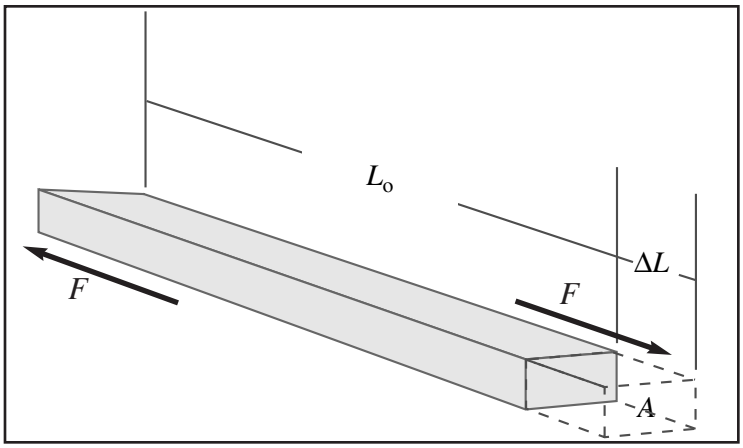
Elasticity

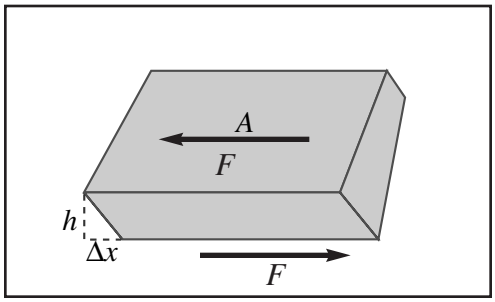
A discussion of **elasticity** focuses on solid body deformations and the forces that cause such deformations. The **stress** upon a body is a quantity that depends upon the forces causing deformation. The **strain** measures the degree to which the body is deformed. Different materials are deformed to a greater or lesser degree by applied force. For deformations which obey Hooke's law, in that the force of compression is proportional to displacement from equilibrium, the elasticity of a material is quantified by the **elastic modulus**, the ratio of stress to strain:

The elastic modulus applies up to the *elastic limit* (the *yield point*), beyond which the stress produces such a strain that, when the force is removed, the object does not return to its original shape. Even further beyond the yield point one can reach the *breaking point.*

There are three types of elastic modulus for the three major kinds of deformation. **Young's modulus** describes the deformation pictured at right. This modulus is the ratio of *tensile stress*, (the ratio of the external force to cross-sectional area) to *tensile strain* (the ratio of the change in length to original length):



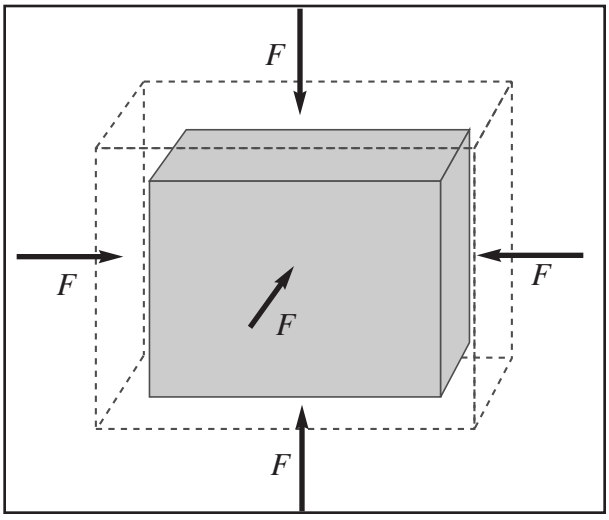
$$\text{Young's modulus} = \frac{F/A}{\Delta L/L_o}$$



The **shear modulus** describes the type of deformation, pictured at lower left, which occurs when an object is subjected to a tangential force on one of its faces while the other is held in a fixed position. The *shear stress* is computed by taking the ratio of the force applied to the area of one of the faces. The *shear strain* is the ratio of the horizontal distance the sheared face moves to the height of the object.

$$\text{shear modulus} = \frac{F/A}{\Delta x/h}$$

At right is pictured the type of deformation described by the **bulk modulus**. This type of deformation occurs when an object is subjected to a uniform pressure on all of its faces. The *volume stress* can be found by taking the ratio of the force on each face to the area (pressure). The *volume strain* is the ratio of the change in the object's volume to its original volume.



$$\text{bulk modulus} = -\frac{F/A}{\Delta V/V}$$