



ECH 4604

# Process Economics and Optimization

Academic Term: Spring 2019

## Course Section(s):

Find your section and make sure to take note of your class time and location.

Class #/Section	Meeting Info	
13192	M,W,F   Period 8 (3:00 PM - 3:50 PM)	RNK 0110

## Instructor:

**Sindia Rivera-Jiménez, Ph.D.** (Call me Dr. Rivera or Prof. Rivera)

Lecturer,

**Institute for Excellence in Engineering Education, Affiliate Faculty Chemical Engineering Department**

- Office Location: 202D Nuclear Science Building
- Telephone: 352-846-1974
- Email: [rivera.jimenez@eng.ufl.edu](mailto:rivera.jimenez@eng.ufl.edu) .
  - **You MUST use ECH4604 in the subject heading to receive an answer.** It makes it more efficient for all.
  - Expect 24 hrs. response time from M-F and 48 hrs. for weekends
  - Office hours: To be announced on Canvas (3 hrs. per week). You can email to make an appointment with your instructor. Also, I am available immediately after class. This has worked very well for students in the past. On certain weeks, we will post EXTRA office hours as well.
- Teaching Assistant- N/A

## Course Description

*Credits: 3. Description:* Introduction to the principles of process economics including specifications and costing of equipment, operations costing and economic evaluation of processes

## Course Pre-Requisites / Co-Requisites

*Prereq:* ECH 3203 (Fluid and Solid Operations), ECH 3223 (Energy Transfer Operations)

*Coreq:* ECH 4403 (Separations and Mass Transfer Operations)

## Course Learning Objectives (CLO)

Upon completion of this course, a student should be able to:

- CLO 1. Draw and interpret flow diagrams at different levels of sophistication such as Block Flow diagrams, Process Flow Diagrams and Piping and instrumentation Diagram.
- CLO 2. Estimate the capital and the operating costs.
- CLO 3. Understand the concept related to 'Time value of money' such as Simple and compound interest, Annuities, Depreciation.
- CLO 4. Draw and interpret cash flow diagrams.

- CLO 5. Perform cash flow analysis.
- CLO 6. Calculate the various metrics for accessing the financial attractiveness of a project
- CLO 7. Analyze alternatives to determine the most cost-effective equipment/process.
- CLO 8. Determine the design equations for batch and mixed reactors arranged in series/parallel.
- CLO 9. Develop mathematical models for costs of processes and optimize the design to maximize the cost effectiveness.
- CLO 10. Perform multivariable constrained and unconstrained optimization.
- CLO 11. Understand and quantify model uncertainty and perform optimization in the face of model uncertainty
- CLO 12. Quantify reliability of processes and incorporate reliability in the process optimization.
- CLO 13. Use tables, charts, or software to estimate physical property data needed for design or economic data to estimate costs
- CLO 14. Report engineering calculations, problem solutions and group project reports in a professional manner.

Materials and Supply Fees: None

Professional Component (ABET):

(ABET) Skills acquired during course: (1) Engineering problem solving and critical thinking that includes basics of Chemical Engineering.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
a. apply knowledge of mathematics, science, and engineering	High***
b. design and conduct experiments, as well as to analyze and interpret data	
c. 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	Medium
d. function on multidisciplinary teams	Medium
e. identify, formulate, and solve engineering problems	High***
f. professional and ethical responsibility	High
g. communicate effectively	Low
h. understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
i. recognition of the need for, and an ability to engage in life-long learning	High***
j. knowledge of contemporary issues	High
k. use the techniques, skills, and modern engineering tools necessary for engineering practice	High

\*Coverage is given as high, medium, or low. \*\*\*Outcome will be assessed in this course. An empty box indicates that this outcome is not part of the course.

The ABET objectives are supported as follows:

- Students develop the ability to apply knowledge of mathematics, science and engineering in context of economic analysis including specifications and costing of equipment, operations costing and economic evaluation of processes.

- Student will learn and apply principles of design to analyze a chemical engineering process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- Students must seek out the information (knowledge) needed for developing the design solution in appropriate references or other repositories of knowledge.
- Students are assigned in teams so as to mix personalities and abilities and work on a 4 weeks-long project.
- Students are required to perform an economic analysis by optimizing specific function for a given process– thus identifying, formulating and solving engineering problems.
- Written communication will be evaluated during weekly homework and final report.
- An ability to engage in lifelong learning is fostered through the different course activities. Students will be presented with software tools, resources, and case studies.
- Through video class tutorials and homework students will become proficient in the use of the software Aspen Hysys and Aspen Plus.
- Lectures review safety concepts like flammability and toxicity. Information gathering includes obtaining MSDS sheets for all components involved in the design, as well as flammability limits. Safety and environmental impact are factors that students consider when selecting design.

