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 $10^{-6}$ $(°C)^{-1}$. Thus,

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

$$= 0.0280 \text{ mm}$$

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

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

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

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

And, therefore,