ChBE490/ENCH781
Introduction to Polymer Science and Engineering
Department of Chemical and Biomolecular Engineering
University of Maryland at College Park

Spring 2019

Credit: 3
Prerequisites: ChBE 424 (Transport Processes II), CHBE 440 (Chemical Engineering Kinetics)
Instructor: Kyu Yong Choi, Professor (1208B, choi@umd.edu)
Grader: Dennis Tran (dennistran91@gmail.com)

Class Hour: Tu/Th 9:30-10:45 pm
Office Hour: Wednesday 2-4 pm

Classroom: CHE2145

Spring Break: 3/17-3/24
Last Day of Class: May 14 (Tu)
ENCH781: Term project proposal due: Feb 28 (Th), Term project due: Apr 30 (Tu)
Exam 1: March 7 (Thu), Exam 2: April 18 (Thu) [All exams are closed book]
Final Exam: May 16-22 (Exact date TBA)

Relevant ENCH Program Learning Outcomes: 1,2,3,4,5,7,11,12,13,14
Relevant ABET Learning Outcomes: a, b, e, h, i, k

Course Description: Introduction to fundamental polymer science and engineering. Structure and properties of polymers. Synthesis of polymers. Industrial polymerization processes. Characterization of polymers. Basic rheological properties of polymers; Development of student's ability to understand technical literature on polymers. Problem solving based on conceptual understanding of basic principles. Broad knowledge on polymers.

Testudo Description (ChBE 490): The elements of the polymer chemistry and industrial polymerization, polymer structures and physics, thermodynamics of polymer solutions, polymer processing methods, and engineering applications of polymers.

Testudo Description (ENCH781): Advanced topics in polymerization kinetics, reactor design and analysis; addition and step-growth polymerization; homogeneous and heterogeneous polymerization; photopolymerization; reactor dynamics; optimal operation and control of industrial polymerization reactors.

Objectives:

Objective 1: To develop a student's understanding of basic polymer science and engineering principles
Objective 2: To develop a student's ability to understand polymer literature.
Objective 3: To develop a student's ability to quantify polymerization kinetics and related process design and analysis problems

Requirements: Calculus (differential equations), thermodynamics (ChBE302), reaction kinetics (ChBE 440); Students are expected to know how to solve ordinary differential equations analytically (linear o.d.e's) and numerically (nonlinear equations), and how to use Excel and MATLAB.

Textbook: Painter and Coleman, "**Fundamentals of Polymer Science**", 1997, Technomic Publishing Co. Other materials will be furnished when necessary.

References: (Most of these books are available at Engineering and/or Chemistry Libraries)

"Principles of Polymer Systems", Rodriguez et al., Taylor and Francis (This book was last year's required textbook).

"**Fundamental Principles of Polymeric Materials"**, S. Rosen, 2nd edition, Wiley Interscience, New York, 1993.

"Principles of Polymer Engineering," N. G. McCrum, C.P. Buckley and C.B. Bucknall**,** Oxford Univ. Press, Oxford, 1988.

"Principles of Polymer Chemistry," P.J. Flory**,** Cornell Univ. Press, Ithaca, 1953.

"Principles of Polymerization," G. Odian**,** 3rd ed., Wiley, New York, 1991

Grading Policy:

ChBE490 80-100 (A), 65-79 (B), 45-64 (C), 35-44 (D), 0- 34 (F)

1. 2 Hour exams (100 pts. each): Closed book
2. Final exam (150 pts.): Closed book
3. Homework (50 pts.)

ENCH 781 80-100 (A), 65-79 (B), 45-64 (C), 35-44 (D), 0- 34 (F)

1. 2 Hour exams (100 pts. each): Closed book
2. Final exam (100 pts.): Closed book
3. Homework (50 pts.)
4. Term Project (100 pts.)

Policies:

(i) Homework must be turned in at the beginning of class on the date due. No late submissions will be accepted.

