Aerospace Composites Exam 1 Spring 2023

Instructions: Perform work on your own paper. Legibly write your name on each page and **sign each page**. By signing each page, you are testifying that you did not cheat. After you have completed the exam, scan each page, your formula sheet, and upload your exam as a single file. If you have a problem with the upload, email it to Dr. Ifju at ifju@ufl.edu

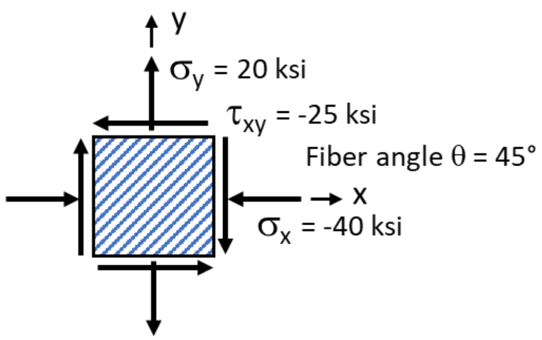
1. (12 pts) The engineering elastic properties of a unidirectional fiber (**orthotropic transversely isotropic**) composite are (GPa units):

$$E_1 = 200,\ \ G_{12} = 5,\ \ \nu_{12} = 0.3,\ \ \nu_{21} = 0.02,\ \ \nu_{23} = 0.2$$

What are the values of the missing orthotropic elastic constants?

E_1	E_2	E_3	G_{12}	G_{23}	G_{13}	ν_{12}	ν_{23}	ν_{21}
200			5			0.3	0.2	0.02

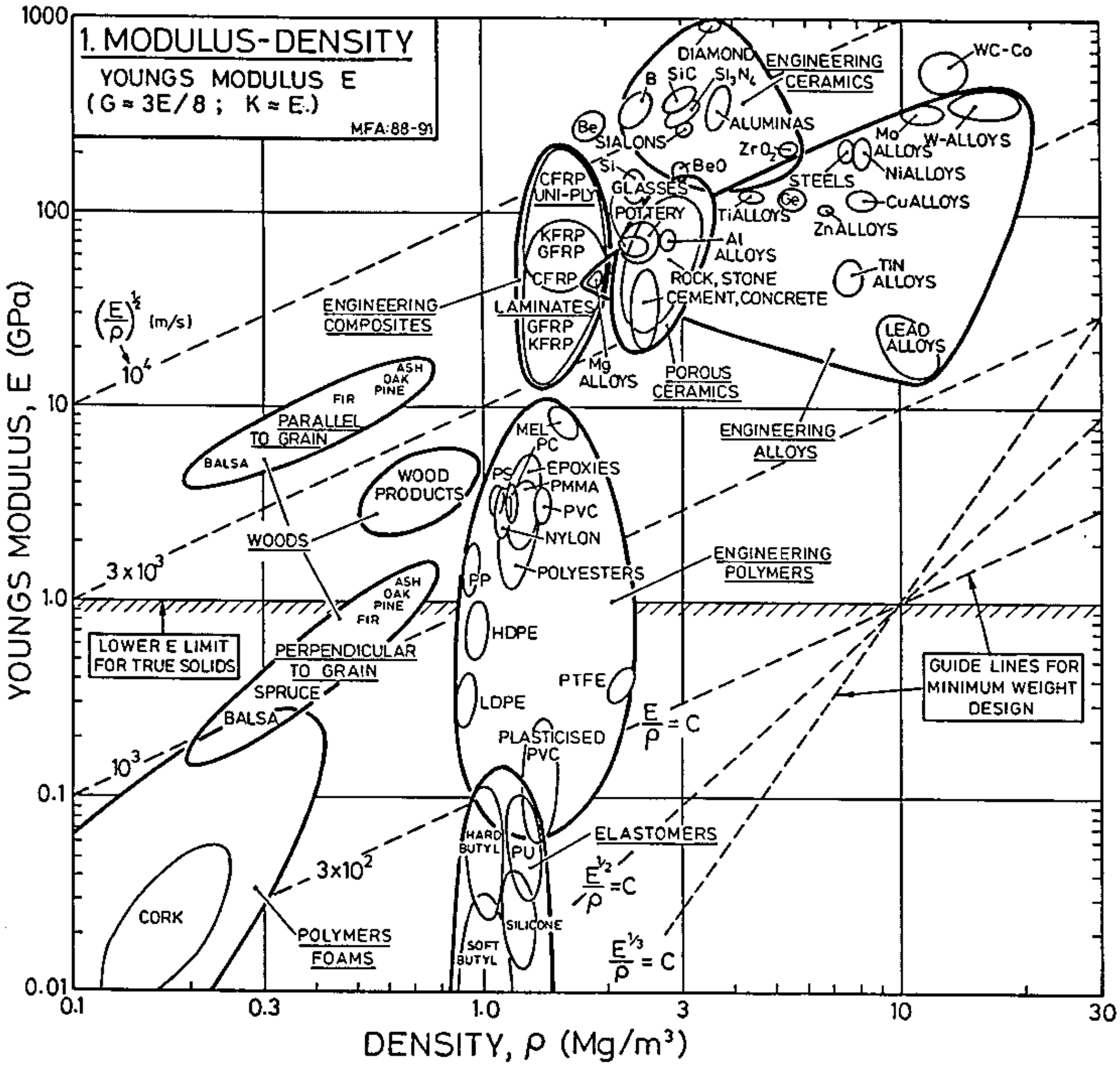
2. (20 pts) Assuming plane stress, for the stress state in the global coordinate system shown below, on a unidirectional composite, **determine the strains in the material coordinate system** $\boldsymbol{\varepsilon_1, \varepsilon_2, \gamma_{12}}$. ($E_1 = 200 \times 10^6$ psi, $E_2 = 10 \times 10^6$ psi, $\nu_{12} = 0.25$, and $G_{12} = 5 \times 10^6$ psi).



