BE/ME/MS 504 – Polymers and Soft Materials

Spring 2022
Tuesday/Thursday 3:30 pm – 5:15 pm, PHO 210

Instructor	Email	Office Location & Hours
Dr. Joshua Kays	jkays@bu.edu	64 cummington, Rm207: Tues 9am-11am, Thursday after class, or by appointment (if scheduled in advance)

Course description and goal

This class is an introduction to polymer and soft matter science at the graduate level. Soft matter (or soft condensed matter) is a multidisciplinary field: as such, this class includes chemistry, physics, thermodynamics, and materials science content. Topics include:

1) understanding the underlying forces that govern soft materials, and their common properties (e.g. viscoelasticity)
2) polymer chemistry and behavior (crystallinity and phase transitions, random walks, Flory radius, polymer conforgmation)
3) colloids and self-assembly in solutions,
4) Applications of the above in life and in research.

The **goal** is for you to enjoy the science behind these "everyday" phenomena (think: Jello! Beer foam! TV screens! Kevlar!)

Prerequisites (read carefully!)

Graduate or advanced undergraduate standing in a physical science or engineering, with knowledge of basic chemical bonds and structure, basic kinetics and **thermodynamics** (read, lots of thermo), some basic MATLAB skill (or other software), and calculus/differential equations.

Grading

Course grading will be based on the following:

- Homework (4 assignments) 30%
- Participation 20%
- Midterm 25%
- Final 25%

Students must submit their own work for homework assignments. You may work with others, but you list anyone you worked with on the top of the HW, *and must demonstrate your own work*.
Tests will be closed book, but with an index card of notes.
Any suspected violation of the Academic Conduct Code will be immediately referred to the College of Engineering Academic Conduct Committee.
Don't hurt yourself by cheating.

Expectations

This is meant to be an interactive class – there will be in-person demonstrations, questions asked throughout the lecture, and so forth. Attendance is part of your participation grade, as is your involvement in class. You will do best if you **attend and be an active learner** during the class.

Recommended Materials

There are no required materials for this class, save access to the internet (for HW assignments). "Soft Condensed Matter" by Richard Jones will be the go-to textbook for much (but not all) of the material. Any mandatory readings I will post on blackboard and email out.

Topics

Exact list to be determined by you all, during the first class! But in general, here's where we're most likely headed:

Introduction

- Intermolecular forces
  - Understanding LJ potential
- Viscous, elastic, and viscoelastic responses
  - Response of matter to shear stress; G' and G''
  - Molecular level understanding

Colloids

- Brownian motion
- Stability and DLVO theory
  - How zeta potential measurements work
- Crystallization of hard sphere colloids
- Sedimentation and diffusion
- Application of colloids
  - *Deep dive:* specific topical lecture
- Surfactants and detergency
- Micelles, CMC

Midterm + first two HWs

Polymers

- Intro on structure/chemistry (brief)
- Molecular weight and Zimm plots
- Polymer size and conformation
  - Average end-to-end distance for model chains (freely-jointed, freely-rotating, and hindered rotation chains)
  - Characteristic ratio, statistical segment length, persistence length
  - Radius of gyration
- Thermodynamics of polymer solutions
  - Flory-Huggins theory
  - Phase behavior; UCST and LCST
  - Flory-Huggins parameter chi
  - Excluded volume
- *Deep dive:* Kevlar

3rd and 4th HWs + Final