FCK3107 (and FCK3108) Polymer physics including polyelectrolytes – 2026

Polymer physics covers a broad range of fundamental topics in polymer science and engineering. It starts at the atomic level with chain conformations, which have implications on the macroscopic properties, e.g. the stress-strain behaviour of rubbers. The thermodynamics of solutions is a particularly important field. It is also one of the areas that are visited by both theoreticians and engineers. Polyelectrolytes and polyelectrolyte gels are fascinating materials because their solution properties/conformations are highly dependent on the charge of the polyelectrolyte and by changes in the ion concentration. The fundamental physics and chemistry of polyelectrolytes are applicable in different fields such as DNA-related research and surface engineering. The glassy state has interested physicists for more than five decades. Polymers follow largely the general scheme for glasses but there are features unique to polymeric glasses. The physics of crystalline polymers starts from the unit cell, travels through the crystal lamellae and stops with the superstructures. A brief account of polymer crystallisation and oriented polymers follows and ends the course. Many of you have an interest in cellulose and will find the descriptions of the oriented states useful.

The course literature *Fundamental Polymer Science* (3rd edition, 2025) in paper form is preferred. It actually contains more material than required for this course. A reference book for your Ph. D. study! The electronic version can be obtained from KTH Library. For polyelectrolytes the course literature is stated below.

Course credits: 6 credits (FCK3107); additional 3 credits are obtained by submission of solutions of the 3 home-work assignments (course code FCK 3108) → total of 9 credits.

Language: English

Literature: **A)** *Fundamental Polymer Science*, 3rd edition (2025), U.W. Gedde, M.S. Hedenqvist, M. Johansson, L. Berglund, J. Wohlert, Springer Nature.

B) *Physics of Charged Macromolecules – Synthetic and Biological Systems*, Murugappan Muthukumar, Cambridge university press, 2023. Reach out to Tobias or Lars for access.

C) *Theory of Charged Gels: Swelling, Elasticity, and Dynamics*, Murugappan Muthukumar, Gels 2021, 7(2), 49; https://doi.org/10.3390/gels7020049

D) Chapter 7. *Electrostatic effects: Charged surfaces and polyelectrolyte adsorption* in Polymers at Interfaces (1998). Fleer, Cohen Stuart, Scheutjens, Cosgrove, Vincent. Springer Science & Business Media. https://link.springer.com/chapter/10.1007/978-94-011-2130-9_7

E) Schlenoff, J. B., & Dubas, S. T. (2001). *Mechanism of polyelectrolyte multilayer growth: charge overcompensation and distribution.* Macromolecules, 34(3), 592-598. https://doi.org/10.1021/ma0003093

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Prerequisites for participation: knowledge in basic macromolecular science

Application is required through the registration form (or mail to Tobias Benselfelt; bense@kth.se). Fee for participants from industry, other universities and or schools at KTH: 4500 SEK excluding moms.

Important about the course: Before each lecture, you should read the recommended text. The advised texts are displayed in the Schedule section. It is preferably a careful reading or, in the case of an emergency situation, a more brief reading. The lecture will be much more rewarding for you with this preparation. We can have a dialogue lecture directing the focus on essentials and more complex parts of the topics. This means that you should buy or download the texts well before the start of the course.

Schedule: (G: Gedde, W: Wågberg, B: Benselfelt and all = G, W, B). Let us start at the usual 15 min past time: 13 – 16 is 13.15 – 14.00; 14.15 – 15.00; 15.15 – 16.00.
The Rånby lecture room (Teknikringen 56, enter at K1 and go one floor down) will be used for most of the lectures. Two of the lectures will be held in WWSC (entrance opposite the one leading to the Rånby room).

1. Course introduction, overview; text: **A**(1–58)	6/5, 9–12 (all)
2. Chain conformation; text: **A**(59–114)	6/5, 13–15 (G)
	7/5, 13–16 (G)
3. Rubber elasticity; text: **A**(115–168)	13/5, 13–16 (G)
4. Polymer solutions; text: **A**(169–238) WWSC	18/5, 9–12 (G)
5. Glassy polymers; text: **A**(239–302)	18/5, 15–17 **WWSC** (G)
6. Crystalline polymers, orientation; text: **A**(365–618)	19/5, 9–12 **WWSC** (G)
	19/5, 13–15 (G)
7. Polyelectrolytes:	
i. Introduction; text: **B**(Chapter 1 and 3)	20/5, 9–11 (B)
ii. Solutions and gels; text: **B**(Chapter 5-6) and **C**	26/5, 10–12 (B)
iii. Polyelectrolytes at interfaces; text: **D**	26/5, 13–15 (W)
iv. Polyelectrolyte multilayers; text: **E**	27/5, 10–12 (W)
8. Seminar with solved homework problems	June 11 or 12 (all)
9. Examination	June 18 or 23 (all)