(ii) HW must be turned in on paper **with the sheets stapled together (No loose papers please)**. The Honor Pledge must be written on the cover of every HW. HW that is not submitted this way will NOT be graded.

(iii) Exams: No make-up exams will be given. Exception: Hospitalization due **to life-threatening medical conditions**. Request to re-grade an exam or part of an exam must be submitted within 24 hours after you receive the graded exam. The submitted exam paper for re-consideration must be in its original form. Any exam papers with additional post-exam additional /changes/modifications will be denied of review.

(iv) E-mail: Please refrain from sending emails concerning hw or exam on weekend (Sat-Sunday). These emails sent on weekend will be responded during the regular weekdays (M-F). A reply to email during the weekdays can usually be expected within two business days (not counting weekends and holidays). E-mails not originating

from umd.edu address will not be replied. When emailing, **begin the subject line with ChBE490 with your name (ex. ChBE490 John Doe)**.

(v) Class lectures and other materials (eg., materials posted on the class website, handouts, etc.) are the intellectual properties of the instructor. Selling class notes, hw solutions, exam problems, class presentation materials to anyone is legally prohibited.

(vi) In case the instructor cancels the class(es) due to conferences or personal illness, efforts will be made to either substitute instructor or to reschedule the missing class.

Academic integrity

The University has a student-administered Honor Code and an Honor Pledge, available at https://president.umd.edu/administration/policies/section-iii-academic-affairs/iii-100a.

New Policy (Approved by the UMD in 2018):

ACADEMIC DISHONESTY: any of the following acts, when committed by a student, constitute academic dishonesty:

(a) CHEATING: fraud, deceit, or dishonesty in any academic course or exercise in an attempt to gain an unfair advantage, and/or using or attempting to use unauthorized materials, information, or study aids in any academic course or exercise.

(b) FABRICATION: unauthorized falsification or invention of any information or citation in any academic course or exercise.

(c) FACILITATING ACADEMIC DISHONESTY: knowingly helping or attempting to help another to violate any provision of this Code.

(d) PLAGIARISM: representing the words or ideas of another as one's own in any academic course or exercise.

(e) SELF-PLAGIARISM: the reuse of substantial identical or nearly identical portions of one's own work in multiple courses without prior permission from the current instructor or from each of the instructors if the work is being submitted for multiple courses in the same semester.

Thereby, you are prohibited from cheating or consulting your colleagues during exams, plagiarizing papers and **homework**, buying papers, submitting fraudulent documents, and forging signatures. Although you may discuss homework with your colleagues, you may not copy solutions to problems verbatim. The Honor Pledge (**I pledge on my honor that I have not given or received any unauthorized assistance on this assessment**.) must be written on every exam and homework in the course. Graded exams will be routinely photocopied and filed. Altering a graded exam and then requesting re-grading is an extremely serious violation of aca-

demic integrity. Violations of academic integrity or the Honor Code may have negative consequences on the course outcome (e.g., immediate failure) and/or result in disciplinary action. No warnings will be given.

Attendance

Regular attendance and participation in this class is the best way to grasp the concepts and principles being discussed. However, in the event that a class must be missed due to an illness, the policy in this class is as follows:

1. For every medically necessary absence from class (lecture, recitation, or lab), a reasonable effort should be made to notify the instructor in advance of the class. **When returning to class, students must bring a note identifying the date of and reason for the absence, and acknowledging that the information in the note is accurate.**
2. If a student is absent more than 2 time(s), the instructor may require documentation signed by a health care professional.
3. If a student is absent on days when tests are scheduled or papers are due *[or other such events as specified in the syllabus]* **he or she is required to notify the instructor in advance (NOT ON THE EXAM DAY)**, and upon returning to class, bring documentation of the illness, signed by a health care professional.

If you miss an exam, homework, or class activity without a documented, University-approved reason, you will not be able to make up. If you miss class you are still responsible for the material covered in class and you should obtain notes from a classmate. Dr. Choi will not provide you notes if you miss class. Each absence from class without a valid reason may result in points being taken away from the total points. Please visit http://faculty.umd.edu/teach/attendance.html for the University of Maryland Attendance Policy.

