

# CHEN 4520: Chemical Process Synthesis

## Fall 2020 Syllabus

Instructors Alan (Al) Weimer, Melvin E. and Virginia M. Clark Professor  
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### Teaching Assistants

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Davis Conklin	<a href="mailto:Davis.Conklin@colorado.edu">Davis.Conklin@colorado.edu</a>
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Sage Hurta	<a href="mailto:Sage.Hurta@colorado.edu">Sage.Hurta@colorado.edu</a>

### Meeting Times/Dates

**Lectures:** Mondays & Wednesdays at 2:00 pm via zoom

AW: <https://cuboulder.zoom.us/j/5265213468> Passcode: Design

WY: <https://cuboulder.zoom.us/j/9958460633> Passcode: Design

**Group Meetings:** Tuesday & Thursday via zoom (8:30 – 9:45 a.m. and 10:00 – 11:15 a.m.)

Students are expected to read materials before class (text and extra) & encouraged to attend/participate-in class. It is expected that students will have read and understood material in order to do in-class workshops (workshop questions will be in clicker quizzes). Very important – this class will emphasize in-class workshops and so, for students to get the most out of class, students need to substantially prepare before coming into class!

Office Hours (URLs for zoom sessions will be given in Canvas each week)

Mon: 12:45 a.m. – 2:00 p.m. in A115 & zoom DC, NR, NS, SH

Tues: 6:10 p.m. – 7:30 p.m. in A115 & zoom DF, NR, NS, SH

Wed: 4:00 p.m. – 5:40 p.m. in A104 & zoom DC, DF, NS, SH

Thur: 3:35 p.m. – 5:00 p.m. in A115 & zoom DC, DF, NR

Text *Product and Process Design Principles (4th Edition)*

Warren D. Seider, Daniel R. Lewin, J.D. Seader, Soemantri Widagdo, Rafiqul Gani and Ka Ming Ng; 2017 (Wiley)

### Prerequisites

CHEN 3010, 3210, 3320 (all C- or higher)

CHEN 3220 “Separations” (C- or higher)

CHEN 4330 “Kinetics” (C- or higher)

This is the 1<sup>st</sup> course in the capstone chemical engineering sequence of classes. The chemical and biological engineering department enforces all pre-requisites!

### Course Content

The fall semester Chemical Process Synthesis course, CHEN 4520, along with the spring semester Design Projects course, CHEN 4530, is the *capstone* course sequence in chemical and chemical & biological engineering. The design-synthesis activities, the considerations of numerous options, and the practical application of the fundamentals all need to be integrated from freshman courses through to this senior design course. The sequence provides a culmination for all previous chemical engineering courses (transport processes, thermodynamics, reaction kinetics, unit operations, etc.). Students are expected to know the basics of fluids, heat transfer, separations, and reactor engineering (kinetics). In CHEN 4520, students will be exposed to design of pumps, compressors, heat exchangers, distillation columns (ideal and non-ideal), and chemical reactors (fixed bed and CSTRs). Students will be taught how to select process units and interconnect them in an overall process flowsheet with the primary goal being to find the optimal design conditions for the best possible design scenario among various conceptualized alternatives. With the exception of cost estimation, process economics, heat integration, separation trains, & simulation tools, the material is not new, but the conceptualization approach required to build a process flowsheet will help students to take their understanding of previous subjects to a new and higher level.

