50.2: Longitudinal (Normal) Stress

In longitudinal (or normal) stress, the applied force is normal (perpendicular) to the surface.

Imagine a metal rod, for example: pulling on both ends of the rod (so as to stretch it to a longer length) is called tensile stress. If instead we push the ends of the rod together (so as to compress the rod to a shorter length), it is called compressional stress. In either case, the area A in Eq. 50.1.2 is the cross-sectional area of the rod; the longitudinal stress is then the force applied to either end of the rod divided by the rod's cross-sectional area.

Strain

When applying a longitudinal stress to the rod, it changes from its original length L_0 to a new deformed length L. Then the longitudinal strain ε is defined by

$$\varepsilon = \frac{\Delta L}{L_0} \tag{50.2.1}$$

where $\Delta L = L - L_0$ is the change in the length of the rod from its original length, and will be positive for tensile stress and negative for compressional stress.

Young's Modulus

In the case of a longitudinal stress, the appropriate elastic modulus is the Young's modulus Y :

$$Y = \frac{F_n L_0}{A \Delta L} \tag{50.2.2}$$

Here F_n is the force applied normal to the area A, L_0 is the original (unstressed) length of the rod, L is the stressed length of the rod, and $\Delta L = L - L_0$.