Mechanics of Materials: A Lecturebook

A set of conceptual questions
Conceptual question 2.1
A rectangular cross-section rod (made up of a material with an elastic modulus of \( E \) and Poisson’s ratio \( \nu \)) has undeformed dimensions of \( L, h \) and \( b \), with \( L > h > b \). As a result of the tensile axial load \( P \) being applied to the ends of the rod, the dimensions of the rod change by amounts of \( \Delta L, \Delta h \) and \( \Delta b \), respectively. Circle the correct answer below:

a) \( |\Delta h| > |\Delta b| \)

b) \( |\Delta h| = |\Delta b| \)

c) \( |\Delta h| < |\Delta b| \)

Conceptual question 2.2

A homogeneous rod having a length of \( L = 30 \text{ in} \) and circular cross section with an outer diameter of \( d \) is acted upon by an axial load \( P = 4000 \text{ lb} \). The material of the rod has a Poisson’s ratio, a Young’s modulus, a yield strength and an ultimate strength of: \( \nu = 0.3 \), \( E = 30 \times 10^6 \text{ psi} \), \( \sigma_y = 36 \times 10^6 \text{ psi} \) and \( \sigma_u = 58 \times 10^6 \text{ psi} \), respectively.

a) Determine the minimum value of \( d \) for which the elastic strains in the rod do not exceed \( 10 \times 10^{-3} \text{ in/in} \).

b) Determine the minimum value of \( d \) for which the material does exhibit an offset in length once the load is removed.

c) Determine the minimum value of \( d \) for which the material does not exhibit necking.
**Conceptual question 3.1**
Consider the hinge shown below that is supported by a single pin whose cross-sectional area is $A$. A load $P$ is applied to end $B$ of the hinge. What is the maximum shear stress in the pin?

$$\sigma(y)$$

$A = \text{cross sectional area of pin}$
**Conceptual question 5.1**

For each state of plane stress shown below, i.e., for configurations (a) and (b), indicate whether each component of the state of strain is:

- \( \varepsilon = 0 \) (equal to zero)
- \( \varepsilon > 0 \) (greater than zero)
- \( \varepsilon < 0 \) (less than zero)

The material is linear elastic with Poisson’s ratio \( \nu \) \((0 < \nu < 0.5)\), and the deformations are small.

\[
\begin{array}{ccc}
& \sigma & \\
\sigma & & \\
\end{array}
\]

(a) \( \sigma \)

(b) \( \sigma \)

\[
\begin{array}{|c|c|}
\hline
\varepsilon_x & (a) \\
\varepsilon_y & (b) \\
\varepsilon_z & \\
\gamma_{xy} & \\
\gamma_{xz} & \\
\gamma_{yz} & \\
\hline
\end{array}
\]

*Fill in with ‘= 0’, ‘> 0’, or ‘< 0’.***
**Conceptual question 5.2**

A cube of dimensions \((L_x, L_y, L_z)\) experiences a state of stress with uniform components of stress though out the cube. The material of the cube has a Young’s modulus of \(E\) and a Poisson’s ratio of \(\nu = 0.4\). As a result of the loading on the cube, it is known that \(\sigma_y = \sigma_z = \sigma_x / 2 > 0\). As a result of this loading (circle the correct answer):

a) The dimension \(L_z\) is increased.

b) The dimension \(L_z\) remains the same.

c) The dimension \(L_z\) is decreased.

d) More information is needed to answer this question.
**Conceptual question 5.3**

A square homogeneous block made up of a material with a Poisson’s ratio of $\nu = 0.3$ is placed between two smooth, rigid walls. Initially, the temperature of the block in Figure (a) above is increased by an amount that produces a compressive normal stress of $\sigma_y = -20 \text{ ksi}$. After that, the block is given an additional tensile stress component $\sigma_x$, as shown in Figure (b) above, with this stress, in turn, reducing the $y$-component of stress to $\sigma_y = -5 \text{ ksi}$. Determine the value of $\sigma_x$.

**Conceptual question 5.4**

A block of dimensions $(L_x, L_y, L_z)$ is placed between two smooth walls, as shown above. The block experiences a state of plane stress ($\sigma_z = 0$) as a result of a uniform compressive stress of $\sigma_0$ acting on the $y$-faces of the block. The material making up the block has a Young’s modulus of $E$ and a Poisson’s ratio of $\nu$. Determine the three components of normal strain in the block.