Problem 2.7-9 A slightly tapered bar $AB$ of rectangular cross section and length $L$ is acted upon by a force $P$ (see figure). The width of the bar varies uniformly from $b_2$ at end $A$ to $b_1$ at end $B$. The thickness $t$ is constant.

(a) Determine the strain energy $U$ of the bar.
(b) Determine the elongation $\delta$ of the bar by equating the strain energy to the work done by the force $P$.

Problem 2.7-11 A block $B$ is pushed against three springs by a force $P$ (see figure). The middle spring has stiffness $k_1$, and the outer springs each have stiffness $k_2$. Initially, the springs are unstressed and the middle spring is longer than the outer springs (the difference in length is denoted $s$).

(a) Draw a force-displacement diagram with the force $P$ as ordinate and the displacement $x$ of the block as abscissa.
(b) From the diagram, determine the strain energy $U_1$ of the springs when $x = 2s$.
(c) Explain why the strain energy $U_1$ is not equal to $P\delta/2$, where $\delta = 2s$.

Problem 2.10-3 A flat bar of width $b$ and thickness $t$ has a hole of diameter $d$ drilled through it (see figure). The hole may have any diameter that will fit within the bar.

What is the maximum permissible tensile load $P_{\text{max}}$ if the allowable tensile stress in the material is $\sigma_t$?

Problem 2.12-8 A rigid bar $ACB$ is supported on a fulcrum at $C$ and loaded by a force $P$ at end $B$ (see figure). Three identical wires made of an elastoplastic material (yield stress $\sigma_y$ and modulus of elasticity $E$) resist the load $P$. Each wire has cross-sectional area $A$ and length $L$.

(a) Determine the yield load $P_y$ and the corresponding yield displacement $\delta_y$ at point $B$.
(b) Determine the plastic load $P_p$ and the corresponding displacement $\delta_p$ at point $B$ when the load just reaches the value $P_p$.
(c) Draw a load-displacement diagram with the load $P$ as ordinate and the displacement $\delta_p$ of point $B$ as abscissa.

Problem 2.11-1 A bar $AB$ of length $L$ and weight density $\gamma$ hangs vertically under its own weight (see figure). The stress-strain relation for the material is given by the Ramberg-Osgood equation (Eq. 2-71):

$$\epsilon = \frac{\sigma}{E} + \frac{\sigma_0}{E} \left( \frac{\sigma}{\sigma_0} \right)^m$$

Derive the following formula

$$\delta = \frac{\gamma L^2}{2E} + \frac{\sigma_0 \alpha L}{(m+1)E} \left( \frac{\gamma L}{\sigma_0} \right)^m$$

for the elongation of the bar.