Composite Materials: Analysis and Design

Homework no.4

Due Date: 3th May

Problem 1

Fig. 1 illustrates a rectangular array of elliptical-shaped fibers. Determine: a) the relationship between the fiber volume fraction and the specified geometrical parameters, b) the maximum possible fiber volume fraction for this packing geometry.

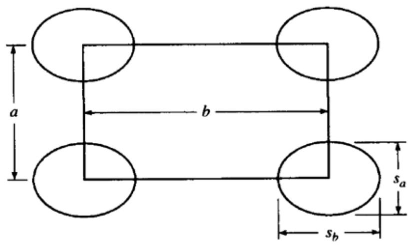

Fig. 1

Problem 2

Homogeneous engineering materials are infrequent. Consider a composite which consists of a small spherical particle of one material that is embedded in a large matrix of another material. The particle has a radius of a. The composite is solidified at an elevated temperature T_h, at which the composite is in a stress-free condition. The particle has a larger thermal expansion coefficient than the matrix, $\alpha_p > \alpha_m$. Upon cooling process, the composite develops a residual stress field because of the thermal expansion mismatch.

(a) At room temperature T_r, is the particle under tension or compression?

(b) Find out the complete stress field in the particle and the matrix at room temperature. Assume that both the materials are isotropic. To simplify algebra, assume the same Young's modulus E and the same Poisson's ratio ν for both the materials.

Problem 3

Fig. 2 presents a unidirectional composite, in which the fiber and matrix materials are assumed to be isotropic and perfectly bonded together. By using a mechanics of materials approach, derive the micromechanics equations for the effective in-plane shear modulus, G_{12}, for these cases:

(a) The ends of composite are perfectly bonded to supports which are restrained against rotation, then subjected to the uniform in-plane shear stress, τ_{12} (Fig. 2-a).

(b) Both the top and bottom surfaces of the composite are subjected to the uniform in-plane shear stress, τ_{12}, and the ends of the composite are free to rotate, as depicted in Fig. 2-b.

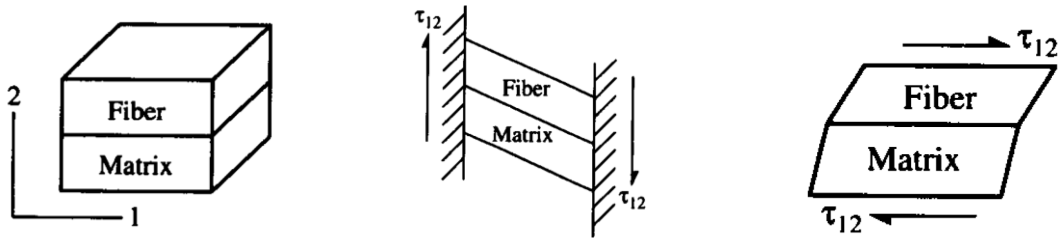

Fig. 2 (a) (b)

Problem 4

As shown in Fig. 4, a unidirectional 45^o off-axis E-glass/epoxy composite lamina is supported on frictionless rollers between two rigid walls. The lamina is fixed against displacements in the y direction and is free to move in the x direction. The lamina is heated from 20^o to 120^o. Determine all of the lamina strains associated with x, y axes.

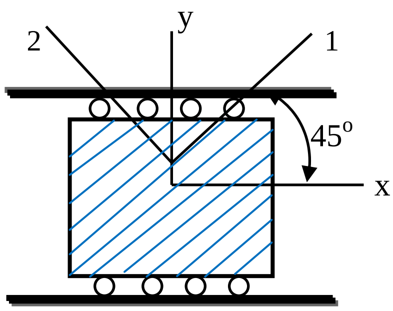

Fig. 3