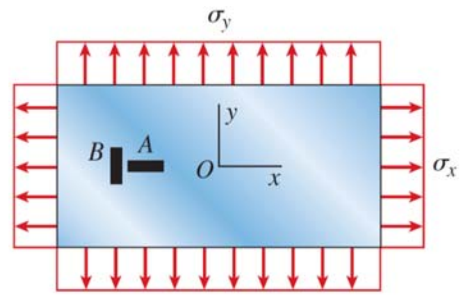
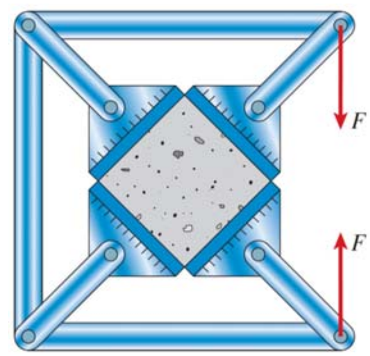
Mechanics of Materials I
Homework assignment # 3

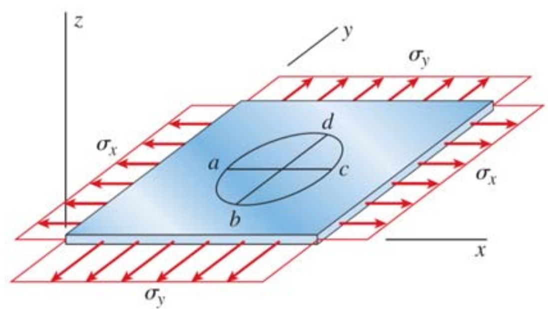
Problem 1. A rectangular steel plate with thickness t=0.25 in is subjected to uniform normal stresses σ_x and σ_y, as shown in the figure. Strain gages A and B, oriented in the x and y directions, respectively, are attached to the plate. The gage readings give normal strains $\epsilon_x = 0.0010$ (elongation) and $\epsilon_y = -0.0007$ (shortening). Knowing that $E = 30 \times 10^6$ psi and $\vartheta = 0.3$, determine the stresses σ_x and σ_y and the change Δt in the thickness of the plate.



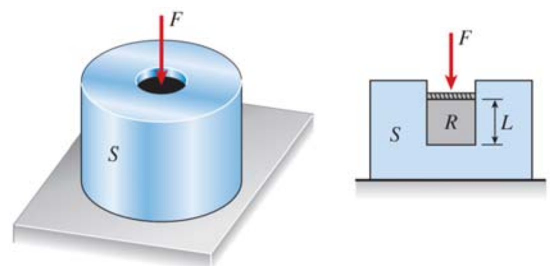
Problem 2. A 4.0-inch cube of concrete ($E = 3.0 \times 10^6$ psi and $\vartheta = 0.1$) is compressed in biaxial stress by means of a framework that is loaded as shown in the figure. Assuming that each load equals 20 kips, determine the change ΔV in the volume of the cube.



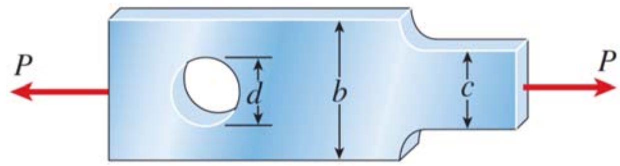
Problem 3. A circle of diameter d=200 mm is etched on a brass plate (see figure). The plate has dimensions $400 \times 400 \times 20$ mm. Forces are applied to the plate, producing uniformly distributed normal stresses $\sigma_x = 42$ MPa and $\sigma_y = 14$ MPa.
Calculate the following quantities: (a) the change in length Δ_{ac} of diameter ac; (b) the change in length Δ_{bd} of diameter bd; (c) the change Δ_t in the thickness of the plate; (d) the change ΔV in the volume of the plate. (Assume E=100 GPa and $\vartheta = 0.34$.)



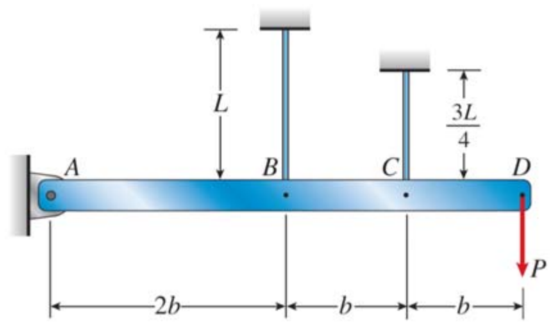
Problem 4. A rubber cylinder R of length L and cross-sectional area A is compressed inside a steel cylinder S by a force F that applies a uniformly distributed pressure to the rubber (see figure).
(a) Derive a formula for the lateral pressure between the rubber and the steel. (Disregard friction between the rubber and the steel, and assume that the steel cylinder is rigid when compared to the rubber.) (b) Derive a formula for the shortening δ of the rubber cylinder.



Problem 5. A stepped bar with a hole (see figure) has widths b=2.4 in and c=1.6 in. The fillets have radii equal to 0.2 in.
What is the diameter d_{max} of the largest hole that can be drilled through the bar without reducing the load-carrying capacity?

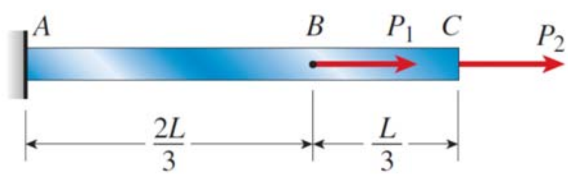


Problem 6. The structure shown in the figure consists of a horizontal rigid bar ABCD supported by two steel wires, one of length L and the other of length 3L/4. Both wires have cross-sectional area A and are made of elastoplastic material with yield stress σ_Y and modulus of elasticity E. A vertical load P acts at end D of the bar. (a) Determine the yield load P_Y and the corresponding yield displacement σ_Y at point D. (b) Determine the plastic load P_P and the corresponding displacement δ_P at point D when the load just reaches the valueP_P. (c) Draw a load-displacement diagram with the load P as ordinate and the displacement δ_D of point D as abscissa.



Problem 7. A prismatic bar of length L=1.8 m and cross-sectional area $A = 480\ mm^2$ is loaded by forces $P_1 = 30\ kN$ and $P_2 = 60\ kN$ (see figure). The bar is constructed of magnesium alloy having a stress-strain curve described by the following Ramberg-Osgood equation:

$$\epsilon = \frac{\sigma}{45000} + \frac{1}{618}\left(\frac{\sigma}{170}\right)^{10} \qquad (\sigma = MPa)$$



in which σ has units of megapascals.
(a) Calculate the displacement δ_C of the end of the bar when the load P_1 acts alone. (b) Calculate the displacement when the load P_2 acts alone. (c) Calculate the displacement when both loads act simultaneously.