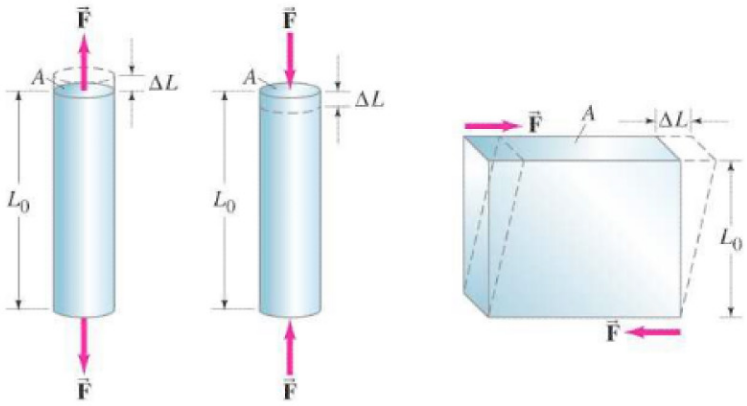

FIGURE 9–22 The three types of stress for rigid objects.

Figure 9–22 compares tensile and compressive stresses as well as the third type, shear stress. An object under **shear stress** has equal and opposite forces applied *across* its opposite faces. A simple example is a book or brick firmly attached to a tabletop, on which a force is exerted parallel to the top surface. The table exerts an equal and opposite force along the bottom surface. Although the dimensions of the object do not change significantly, the shape of the object does change, Fig. 9–22c. An equation similar to Eq. 9–4 can be applied to calculate shear strain:

Shear

$$\Delta L = \frac{1}{G}\frac{F}{A}L_0, \tag{9–6}$$

but ΔL, L_0, and A must be reinterpreted as indicated in Fig. 9–22c. Note that A is the area of the surface *parallel* to the applied force (and not perpendicular as for tension and compression), and ΔL is *perpendicular* to L_0. The constant of proportionality G is called the **shear modulus** and is generally one-half to one-third the value of Young's modulus E (see Table 9–1). Figure 9–23 illustrates why $\Delta L \propto L_0$: the fatter book shifts more for the same shearing force.

Shear modulus

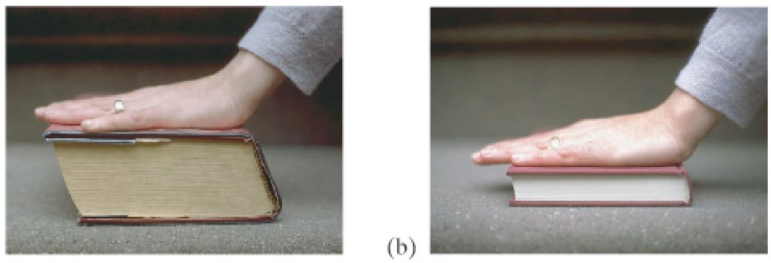

FIGURE 9–23
The fatter book (a) shifts more than the thinner book (b) with the same applied shear force.

* Volume Change—Bulk Modulus

If an object is subjected to inward forces from all sides, its volume will decrease. A common situation is an object submerged in a fluid; in this case, the fluid exerts a pressure on the object in all directions, as we shall see in Chapter 10. *Pressure* is defined as force per unit area, and thus is the equivalent of stress. For this situation the change in volume, ΔV, is proportional to the original volume, V_0, and to the change in the pressure, ΔP. We thus obtain a relation of the same form as Eq. 9–4 but with a proportionality constant called the **bulk modulus** B:

$$\frac{\Delta V}{V_0} = -\frac{1}{B}\Delta P \tag{9–7}$$

or

Bulk modulus defined

$$B = -\frac{\Delta P}{\Delta V/V_0}.$$

The minus sign means the volume *decreases* with an increase in pressure.