

## Syllabus for Polymer Science & Technology (CHE 543)

### Purpose

This course provides a broad overview of polymer science and engineering. The emphasis is on the synthesis and structure of polymeric materials, the crystalline and glassy states, solution and melt properties, phase behavior, mechanical and rheological properties.

### Objectives

By the end of the course, you should be able to do the following:

- Understand and describe the manufacture (using both traditional and non-traditional synthesis schemes) of commercially important polymers using concepts from chemical kinetics and equilibrium thermodynamics.
- Present a basic understanding of the structure of polymer chains in solution (including, molecular weight, molecular weight distribution, chain conformation) and methods to characterize polymers in solution.
- Describe polymer phase behavior using basic Flory-Huggins theory of polymer solutions/melts.
- Understand the structure of polymers in the solid state and describe the effects of structural organization (*i.e.*, crystallinity, liquid crystallinity, phase separation) on molecular and end use properties of polymers, and recognize the basic stress/strain and viscoelastic behavior of polymers based on a knowledge of structure and thermal properties (*e.g.*, melting and glass transition) and apply the Boltzmann superposition principle and Williams-Landel-Ferry equation to predict viscoelastic behavior of polymeric melts.

### Instructor

Dr. Jan Genzer

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### Teaching assistants

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### Time, location & format

The class uses pre-recorded lectures (from Fall 2025). The recordings are posted at:

<https://ncsu.hosted.panopto.com/Panopto/Pages/Sessions/List.aspx#folderID=da4de190-f213-4ec8-af7f-b32c015bb568>

The "class schedule" in this document lists a corresponding recording with a file name in the form "**CHE 543 mm/dd/2025**."

### Textbook

Main text (pick one, the latter – while more pricey – is beautifully done):

- P. C. Painter and M. M. Coleman, "Fundamentals of Polymer Science," 2<sup>nd</sup> edition, Technomic Publishing, Co.: Lancaster, PA, 1997
- P. C. Painter and M. M. Coleman, "Essentials of Polymer Science & Engineering," 1<sup>st</sup> edition, DEStech Publications: Lancaster, PA, 2009

Supplementary text (not required but recommended):

- R. J. Young and P. A. Lovell, "Introduction to Polymers," Chapman & Hall: London, 2011
- P. J. Flory, "Principles of Polymer Chemistry," Cornell University Press: Ithaca, 1967

### Prerequisites

CHE 316 (Thermodynamics of Chemical & Phase Equilibria) or equivalent. Please contact the instructor if you have not taken this course (or its equivalent).

### Course material dissemination

All documents made available in the course, including (but not limited to) copies of lecture notes, video lectures, homework, and exams, are intended only for the student's personal use. The students are not allowed to share any content from the CHE 543 website with a third party (i.e., any person not signed up for the course this semester, a personal website, a public website, or any other news or advertising media) without the course instructor's written permission. You must email **the signed document** to the instructor within the first two weeks of the session. Failure to submit will result in an incomplete (IN) grade in the course.

### Homework

*Purpose.* Work on your homework diligently; its primary goal is to practice and better understand the material covered in class, and to prepare you for the tests. The homework contributes a significant portion to the final grade. Unless the assignment specifies otherwise, you must work on each homework set individually.

*Format.* Either complete the homework entirely electronically or write it by hand, then scan/take a photo of each page and combine all pages into a single PDF document for submission. Begin each problem on a new page, and box the final answers. You will submit it electronically via Moodle (see schedule).

*Due dates.* All assignments are due on the date (see schedule) at midnight (EDT) via the course Moodle. After that time, homework submitted to the instructor counts as 50% of the actual grade. Homework submitted 24 hrs after the due time will be considered not submitted at all (meaning you would be assigned 0 points) - it will still be graded.

### Midterm tests & final exam

*General.* There will be two midterm tests during the semester. The midterm tests are open-book/open notes. See the schedule for times. There will also be a comprehensive final exam. See the schedule for times. The final exam is closed-book/closed-notes. It will be designed so that no information that the students did not previously learn in class is used. If equations (or other material) that are not easy to remember are needed, the instructor will provide them.

*Missed tests/final exams.* Zero units will be added to your grade if you miss submitting a midterm test or the final exam without a certified medical excuse or prior instructor approval. Missing the midterm and final exams will cost you 30% of the total grade.

*Proctoring.* The students need a proctor to conduct the midterm tests/final exam. She/he will then submit your work to the EOL office for grading. Please contact the EOL office ([ex-amsforeol@ncsu.edu](mailto:amsforeol@ncsu.edu)) as soon as possible regarding proctoring.

