

CHEN 4460/5460: Polymer Engineering
Spring 2021

- Instructor:** Ryan Hayward (303-735-0189, ryan.hayward@colorado.edu, he/him)
- TA:** Kyle Schlafmann (kyle.schlafmann@colorado.edu, he/him)
- Lecture Schedule:** Monday, Wednesday, Friday 3:30 – 4:20 PM
See Canvas for Zoom link
- Dates to Note:** No class on Mon. Jan. 18 (Martin Luther King Jr. Day)
No class on Wed. Feb. 17
“Spring pause”: Mon. Mar. 22 – Fri. Mar. 26
- Office Hours:** TBD
- Evaluation:** Attendance/Class Participation: 10%
Homework Sets (6): 30%
Mid-term exams (2): 30%
Final exam: 30%
- Required Text:** *Polymer Chemistry*, 3rd ed., Lodge & Hiemenz
- Communication:** Course communication will be through Canvas at canvas.colorado.edu. Please feel free to contact Prof. Hayward and/or Kyle by e-mail as well, but be sure to include “CHEN 4460” or “CHEN 5460” at the beginning of your subject line so we can easily spot your e-mail in our inboxes.
- Attendance:** Attendance at nearly all lectures, which will be held synchronously by Zoom, is expected, and asking questions and participating in class discussion is strongly encouraged. Occasional absences are understandable, and recorded lectures will be available for viewing after the fact, but if you will have to miss more than a few throughout the semester for any reason, please contact Prof. Hayward to discuss as soon as you are aware of the absences.
- Course Description:** An introduction to basic principles of polymer science, in particular aspects related to physical chemistry, thermodynamics, mechanical properties, and engineering, for persons with a background in chemistry, physics, or engineering. Introduction and history of polymer science; classes of polymers; physical chemistry of polymer molecules in solution, liquid, and solid phases; thermodynamics and statistics of polymers; methods of characterization; mechanical properties of polymeric solids; polymer morphology; processing.
- Prerequisites:** Organic Chemistry I, Chemical Engineering Thermodynamics

Course schedule

Dates listed subject to change, with prior notice, to minimize conflicts

I. Introduction (Fri. 1/15 – Wed. 1/20)

Course overview
Brief history of polymer engineering
Current challenges and opportunities in polymers
Classes of polymers and characteristics

II. Single chain behavior (Fri 1/22 – Mon 2/1)

Conformation of a single chain, ideal chain models
Single chains as “entropic springs”
Excluded volume and solvent quality
Homework set 1 due Mon. 2/1

III. Characterization of molecular weight and chain dimensions (Wed. 2/3 – Mon. 2/15)

Molecular weight distribution, number/weight averages, dispersity
Viscometry, osmometry, chromatography, light scattering
Homework set 2 due Mon. 2/15

Midterm Exam 1: Fri. 2/19

IV. Polymer thermodynamics and phase behavior (Mon. 2/22 – Fri. 3/5)

Flory-Huggins (regular solution) theory
Polymer solutions and blends
Microphase separation of blocky copolymers
Homework set 3 due Mon. 3/8

V. Polymer Networks and Rubber Elasticity (Mon. 3/8 – Fri. 3/19)

Crosslinking of polymer networks
Entropic elasticity and classical models
Homework set 4 due Mon. 3/29

Spring pause (Mon. 3/22 – Fri. 3/26): meet at normal times, attendance expected as usual, no assignments due

VI. Polymer Melts and Glasses (Mon. 3/29 – Fri. 4/9)

Linear viscoelasticity, rheological characterization
Melt dynamics and entanglements
The glass transition
Homework set 5 due Mon. 4/12

Midterm Exam II: Fri. 4/16

VII. Semi-crystalline Polymers (Mon. 4/12 – Fri. 4/23)

Structural regularity in polymers
Chain folding and lamellar thickness
Dependence of structure on thermomechanical history
Yield and fracture
Homework set 6 due Mon. 4/26

VIII. Polymer Processing (Mon. 4/26 – Wed. 4/28)

Injection molding, blow molding, fiber spinning
Polymer reinforcement
Additive manufacturing

Cumulative Final Exam: Date TBD (during assigned Final Exam slot)

Readings

Reading assignments from the textbook will be posted on Canvas throughout the semester.

Assignments

Students are encouraged to work together on homework assignments, however, *each student must submit their own version of the assignment showing their own independent work and writing.* Students must work *independently on exams, without consulting each other or any other resources* that are not explicitly specified as being allowed.

Homework assignments will be distributed, collected, and returned via Canvas. Due dates are currently Monday evenings by midnight. Each homework problem will be graded using the following scale: check plus (3 points) = almost entirely correct; check (2 points) = mostly correct, check minus (1 point) = some correct elements, 0 points = did not complete or make a serious effort.

Especially in light of the current circumstances, we will make every effort to be accommodating to avoid conflicts. However, any requests for extensions or scheduling changes should be made *as soon as the conflict is apparent*, and certainly well before the scheduled date.

Zoom Etiquette

When possible, please have your camera turned on during synchronous lectures to facilitate interactions. Please keep your microphone muted by default to minimize background noise. At least to begin the semester (we may revisit this depending on how things go), please use the 'raise hand' feature in Zoom when you would like to ask a question or volunteer a response; however, if we miss your raised hand, do not hesitate to unmute and ask your question.

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.

All students who are new to campus must complete the [COVID-19 Student Health and Expectations Course](#). Before coming to campus each day, all students are required to complete the [Buff Pass](#).

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. In this class, if you are sick or quarantined, and therefore unable to participate in any class activities, please contact Professor Hayward to let him know.

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 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.

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; 303-492-5550). Students 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](#).

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. Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

Please know that faculty and graduate 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 Holidays

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. In this class, please contact Professor Hayward in advance, as soon as you are aware of such conflicts.

See the [campus policy regarding religious observances](#) for full details.