Process Economics and Optimization

ECH 4604, Section 23971
Class Periods: MWF, Period 8 (3:00 PM - 3:50 PM)
Location: CSE E220
Academic Term: Spring 2024

Instructor:
Dmitry Kopelevich
- Email: dkopelevich@che.ufl.edu (you may also contact me through Canvas)
- Phone: (352)-392-4422
- Office location: CHE 315
- Office hours: Fridays, 12 noon – 2 pm

Teaching Assistant/Peer Mentor/Supervised Teaching Student: *None*

Course Description
3 Credits. Introduces 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:

1. Apply the design methodology to design diverse chemical manufacturing processes.
2. Apply knowledge of fundamental science and chemical engineering concepts to describe, analyze and improve processes that will benefit society.
3. Evaluate the economic, environmental, safety, and ethical implications that are involved in developing different new or improved processes.
4. Calculate costs of chemical processes using tables, charts, or software to estimate physical and economic data.
5. Perform risk and profitability analysis of chemical processes.
6. Optimize chemical processes to improve their performance.
7. Collaborate effectively in a team by applying professional practices such as leadership, inclusive environment, project management, and communication in both oral and written forms.

Materials and Supply Fees: None

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Medium
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	High
3. An ability to communicate effectively with a range of audiences	High

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	High
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Low
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	High

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in 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 and optimization of processes.
- Students will learn and apply principles of design to analyze a chemical engineering process to meet desired needs within realistic constraints such as economic, environmental, health and safety.
- Students are assigned in teams so as to mix personalities and abilities and work on a term 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 through project deliverables and final report.
- An ability to engage in lifelong learning is fostered through various course activities. Students will be presented with software tools, online resources, and case studies.
- Information gathering includes obtaining MSDS sheets for all components involved in the design. Safety and environmental impact are factors that students consider when selecting design.
- Through video tutorials and homework students will become proficient in the use of the software Aspen HYSYS.

Required Textbooks and Software

A. Main course text (required):

R. Turton, J. A. Shaeiwitz, D. Bhattacharyya, and W. B. Whiting, *Analysis, Synthesis, and Design of Chemical Processes*, 5th Edition (2018), Pearson, ISBN 978-0-13-417740-3.

B. Required Software:
- Microsoft Office
- Python
- HYSYS and ASPEN Plus (installation instructions are provided on Canvas).
- UF VPN (if using HYSYS and ASPEN off-campus)

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/advising/fall-semester-checklist/computer-requirements/
- Windows Operating System (10 or 11) is required to run HYSYS and ASPEN. Mac and Linux users will need to dual boot their computer with Windows or run Windows in a Virtual environment. Detailed instructions are provided on Canvas.

- **Important:** your computer should have an Intel or an AMD processor. HYSYS and ASPEN do not run on new Macs with M1 CPUs.

Recommended Materials

- Online Resource: *Learn ChemE*, Educational Resources from ChemE at the University of Colorado at Boulder. Available at: http://www.learncheme.com/screencasts/process-design
- Online Resource: M. H. Hamayun, *Chem Engg and Aspen Channel*, Available at: https://www.youtube.com/@aspenchemchannel/featured
- Book: G. Towler and R. Sinnott, *Chemical Engineering Design*, 2nd Edition (2012), Butterworth-Heinemann, ISBN: 978-0-08-096659-5. Available via UF Libraries: https://doi.org/10.1016/C2009-0-61216-2.
- Book: W. D. Seider, D. R. Lewin, J. D. Seader, S. Widagdo, R. Gani, and K. M. Ng. *Product and Process Design Principles: Synthesis, Analysis and Evaluation,* 4th Edition (2019), ISBN 978-1-119-47526-2 (E-book); 978-1-119-62620-6 (Print). Available via UF Libraries: https://app.knovel.com/kn/resources/kpPPDPSAE1/toc?cid=kpPPDPSAE1

Course Schedule

Note that the schedule may change according to needs and circumstances. Any revisions will be announced in class and posted on Canvas.

