M21 a) Uniaxial loading

$$\varepsilon_z = \frac{\sigma_z}{E} = \frac{100\times10^6}{3\times10^9} = 0.033 \Leftarrow$$

$$\varepsilon_y = \varepsilon_x = -\nu\varepsilon_z = -0.3 \times (0.033) = -0.01 \Leftarrow$$

b) Assume $\varepsilon_x = \varepsilon_y = 0$ $\quad (E_{SiC} \gg E_{epoxy})$

$$\begin{pmatrix} 0 \\ 0 \\ \varepsilon_z \end{pmatrix} = \begin{pmatrix} \frac{\sigma_x}{E} & -\frac{\nu\sigma_y}{E} & -\frac{\nu\sigma_z}{E} \\ -\frac{\nu\sigma_x}{E} & \frac{\sigma_y}{E} & -\frac{\nu\sigma_z}{E} \\ -\frac{\nu\sigma_x}{E} & -\frac{\nu\sigma_y}{E} & \frac{\sigma_z}{E} \end{pmatrix} \cancel{\begin{pmatrix} 0 \\ 0 \\ \varepsilon_z \end{pmatrix}}$$

by symmetry $\sigma_x = \sigma_y = \sigma_T$ $\qquad \sigma_z = 100\text{ MPa}$

$$0 = \frac{\sigma_T}{E}(1-\nu) - \frac{\nu\sigma_z}{E} \qquad (1)$$

$$\varepsilon_z = \frac{-2\nu}{E}\sigma_T + \frac{\sigma_z}{E} \qquad (2)$$

from (1) $$\sigma_T = \frac{\nu\sigma_z}{(1-\nu)} = \frac{0.3\times100\times10^6}{(1-0.3)}$$

$\sigma_T = 42.9$ MPa

$$\varepsilon_z = \cancel{\ldots} \quad \frac{1}{E}\left(-2\nu\sigma_T + \sigma_z\right)$$

$$= \frac{1}{2\times10^9}\left(-2\times0.3\times42.9+100\right)\times10^6$$

$$= 0.0371$$

(Note $\frac{\sigma_z}{E} = 0.05$ so transverse restraint makes epoxy appear stiffer)