## Required Textbooks and Software

- A. Main course text (required)
- Title – Analysis, Synthesis, and Design of Chemical Processes
  - Author – Richard Turton, Richard Bailie, Wallace B. Whiting, Joseph Shaeiwitz, Debangsu Bhattacharyya
  - Publication date and edition – Any edition will work (I will use 4<sup>th</sup> Ed, 2012).
  - ISBN number 978-0-13-261812-0 (4<sup>th</sup> edition)
- B. Required Software: Microsoft Office, access to a scanner (or pdf converted), and access to Internet for Canvas LMS. Also, UniSim, HYSYS and ASPEN (Go to Canvas for instruction for installation).
- C. Computer requirements:



- All students must have a computer for this class. Make sure that your computer meets the minimum requirements established by the College of engineering: <https://www.eng.ufl.edu/students/resources/computer-requirements/>
- If your computer is almost full or lack memory, ChemE IT personnel have some recommendations for you (Find it on Canvas).
- A Windows laptop is required. Emulators will not work. For Mac users, ChemE IT personnel have some recommendations for you (Find it on Canvas).

## Recommended Materials

- Online Resources: Learn ChemE, Educational Resources from ChemE from University of Colorado Boulder. Available at: <http://www.learncheme.com/screencasts/process-design>
- Book: Gavin Towler and Ray Sinnott (2nd Edition , 2012). Chemical Engineering Design. Butterworth-Heinemann, ISBN: 978-0-08-096659-5. Available via UF Libraries: DOI: <https://doi.org/10.1016/C2009-0-61216-2>

## Course Schedule

**THE DETAILED SCHEDULE BELOW MAY CHANGE ACCORDING TO NEEDS AND CIRCUMSTANCES.** Any revisions will be announced in class and will be posted on Canvas.

- Course logistics/structure:
  - face to face lecture: 3 days per week (except holidays)
  - Video tutorials: average time per homework should be ideally 1-2 hour/week. Student must submit homework in Canvas.
  - Teams of 4 students will be formed to work on a final project.
- Topics covered and expected time to be covered:

Unit 1: CONCEPTUALIZATION AND ANALYSIS OF CHEMICAL PROCESS	
Topic 1. Introduction to Chemical Process and Product Design Topic 2. PFD Structure and Synthesis Topic 3. Tracing Chemical through the Process Flow Diagram Topic 4. Understanding Process Conditions	~ 3 weeks
Unit #2: ENGINEERING ECONOMIC ANALYSIS OF CHEMICAL PROCESSES	
Topic 5. Intro to Cost Accounting Topic 6: Estimation of Capital Costs Topic 6. Estimation of Cost of Manufacturing Topic 7. Economic Analysis: Interest rates, Cash Flow Diagrams, and calculations Topic 8. Economic Analysis: Profitability Analysis	~ 6 weeks
Unit #3: SYNTHESIS AND OPTIMIZATION OF CHEMICAL PROCESSES	
Topic 9. Experience Based Principles in Process Design Topic 10. Synthesis of the PFD from the Generic BFD ( <i>Final Project Statement Announced</i> ) Topic 11. Process Optimization: topographical and parametric Topic 12. Energy Integration and Design of Heat Exchanger Network-Pinch Tech ( <i>Optional</i> )	~ 4 weeks
Unit #4: CHEMICAL ENGINEERING LONG TERM SKILLS	
Topic 13. Case Studies with steady-state simulation ( <i>Project Support</i> ) Topic 14: Chemical Engineering Design Documentation and Written Reports	~ 2 weeks

- Important dates: The following dates are subject to change. Always check Canvas Announcements and Assignment list for final information.

Mostly every week	A video tutorial or assigned problems will be published and students must submit the corresponding HW in Canvas individually.
Exam 1-Friday, February 4 <sup>th</sup> Exam 2- Friday, February 25 <sup>th</sup> Exam 3- Friday, March 25 <sup>th</sup>	Exam will start on Period 8 (3:00 PM - 3:50 PM) and will last only 50 mins. Look up in Canvas for details under exam study guide. Students with special accommodations (DRC) must talk to me at least 2 weeks before the exam.
Wednesday, March 20 <sup>th</sup>	Project Disclosure. Teams of 4 students will be formed and will work on the creation, optimization, and economic evaluation of a plant design.
3 deliverables between March 25 <sup>th</sup> - April 24 <sup>th</sup>	Weekly Deliverables: Preliminary mini-reports to get feedback from your instructor before submitting for final report. Check Canvas for details. Deliverables will be submitted via Canvas.
Monday, April, 29 <sup>th</sup> before 5:00 pm	Last day to submit final report is Monday, April, 29 <sup>th</sup> before 5:00 pm sharp. No exceptions. Report will be submitted via Canvas.

