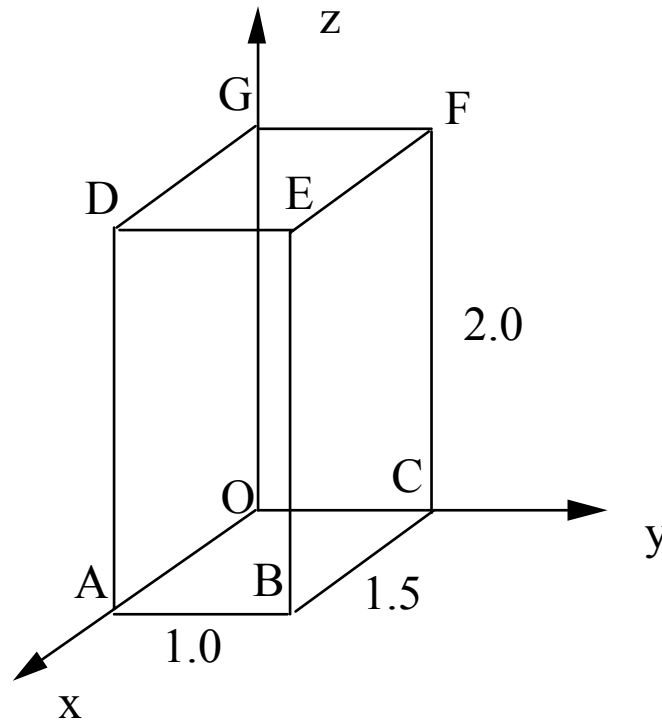


Strain and Stress-Strain Problems

1. The parallelepiped shown below is subjected to the following uniform state of strain

$$[e] = \begin{bmatrix} 2670 & 2670 & -330 \\ 2670 & 2000 & -1500 \\ -330 & -1500 & -2000 \end{bmatrix} \times 10^{-6}$$



Determine

- the normal strain in the direction of line EA
- the normal strain in the direction of line EO
- the engineering shear strain, γ , for the lines EA and EF
- the engineering shear strain, γ , for the lines ED and EC
- the principal strains and principal directions
- the magnitude of the maximum engineering shear strain, γ_{\max}

2. Although aluminum is often treated as if it isotropic ($E = 69 \text{ GPa}$, $\nu = 0.33$) it is in fact a cubic material with $C_{11} = 103 \text{ GPa}$, $C_{12} = 55 \text{ GPa}$, $C_{44} = 27.6 \text{ GPa}$. If the state of strain at a point in an aluminum part with respect to a set of (x, y, z) axes is

$$[e] = \begin{bmatrix} 300 & 50 & 0 \\ 50 & 200 & 0 \\ 0 & 0 & 100 \end{bmatrix} \times 10^{-6}$$

determine

- the principal strains and principal strain directions
- the stress components with respect to the (x, y, z) axes
- the principal stresses and principal directions
- repeat part (b) assuming that the aluminum is isotropic (i.e. use the E, ν values given above). Determine the principal stresses and principal stress directions. How much error is introduced by the isotropy assumption?

3. Along the orthotropic axes of a birch wood material the stress-strain relations are

$$\begin{Bmatrix} e_{xx} \\ e_{yy} \\ e_{zz} \\ \gamma_{xy} \\ \gamma_{xz} \\ \gamma_{yz} \end{Bmatrix} \times 10^6 = \begin{bmatrix} 72.5 & -36.25 & -36.25 & 0 & 0 & 0 \\ -36.25 & 942.5 & -652.5 & 0 & 0 & 0 \\ -36.25 & -652.5 & -1450 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1015 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1087.6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 4350 \end{bmatrix} \begin{Bmatrix} \sigma_{xx} \\ \sigma_{yy} \\ \sigma_{zz} \\ \sigma_{xy} \\ \sigma_{xz} \\ \sigma_{yz} \end{Bmatrix}$$

where the stresses are in MPa. The x-axis here is along the wood grain, the y-axis is radial to the tree, and the z-axis is tangent to the growth rings in the tree. If the stresses at a point in the wood with respect to the (x, y, z) axes are

$$[\sigma] = \begin{bmatrix} 7 & 1.4 & 0 \\ 1.4 & 2.1 & 0 \\ 0 & 0 & -2.8 \end{bmatrix} MPa$$

determine

- the principal stresses and principal stress directions
- the state of strain with respect to the (x, y, z) axes
- the principal strains and principal strain directions