

MATE 221:

Introduction to Mechanical Properties of Materials

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Homework 3

H3.Q1 (CES Level 2): Explore the potential of PP-SiC (polypropylene-silicon carbide) fiber composites in the following way. Make a modulus-density (E - ρ) chart and change the axis ranges so that they span the range $1 < E < 1000$ GPa and $500 < \rho < 5000$ kg/m³. Find and label PP and SiC, then print it. Retrieve values for the modulus and density of PP and of SiC from the records for these materials (use the means of the ranges). Calculate the density $\rho_{\text{composite}}$ and upper and lower bounds for the modulus E at a volume fraction f of SiC of 0.5 and plot this information on the chart. Sketch by eye two arcs starting from (E, ρ) for PP, passing through each of the $(E_{\text{composite}}, \rho_{\text{composite}})$ points you have plotted and ending at the (E, ρ) point for SiC. PP-SiC composites can populate the area between the arcs roughly up to $f = 0.5$ because it is not possible to insert more than this.

H3.Q2 (CES Level 2): Explore the region that can be populated by making PP foams. Expand an E - ρ plot so that it spans the range $10^{-4} < E < 10$ GPa and $10 < \rho < 2000$ kg/m³. Find and label PP, then print the chart. Construct a band starting with the PP bubble by drawing lines corresponding to the scaling law for foam modulus $E_{\text{composite}} \propto \rho_{\text{composite}}^2$ touching the top and the bottom of the PP bubble. The zone between these lines can be populated by PP foams.

H3.Q3: The stiffness of an atomic bond in a particular material is 50 N/m and its center-to-center atom spacing is 0.3 nm. What, approximately, is its elastic modulus?

H3.Q4: What is meant by:

- (a) a crystalline solid
- (b) an amorphous solid
- (c) a thermoplastic
- (d) a thermoset
- (e) an elastomer?

H3.Q5: Case study: Automotive headlight lens.



The lens of an automobile headlamp protects the bulb and reflector and focuses the light where it is most needed.

What are the design requirements?

List these and use CES to select materials for the lens.

Explain advantages and disadvantages of possible solutions.