## Attendance Policy, Expectations, and Make-Up Policy

### a) Attendance

- Regular attendance expected in addition to class discussions and satisfactory performance on class activities.
- Attendance will be taken in class periodically. Make sure to be in class or send an excuse to your instructor.
  - Signing an attendance on behalf of an absent or tardy student is in violation of the academic honesty policy and will result in disciplinary action. A first violation will result in a letter grade reduction for all involved parties. A second violation will result in course failure for all involved parties.
- **HOW TO SEND AN EXCUSE:**
  - Email Dr. Rivera at [rivera.jimenez@eng.ufl.edu](mailto:rivera.jimenez@eng.ufl.edu)
  - Use the Following Subject line: **ECH 4604: Absence Excuse**
  - What constitute a valid excuse? Excused absences are consistent with university policies in the [undergraduate catalog](#) and require appropriate documentation. Absences will be excused under the following conditions:
    - 24 hours ahead of time that you have a legitimate, unavoidable absence (such as an exam conflict for a higher-numbered academic course)
    - A verifiable medical or family emergency
    - Travel for a student conference—provided all excuse request prior to travel
    - Need to come to class late or leave early for a legitimate reason
  - Email instructor at least 24 hours before missing class due to interview confirmation email; conference email; UF official sporting event.

### b) Basic Responsibilities Expected from You:

- Attendance is critical! The material you will learn is invaluable. In case of absence, you can ask a class mate for lecture material, use your book, and access supporting slides on Canvas. Note: supporting slides are NOT the complete lecture material, these are diagrams and pictures that I use to support the lecture.
- Don't be afraid to ask for help during class or office hours.
- Be an active learner - ask yourself questions during lectures, as you read, and as you attempt problems.
- Study in advance and go to office hours. Don't wait until the day before the exam, homework, or report to get clarification on the material.
- Check Canvas for class updates, assignments, announcements, lessons, calendar, and resources. If using a laptop and other devices in class, you shouldn't be on Facebook, Netflix, Hulu, etc. or do other things that are not class-related. When instructor asks you to put your device away, please do so.
- Recording the lecture is not allowed using any type of media. If you need special accommodations, please contact your instructor.
- You need to notify your instructor if your need accommodation from the Disability Resource Center. I would love to help you out.

### c) Emails, Announcements, Feedback, and Communications

- Announcements will be shared periodically during class and on Canvas. It is your responsibility to attend to class and read the emails/announcements from Canvas.
- After each assignment is graded, you are responsible for reviewing your instructor's feedback.
- Emails, announcements, and feedback may occur outside business hours.

- Your instructor should respond within 24 hrs during workdays (M-F). There is not guarantee of response during weekends. Plan accordingly.

## Grading Policy:

- Evaluation of Grades:**

Categories	Percentage of Final Grade	Approximate number of points
Homework/Assignments (~10-12 in total)	20 % (Individual)	~20-30 pts each
Exams	30 % (Individual)	~50 pts each
Class participation	5 % (Individual)	~15 pts total
Preliminary Deliverables	15 % (Individual)	10 pts each
Final report grade	30 % (Individual)***	100 pts

\*\*\*The individual team members' grade is adjusted according to peer evaluations as follows:  
 Individual grade = team grade \* {0.5 + [0.5 x (average of student's evaluation)/(team average)]}  
 \*\*\* I will show an example when project expectations are announced.

- Grading Scale:** The students are sorted in the order of decreasing overall points. Grades are then decided as follows:

Division between A and A-	Largest gap between two students with 90 >= overall points > 85
Division between A- and B+	Largest gap between two students with 85 >= overall points > 80
Division between B+ and B	Largest gap between two students with 80 >= overall points > 75
Division between B and B-	Largest gap between two students with 75 >= overall points > 70
Division between B- and C+	Largest gap between two students with 70 >= overall points > 65
Division between C+ and C	Largest gap between two students with 65 >= overall points > 55
Division between C and C-	Largest gap between two students with 55 >= overall points > 45
Division between C- and D+	Largest gap between two students with 45 >= overall points > 30
Division between D+ and D	Largest gap between two students with 30 >= overall points > 10
Division between D and D-	Largest gap between two students with 10 >= overall points >= 0
E	Given to students for honesty violations.

## Institutional Policies:

### **Students Requiring Accommodations**

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### **Course Evaluation**

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

### **University Honesty Policy**

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor

Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### **Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### **Student Privacy**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. Review this [website](#) for more information about FERPA. Access:

<http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

### **Commitment to a safe and inclusive learning environment**

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. If you feel like your performance in class is being impacted by discrimination or harassment of any kind please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@ufl.edu](mailto:nishida@ufl.edu)

*Sexual Discrimination, Harassment, Assault, or Violence:* If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

## **Campus Resources:**

### **Health and Wellness**

- **U Matter, We Care:** If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352 392-1575 so that a team member can reach out to the student.
- **Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc> , and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.
- **Sexual Assault Recovery Services (SARS).** Student Health Care Center, 392-1161.
- **University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>

### **Academic Resources**

- **E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu) . <https://lss.at.ufl.edu/help.shtml> .
- **Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/> .
- **Library Support**, <http://cms.uflib.ufl.edu/ask> . Various ways to receive assistance with respect to using the libraries or finding resources.
- **Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
- <https://teachingcenter.ufl.edu/> .
- **Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
- <https://writing.ufl.edu/writing-studio/> .
- **Student Complaints Campus:** [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf) .
- **On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process> .