Introduction to Chemical Process Analysis, CBE 140, Fall 2020

MWF 8:10-9 am, online

Discussion (attendance to one per week):

M: 9:10-10:00am; T: 1:10-2:00pm; W: 9:10-10:00am & 3:10-4:00pm; Th: 1:10-2:00pm; F: 9:10-10:00am

Instructors

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Office hours: Fridays, 3:00-4:30 pm

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See links on bCourses homepage for office hour Zoom links.

Description

An introduction to concepts that are necessary to design large-scale chemical processes. Concepts covered are generally related to mass and energy conservation in open and closed systems, both at steady state and in transient operation. An introduction to basics of transport, thermodynamics, and kinetics in the context of reactor, separator, and heat exchanger design.

Course Prerequisite(s)

-Chemical Engineering 40 (Introduction to Chemical Engineering Design)
-Chemistry 1B (General Chemistry) or concurrent enrollment in 4B (Quantitative Analaysis)
-Concurrent enrollment in Physics 7B (Physics for Scientists and Engineers)

Topics to be covered

1. Process flow sheets, process modeling, dimensional analysis
2. Mass conservation in steady-state and transient systems
3. Introduction to reactor design and kinetic models
4. Introduction to equilibrium separations
5. Process economics and optimization
6. Energy conservation in steady-state and transient systems
7. Design of heat exchangers, non-isothermal reactors
8. Chemical and systems safety, runaway reactors

Textbooks

Required:
Elementary Principles of Chemical Processes, 4th Ed. (available as ebook), Richard Felder, Ronald Rousseau, Lisa Bullard, Wiley and Sons, 2019.

Suggested supplemental texts:
-*Introduction to Chemical Processes*, Regina Murphy, McGraw Hill, 2007.
-*Chemical Engineering Design and Analysis: An Introduction*, 2nd Ed., T. M. Duncan, J. A. Reimer, Cambridge University Press, 2018.
-*Chemical Engineering, An Introduction*, Morton M. Denn, Cambridge University Press, 2012.
-All above textbooks are (or will be shortly) on reserve in the Chemistry library

Excellent online resource: http://www.learncheme.com/screencasts/mass-energy-balances

Remote instruction
Lectures and discussion sections will be held at the regularly scheduled time via Zoom. Synchronous (real time) attendance will not be mandatory but we strongly encourage you to attend the live lectures and the live discussion sections if you can. We will post all lecture recordings and notes on bCourses, barring technical difficulties, immediately following the live sessions. If you object to being recorded, you may at any time refrain from participating visually, verbally, or in the "chat". Because of the nature of online instruction, we expect you to view the material assigned before class, as well as view all prior lectures.

Homework and quizzes
On average, problem sets will be assigned every week. Due to class size and staffing constraints, we may not be able to grade every homework problem on every problem set. Instead, we may grade only a subset of total assigned problems and your grade will be based on your performance on that subset. You are encouraged to work with your classmates, but you must turn in your own answers and you are responsible for understanding all assigned problems. Work not submitted by lecture on the due date will be considered late and receive no credit. Our policy will be to incorporate reasonable flexibility regarding deadlines and accommodations, but it is your responsibility for communicating special circumstances prior to the deadline.

10-20 minute quizzes (~10) will be administered on most Fridays throughout the semester to gauge understanding of lecture material in the prior week. Quizzes will typically be a mix of T/F and multiple choice questions and administered through bCourses, although some questions can be expected that will require you to show work throughout a calculation. Assignments, partial solutions, and handouts will be posted on the course website. Your lowest quiz and homework score will be dropped prior to assigning final grades.

Basis for grading	Homework	10%
	Quizzes	25%
	Midterms (20% x 2)	40% (tentatively Wed. 9/30 and Wed. 11/04)
	Final	25% (12/14, 2.5 hr exam, time window: 1-10pm)

Midterm conflicts
The current tentative schedule for midterms is Wed. 9/30 and Wed, 11/04, likely both 1.5 hr exams given within a ~6 hr time window. If you have a known conflict with the scheduled midterms, let Prof. McCloskey know as soon as possible. Missing an exam will result in a score of zero unless appropriate documentation for an excused absence is provided. If such documentation is provided, instead of a make up midterm, the missed midterm percentage will be redistributed between the other midterm and final, such that the other midterm will be 30% of your final grade and the final exam will be 35%. The final exam must be taken, no excuses.

Cheating and academic dishonesty
The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The instructors expect that you will adhere to this code. While working with others on homework problems and during preparation for exams is encouraged, exams and quizzes are individual exercises and may not be completed with help from anyone. Additional rules for exams and quizzes (e.g., open/closed notes or book, cheat sheet allowed, etc.) will be clarified by Prof. McCloskey prior to each. Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will be reported to campus student affairs officials.

Tentative schedule (Textbook reading associated with this content will be announced at the end of lectures)

Week 1: No class 8/24, examples of large scale processes, process flow sheets, introduction to units, conservation of mass, control volumes

Week 2: Steady-state and unsteady mass balances, residence times, ordinary differential equations (ODEs), dimensionless numbers, continuous stirred tank, wash out of tank

Week 3: No class 9/7, continuous stirred tank reactor (CSTR), reactor kinetics, homogneous rate constants, conversion, recycle

Week 4: Batch stirred tank reactor (BSTR), CSTR in series, flowsheets for nonreactive unit operations, degree of freedom analysis

Week 5: Multiple unit processes with no reactions, mass balances on reactors, combustion, element balances, balances using conversion

Week 6: Extent of reaction, yield, selectivity, chemical reaction equilibrium, chemical potential and the criterion for equilibrium, **Midterm #1**

Week 7: Equilibrium constants, equilibrium distribution calculations, gas phase reactors, Haber-Bosch process

Week 8: Packed bed/plug flow reactors (PBR/PFRs), heterogeneous catalysis, Van't Hoff equation, design equation, reaction rate expressions, numerical solution to non-linear ODEs

Week 9: Pressure-Volume-Temperature properties of single component systems, the ideal gas law, intermolecular forces, Van der Waals equation of state, liquid formation from condensation of a gas, Antoine's equation, vapor pressures, dew points, bubble points, critical temperatures, reduced properties, law of corresponding states

Week 10: P-V and P-T phase diagrams for a single component, multicomponent vapor-liquid equilibrium, Raoult's Law, Henry's Law, Gibbs Phase Rule

Week 11: Separations using vapor-liquid equilibrium, binary mixture phase diagrams, **Midterm #2**

Week 12: No class 11/11, intro to energy balances, kinetic and potential energy, internal energy, heat, work, unreactive systems

Week 13: Heat transfer coefficients, closed/open systems, enthalpy, 1st law of thermodynamics, heat capacities

Week 14: No class 11/25 & 11/27, reference states, phase changes, latent heat, heat of vaporization

Week 15: Energy balances in multi-component separations, hypothetical paths, energy balances in reactors, adiabatic flame temperature