

MATSE 443: INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS

Textbook: *Fundamentals of Polymer Science*, Painter and Coleman (2nd ed, CRC press)

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Description: This course is an introduction to the field of polymer science and engineering, providing an overview of the synthesis and structure of these materials; the crystalline and glassy states; solution properties and phase behaviour; mechanical and rheological properties.

Course Topics:

- 1 The nature of polymer materials and polymer microstructure: including branching, networks, tacticity and copolymers.
- 2 Polymer synthesis: step-growth and chain polymerizations.
- 3 Kinetics of polymerization: the kinetics of step growth and free radical chain polymerizations; relationship to molecular weight.
- 4 Statistics of step-growth polymerization: the use of statistics in describing molecular weight distributions in step-growth polymerization.
- 5 Copolymerization: the kinetics of free radical copolymerization.
- 6 Structure: chain conformations, amorphous polymers, and the morphology of semicrystalline polymers.
- 7 Crystallization, melting and the glass transition: an introduction to crystallization kinetics, melting and glass formation.
- 8 Polymer solutions: the Flory-Huggins theory and phase behaviour.
- 9 The measurement of molecular weight: osmometry, light scattering, viscosity and size exclusion chromatography.
- 10 Mechanical and rheological properties: stress/strain behaviour, viscoelasticity, nonlinear mechanical and rheological behaviour, ultimate properties.

Course Objectives

1. To provide students with an elementary understanding of the reaction mechanisms involved in polymer synthesis and the kinetics of these reactions.
2. To teach students basic concepts of polymer chain architecture, structure and morphology, with particular emphasis on the relationship between chemical structure (chain architecture) and the morphology of the solid state (semi-crystalline vs. amorphous polymers)
3. To provide students with a basic knowledge of the thermal properties of polymers, particularly the crystallization temperature and elementary aspects of crystallization kinetics, the melting temperature and the glass transition; to teach how these properties depend on structure.
4. To teach students basic aspects of the solution properties of polymers, interactions and the relationship to chemical structure, including phase behaviour and the measurement of molecular weight.
5. To teach students how the above material is related, the fundamentals of polymer structure/property relationships, so that they can make simple predictions for design.

Course Outcomes

1. Given a polymer structure the student should be able to specify a general synthesis scheme and predict molecular weight averages as a function of reactant concentration and monomer conversion.
2. A student should be able to calculate number and weight average molecular weight from a given distribution.
3. Given a polymer, a students should be able to specify methods for the measurement of number and weight average molecular weight and also the entire molecular weight distribution.
4. A student should be able to describe basic chain conformations and calculate the average chain end-to-end distance.
5. Given micrographs of polymer materials the student should be able to identify the morphology and how it depends upon crystallization conditions.
6. A student should be able to describe basic aspects of the phase behaviour of polymer solutions and blends and how this behaviour depends on the Flory-Huggins χ parameter.
7. The student should be able to predict the basic stress/strain and viscoelastic behaviour of polymer materials based on a knowledge of structure and thermal properties (T_m and T_g).
8. The student should be able to apply the Boltzmann Superposition Principle and WLF equation to the prediction of viscoelastic behaviour.
9. Given simple material requirements (optical transparency for bottles, flexibility and toughness for buckets, etc), a student should be able to select the most suitable polymer material for a given application.

EXAMINATION & GRADING POLICY

Assessment Tools, WEB-course (SPRING, E Manias)	wt. in grade
1. SEVEN on-line homeworks (after each chapter, multiple choice)	25%
2. THREE on-line quizzes (after chapters 5, 10, and 11)	<i>each</i> 15%
3. FINAL EXAM on-line (cumulative for all chapters)	30%
4. One extra credit on-line quiz	<u>5%</u>
	105%

The **Final Grade** is calculated as follows: (1) the lowest homework grade is given as "extra credit" and is not included in the 25%. The cumulative score is (see above):

25% homeworks + 15% *each* quiz +30% final + 5% for the extra credit(s)

Based on this score, a letter grade is assigned as follows: A =90% or more; A- = 85-90%; B+ = 80-84%; B =75-80%; B- =70-74%; C+ =65-70%; ... *etc*

ACADEMIC INTEGRITY POLICY

All University policies regarding academic integrity/academic dishonesty apply to this course and the students enrolled in this course. Team-work is encouraged for the on-line homeworks and exams provided that each team is comprised by 2 to 3 (max) people and that the instructor is notified by email *before* each quiz or homework is started; otherwise, each student in this course is expected to work entirely on her/his own while

taking any exam, to complete assignments on her/his own effort without the assistance of others, and to abide by University policies about academic integrity and academic dishonesty. Academic dishonesty can result in assignment of "F" by the course instructors or "XF" by Judicial Affairs as the final grade for the student.

Academic dishonesty is not limited to simply cheating on an exam or assignment. The following is quoted directly from the "PSU Faculty Senate Policies for Students" regarding academic integrity and academic dishonesty: "Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students." Refer to the following URL for further details on the academic integrity policies: <http://www.psu.edu/ufs/policies/>.

In addition, for the WEB-course any attempt to hack the quiz server, any incidents of copying, saving, and/or transmitting materials from the on-line quizzes and homeworks, and any attempts to tamper with the grades on ANGEL or the quiz-server will be prosecuted through the academic integrity channels.