Ae/AM/CE/ME 102c
Mechanics of Structures and Solids – Spring 2007-08
Assignment 3, Due Apr 24, 9:00AM, in class

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*****Please indicate the number of hours spent on this assignment*****

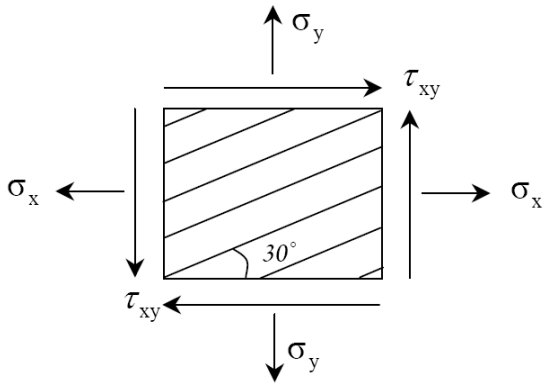
Problem 1 (10 points)

A unidirectional glass fiber reinforced epoxy lamina with 60% fiber volume fraction is subjected to biaxial loading as shown in the figure, with σ_x=200 MPa, σ_y=-80 MPa, τ_{xy}=40 MPa. Use the material properties given in the table below to

(a) Calculate in-plane normal and shear strains;

(b) Calculate the ratio of shear strain from normal-shear coupling to the total shear strain;

(c) Calculate the normal stress and strain in fiber direction.



Property	Young's Modulus (Gpa)	Shear Modulus (Gpa)	Poisson's Ratio
Glass	85	35.4	0.2
Epoxy	3.4	1.3	0.38

Problem 2 (10 points)

Derive an expression for the in-plane bulk modulus κ_{23} $\left(=\left(\sigma_{22}+\sigma_{33}\right)/\varepsilon_{kk}\right)$ of an unidirectional fiber reinforced composite (fiber direction x_1) in terms of the properties of the fiber (f) and the matrix (m), i.e., κ_f, E_f, ν_f, κ_m, E_m, and ν_m, and the volume fraction of the fiber, f, where κ is bulk modulus, E is Young's modulus and ν is Poisson's ratio.

Use the Lame solution for a plane-strain composite cylinder consisting of the fiber at the core of radius a surrounded by the matrix of radius b subjected to a uniform radial strain ε_0 at the outer boundary $r=b$. The geometrical parameters in the solution are to be eliminated in favor of f.

(a) Show that $\sigma_{rr}\big|_{r=b}=2\kappa_{23}\varepsilon_0$.

(b) Use (a) to obtain κ_{23}.

Problem 3 (10 points)

Consider a thin rectangular plate made of an angle ply (θ) fiber reinforced composite subjected to uniaxial tensile stress σ in the x direction in the global.

(a) Compute the transformed compliance matrix $\bar{S}$ for the angle ply composite in the global coordinate system (x, y) given the compliance matrix S in the material coordinate system (x_1, x_2). Use engineering constants $E_1/E_2=5$, $G_{12}/E_1=0.1$, $\nu_{12}=0.25$ and $E_1=1$.

(b) Compute the state of strain in the plate.

(c) Determine the ratio of the shear to axial strain for $\theta=45^\circ$. Comment on the deformed shape of the plate by using a simple sketch.

(d) Determine the non-trivial angle of the ply (θ) for which there is minimal distortion.