

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 6

LEFEL 6

EXAMINATION PERIOD
JANUARY 2017

CYFNOD ARHOLIADAU
LONAWR 2017

MODULE CODE:
M6X01201: MATERIALS & MANUFACTURING FOR NICHE
MARKETS

TIME: 2 HOURS

ANSWER 3 FROM 4 QUESTIONS

Equipment or materials required – None

Adnoddau neu ddefnyddiau sydd eu hangen – Dim

A formula sheet is provided for reference.

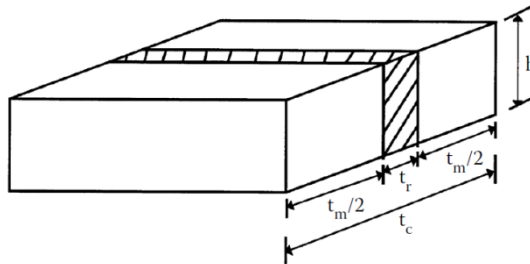
Calculators are permitted.

Assume 'g' = 9.81 m/s².

ONE

- a) Composite materials are composed of two phases. Identify these, and discuss how the primary phase can be used to classify composites. Discuss the different physical forms that the secondary phase can take.

[11 Marks]



The above Representative Volume Element represents a unidirectional composite.

- b) Given that $F_C = F_f + F_m$, where F is the force being applied to the structure and the subscripts c , f and m represent the composite, the fibre and the matrix respectively, prove the rule of mixtures $E_1 = E_f V_f + E_m V_m$ from first principles. E represents the Young's Modulus, V is the volume fraction and the subscript 1 represents the longitudinal (or fibre) direction.

[6 Marks]

- c) Discuss the assumptions that you have made in your derivation of the rule of mixtures.

[3 Marks]

TWO

a) Given the following for an isotropic material;

$$\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \\ \gamma_{23} \\ \gamma_{31} \\ \gamma_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{21} & S_{22} & S_{23} & S_{24} & S_{25} & S_{26} \\ S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{36} \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} & S_{46} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & S_{56} \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \tau_{23} \\ \tau_{31} \\ \tau_{12} \end{bmatrix}.$$

And the fact that for an Orthotropic composite the compliance matrix reduces to;

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & 0 \\ S_{12} & S_{22} & S_{23} & 0 & 0 & 0 \\ S_{13} & S_{23} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66} \end{bmatrix}.$$

Prove that the compliance matrix in terms of the 9 engineering constants for an orthotropic material is given by;

$$[S] = \begin{bmatrix} \frac{1}{E_1} & -\frac{\nu_{12}}{E_1} & -\frac{\nu_{13}}{E_1} & 0 & 0 & 0 \\ -\frac{\nu_{12}}{E_1} & \frac{1}{E_2} & -\frac{\nu_{23}}{E_2} & 0 & 0 & 0 \\ -\frac{\nu_{13}}{E_1} & -\frac{\nu_{23}}{E_2} & \frac{1}{E_3} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{23}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{31}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{12}} \end{bmatrix}$$

[10 Marks]

- b) Hence find the compliance matrix for an orthotropic Graphite/Epoxy lamina whose material properties are as follows;

$$E_1 = 181 \text{ GPa}$$

$$E_2 = 10.3 \text{ GPa}$$

$$E_3 = 10.3 \text{ GPa}$$

$$\nu_{12} = 0.28$$

$$\nu_{23} = 0.60$$

$$\nu_{13} = 0.27$$

$$G_{12} = 7.17 \text{ GPa}$$

$$G_{23} = 3.0 \text{ GPa}$$

$$G_{31} = 7.0 \text{ GPa}$$

[5 Marks]

- c) For the material in b), what will the strain in the 1 direction (ε_1) be if $\sigma_1 = 10 \text{ MPa}$, $\sigma_2 = -5 \text{ MPa}$ and $\sigma_3 = 7 \text{ MPa}$?

[5 Marks]

THREE

- a) Discuss why a typical composite structure manufactured from a FRP would have several lamina stacked on top of each other in order to form a laminate. [4 Marks]
- b) Discuss what problems and opportunities this presents and engineer when designing a structure. [4 Marks]
- c) With the aid of a diagram, show the lay-up of the following laminates. For Example $[0/-45/90/60/30]$ would be shown diagrammatically as;

0
-45
90
60
30

- i) $[0/-45/90_2/60/0]$
- ii) $[0/-45/60]_s$
- iii) $\left[0/-45/\overline{60}\right]_s$
- iv) $\left[0^{Gr}/\pm 45^B\right]_s$ [4 Marks]
- d) Discuss what is mean by the following terms
- i) A cross-ply laminate
- ii) An angle ply laminate
- iii) An antisymmetric laminate
- iv) A balanced laminate [4 Marks]
- e) Discuss what causes hygrothermal stresses and strains in a laminate and how this can be minimised. [4 Marks]

FOUR

- a) When considering failure in a laminate in the 12 plane, what is considered instead of the principal stresses?
[7 Marks]
- b) Discuss 4 failure theories that are used to predict failure in composites
[8 Marks]
- c) With the aid of a diagram, show how the four theories compare to experimental results and comment on their relative predictions.
[5 Marks]

Diwedd/End