

## ASSIGNMENT #1

1. If a laminate consists of three or more identical orthotropic laminae that are oriented at the same angle relative to adjacent laminae, the extensional stiffness matrix will be isotropic. This means that if all laminae are rotated by the same amount, the extensional stiffness matrix will remain unchanged. Consider the following two laminates made of same materials:  $[-45/0/45/90]$  and  $[0/30/60/90]$ . Rotate the given laminates and plot the elements of the extensional stiffness matrix,  $A_{ij}$ , as a function of the top ply orientation. Based on the definition given above, determine if any of the laminates is quasi-isotropic or not. You can arbitrarily choose an orthotropic material and ply thickness.
2. A  $[0/90/0]_s$  laminate is fabricated from unidirectional laminae composed of isotropic fibers and an isotropic matrix. The fibers exhibit  $E_f = 220$  GPa and  $\nu_f = 0.25$ ; the matrix has  $E_m = 3.6$  GPa and  $\nu_m = 0.40$ . Each lamina has a thickness of 0.25 mm which contains circular fibers with a diameter of  $d = 10 \mu\text{m}$  arranged uniformly. If the number of fibers per 1 mm width was approximately 1900, determine the engineering constants of the laminate.
3. Consider a laminate with the stacking sequence of  $[30/\theta_1/\theta_2/-30]_s$  subjected to  $N_x = N_y = 1000$  N/m and  $M_y = M_{xy} = 50$  N. The laminate is made of Kevlar/Epoxy with material properties  $E_1 = 76$  GPa,  $E_2 = 5.50$  GPa,  $G_{12} = 2.30$  GPa,  $\nu_{12} = 0.34$ ,  $t = 1.25$  mm. If no shear strain is to be observed as a result of the applied loads, determine and plot the mid-plane strains and curvatures as a function of  $\theta$ . Discuss your results.
4. A laminate with the stacking sequence  $[-45/45]$  is composed of equal-thickness layers (0.5 mm each) of AS/3501 graphite-epoxy composite with material properties  $E_1 = 181$  GPa,  $E_2 = 10.3$  GPa,  $G_{12} = 7.17$  GPa, and  $\nu_{12} = 0.28$ .
  - a. Using the given material properties below, determine the laminate stiffness matrices **A**, **B**, and **D**.
  - b. Then, if two additional layers are added to form the stacking sequence  $[-45/45/-45/45]$ , discuss how the stiffness matrices are affected.