Wednesday warm-up: Forces IV

Prof. Jordan C. Hanson

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1 Memory Bank

- Spring force: $\vec{s} = -k\Delta\vec{x}$, where k is the spring constant and $\Delta\vec{x}$ is the displacement.
- Young's Modulus, Y, has units of N m^{-2}, and it relates the change in length ΔL of a system of original length L_0 and cross-sectional area A subject to a force F:

$$\frac{\Delta L}{L_0} = \frac{1}{Y}\frac{F}{A} \tag{1}$$

- Shear Modulus, S, has units of N m^{-2}, and it relates the sideways change in length Δx of a system of length L_0 and cross-sectional area A subject to a force F:

$$\frac{\Delta x}{L_0} = \frac{1}{S}\frac{F}{A} \tag{2}$$

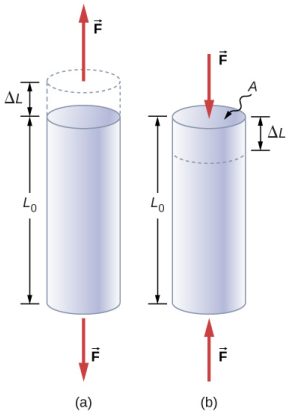

Figure 1: Stress equals Y times strain.

2 Springs and Restoring Forces

1. Calculate the change in length of the upper leg bone (the femur) when a 70.0 kg man supports 62.0 kg of his mass on it, assuming the bone to be equivalent to a uniform rod that is 40.0 cm long and 2.00 cm in radius. Young's Modulus for bone is 9×10^9 N m^{-2}.

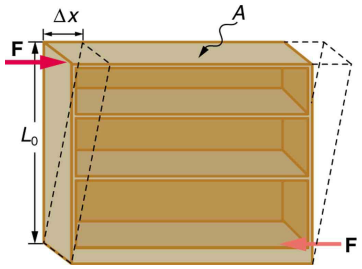

Figure 2: Stress equals S times shear.

2. Find the mass of the picture hanging from a steel nail, given that the nail bends only 1.80 microns (10^{-6} m). The shear modulus is 80×10^9 N m^{-2}.

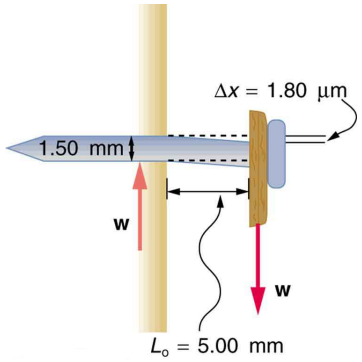

Figure 3: Stress equals S times shear.

3. Suppose three springs with equal k constants are connected *in series* (back to back). If the springs have original length L_0, what is the total length if a mass m is hung from them?