### Individual project

You are required to write a paper (following this [\*] format) describing the science underpinning a recent technological advance in polymer science & technology and clearly explaining the implications of this advance for the future of polymer science and Mankind. To identify potential ideas for this paper, you are free to ask anyone, read patent literature, peer-reviewed scientific literature, or use non-peer-reviewed trade journals. As a source, you may use any discovery described in a peer-reviewed journal article within the last 5-10 years. However, the final document should include references to the peer-reviewed literature (patents or journal articles) in which the discovery is first reported, subsequent reports of the idea, and the literature describing its technological implications. Topics related to your (or other) graduate research projects are acceptable. The objectives of this project are: (1) to help you become familiar with peer-reviewed polymer science literature and the non-peer-reviewed trade literature, (2) to develop your research and writing skills further, and (3) to provide you with the opportunity to explore in-depth a particular feature of polymer science and engineering. Note that the project's purpose is not to review a given topic. Instead, the instructor expects every student to contribute their thoughts on the subject. A partial review is acceptable if the student provides a personal critique.

We encourage you to discuss your ideas with the instructor and begin preliminary research to help you identify a topic. We encourage you to submit a one-paragraph description of your idea (including reference to the essential citations) to the instructor (via email). The instructor will provide feedback on the suitability of the topic and help refine your idea as needed.

\* Maximum 10 pages double spaced or 5 pages single spaced, 12 size font (Times, Times New Roman, Arial, or Calibri), 1 inch margins on each side. This page limit does not include the references.

Please submit the Individual project to the instructor via email by midnight on **July 24, 2026**. The project grade will be determined as follows: suitability and appropriateness of the topic (25%), depth of the literature search and review (25%), and clarity/coherence of the written document (50%).

### Use of Artificial Intelligence

Artificial Intelligence (AI) has become an increasingly influential and powerful tool in various fields, including education. In this course, you are welcome to explore and incorporate AI-related concepts and technologies, provided they align with this class's learning objectives and academic integrity standards. Below are the acceptable uses of AI in this course:

- **AI as a Learning Aid:** You are encouraged to leverage AI-based tools and platforms to enhance your learning experience. These tools can provide personalized study resources, interactive simulations, and adaptive learning experiences tailored to your progress and needs.
- **AI for Research and Data Analysis:** If your course involves research or data analysis, you can utilize AI tools to assist in data processing, pattern recognition, and insights generation. However, it is essential to understand the underlying algorithms and interpret the results critically.
- **AI for Creative Projects:** You may use AI in creative projects, such as generating art, music, or creative writing. However, it is important to maintain your creative input and to properly attribute any AI-generated content in your work.
- **AI Programming and Implementation:** If the course involves programming or implementing AI algorithms, you are encouraged to explore and experiment with various AI techniques to achieve the learning objectives of the assignments.
- **Ethical Considerations:** In any AI-related work, it is crucial to consider the ethical implications of AI technologies. Ensure that your use of AI aligns with ethical guidelines, respects privacy, avoids bias, and promotes fairness and transparency.
- **Collaboration with AI Systems:** You may collaborate with AI systems in projects or assignments but remember that the primary goal is to enhance your understanding of course materials and concepts. Avoid overreliance on AI to complete tasks without actively engaging with the subject matter.

While we encourage the integration of AI in your learning experience, certain uses of AI are not permitted in this course:

- **Cheating and Academic Dishonesty:** Using AI to plagiarize or produce work without proper attribution is prohibited. Per the [Code of Student Conduct](#), all work submitted must be your original creation, with appropriate citations when referring to external sources.
- **Unauthorized Assistance:** Do not use AI to access unauthorized materials or solutions during examinations, quizzes, or other assessments. Any form of unauthorized assistance is a violation of academic integrity.

- **Malicious Intent:** Do not use AI for any activities that may cause harm or compromise security.

## Grades

A weighted average grade will be calculated as follows:

Midterm exams: 30%

Homework: 20%

Final test: 30%

Individual project: 20%

|                         |                        |                         |
|-------------------------|------------------------|-------------------------|
| 95.50< <b>A+</b>        | 90.50< <b>A</b> <95.50 | 85.00< <b>A-</b> <90.50 |
| 80.50< <b>B+</b> <85.00 | 74.50< <b>B</b> <80.50 | 70.00< <b>B-</b> <74.50 |
| 67.00< <b>C+</b> <70.00 | 63.00< <b>C</b> <67.00 | 60.00< <b>C-</b> <63.00 |
|                         | 50.00< <b>D</b> <60.00 |                         |
|                         | <b>F</b> <50.00        |                         |

We do not curve grades in this course. Your performance depends only on how you do in the class.

