Faculty of Mechanical Engineering
Universiti Malaysia Pahang

BMM4893 Mechanics of Composite Materials
Assignment No.2

Answer all questions. Important note: This assignment must be *in handwriting*, no MS Word/Latex etc.

1. The engineering constants for an orthotropic material are found to be

   $E_1 = 4$ MPa , $E_2 = 3$ MPa , $E_3 = 3.1$ MPa

   $v_{12} = 0.2$, $v_{23} = 0.4$, $v_{31} = 0.6$

   $G_{12} = 6$ MPa , $G_{23} = 7$ MPa , $G_{31} = 2$ MPa

   Find the matrices of $[C]$ and $[S]$

2. Consider an orthotropic material with the stiffness matrix given by

$$[C] = \begin{bmatrix} -0.67308 & -1.8269 & -1.0577 & 0 & 0 & 0 \\ -1.8269 & -0.67308 & -1.4423 & 0 & 0 & 0 \\ -1.0577 & -1.4423 & 0.48077 & 0 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.5 \end{bmatrix} GPa$$

   Find:

   a. The stresses in the principal directions of symmetry if the strains in the principal directions of symmetry at a point in the material are $\varepsilon_1 = 1\mu m/m$, $\varepsilon_2 = 3\mu m/m$, $\varepsilon_3 = 2\mu m/m$, $\gamma_{23} = 0$, $\gamma_{31} = 5\mu m/m$, $\gamma_{12} = 6\mu m/m$.

   b. The compliance matrix $[S]$

   c. The engineering constants E_1, E_2, E_3, v_{12}, v_{23}, v_{31}, G_{12}, G_{23}, G_{31}

   d. The strain energy per unit volume at the point where strains are given in part (a).

3. Show that for an orthotropic material $Q_{11} = C_{11}$. Explain why? Also, show $Q_{66} = C_{66}$. Explain why?
4. The reduced stiffness matrix [Q] for a UD is given as follows:

$$[Q] = \begin{bmatrix} 5.681 & 03.164 & 0 \\ 0.3164 & 1.217 & 0 \\ 0 & 0 & 0.606 \end{bmatrix} MPa$$

What are the four engineering constants of the lamina?

5. For a 55^o angle lamina of boron/epoxy under stresses in global axes as σ_x = 4MPa, σ_y = 2 MPa and τ_{xy} =-3MPa, using the properties of a UD boron/epoxy, find the following
   a. Global strains
   b. Local stresses and strains
   c. Principal normal stresses and principal normal strains
   d. Maximum shear stress and maximum shear strain

Typical Mechanical Properties of an Unidirectional lamina

Property	**Symbol**	**Units**	**Glass/ epoxy**	**Boron/ epoxy**	**Graphite/ epoxy**
Fiber volume fraction	V_f		0.45	0.5	0.7
Longitudinal elastic modulus	E_1	GPa	38.6	204	181
Transverse elastic modulus	E_2	GPa	8.27	18.5	10.3
Major Poisson's ratio	ν_{12}		0.26	0.23	0.28
Shear modulus	G_{12}	GPa	4.14	5.59	7.17
Ultimate longitudinal tensile strength	$(\sigma_1^T)_{ult}$	MPa	1062	1260	1500
Ultimate longitudinal compressive strength	$(\sigma_1^C)_{ult}$	MPa	610	2500	1500
Ultimate transverse tensile strength	$(\sigma_2^T)_{ult}$	MPa	31	61	40
Ultimate transverse compressive strength	$(\sigma_2^C)_{ult}$	MPa	118	202	246
Ultimate in-plane shear strength	$(\tau_{12})_{ult}$	MPa	72	67	68
Longitudinal coefficient of thermal expansion	α_1	μm/m/°C	8.6	6.1	0.02
Transverse coefficient of thermal expansion	α_2	μm/m/°C	22.1	30.3	22.5
Longitudinal coefficient of moisture expansion	β_1	m/m/kg/kg	0	0	0
Transverse coefficient of moisture expansion	β_2	m/m/kg/kg	0.6	0.6	0.6

Source: Tsai, S.W and Hahn, H.T., Introduction to Composite Materials, CRC Press