### Course Objectives

- Emphasis of safety, environmental, health, and ethical issues related to chemical process synthesis and operations
- Review and apply prerequisite knowledge, including fluid mechanics, heat transfer, separations, and reaction kinetics, in conceptualizing chemical processes
- Set up complex chemical process material and energy balance systems and use commercial chemical and biological process simulation software to solve them and to specify unit operations equipment – software includes ASPENPlus™, ASPENHysys™, and Super Pro Designer™; employ Microsoft Visio™ for schematic diagrams; incorporate heat integration methodology for efficiency improvement
- Carry out economic analysis for chemical processes, including capital cost, variable cost, cash flow, and profitability analysis
- Complete a well-defined, team-based chemical process design project, including process material and energy balances, equipment design, and economic analysis, and write a detailed project report; use Microsoft Project™ software for team project management; prepares students with working knowledge to carry out a capstone design project in CHEN-4530, working with an external liaison
- Provide a broad background suitable for both chemical engineering and chemical and biological engineering professions
- Create awareness of world current events related to chemical and chemical and biological process and product design

Every student who passes Chemical Process Synthesis, CHEN-4520, will be well-prepared to tackle Design Projects, CHEN-4530, from Day 1. Students will “hit the ground running” and will know exactly how to approach the undefined project problems posed in CHEN-4530.

### Simulation, Design, Costing, and Economics Software

Students are expected to know how to carry out spreadsheet type engineering calculations using Microsoft Excel™ or equivalent, as well as how to use differential equation solvers such as

PolyMath™. The process simulation programs ASPEN HYSYS™, ASPEN Plus™ and Super Pro Designer® will be used extensively throughout the course and for the design projects. It is the responsibility of the students to learn how to use the process simulators and all software programs as needed. Basic instruction will be given for process simulation via tutorials. All of the simulation software is available on “the cloud” via a CU VPN access. Students will also use Microsoft VISIO™ for flow sheet preparation. Tutorials will be provided. Students are also encouraged to use the ~70 screencasts available for design on [www.LearnChemE.com](http://www.LearnChemE.com).

#### ABET Student Outcomes Addressed

- (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- (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
- (3) an ability to communicate effectively with a range of audiences
- (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
- (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
- (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

#### Recording of Lectures and Office Hours

All lectures and office hours will be recorded. Class recordings will not be distributed outside the audience of students, instructors, and other class staff. Access to a recording is limited to class participants and staff through one's CU Boulder IdentiKey. Only the course instructors and staff are authorized to record a class; students are not authorized to record a class through any means.

#### Student Comportment on Zoom

The instructors strongly recommend but do not require students to use their video when attending zoom lectures and office hours; being able to see one another strengthens our community and the instructors enjoy seeing everyone. Students should mute themselves except when they are asking or answering a class question. Students are expected to present themselves as if each individual were actually in the classroom (i.e. be respectful, wear appropriate attire).

#### Course Communication

All class slides, extra reading materials, tutorials/homework, and videos will be placed on Canvas for students to download.

#### Overall Course Grading

- 10% - Clicker Quizzes*
- 25% - Team Homework*
- 45% - Design Report*
- 20% - Peer/Instructor Review*

The overall course letter grades will be assigned in accordance with overall numerical grades. Breakpoints between letter grades will be determined by the instructor. It is anticipated that the course will be “straight graded”, but possibly curved for individual midterms.

### Homework

**NO LATE HOMEWORK WILL BE ACCEPTED FOR ANY REASON because you are on a team; make sure to have a backup and a backup of the backup.** When Canvas “times out”, no additional submissions can be made regardless of the reason (for instance, it was done but not turned in; our submitter got sick; turned in the wrong file; missed one file by accident).

**Talk with the instructors AHEAD OF THE DEADLINE if there are extenuating circumstances warranting a deadline push.**

Note – Prof. Weimer was once involved on a \$45M USDA proposal where another faculty member at another university was Principal Investigator. Literally, 1000’s of hours were spent writing the proposal and convincing industry to donate ~\$4M cash towards the required cost share. It was an outstanding proposal. The proposal was submitted to the “grants.gov” web site 18 seconds late and was rejected without review because it was late! Complaints were made that the “grants.gov” web site had issues, etc. and had been down at times. The USDA said everyone knew the web site had issues and that the proposal should have been submitted earlier. Their rejection stuck. The same applies here.

