CHAPTER 10 | SIMPLE HARMONIC MOTION AND ELASTICITY

47. **REASONING AND SOLUTION** The amount of compression can be obtained from Equation 10.17,

\[ F = Y \left( \frac{\Delta L}{L_0} \right) A \]

where \( F \) is the magnitude of the force on the stand due to the weight of the statue. Solving for \( \Delta L \) gives

\[
\Delta L = \frac{F L_0}{YA} = \frac{mgL_0}{YA} = \frac{(3500 \text{ kg})(9.80 \text{ m/s}^2)(1.8 \text{ m})}{(2.3 \times 10^{10} \text{ N/m}^2)(7.3 \times 10^{-2} \text{ m}^2)} = 3.7 \times 10^{-5} \text{ m}
\]

61. **REASONING** The strain in the wire is given by \( \Delta L / L_0 \). From Equation 10.17, the strain is therefore given by

\[
\frac{\Delta L}{L_0} = \frac{F}{YA}
\]

where \( F \) must be equal to the magnitude of the centripetal force that keeps the stone moving in the circular path of radius \( R \).

**SOLUTION** Combining Equation (1) with Equation 5.3 for the magnitude of the centripetal force, we obtain

\[
\frac{\Delta L}{L_0} = \frac{F}{Y(\pi r^2)} = \frac{(mv^2 / R)}{Y(\pi r^2)} = \frac{(8.0 \text{ kg})(12 \text{ m/s})^2 / (4.0 \text{ m})}{(2.0 \times 10^{11} \text{ Pa})\pi(1.0 \times 10^{-3} \text{ m})^2} = 4.6 \times 10^{-4}
\]

65. **REASONING** Equation 10.20 can be used to find the fractional change in volume of the brass sphere when it is exposed to the Venusian atmosphere. Once the fractional change in volume is known, it can be used to calculate the fractional change in radius.

**SOLUTION** According to Equation 10.20, the fractional change in volume is

\[
\frac{\Delta V}{V_0} = -\frac{\Delta P}{B} = -\frac{8.9 \times 10^6 \text{ Pa}}{6.7 \times 10^{10} \text{ Pa}} = -1.33 \times 10^{-4}
\]
The initial volume of the sphere is \( V_0 = \frac{4}{3} \pi r^3 \). If we assume that the change in the radius of the sphere is very small relative to the initial radius, we can think of the sphere's change in volume as the addition or subtraction of a spherical shell of volume \( \Delta V \), whose radius is \( r \) and whose thickness is \( \Delta r \). Then, the change in volume of the sphere is equal to the volume of the shell and is given by \( \Delta V = (4 \pi r^2) \Delta r \). Combining the expressions for \( V_0 \) and \( \Delta V \), and solving for \( \Delta r / r \), we have

\[
\frac{\Delta r}{r} = \frac{1}{3} \frac{\Delta V}{V_0}
\]

Therefore,

\[
\frac{\Delta r}{r} = \frac{1}{3} (-1.33 \times 10^{-4}) = -4.4 \times 10^{-5}
\]

67. **REASONING AND SOLUTION** According to Equation 10.6, \( \omega = 2 \pi f \). The maximum speed and maximum acceleration of the atoms may be calculated from Equations 10.8 and 10.10, respectively.

a. Combining Equations 10.6 and 10.8, we obtain

\[
v_{\text{max}} = \omega A = (2 \pi f) A = 2 \pi (2.0 \times 10^{12} \text{ Hz})(1.1 \times 10^{-11} \text{ m}) = 140 \text{ m/s}
\]

b. Combining Equations 10.6 and 10.10, we obtain

\[
a_{\text{max}} = \omega^2 A = (4 \pi^2 f^2) A = 4 \pi^2 (2.0 \times 10^{12} \text{ Hz})^2 (1.1 \times 10^{-11} \text{ m}) = 1.7 \times 10^{15} \text{ m/s}^2
\]