Inclement weather

In case of inclement weather, Dr. Choi will abide by University's policy on closures and delays, which will be posted at www.umd.edu. If the University closes on a class day due to inclement weather, any HW due will become due on the next day the class meets, and any exams scheduled will be postponed, with the new date notified on ELMS (https://bb.eng.umd.edu)

Student expectations in class

Students are expected to maintain an atmosphere conducive to learning by
Coming to class prepared,
Not talking to your classmates unless the instructor specifically asks you to discuss,
Not arriving in class late,
Not exiting the class before Dr. Choi indicates that the lecture is over, and
Not consuming food in class (although a beverage or water is acceptable).

Electronic devices in class

Electronic devices meant for communication and/or entertainment (smart phones, tablet PCs etc.) should be switched off and kept out of sight during class. The use of such devices disturbs both instructor and students. Calculators are permissible (and should be brought to class) as long as

they do not have communication or entertainment capability. **The use of internet accessible devices such as smart phones during exams is strictly prohibited: violators will be asked to leave the classroom immediately and no makeup exam will be offered. You cannot use a smart phone as calculator during the exam.**

Topics (Painter and Coleman, Fundamentals of Polymer Science):

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1. The nature of polymeric materials (Chapter 1)
   Basic structures of polymers
   Definitions of terminology
2. Polymer synthesis (Chapter 2)
   Mechanisms of polymerization: step-growth, ionic, free radical, coordination polymerizations; Qualitative understanding of synthetic mechanisms
3. Kinetics of step-growth polymerization (Chapter 3, Chapter 4)
   Linear step-growth polymerization kinetics
   Most probable distribution of chain length
   Basic theory of nonlinear step-growth polymerization (gel formation)
4. Kinetics of addition polymerization (Chapter 3, extra materials)
   Mechanisms of free radical polymerization
   Development of a kinetic model for free radical homopolymerization
   Predictions of polymer chain length distributions
   Industrial processes for free radical polymerization of vinyl monomers
5. Copolymerization (Chapter 5)
   Kinetic modeling of a free radical copolymerization process
   Sequence length distribution
   Reactivity ratios and experimental data analysis
   Semibatch operations
6. Polymer structure (Chapter 7)
   Bonding in polymers and intermolecular forces
   Chain conformations and chain configurations
   Random walk model
7. Glass transition and crystallization (Chapter 8)
   Glass transition temperature
   Thermodynamics of polymer melting
   Crystalline polymer structures and properties
8. Thermodynamics of polymer solutions (Chapter 9)
   Thermodynamics of mixing
   Flory-Huggins theory
   Phase behavior of polymer solutions and blends
9. Molecular weight and branching (Chapters 6 and 10)
   Characterization of polymer molecular weight properties
   Solution viscometry
10. Mechanical and rheological properties (Chapter 11)
    Stress and strain: basic concepts
    Viscoelasticity of polymers
    Models of viscoelastic behavior

Performance Criteria:

Objective 1

1.1 The student will demonstrate an ability to retrieve scientific and technical information/data on a given topic.
1.2 The student will demonstrate an ability to effectively summarize and review technical literature.
1.3 The student will demonstrate an ability to present technical knowledge in writing.

Objective 2

2.1 The student will demonstrate an ability to understand basic polymerization kinetic and process models.
2.2 The student will demonstrate an ability to conceptualize a given polymerization process system.
2.3 The student will demonstrate an ability to solve basic process modeling equations.
2.4 The student will demonstrate an ability to interpret experimental and computational data/results.

Objective 3

3.1 The student will demonstrate an ability to use various chemical engineering subjects to formulate and solve polymerization process design problems.
3.2 The student will demonstrate an ability to assess economic aspects of polymer processes.
3.3 The student will demonstrate an ability to construct a professional quality technical report.

1/28/2019