

MATSE 259 – Course Outline and Study Guide

Introduction

This part of the course is aimed at providing you with a basic understanding of the structure and properties of polymer materials. It has been organized so as to use the history of the development of these materials as a narrative thread – at least in the first part of the course. Instead of a book, the course content is contained in a two CD set, “Painter and Coleman on Polymers”, available at the bookstore. One of these CD’s covers the science and engineering of polymer materials (“Polymer Science and Engineering” CD), while the other describes the major classes of polymer materials in the context of their historical development (“The Incredible World of Polymers” CD). The historical material will not be included in any of the tests. Both CDs are comprehensive and cover a much broader range of material than the course itself. The course content and the Chapters you will be expected to know are outlined lecture by lecture below.

LECTURE 1: Introduction

This introductory lecture simply describes the range of applications of polymer materials.

Reading Assignments:

The Incredible World of Polymers CD: Preamble

Polymer Science and Engineering CD: Introduction sections of Chapter 1 and Chapter 2.

What you should know:

Basic definitions (monomer, polymer, copolymer)

Review of basic chemistry

LECTURE 2: Early History

This lecture reviews the early history of the subject from the introduction of the “semi-synthetics” to the first true synthetic – Bakelite.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 1 (Semi-Synthetic Polymers) and Chapter 2 (The First Synthetic Plastic)

Polymer Science and Engineering CD: Introduction sections of Chapter 1 and Chapter 2, again (because you didn’t read them the first time!)

What you should know:

What is a functional group

Simple condensation reactions

What is a network

LECTURE 3: The Dawn of Understanding

This lecture deals with the introduction of the macromolecular concept by Staudinger and the development of Nylon by Carothers. Essentially, Carothers goal was to prove the existence of long-chain molecules using well-known chemistry and as a result he developed a material that had an extraordinary impact on everyday life.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 4 (The Dawn of Understanding)
Polymer Science and Engineering CD: Chapter 1 and Chapter 2.

What you should know:

How to make linear chains using “condensation” reactions
Multifunctional monomers and network formation

LECTURE 4: Polyolefins

In this lecture the development of polyethylene and polypropylene will be described. In this context, the other principle method of polymerization – chain polymerization – will be introduced. Also included is a discussion of branching and tacticity and their affect on the ability of a polymer to crystallize.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 5 (Polyolefins)
Polymer Science and Engineering CD: Chapter 1 and Chapter 2.

What you should know:

The nature of vinyl monomers and the four basic steps in a chain polymerization (initiation, propagation, termination and chain transfer). How chain transfer leads to branching. The nature of tacticity in vinyl polymers. Some basic aspects of the effect of crystallinity on properties.

LECTURE 5: Natural Rubber

This lecture describes the extraordinary history of natural rubber and its unique properties, which have their origin in the flexible nature of their chains.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 2 and 9 (Rubber).
Polymer Science and Engineering CD: Chapter 7.

What you should know:

The extraordinary number of conformations allowed to flexible chains and the entropic origin of rubber elasticity.

LECTURE 6: Structure and Morphology

With this chapter the focus of the course largely (but not completely) shifts from a historical viewpoint and plunges into a more detailed discussion of structure. In particular, the nature of crystallization and order in polymer materials.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 10 and 12 (Synthetic Fibers and Engineering Thermoplastics).

Polymer Science and Engineering CD: Chapter 7.

What you should know:

The folded-chain nature of polymers crystallized from solution and the melt. The more extended-chain form found in fibers. The broad effects of crystallinity on properties.

LECTURE 7: Crystallization and Melting

This part of the course deals with how polymers crystallize and the factors that affect the melting point.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 10 and 12 (Synthetic Fibers and Engineering Thermoplastics).

Polymer Science and Engineering CD: Chapter 8.

What you should know:

Why polymers crystallize in a chain folded manner. The factors that affect the melting temperature.

LECTURE 8: Glassy Polymers

This part of the course deals with glassy polymers and the glass transition temperature.

Reading Assignments:

The Incredible World of Polymers CD: Chapter 6 (Glassy Polymers).

Polymer Science and Engineering CD: Chapter 8.

What you should know:

The origin of the glass transition temperature. The effect of structure and additives on the T_g .

LECTURES 9 and 10: Mechanical Properties I

These two lectures deal with the mechanical properties of polymers, focusing on strength, stiffness and toughness and comparing the properties of polymers to other materials. Stress-strain characteristics and yielding phenomena are also discussed.

Reading Assignments:

The Incredible World of Polymers CD: Chapters 10 and 12 (Synthetic Fibers and Engineering Thermoplastics).

Polymer Science and Engineering CD: Chapter 11.

What you should know:

What makes materials in general strong and tough (or weak or brittle). The nature of yielding and relaxation in polymers. The elastic properties of rubber and other elastomers.

LECTURE 11 and 12: Mechanical Properties II: Viscoelasticity

Starting with a brief review of the viscoelastic properties of polymer melts, the viscoelastic properties of polymers is considered, focusing on creep and stress relaxation.

Reading Assignment:

The Incredible World of Polymers CD: Chapters 10 and 12 (Synthetic Fibers and Engineering Thermoplastics).

Polymer Science and Engineering CD: Chapter 11.

What you should know:

The properties of polymer melts, the nature of creep and stress relaxation in polymers; polymer relaxation processes, simple models of viscoelasticity, the time-temperature superposition principle.