50.1: Introduction to Elasticity

We have generally been treating solid bodies as if they are infinitely rigid, and do not deform when forces are applied to them, and this is often not a bad approximation. But in the real world, solid bodies do deform somewhat, and we sometimes need to allow for these deformation effects. Elasticity refers to the ability of a material to be deformed somewhat, then return to its original state. Broadly speaking, we apply a stress (deforming force) to a body, which produces a strain (deformation). The body responds following a law similar to Hooke's law:

$$\sigma = E\varepsilon \tag{50.1.1}$$

where σ is the stress, ε is the strain, and E is the elastic modulus, which takes the place of the spring constant in Hooke's law.

In Eq. $50.1.1$, the stress σ and elastic modulus E both have units of $\mathrm{N/m^2}$; the strain ε is dimensionless.

There are different types of stress, depending on the method by which the body is deformed. The three main categories are (1) longitudinal (or normal) stress, (2) transverse (or shear) stress, and (3) volume stress. In all cases, the stress σ is defined as the force F applied to the body, divided by the area A over which the force acts:

$$\sigma = \frac{F}{A} \tag{50.1.2}$$

There are three types of elastic moduli, depending on the stress involved: the Young's modulus, shear modulus, and bulk modulus. These moduli are described below.