### Clicker Questions

Clickers will be used in this course and every student needs one for class starting on Day 2. The lowest clicker score will be discarded. Clicker questions will be related to reading assignment materials and Workshop participation. For the structure of the class to provide a high learning value, students need to come prepared to do the Workshops. Otherwise, students will not learn as they need to.

### Team Organization

It is the responsibility of every student to determine her or his team. Instructors will not determine teams, but maintain the option of approving final teams and of moving students into/out of teams to ensure that everyone is placed on a team. Students should be thinking of who might comprise their teams from the 1<sup>st</sup> day in class. Teams will have 4-5 students and there will be no more than 13 teams. Instructors maintain the option to reorganize teams as necessary, potentially resulting in some students working with fewer team members or on their own.

### Peer-Review

Instructors determine the final allocation of points, but heavily consider peer-review input. It is extremely important that everyone contribute to important aspects of group work. Students do not want to receive poor peer reviews because they did not have a lot of responsibility – take responsibility and come through for the team! Students will be asked to turn in written peer-review assessments to the instructors, regarding their team effort. It cannot be overemphasized how important it is for the team to be functional and bring out the best in all members.

### Attendance

Answers to “clicker questions” will be at least 50% credit for a wrong answer and so attendance will count towards the final grade. Note that professors often consider attendance records when asked to write letters of recommendation for students.

### Current Events

Each student group has the option to sign up for one current events presentation. Groups present 1-2 slides on a chemical and biological engineering-related current event during the first five minutes of class; slides are emailed to the instructors so students do not need to use their own

computers. All group members receive extra credit in the form of one extra clicker day of full points. Students sign up for a week on the Calendar in Canvas.

### Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on [classroom behavior](#) and the [Student Code of Conduct](#).

### Requirements for COVID-19

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert [CU Boulder Medical Services](#).

Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to [Student Conduct and Conflict Resolution](#). For more information, see the policies on [COVID-19 Health and Safety](#) and [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the “Accommodation for Disabilities” statement on this syllabus.

Before returning to campus, all students must complete the [COVID-19 Student Health and Expectations Course](#). Before coming on to campus each day, all students are required to complete a [Daily Health Form](#).

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home and complete the [Health Questionnaire and Illness Reporting Form](#) remotely. In this class, if you are sick or quarantined, **please immediately email Professor Weimer or Dr. Young**.

### Accommodation for Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu)

for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

#### Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

#### Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or [cureport@colorado.edu](mailto:cureport@colorado.edu). Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

#### Religious Observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please talk with the class instructors if you have a religious conflict. See the [campus policy regarding religious observances](#) for full details.

#### Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code ([honor@colorado.edu](mailto:honor@colorado.edu)); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code Office website](#).

All students are asked to sign a copy of the [CHEN-4520 Honor Code](#) that is included in this Syllabus below. The signed CHEN-4520 Honor Code will be turned in to Canvas.

**Fall, 2020 CHEN-4520 Honor Code**

**Please turn in the signed Honor Code to Canvas (1<sup>st</sup> week)**

On my honor, as a University of Colorado Boulder student in the Department of Chemical and Biological Engineering, I will neither give nor receive unauthorized assistance in CHEN-4520 for clicker quizzes; nor will I receive unauthorized assistance outside of my team on homework or the final project. I will not attempt to obtain or use any prior year's course project information that may be available to me through personal contacts or organized filing systems whether electronic or paper. I will not complete any clicker quiz other than my own. I understand that course work submitted by me, if contrived/completed/written in part or in whole by someone other than myself, shall be considered to constitute fraud under the University Honor Code, and will result in the assignment of an 'F' for the entire course. I understand that plagiarism for work will be investigated using software available to the University of Colorado. I understand that 20% of my grade in CHEN 4520 is based on peer-reviews within my team per the guidelines in the Syllabus. I understand that Instructors maintain the option to reorganize teams as necessary, potentially resulting in some students working with fewer team members or on their own.

