Chapter 12

$$\text{Elastic modulus} \equiv \frac{\text{stress}}{\text{strain}}$$
$$Y \equiv \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F/A}{\Delta L/L_i}$$
$$S \equiv \frac{\text{shear stress}}{\text{shear strain}} = \frac{F/A}{\Delta x/h}$$
$$B \equiv \frac{\text{volume stress}}{\text{volume strain}} = -\frac{\Delta F/A}{\Delta V/V_i} = -\frac{\Delta P}{\Delta V/V_i}$$
$A = \pi r^2,$
$$L_z = I\omega$$
$$\sum \tau_{\text{ext}} = I\alpha$$
$$\mathbf{L}_i = \mathbf{L}_f$$

27. A 200-kg load is hung on a wire having a length of 4.00 m, cross-sectional area 0.200×10^{-4} m^2, and Young's modulus 8.00×10^{10} N/m^2. What is its increase in length?

$$\frac{F}{A} = Y\frac{\Delta L}{L_i}$$

$$\Delta L = \frac{FL_i}{AY} = \frac{(200)(9.80)(4.00)}{(0.200 \times 10^{-4})(8.00 \times 10^{10})} = \boxed{4.90 \text{ mm}}$$

28. Assume that Young's modulus is 1.50×10^{10} N/m^2 for bone and that the bone will fracture if stress greater than 1.50×10^{8} N/m^2 is imposed on it. (a) What is the maximum force that can be exerted on the femur bone in the leg if it has a minimum effective diameter of 2.50 cm? (b) If this much force is applied compressively, by how much does the 25.0-cm-long bone shorten?

(a) $$\text{stress} = \frac{F}{A} = \frac{F}{\pi r^2}$$

$$F = (\text{stress})\pi\left(\frac{d}{2}\right)^2$$

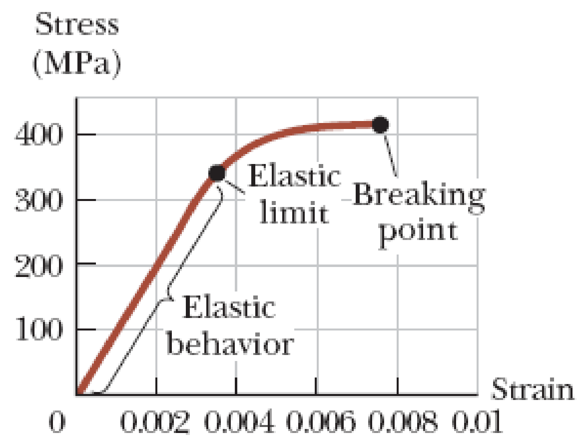
$$F = \left(1.50 \times 10^{8} \text{ N/m}^2\right)\pi\left(\frac{2.50 \times 10^{-2} \text{ m}}{2}\right)^2$$

$$F = \boxed{73.6 \text{ kN}}$$

(b) $$\text{stress} = Y(\text{strain}) = \frac{Y\Delta L}{L_i}$$

$$\Delta L = \frac{(\text{stress})L_i}{Y} = \frac{\left(1.50 \times 10^{8} \text{ N/m}^2\right)(0.250 \text{ m})}{1.50 \times 10^{10} \text{ N/m}^2} = \boxed{2.50 \text{ mm}}$$

29. Evaluate Young's modulus for the material whose stress-versus-strain curve is shown in Figure 12.15.



The definition of $Y = \dfrac{\text{stress}}{\text{strain}}$ means that Y is the slope of the graph:

$$Y = \frac{300 \times 10^6 \text{ N/m}^2}{0.003} = \boxed{1.0 \times 10^{11} \text{ N/m}^2}.$$

33. If the shear stress in steel exceeds 4.00×10^8 N/m^2, the steel ruptures. Determine the shearing force necessary to (a) shear a steel bolt 1.00 cm in diameter and (b) punch a 1.00-cm-diameter hole in a steel plate 0.500 cm thick.

(a) $F = (A)(\text{stress})$

$$= \pi\left(5.00 \times 10^{-3} \text{ m}\right)^2\left(4.00 \times 10^8 \text{ N/m}^2\right)$$

$$= \boxed{3.14 \times 10^4 \text{ N}}$$

(b) The area over which the shear occurs is equal to the circumference of the hole times its thickness. Thus,

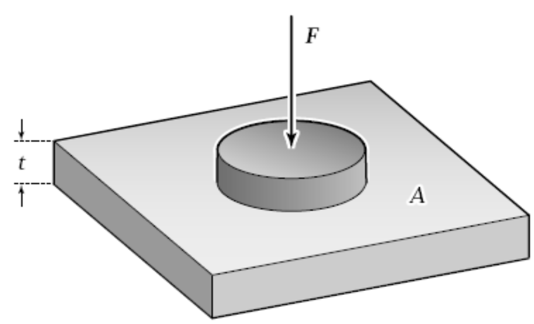


FIG. P12.33

$$A = (2\pi r)t = 2\pi\left(5.00 \times 10^{-3} \text{ m}\right)\left(5.00 \times 10^{-3} \text{ m}\right)$$

$$= 1.57 \times 10^{-4} \text{ m}^2$$

So, $F = (A)\text{Stress} = \left(1.57 \times 10^{-4} \text{ m}^2\right)\left(4.00 \times 10^8 \text{ N/m}^2\right) = \boxed{6.28 \times 10^4 \text{ N}}$.