19.28 This problem asks for us to determine the change in diameter of a cylindrical brass rod 150.00 mm long and 10.000 mm in diameter when it is heated from 20°C to 160°C while its ends are maintained rigid. There will be two contributions to the diameter increase of the rod; the first is due to thermal expansion (which will be denoted as  $\Delta d_1$ ), while the second is from Poisson's lateral expansion as a result of elastic deformation from stresses that are established from the inability of the rod to elongate as it is heated (denoted as  $\Delta d_2$ ). The magnitude of  $\Delta d_1$  may be computed using a modified form of Equation 19.3 as

$$\Delta d_1 = d_0 \alpha_l (T_f - T_0)$$

From Table 19.1 the value of  $\alpha_l$  for brass is 20.0 x 10<sup>-6</sup> (°C)<sup>-1</sup>. Thus,

$$\Delta d_1 = (10.000 \text{ mm}) \left[ 20.0 \text{ x } 10^{-6} (^{\circ}\text{C})^{-1} \right] (160^{\circ}\text{C} - 20^{\circ}\text{C})$$

## = 0.0280 mm

Now,  $\Delta d_2$  is related to the transverse strain ( $\varepsilon_x$ ) according to a modified form of Equation 6.2 as

$$\frac{\Delta d_2}{d_0} = \varepsilon_x$$

Also, transverse strain and longitudinal strain ( $\varepsilon_{z}$ ) are related according to Equation 6.8:

$$\varepsilon_x = -\nu\varepsilon_z$$

where v is Poisson's ratio. Substitution of this expression for  $\varepsilon_x$  into the first equation above leads to

$$\frac{\Delta d_2}{d_0} = -v\varepsilon_z$$

Furthermore, the longitudinal strain is related to the modulus of elasticity through Equation 6.5—i.e.,

$$\varepsilon_z = \frac{\sigma}{E}$$

And, therefore,

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