I understand the CHEN-4520 class Honor Code as stipulated herein and understand the ramifications for breaking the code.

\_\_\_\_\_ Signed

\_\_\_\_\_ Printed Name

## Tentative CHEN 4520 Course Schedule – Fall 2020

SUBJECT TO CHANGE

AW Zoom: <https://cuboulder.zoom.us/j/5265213468> Passcode: Design

WY Zoom: <https://cuboulder.zoom.us/j/9958460633> Passcode: Design

Week	Monday 2pm	Wednesday 2pm
#1 8/24	AW WY Intro to the class and WY Aspen PLUS/HYSYS/Heat Integration, SuperPro, Visio, organize teams; AW Process Design / Creation General (Chs 1,2,5,24,25)	AW Process Design / Creation Vinyl Chloride (Ch 2)
#2 8/31	AW Heuristics 1 (Ch 6)	AW Heuristics 2 (Ch 6) & Design of Idealized Separation Trains (Ch 9) <b>HW#1 due 11:59pm Thur 9/3</b>
#3 9/7	WY Safety & HAZOP (Ch 3)	WY Environmental & Ethics (Ch 3) <b>HW#2 due 11:59pm Thur 9/10</b> Aspen HYSYS Tutorial Sat/Sun, 9/12 - 13
#4 9/14	WY Pumps & Compressors (Ch 14)	WY Heat Exchanger Design (Ch12) <b>HW#3 Due 11:59pm Thur 9/17</b>
#5 9/21	WY Separation Tower Design (Ch 13) Aspen PLUS/HYSYS Tower design/simulation	WY Design of non-idealized separation Trains (Ch 9) <b>HW#4 Due 11:59pm Thur 9/24</b> Peer Review #1 Due Fri at midnight
#6 9/28	WY Heat & Power Integration 1 (Ch 11)	WY Heat & Power Integration 2 (Ch 11) <b>HW#5 Due 11:59pm Thur 10/1</b> Mat Lab Tutorial Sat, 10/3
#7 10/5	AW Chemical & Biochemical Reactor Design (Ch 15)	AW Solids Processing Reactor Design (Ch 15) <b>HW#6 Due 11:59pm Thur 10/8</b> Super Pro Tutorial Sat, 10/10
#8 10/12	WY Batch Processing & Scheduling (Ch 22)	AW Cost Accounting & Capital Estimation; Economics Excel (Chapter 16) <b>HW#7 Due 11:59pm Thur 10/15</b>
#9 10/19	AW Estimating Total Capital Investment; Economics Excel (Ch 16)	AW Cash Flow Analysis & Depreciation; Economics Excel (Ch 17) <b>HW#8 Due 11:59pm Thur 10/22</b>
#10 10/26	AW Profitability Analysis; Economics Excel (Ch 17)	AW WY Class Design Project Described <b>HW#9 Due 11:59pm Thur 10/29</b> Aspen PLUS Tutorial Sat/Sun, 10/30-11/1 Peer Review #2 Due Fri at midnight
#11 11/2	No Mon lecture, Meeting with Groups Tues	No Wed lecture, Meeting with Groups Thurs
#12 11/9	No Mon lecture, Meeting with Groups Tues	No Wed lecture, Meeting with Groups Thurs
#13 11/16	No Mon lecture, Meeting with Groups Tues	No Wed lecture, Meeting with Groups Thurs
#14 11/23	No Mon lecture, Meeting with Groups Tues	No Wed lecture, Thanksgiving Holiday Thurs/Fri
#15 11/30	No Mon lecture, Meeting with Groups Tues	No Wed lecture, Meeting with Groups Thurs
#16 12/7	No Class <b>Design Report Due Monday, Dec 7 by 11:59 pm</b>	<b>Peer Review #3 Due Thurs 12/10 at midnight</b>
<b>No Final</b>		