Unit 1. Process Design: Conceptualization and Analysis		
Week 1	Representation of chemical processes. Structure of Process Flow Diagrams. Tracing chemicals.	Chapters 1, 5
Week 2	Synthesis of Process Flow Diagrams.	Chapters 2
Weeks 3, 4	Using HYSYS for process simulation.	Chapters 12, 13
Week 5	Understanding process conditions. Heuristics.	Chapter 6 Chapter 11
Unit 2. Engineering Economic Analysis of Chemical Processes		
Week 6	Capital cost estimation	Chapter 7
Week 7,8	Operating cost estimations	Chapter 8
Week 9	Time value of money, cash flow diagrams	Chapter 9
Weeks 10, 11	Profitability analysis Risk analysis	Chapter 10
Unit 3. Design Alternatives and Optimization		
Weeks 12, 13	Process Optimization	Chapter 14
Week 14	Pinch Technology	Chapter 15
Week 15	Life Cycle Analysis, Green Engineering	Chapter 27
Week 16	Wrap-up of the term project	

Attendance Policy, Class Expectations, and Make-Up Policy

(a) Attendance

- Regular attendance is expected, in addition to participation in class discussions and satisfactory performance on in-class activities.
- Exams and quizzes will be rescheduled only for those students who missed them due to an acceptable reason, such as illness, serious family emergencies, military obligation, religious holidays, participation in official university activities, travel to a student conference or a job interview. Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies: https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/
- Students arriving late for a quiz/exam will be given only the balance of time remaining to complete their work unless an acceptable reason (see above) is provided.
- HOW TO SEND A REQUEST FOR AN EXCUSED ABSENCE:
  - Email Dr. Kopelevich at dkopelevich@che.ufl.edu
  - Please inform the instructor about a planned absence at least 24 hours ahead of time.

(b) Basic Responsibilities Expected from You:

- Attendance is critical! If you missed a class, it is your responsibility to obtain the information (e.g. notes, assignments, and announcements) that you missed due to the absence.
- Check Canvas for class updates, assignments, announcements, lessons, calendar, and resources.
- 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 to solve problems.
- Study in advance and go to office hours. Don't wait until the day before the exam, homework or report due date to get clarification on the material.
- If using a laptop and other devices in class, you should not 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.
- You need to notify your instructor if you need accommodation from the Disability Resource Center. Your instructor wants to help you.

(c) Expectation from team and individuals on each team: Conflict Resolution

- **Be Aware That Conflict Occurs**. Knowing that conflict may and will occur is the first step to resolving it, especially if you know that certain team members may disagree with each other.
- **Set the Ground Rules**. At the beginning of your project set some ground rules in your first meeting. Be sure to address what process will be taken to address conflicts, as they are bound to rise and will need to be taken care of before they spiral out of control.
- **Document Team Dynamics**. Project reports must contain a weekly summary of each team member technical contributions, distribution of tasks, accomplishment of tasks, attendance of group meetings, and overall project status.
- **Stop Conflict When It Happens**. Conflict should be addressed immediately before it can grow. If a discussion grows heated during a meeting, do not wait until the next meeting to address the issue. Instead, discuss the issue while in the meeting; even if members disagree, they should still be able to see each other's points of view. Your instructor can serve as a moderator for these discussions.
- **Discuss Both Sides of a Perspective**. Even if you are inclined to agree with one side of the conflict, do not make a final judgment until each person has had their say. Ending a discussion without hearing each person out can escalate the problem. Explain the pros and cons of both ideas, so that everybody can consider the opposing view.

