***web*-MatSE443 (E. Manias)**

Introduction in Polymer Science & Engineering

Textbook: **"Fundamentals of Polymer Science" (2nd ed.) by PC Painter & MM Coleman (CRC Press)**

Alternate: "Essentials of Polymer Science and Engineering" by PC Painter & MM Coleman (DEStech Publications)

You only need ONE of the two textbooks (not both!)

Instructor: **Evangelos Manias**

313 Forest Resources LAB Tue 11^{00} am-$2^{:00}$pm

manias@psu.edu

(other times by appointments through email are also OK)

Grading:		
	All (7) Homeworks	25%
	Quiz 1	15%
	Quiz 2	15%
	Quiz 3	15%
	Final Exam	**30%**

MATSE 443: INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS

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

Faculty: E. Manias (manias@psu.edu , office: 313 Forest Resources Lab)

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, visoelasticity, 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 (Tm and Tg).
8. The student should be able to apply the Bottzmann 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)	*each* 15%
3. FINAL EXAM on-line (cumulative for all chapters)	30%
4. One extra credit on-line quiz	5%
	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 coping, saving, and/or transmiting 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 though the academic integrity channels.

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Material Covered in Assignments from Painter & Coleman's Textbooks:

Required: "Fundamentals of Polymer Science" (older, CRC)
vs.
Alternate: "Essentials of Polymer Science" (newer, DesTECH)

Assignment	**"Fundamentals …"**	**"Essentials …"** [1]
Homework 1	Chapters 1 and 2 (pgs 1-6	Chapter 1 (pgs 1-4 onl Chapters 2 and 3 (pgs 23-8
Homework 2	Chapter 3 (pgs 63-8	Chapter 4 (pgs 87-11
Homework 3	Chapter 4 A-C (pgs 83-93 onl Chapter 5 A-C (pgs 107-119 onl example of copolymer (pgs 130-13	Chapter 5 (pgs 113-120 onl Chapter 6 (pgs 135-148 onl example of copolymer (pgs 159-16
Quiz 1	All the above (Homeworks 1-	All the above (Homeworks 1-
Homework 4	Chapter 7 (pgs 207-25	Chapter 8 (pgs 205-24
Homework 5	Chapter 8 (pgs 259-30	Chapter 10 (pgs 281-33
Homework 6	Chapter 9 (pgs 307-33 Lecture Notes (web), **or** Chapter 10 (pgs "339-381"	Chapter 11 (pgs 331-35 Lecture Notes (web), **or** Chapter 12 (pgs "357-389"
Quiz 2	All the above (Homeworks 4-	All the above (Homeworks 4-
Homework 7	Chapter 11 (pgs 395-46	Chapter 13 (pgs 399-47
Quiz 3	All the above (Homework	All the above (Homework
FINAL EXAM	All the above (Homeworks 1-	All the above (Homeworks 1-

[1] Items in boxes, i.e. "Polymer Milestones" and "Fascinating Polymers", are not examined in any assignment.
[2] Focus on Concepts and Methods; No mathematical derivations.