Physics 151 Class Exercise: Elasticity

1. A steel wire 4.5 m long stretches 0.15 cm when it is given a tension of 370 N. **(a)** What is the diameter of the wire? **(b)** If it is desired that the stretch be less than 0.15 cm, should its diameter be increased or decreased? Explain.

(a)
$$F = Y\left(\frac{\Delta L}{L_0}\right)A$$

$$F = Y\left(\frac{\Delta L}{L_0}\right)\left(\frac{\pi D^2}{4}\right)$$

$$D = \sqrt{\frac{4F}{\pi Y}\left(\frac{L_0}{\Delta L}\right)}$$

$$= \sqrt{\frac{4(370 \text{ N})}{\pi\left(20\times10^{10} \frac{\text{N}}{\text{m}^2}\right)}\left(\frac{4.5 \text{ m}}{0.0015 \text{ m}}\right)}$$

$$= \boxed{0.27 \text{ cm}}$$

(b) The diameter should be $\boxed{\text{increased}}$ because a wire's cross-sectional area and its elongation are inversely related.

2. The American naturalist Charles William Beebe (1877–1962) set a world record in 1934 when he made a dive to a depth of 923 m below the surface of the ocean. The dive was made in a device known as the bathysphere, which was basically a steel sphere 4.75 ft in diameter. How much did the volume of the sphere change as it was lowered to its record depth?

$$\Delta P = -B\left(\frac{\Delta V}{V_0}\right)$$

$$\Delta V = \frac{(\Delta P)V_0}{-B}$$

$$= \frac{\rho_w gh\left(\frac{\pi}{6}D_0^3\right)}{-B}$$

$$= \frac{\left(1025 \frac{\text{kg}}{\text{m}^3}\right)\left(9.81 \frac{\text{m}}{\text{s}^2}\right)(923 \text{ m})\frac{\pi}{6}\left[(4.75 \text{ ft})\left(\frac{1 \text{ m}}{3.281 \text{ ft}}\right)\right]^3}{-16\times10^{10} \frac{\text{N}}{\text{m}^2}}$$

$$\Delta V = \boxed{-9.2\times10^{-5} \text{ m}^3}$$