

Polymer Physics, MSE 458
Fall 2026, Instructor: Prof. Christopher Evans

Course Summary

An intermediate-level introduction to the fundamental physical chemistry and physics of polymeric systems. The focus is entirely on equilibrium phenomena: structure and properties of polymer solutions, dense liquids, gels and rubber networks, mixtures, surfaces and interfaces, confined polymers, and biopolymers. For a detailed list of topics see **Course Coverage**.

Prerequisites

MSE 401 – Thermodynamics of Materials or a 300-level course in thermo, statistical thermodynamics, or physical chemistry

Class

Location: 4039 CIF

Time: 2:00 – 3:20 pm on Tuesdays and Thursdays

Office Hours: Prof. Evans, MSEB 202A, Wednesdays: 3-4 PM

This class utilizes Canvas for communications and assignments. The course is divided by weeks and there are assignments and activities to be completed each week, including homework, quizzes, and discussions. The class is designed to be interactive and your active participation is required.

Important Dates: **September 24**-Midterm 1, **November 12**-Midterm 2

Required Textbook

Rubinstein and R.H. Colby, *Polymer Physics* (Oxford University Press, 2003, any edition)
Additional texts of interest are listed below.

Course Coverage

I. Polymer Structure & Ideal Chain Statistics (R&C §1, 2)

Macromolecular structure; fractal nature of polymer conformations; molar mass distributions; chain flexibility; ideal chain models; persistence length; radius of gyration; end-to-end vectors; conformational statistics; elementary statistical mechanics; ideal chain free energy; scaling arguments; coarse graining; pair correlation functions;

II. Dilute Solutions & Real Chain Statistics (R&C §3, 5.5-5.6)

Monomer-monomer interactions; excluded volume; solvent quality; Flory theory; polymer deformation; temperature effects; role of spatial dimension; polymer collapse; three-body effects; virial expansion; tethered polymer brushes; chain adsorption and confinement.

III. Liquid-Liquid Phase Separation (R&C §4)

Energy and entropy of mixing; mean field binary mixture theory – regular solution theory, polymer solutions, polymer blends; Flory interaction parameter; stability conditions; metastability, binodals, and spinodals; phase diagrams; lever rule; osmotic pressure; temperature-induced phase separation.

IV. Dense Solutions & Melts (R&C §5.1-5.4, 5.7)

Dilute, semi-dilute, and concentrated regimes; theta, poor and good solvents; scaling concepts; osmotic pressure; correlation length.

V. Rubber Networks & Chemical Gelation (R&C §6, 7.1-7.2)

Sol-gel model; random branching; percolation transition; crosslinking; hyperbranching and dendrimers; mean field gelation; scaling, hyperscaling, and universality; rubber thermodynamics; affine network model; phantom network model.

VI. Polymer Physics at U of I

Discussion of ongoing research topics in different groups on Campus and how their research relates to the course content.

Homework

Twelve (12) homework assignments for this class will be issued via Canvas for each week (see **Class Schedule**). Students will have one week to complete the assignment and they are to be submitted on Canvas/Gradescope.

Late work will not accepted. The **lowest two scores for homework and quizzes** will be dropped. *Students with valid reasons precluding on-time submission that should contact Prof. Evans well in advance of the deadline.* Students are strongly encouraged to complete all assignments to assess their own understanding of the course material. **It is acceptable/encouraged to work with fellow students on homework problems, and to ask and answer questions pertaining homework online on Canvas!** Provision will be made for office hours during which to discuss the problems and solutions. Exam questions will be based on assigned homework problems.

Quizzes

Twelve (12) *short* multiple-choice quizzes will be issued at the end of class on Thursdays to gauge elementary understanding and mastery of the course material. Each quiz has a time limit of 30 minutes and can only be taken once. The **lowest two scores for homework and quizzes** will be dropped.

Exams

There will be two (2) midterm exams, and one (1) final exam. Exams are in-person. Specific details will be made available a week before each exam. Both exams will be closed book, but students will be permitted to use a calculator. Resources outside of this are explicitly not permitted. The midterm will take place during scheduled class time, the final during the university final exam period.

Paper (4-credit option only)

Students in the 4-credit option will write a term paper on a student-selected topic in polymer physics. The term paper should be written in the style of a literature review or summary of a relevant research topic. The due dates are listed in Canvas.