## Consulting with faculty

We strongly encourage you to discuss academic or personal questions with the course instructor via email after setting up a Zoom or MS Teams appointment.

## Health and Well-Being Resources

Everyone is encouraged to take care of themselves and their peers. If you need additional support, there are many resources on campus to help you:

- Counseling Center (<https://counseling.dasa.ncsu.edu/>)
- Health Center (<https://healthypack.dasa.ncsu.edu/>)
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team: <https://advising.dasa.ncsu.edu/resources-for-advisors/advisors-toolkit/cares/>
- If you or someone you know are experiencing food, housing, or financial insecurity, please see the Pack Essentials Program (<https://dasa.ncsu.edu/pack-essentials/>).

### Community Standards related to COVID-19

We are all responsible for protecting ourselves and our community. Please see the community expectations and Rule 04.21.01 regarding Personal Safety Requirements Related to COVID-19 <https://policies.ncsu.edu/rule/rul-04-21-01/>

### Other Important Resources

- Keep Learning: <https://dasa.ncsu.edu/students/keep-learning/>
- Protect the Pack FAQs: <https://www.ncsu.edu/coronavirus/frequently-asked-questions/>
- NC State Protect the Pack Resources for Students: <https://www.ncsu.edu/coronavirus/reactivating-campus/resources-for-students/>
- NC State Keep Learning, tips for students opting to take courses remotely: <https://dasa.ncsu.edu/students/keep-learning/>
- Introduction to Zoom for students: <https://youtu.be/5LbPzzPbYEW>
- Learning with Moodle, a student's guide to using Moodle: <https://moodle-projects.wolfware.ncsu.edu/course/view.php?id=226>

### Topics covered

Module 1: Introduction to polymeric materials

Module 2: Polymer microstructure, isomerism, molecular weight, molecular weight distribution

Module 3: Polymerization mechanisms

Module 4: Polymerization kinetics

Module 5: Statistics of step-growth polymerization

Module 6: Copolymerization

Module 7: Polymer microstructure

Module 8: Crystallization, melting, and glass transitions

Module 9: Thermodynamics of polymer solutions and blends

Module 10: Polymer molecular weight and molecular weight distribution

Module 11: Mechanical and rheological properties of polymers

## Class schedule

| Time                             | Topic covered (date of recording)                                                                                        | What is due                              |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| <b>Week 1</b><br>5/20-5/24/2026  | Module 1 (8/23/2025)<br>Module 2 (8/25/2025)<br>Module 2 (8/30/2025)                                                     |                                          |
| <b>Week 2</b><br>5/25-5/31/2026  | Module 3 (9/1/2025)<br>Module 3 (9/6/2025)<br>Module 4 (9/8/2025)                                                        | <b>Homework 1</b><br>(5/27/2026)         |
| <b>Week 3</b><br>6/1-6/7/2026    | Module 4 (9/13/2025)<br>Module 5 (9/15/2025)<br>Module 6 (9/20/2025)                                                     | <b>Homework 2</b><br>(6/3/2026)          |
| <b>Week 4</b><br>6/8-6/14/2026   | Module 7 (9/22/2025)<br>Module 7 (9/27/2025)<br>Module 7 (9/29/2025)                                                     | <b>Homework 3</b><br>(6/10/2026)         |
| <b>Week 5</b><br>6/15-6/21/2026  | Module 8 (10/4/2025)<br>Module 8 (10/6/2025)<br>Review before Midterm Test 1 (10/13/2025)                                | <b>Homework 4</b><br>(6/17/2026)         |
| <b>Week 6</b><br>6/22-6/28/2026  | <b>Midterm test 1 (6/22/2026-6/26/2026)</b><br>Module 9 (10/13/2025)<br>Module 9 (10/20/2025)                            |                                          |
| <b>Week 7</b><br>6/29-7/5/2026   | Module 10 (10/25/2025)<br>Module 10 (10//27/2025)<br>Module 11 (11/1/2025)                                               | <b>Homework 5</b><br>(7/1/2026)          |
| <b>Week 8</b><br>7/6-7/12/2026   | Module 11 (11/8/2025)<br>Module 11 (11/10/2025)<br>Module 11 (11/15/2025)<br>Module 11 (11/17/2025)                      | <b>Homework 6</b><br>(7/8/2026)          |
| <b>Week 9</b><br>7/13-7/19/2026  | <b>Midterm test 2 (7/13/2026-7/17/2026)</b>                                                                              |                                          |
| <b>Week 10</b><br>7/20-7/26/2026 | Review before Final exam (11/22/2025)<br>Review before Final exam (12/1/2025)<br><b>Final exam (7/20/2026-7/24/2026)</b> | <b>Class Project</b><br>(7/20-7/24/2026) |