | 24 | Tues | 4/19 | Meeting 3: Heat integration and full PFD – II | |
| 15 | 25 | Mon | 4/25 | Presentation 3: HEX design / utilities – I | |
| 15 | 26 | Tues | 4/26 | Presentation 3: HEX design / utilities – II | Memo 3 |
| 16 | 27 | Mon | 5/2 | Final presentation: Economics and go/no go – I | |
| 16 | 28 | Tues | 5/3 | Final presentation: Economics and go/no go – II | |
| 17 | X | Mon | 5/9 | **NO CLASS** – Final project due | Project 2 |
| 17 | X | Tues | 5/10 | **NO CLASS** – Grades due by May 12 | |

*Course goals and objectives:*

By the end of this course, you should be able to:

- Design, size, and cost columns for absorption and stripping of dilute mixtures and distillation of concentrated mixtures graphically, analytically, and computationally
- Calculate material and energy requirements for a real production plant
- Describe how to perform manual sizing and simulation of standard chemical engineering unit operations
- Design, size, and cost a fired heater
- Select, size, and cost heat transfer equipment with and/or without mass transfer
- Manually calculate, with a Mollier Chart, the relevant design criteria for a multistage compressor system using the Elliot design methodology
- Select the appropriate number of compressor stages for a given compression task, calculate BHP for each stage, and find the overall BHP
- Design, size, and cost a multistage refrigeration system
- Perform a utility balance for a chemical process and determine an overall utility cost
- Perform an economic analysis of a project and determine the cash flow and the DCFROR/IRR through detailed calculations on plant costs
- Write a detailed report on a chemical process design which addresses aspects of engineering fundamentals, economics, health and safety, environmental performance, and management
- Present technical information in a concise and authoritative manner

*Office Hours:*

Prof. Davis (room 419):

M 5:00 PM - 7:00 PM and R 11:00 AM - 12:00 PM

E-mail Prof. Davis at bdavis@cooper.edu if you would like a separate appointment. If you send E-mail, please put "ChE 161.2" as the start of the subject, e.g. "ChE 161.2 HEX Question".

Prof. Okorafor (room 421); you can E-mail Prof. Okorafor at okoraf@cooper.edu:

M 3:00 PM - 4:00 PM, T 12:30 PM - 2:00 PM, W 3:00 PM - 4:00 PM

*Group Work and Academic Integrity Policy:*

I believe group work is important to learning; you are required to work in groups on your projects. However, each student MUST contribute as equally as possible to the group's submissions. Plagiarism is the presentation of another person's "work product" (ideas, words, equations, computer code, etc.) as one's own. Whether done intentionally or unintentionally, plagiarism will not be tolerated in this class. You are plagiarizing if:

1. You present as your own work product a submission that includes the work product of your other group members and not your own
2. You present as your own work product a submission that contains the efforts or work product of other individuals aside from your other group members
3. The help and contributions of other individuals are not acknowledged in writing on your submission (by writing their names or citing their published work)
4. You submit as part of your project submission material that has been copied from any source (including, but not limited to: a textbook, a periodical, an encyclopedia, the internet) without properly citing the source, and/or without using quotation marks. It is also prohibited to submit such materials in a minimally altered form without proper attribution. Improperly copied material might include text, graphics (computer or otherwise), computer source code, etc.

If I have a strong suspicion that you have plagiarized your submission or not contributed to your groups' effort, you will receive a zero on your evaluation for that week. Other prohibited acts of academic dishonesty include (but are not limited to):

5. Dishonesty in dealing with me or another professor, such as misrepresenting the statements of another professor
6. Bringing any device, electronic or otherwise, into class at any time when not expressly permitted by me

The above was modified from the course catalog from the 2009-10 academic year.

*ABET Outcomes for this Course:*

ABET is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology. As part of the accreditation process, engineering colleges are required to select, for each required course, student outcomes which are acquired by students who have taken that course. Student outcomes are succinct statements that describe what students are expected to know and be able to do by the time of graduation. These outcomes relate to skills, knowledge and behaviors that students acquire as they progress through the program. The outcomes I've associated with this course are:

**(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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability**
**(d) an ability to function on multidisciplinary teams**
**(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, economic, environmental, 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.**

It's essentially all of the outcomes except (b), since we do not conduct experiments in this course. The above definitions and outcomes were taken from the ABET website.

*Resources which may (or may not) be helpful:*

- Separation Process Principles by Seader, Henley, and Roper (3rd ed.) ISBN# 0470481838
- http://www.wiley.com/college/seader – Website for the Seader and Henley textbook
- Perry's Chemical Engineers' Handbook by Don Green and Robert Perry (8th ed.)
- Fundamentals of Momentum, Heat, and Mass Transfer by Welty, Wicks, Rorrer, and Wilson (5th ed.) ISBN# 0470128682
- Transport Phenomena by Bird, Stewart, and Lightfoot (2nd ed.) ISBN# 0470115394
- http://webbook.nist.gov – Thermodynamic and other data for lots of common chemicals
- http://www.matche.com – Gives capital cost estimates for a wide variety of process units
- Plant Design and Economics for Chemical Engineers by Peters, Timmerhaus, and West (5th ed.) ISBN# 0072392665
- Stone and Webster's Ethylene Manufacture write-up
- Shreve's Chemical Process Industries by G. T. Austin (5th ed.) ISBN# 0070571473
- Chemical Process Equipment - Selection and Design by S. M. Walas ISBN# 978-0-7506-9385-1 (available electronically on Knovel)
- Yaws' Critical Property Data for Chemical Engineers and Chemists by C. L. Yaws ISBN# 978-1-61344-932-5 (available electronically on Knovel)
- Ullmann's Encyclopedia of Industrial Chemistry by Fritz Ullmann ISBN# 9783527306732 (available electronically through NYU)
- Kirk-Othmer Encyclopedia of Chemical Technology by Raymond Kirk ISBN# 9780471238966 (available electronically through NYU)
- http://www.icis.com/v2/magazine/home.aspx# – ICIS Chemical Business (good source for market information on different chemicals, fuels, etc.)
- Process Plant Simulation by B. Babu (2004) – available online through Knovel
- DIPPR Project 801 – available online through Knovel
- Pinch Analysis and Process Integration by I. Kemp (2011) ISBN# 0750682604
- http://www.uic-che.org/pinch/about_program.php – Pinch analysis tool by Jeff Umbach
- "How to Estimate Utility Costs" by G. Ulrich and P. Vasudevan *Chemical Engineering* April 2006 (p. 66-69)
- Informing Chemical Engineering Decisions with Data, Research, and Government Resources by Patricia Elaine Kirkwood and Necia T. Parker-Gibson
- Prices for plastic resins: http://www.ides.com/resinpricing/secondary.aspx