Macromolecular Engineering: Networks and Gels

Frühjahrssemester 2022

Instructor:	Prof. Dr. Mark W. Tibbitt	**Time:**	Di 8:15–10:00; Do 14:15–16:00
Email:	mtibbitt@ethz.ch	**Place:**	HG D 1.1

Overall learning goal: By the end of the course, students should be able to evaluate and design polymer networks and gels for industrial and biomedical applications based on macromolecular chemistry and structure. A core aim is to relate macroscale behavior and properties to molecular features in polymer materials.

Course details:

Exercises: 4 written problem sets will be handed out during the course. The due date will be specified on each problem set. In all cases, you will have a minimum of 2 weeks to complete them. We will work through some of these directly during the 'exercise hours' component of the lectures. I encourage you to work together on these problem sets as they are designed to help retain key aspects from the course and to prepare you for the examination. Please hand in the exercises in person on or before the due date. If you cannot hand them in during lecture, you may also upload them to the course Moodle site. You will receive an invitation to join the Moodle site once this is activated. If you upload the documents, **please upload the whole Exercise set as a single PDF** so that it is easier for me to provide helpful feedback.

Presentation: In groups of 4–6, you will give a presentation (∼15 minutes in duration) on a recent paper from the literature on an application of polymer networks or gels. The purpose is to familiarize yourself with reading a scientific paper, to effectively communicate the research concepts to the class, and to broaden your exposure to modern applications of networks and gels. I will work with the class and groups to select the papers.

Examination: The examination will consist of a written examination of 120 minutes. The date of the examination is scheduled for **02.6.2022** from 14:00–16:00.

Grading Policy: Exercises (20%), Presentation (20%), Examination (60%).

The exercises are elective. If you choose not to have them evaluated for grading, the examination will be worth 80% of your final grade. If you choose to have them evaluated, they will only serve as a bonus above the grade of your examination. In select cases, where the examination grade is higher than the exercise grades, the examination will be worth 80% of the final grade and the exercises will not count. Only exercises delivered on or before the due date will count for grading. My advice is to do the exercises, they will help you prepare for the exam and aid your overall course mark. The presentation is compulsory and will be scheduled during the semester. If you need to retake the course, you will also need to redo the presentation. In simple terms, you can help yourself significantly in the final grade *and* in retention of the course material if you take the exercises and the presentation seriously.

Course Information:

- The course structure is not divided into strict 'lecture hours' and strict 'exercise hours'. In general, each course session will contain elements of both and the organization between 'lecture hours' and 'exercise hours' will vary on a weekly basis. The structure of each course session will be varied and may include traditional frontal lectures, demonstrations, and 'flipped' classroom activities. In the 'exercise hours', we will work through sample problems in groups, go over problems from the exercises, and allow time for questions on the subject matter covered.

- A script for this course will be posted as the semester progresses at this site. You can access it at macro.ethz.ch ▷ Education ▷ Macromolecular Engineering: Networks and Gels. All lecture notes will be made available and will compose the final script for the course. All lecture slides will also be made available. While not meant to be comprehensive, these notes and slides will cover all essential subject matter. In the lectures and exercises, we will work through problems of particular importance and if you need to miss a lecture, I recommend that you gather notes from someone who did attend the lecture or contact me directly or visit me during my office hours. Finally, recordings of the lectures (from FS21) will be made available so that you can follow the course even if you cannot attend the lectures or if you want to review the subject matter. If you find any mistakes, errors, or oversights in these materials, please inform me and I will do my best to correct them as soon as possible.
- In this course and in the classroom, we strictly adhere to the D-MAVT Code of Conduct in personal behavior and study and research. If you have not already, please familiarize yourself with these documents. While I believe that a relaxed classroom atmosphere is most conducive to learning, respect is absolutely essential and violations of these codes will not be tolerated.

Office hours:

Prof. Dr. Mark W. Tibbitt
Location: ML H 21
Scheduled office hours: Do 16:00 to 17:00
Additional office hours upon request by email: mtibbitt@ethz.ch

Prerequisites: While there are no strict prerequisites for this course, a Bachelors-level understanding of physics, chemistry, thermodynamics, probability & statistics, mathematics, mechanics, and materials science is assumed. If there is something that is not clear in any of the course material, please ask and we can discuss it in more depth in the lectures or during office hours.

Recommended Texts: There is no required textbook for this course. The following is a non-comprehensive list of various interesting and useful books that will be touched on during the course. You may want to consult them occasionally for additional information.

- *Polymer Physics* by M. Rubinstein and R.H. Colby, Oxford University Press, 2003.
- *Molecular Driving Forces* by Ken A. Dill and Sarina Bromberg, Garland Science, 2003.
- *Introduction to Polymers* by R.J. Young and P.A. Lovell, CRC Press, 2011.
- *Soft Condensed Matter* by R.A.L. Jones, Oxford University Press, 2002.
- *Introduction to Polymer Physics* by M. Doi, Oxford University Press, 1996.
- *Hydrogels in Medicine and Pharmacy* edited by N.A. Peppas, CRC Press, 1986.
- *Soft Matter* by Roberto Piazza, Copernicus Books, 2010.
- *Soft Matter: A Very Short Introduction* by Tom McLeish, Oxford University Press, 2020.

Tentative Course Schedule: subject to change		
Lecture #	**Date**	**Lecture topic**
1	22.2.2022	Introduction: Polymers, networks, & gels
2	24.2.2022	Definitions: polymers & probability; Review of statistical mechanics
3	01.3.2022	Review of statistical mechanics; Ideal polymer chains
4	03.3.2022	Properties of ideal polymer chains – Exercise 1
5	08.3.2022	Entropic elasticity
6	10.3.2022	Properties of real polymer chains – Flory Theory
7	15.3.2022	Boltzmann distribution & Regular solution theory
8	17.3.2022	Flory-Huggins Theory – Exercise 2
9	22.3.2022	Phase behavior of polymer solutions
10	24.3.2022	Percolation & gelation
11	29.3.2022	Thermodynamics of rubber & rubber elasticity
12	31.3.2022	Entangled rubber elasticity & RENT
13	05.4.2022	Swelling of polymer gels – Exercise 3
14	07.4.2022	Viscoelasticity
15	12.4.2022	Methods of gel formation
16	15.4.2021	Physical gels
	19.4.2022	**NO CLASS** – Woche nach Ostern
	20.4.2022	**NO CLASS** – Woche nach Ostern
17	26.4.2022	Dynamic covalent and supramolecular gels
18	28.4.2022	Double network gels – Exercise 4
19	03.5.2022	Diffusion in polymer gels
20	05.5.2022	Tissue engineering & drug delivery
21	10.5.2022	Applications of networks & gels – Presentations
22	12.5.2022	Applications of networks & gels – Presentations
23	17.5.2022	Applications of networks & gels – Presentations
24	19.5.2022	Applications of networks & gels – Presentations
25	24.5.2022	**REVIEW SESSION**
	26.5.2022	**NO CLASS** – Ascension
	02.6.2022	**FINAL EXAMINATION**