Topic: Term paper topic selections are due via Canvas. Submissions should take the form of a one-sentence topic title and short (≤ 250 word) abstract summarizing the topic and projected thrusts of the paper. Prof. Evans will be available to discuss and advise topic choice and general direction of the paper, overlap with relevant research projects of the student in the area of polymers are encouraged. Early topic identification and submission is also encouraged.

Paper: Both first draft and final version of the term papers are due via Canvas. Papers should be 5-6 pages in length (excluding references and abstract); 12-pt font, 1-inch margins, single-spaced). Students will research and summarize the state of the field, reference classic texts and papers, and identify the principal challenges, important questions, and current research directions in the field. Papers will be graded on: (i) topic definition and motivation (10%), (ii) summary of status of field (20%), (iii) identification and motivation of open challenges (25%), (iv) analysis of current research into identified challenge (20%), (v) clarity of report (10%), (vi) appropriate citations and formatted references (5%).

Peer review: Reviews are due via Canvas. Each submitted paper will be assigned to two other randomly selected students in the class for peer review. Each student will write a *short* (≤ 1 page) *constructive* review on their assigned papers, summarizing the content of the paper very briefly, and giving feedback on (i) topic, (ii) summary of the field, (iii) open challenges, (iv) analysis, (v) clarity of the term paper, as well as formatting/style. The remaining 10% of the grade will be the quality of the given peer review. Each student will receive the peer reviews on their paper, will incorporate the feedback and submit a final version via Canvas.

Plagiarism

Each student is responsible for submitting their own original quiz responses, homework assignments, and (if applicable) term paper. Collaborative interaction online and in-person is permissible and encouraged via Canvas, but each student must perform all calculations themselves, and submit their own work. Plagiarism will not be tolerated, and verified incidents will result in all parties receiving a zero on their project and formal academic sanctions. Students are responsible for familiarizing themselves with the definition and penalties for plagiarism detailed in [Section I-401 of the UIUC Student Code](#). Ignorance of these policies is not an excuse for any academic dishonesty. As a student it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found [here](#). Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity. Note that the code's definition of plagiarism includes "copying another student's paper or working with another person when both submit similar papers without authorization to satisfy an individual assignment".

Please note that all course materials are protected by copyright and are considered intellectual property. Course materials should only be used for this course and should not be shared with anyone not in the course, including uploading to a study site, social media, or other online sharing mechanism.

Grading

3-credits:

Quizzes:	15%
Participation:	10%
Homework:	10%
Midterms:	40%
Final:	25%

4-credits:

Quizzes:	15%
Participation:	10%
Homework:	10%
Midterms:	30%
Final:	20%
Term paper:	15%

Participation includes discussions & questions during class, as well as posting content questions on Canvas, and answering content questions on Canvas. If a student participated actively in 50% of all weeks, the student will receive the full 5% credit.

Letter grades will be based on final aggregate student scores, with numerical cutoffs specified by the instructor. However, students with aggregate scores >95% are guaranteed *at least* an A, >85% *at least* a B, and >75% *at least* a C (i.e. cutoffs will not be higher than these values).

Secondary Texts

P.C. Hiemenz, *Polymer Chemistry* (CRC Press, 1984)

P.-G. de Gennes, *Scaling Concepts in Polymer Physics* (Cornell University Press, 1979)

A.Y. Grosberg & A.R. Khoklov, *Statistical Physics of Macromolecules* (AIP, 2002)

Strobl, *The Physics of Polymers* (Springer, 2010)

A.Y. Grosberg & A.R. Khoklov, *Giant Molecules* (World Scientific Publishing, 2010)

U.W. Gedde, *Polymer Physics* (Springer, 1995)

Doi & S.F. Edwards, *The Theory of Polymer Dynamics* (Oxford University Press, 1988)

P.J. Flory, *Statistical Mechanics of Chain Molecules* (Oxford University Press, 1989)

P.J. Flory, *Principles of Polymer Chemistry* (Cornell University Press, 1953)

Branden & J. Tooze, *Introduction to Protein Structure* (Garland, 1999)

Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the

Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Mental Health

Diminished mental health, including significant stress, isolation, mood changes, excessive worry, substance/alcohol abuse, or problems with eating and/or sleeping can interfere with optimal academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings at no additional cost. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do — for yourself and for those who care about you.

Counseling Center: 217-333-3704, 610 East John Street Champaign, IL 61820

McKinley Health Center: 217-333-2700, 1109 South Lincoln Avenue, Urbana, Illinois 61801

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to <https://www.disability.illinois.edu>. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/community-of-care/resources/students/religious-observances/> to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.