Welcome to Polymer Composites and Processing. These notes are intended to summarize some of the material that we’ll be covering this semester. Several sections are intentionally left blank for you to fill in during the lecture. The best approach will be to follow along during the lectures, filling in the empty sections, as well as writing additional notes on blank paper to insert with these pages. You may want to obtain a three ring binder to hold the notes in one place as we progress through the semester. In addition to these formal notes, many classes will not have notes prepared, and you’ll need to prepare your own notes from scratch based on the lecture and discussion. Additional material from the textbook and references will also be assigned that may not be covered in these notes.

Materials In Society and Engineering
Materials have always been an integral part of human culture and civilization.

- Consider the Stone, Bronze, and Iron Ages
- What age are we in today?

[ABET Definition of Engineering -]
“Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the ____________________ and ____________________ of nature for the benefit of mankind”

- Virtually every modern technology is ____________________________ with respect to performance, reliability, and cost.
The materials science tetrahedron

This materials tetrahedron will be a **key theme** throughout this course.

**Composite Materials**

**What is a composites material?**

- A material having two or more
  
  __________________________________________
  __________________________________________

- The composite properties are
  
  __________________________________________
  __________________________________________

- Consist of one or more ________ phases (reinforcement) embedded in a
  _____________ phase (matrix).

- Composite = ________________ + ________________ + ________________.
Why Composites?

• ____________________________
• ____________________________
• ____________________________
• ____________________________
• ____________________________
• ____________________________
• ____________________________
• ____________________________

SPECIFIC STRENGTH

![Graph showing specific strength comparison between non-composite and composite materials]
POLYMER COMPOSITES AND PROCESSING


FIGURE 1-3 Production primary and secondary structure for the Boeing 777, an example of 1990s commercial application of composites.

FIGURE 1-4 Projections for composite use in the Boeing 787.
Structural Composites are often FRPs (________________________________________________________).

Why Fiber?

- Fiber take advantage of high strengths that are not apparent in “solid form”
  - Because ___________________ are restricted to small number of fibers.

The Properties of the FRP composites are determined by:

- __________________________________________________
- __________________________________________________
- __________________________________________________
- __________________________________________________
- __________________________________________________
- __________________________________________________

Distinctive Properties of Composites:

- __________________________________________________
- __________________________________________________
Classifications of Composites:

- Based on Form of Reinforcement

  - Continuous Fibers

  ![Continuous Fibers](image)

  - Short fibers

  ![Short Fibers](image)

  - Whiskers

  ![Whiskers](image)

  - Particulates

  ![Particulates](image)

  - Flakes

  ![Flakes](image)
- Types Based on Matrix

<table>
<thead>
<tr>
<th>Matrix Phase / Reinforcement Phase</th>
<th>Metal</th>
<th>Ceramic</th>
<th>Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td>Powder metallurgy parts – combining immiscible metals</td>
<td>Cermets (ceramic-metal composite)</td>
<td>Brake pads</td>
</tr>
<tr>
<td>Ceramic</td>
<td>Cermets, TiC, TiCN Cemented carbides – used in tools Fiber-reinforced metals</td>
<td>SiC reinforced Al2O3 Tool materials</td>
<td>Fiberglass</td>
</tr>
<tr>
<td>Polymer</td>
<td>Fiber reinforced metals Auto parts aerospace</td>
<td>Kevlar fibers in an epoxy matrix</td>
<td>Rubber with carbon (tires) Boron, Carbon reinforced plastics</td>
</tr>
<tr>
<td>Elemental (Carbon, Boron, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MMC’s (Metal Matrix Composites) CMC’s (Ceramic Matrix Composites) PMC’s (Polymer Matrix Composites)

Figure 1.3. Polymer composite classification scheme.
Polymer Blends and Block Copolymers

Homopolymer

Polymer Blends polymer

Block Copolymer

Polymer blend are multicomponent polymer materials composed primarily of two or more polymers \((A)_N B + (B)_N A\) (usually not \(A\) to each other). Polymer blends are usually hard to mix so \(A\) is the “rule”. These phase separated blends are composite materials with variable \(A\) and \(B\), and \(A\) and \(B\) (these can be controlled, somewhat) by kinetics and quenching.

Block copolymers are linked end to end. The \(A\) and \(B\) chains can be avoided and the size and symmetry of the domain of \(A\) and \(B\) can be controlled by chemically connecting \(A\) and \(B\) chains.
Blends and Copolymer Structures

Classifications of Polymer Blends and Copolymers:
Why Polymer Blends?

<table>
<thead>
<tr>
<th>Property</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-impact strength</td>
<td>38</td>
</tr>
<tr>
<td>Processability (including weld line)</td>
<td>18</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>11</td>
</tr>
<tr>
<td>Rigidity/modulus</td>
<td>8</td>
</tr>
<tr>
<td>Heat deflection temperature</td>
<td>8</td>
</tr>
<tr>
<td>Flammability</td>
<td>4</td>
</tr>
<tr>
<td>Solvent resistance</td>
<td>4</td>
</tr>
<tr>
<td>Thermal stability</td>
<td>3</td>
</tr>
<tr>
<td>Dimensional stability</td>
<td>3</td>
</tr>
<tr>
<td>Elongation</td>
<td>2</td>
</tr>
<tr>
<td>Gloss</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>4</td>
</tr>
</tbody>
</table>