3. (8 pts) For a square packing array of fibers, with a fiber diameter of 7 μm, and a fiber volume fraction of 0.70 or 70%,
   a) determine the average fiber spacing (center to center)
   b) for this packing arrangement, what is the theoretical maximum fiber volume fraction
   c) why would it not be desired to have a fiber volume fraction higher than that in b) above?

4. (8 pts) Name and describe in a few sentences a composite manufacturing method used to produce long prismatic glass fiber/vinyl ester unidirectional composite structure, such as an I-beam.

5. (20 pts) For a simply supported beam, that carries a 50 N center load, the maximum deflection is calculated as $y = PL^3/48EI$. If the beam has a square cross section with sides a, the mass = $a^2L\rho$.
   a) Find the least dense non-porous material to minimize deflection and weight of the beam.
   b) Find a if the beam is 1 meter long and the deflection is not to exceed 1 cm.
   c) What is the weight of that beam?



6. The elastic properties for a T300 fiber and LM matrix are provided below:

T300 Fiber Properties

E_{f1}	E_{f2}	ν_{f12}	G_{f12}
$32 \times 10^6\ psi$	$2 \times 10^6\ psi$	0.25	$1.3 \times 10^6\ psi$

LM Matrix Properties

E_m	ν_m
$0.32 \times 10^6\ psi$	0.43

a) (4 pts) Which micromechanical model gives the best approximation for E_1 for T300/LM composite lamina: Rule of Mixtures, Inverse Rule of Mixtures, or Halpin-Tsai?

b) (4 pts) Using a fiber volume fraction of $v_f = 0.65$, approximate the value of E_1 with the model specified in Part a?

c) (4 pts) The Halpin-Tsai equation for E_2 is specified as

$$\frac{E_2}{E_m} = \frac{1 + \xi\eta v_f}{1 - \eta v_f} \text{ where } \eta = \frac{(E_{f2}/E_m) - 1}{(E_{f2}/E_m) + \xi}$$

Choose an appropriate value for ξ that gives the best approximation for E_2. Then solve for E_2 using Halpin-Tsai with a fiber volume fraction of $v_f = 0.65$.

7. (10 pts) Qualitatively draw and label a plot that shows the effective modulus E_x as a function of fiber direction θ for a unidirectional graphite/epoxy lamina with E_1 = 300 GPa and E_2 = 20 GPa.
   a) Estimate the modulus when θ = 45°.
   b) At what approximate angle θ is the modulus about halfway between E_1 and E_2?
   c) Write the simple equation for E_x as a function of the transformed reduced compliance.

8. (10 pts) Above each laminate shown below, provide the most efficient (shortest) code that describes the stacking sequence.