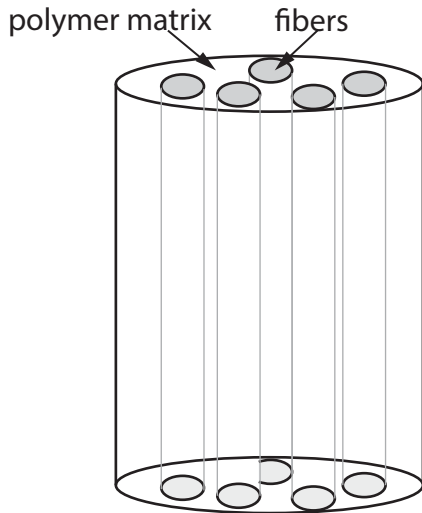# HW07: Questions related Elastic Constants of Composites

1.

 Give physical arguments to show that the directional graphite fiber reinforced polymer composite has four independent elastic constants.

polymer matrix   fibers

2.

In class you have seen the derivation for the Young's Modulus of a unidirectional composite made from aligned graphite fibers and a polymer matrix (GFRP) in the axial direction with the following result

$$E_{comp} = v_f E_{fiber} + (1 - v_f) E_{polymer}$$

Why is the following a good approximation

$$E_{comp} \approx v_f E_{fiber}$$

Consider the modulus vs density plots in the "map" on the next page. Using this data obtain a reasonable value for the volume fraction of fibers in the GFRP composites.

3.

Derive an expression for the elastic modulus of the above composite in the transverse direction. First draw a schematic of the cross section.

4.

Show that the volume fraction of the fibers in the composite is equal to the area fraction of the fibers as seen in a cross-section.

5.

Using the data given on the map, and assuming the GFRP to be uniaxial composites, obtain an approximate, or a range of values for the volume fraction of the fibers in the composite.

4. Modulus-Strength
Metals and Polymers: Yield Strength
Ceramics and Glasses: Compressive
Strength Elastomers: Tear Strength
Composites: Tensile Strength   MFA:88-91

Youngs Modulus, E (GPa)

1000 — 100 — 10 — 1.0 — 0.1 — 0.01

Strength σ_f (MPa)

0.1 — 1 — 10 — 100 — 1000 — 10,000

Min. Energy
Storage per
Unit Volume
Yield before
Buckling

Engineering
Alloys

Diamond
Cermets
WC
Si C
W
Borod
Si₃N₄
Mo Alloys
Beryllium
MgO Al₂O₃
Steels
Zr O₂
Ni Alloys
CFRP
Cast Irons
Uniply
Silicon
BeO
Cu Alloys   Zr Alloy   Ti Alloys
GFRP
Al Alloys
Common   Brick Etc   Glasses   Engineering
Cement   Rocks   Ceramics
Mg Alloys   Engineering
Sn   Composites
Concrete   CFRP
Laminates
Lead   GFRP
Ash
Oak
Pine   Porous
Ceramics
MEL
|| to
Grain   Epoxies
PMMA
Balsa   PS $\frac{\sigma_f}{E} = 0.1$
Woods   PVC   Nylons
Wood
Products
Polyester   PP
Ash
Oak
Pine   HDPE
⊥ to
Grain   PTFE
Balsa   Engineering
LDPE   Polymers $\frac{\sigma_f}{E} = C$
Polymers
Foams $\frac{\sigma_f^{3/2}}{E} = C$
Elastomers
Hard
Butyl   PU
Cork   Silicone $\frac{\sigma_f^2}{E} = C$
Soft
Butyl

$\frac{\sigma_f}{E} = 10^{-4}$
$\frac{\sigma_f}{E} = 10^{-3}$
$\frac{\sigma_f}{E} = 10^{-2}$

Design
Guide
Lines

Max Energy
Storage per
Unit Volume
Buckling
before Yield