- **Make Compromise a Goal.** Compromising between parties is helpful, as it can allow for both conflicting parties the ability to use their ideas. Most times, points can be combined in order to make a better idea or solution.
- **Avoid Falling into Groupthink**. Groupthink is when a group suppresses the opposing views of members in order to create harmony. While it is always good to maintain harmony within a group while working on a project, this idea of keeping opposing viewpoints at bay because they will disrupt the norm will end up doing more harm than good. To avoid this, make sure that there is one or two members that bring up constructive criticism to ideas.
- **Don't Try to Change a Team Member**. This final tip might be the most important. Just as in any type of relationship, do not try to change a member of your team. They are an individual person with unique ideas and forms of expression. Trying to change their feelings or viewpoints will only lead to resentment. You can propose to them alternatives, or list benefits of other ideas, but in the end you may just have to accept that they will disagree with an outcome.

(d) Handling problems between a team member and the rest of the team

- Teams must create and submit a team charter appended to their first deliverable. At the beginning of your project set some ground rules in your first meeting. Be sure to address what process will be taken to address conflicts, as they are bound to rise and will need to be taken care of before they spiral out of control. A template will be provided in class to facilitate the charter creation.
- In all reports. teams must submit a summary of each individual member's technical contributions, distribution of tasks, the accomplishment of tasks, attendance of group meetings (besides meetings with the instructor), overall project status. This will allow your team to document relevant information in case we need it for a conflict resolution meeting.
- You are welcome to discuss any concerns with your instructor.
- Each team member must complete all peer evaluations that will be available on Canvas. This will give each team member an opportunity to evaluate their peers and themselves. All information obtained from peer-evaluation will be used by your instructor to provide feedback to each team member. Only the last peer-evaluation will be used for the final grade adjustment.
- Team dissolution or changing individuals to another team are highly discouraged. One of the main goals of this class is that each student learns how to manage conflict to increase team performance towards an engineering goal. If a dispute with an individual cannot be resolved, this student will not be moved to another group. The student must have a meeting with the instructor to establish a plan for assessment without significant changes in the overall project objectives.

(e) Emails, Announcements, Feedback, and Communications

- Announcements will be shared periodically during class and via Canvas. It is your responsibility to attend class and read the emails/announcements from Canvas.
- After each assignment is graded, you are responsible for reviewing your instructor's feedback.
- Your instructor should respond within 24 hrs during workdays (M-F). There is no guarantee of response during weekends. Please plan accordingly.

Grading Policy:

Evaluation of Grades:

Categories	Percentage of Final Grade
Quizzes (Individual)	10%
Homework (Individual; includes HYSYS training)	20%
Mid-term Exam (Individual)	20%
Final Exam (Individual)	20%
Project Deliverables (Group)	15%
Final Project Report (Group)	15%

- Late submissions of homeworks and project deliverables will incur a 10% penalty per day. No late submissions of the exam and quizzes will be accepted.
- The penalty for a late submission is not imposed if an assignment is submitted late due to a valid reason (as described in the Undergraduate Catalog).
- The individual team members' grade for group assignments is adjusted according to peer evaluations as follows:
  - Individual grade = (Team grade) × (Individual ratio)
  - Individual Ratio= (average of student's evaluation excluding self-eval)/(team average)
  - Peer evaluations will be collected using CATME

Grading Scale

- These percentages will earn you a letter grade of *at least*

Percent	Grade	Grade Points
90.0 - 100	A	4.00
85.0 – 89.9	A-	3.67
80.0 - 84.9	B+	3.33
75.0 - 79.9	B	3.00
70.0 - 74.9	B-	2.67
65.0 – 69.9	C+	2.33
60.0 – 64.9	C	2.00
55.0 - 59.9	C-	1.67
50.0 - 54.9	D+	1.33
45.0 - 49.9	D	1.00
40.0 - 44.9	D-	0.67
0 - 39.9	E	0.00

- The instructor guarantees these grades if you earn the posted percentages.
- The instructor may decide to *lower* the thresholds for the grades listed, based upon a curve. The instructor may employ a curve only to lower these thresholds.
- **Note that academic honesty violations will result in a severe grade penalty, including assignment of an E in the course.**
- More information on UF grading policy may be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

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://sccr.dso.ufl.edu/process/student-conduct-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.

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 Undergraduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

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. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

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

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 suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/state-authorization-status/#student-complaint*.