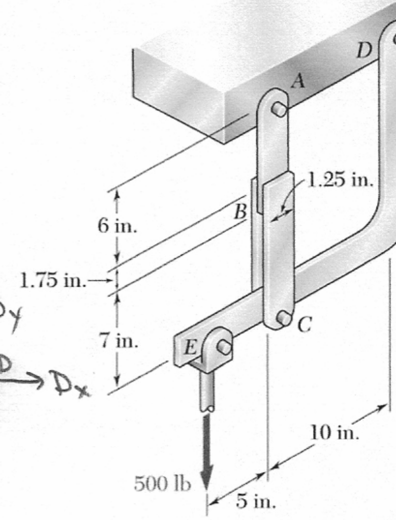
MULTIPLE CHOICE PROBLEMS (10 Points each)

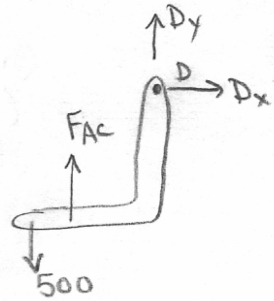
1. In the hanger shown, the upper portion of link *ABC* is 3/8 in. thick and the lower portions are each ¼ in. thick. Epoxy resin is used to bond the upper and lower portions together at *B*. The pin at *A* is of 3/8 in. diameter. The shearing stress in pin *A* is most nearly



(a) 6790 psi
(b) 3400 psi
(c) 2530 psi
(d) 1260 psi
(e) 1070 psi

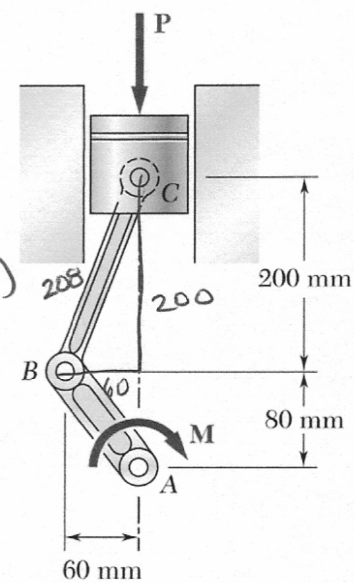
$$\circlearrowleft \Sigma M_D = 0 = (500\text{lb})(15\text{in}) - F_{AC}(10\text{in})$$

$$F_{AC} = 750\text{lb}$$



$$\tau_A = \frac{F_{AC}}{A_{pin}} = \frac{750\text{lb}}{\frac{\pi}{4}\left(3/8\text{in}\right)^2} = 6790\text{ psi}$$

2. A couple **M** of magnitude 1500 N·m is applied to the crank of an engine. For the position shown, the average normal stress in connecting rod *BC* which has a 450-mm^2 uniform cross section is most nearly

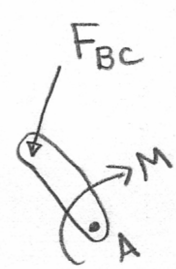


(a) -20.7 MPa
(b) -41.4 MPa
(c) -3.33 MPa
(d) -6.66 MPa
(e) -10.4 MPa

$$\vec{F}_{BC} = -F_{BC}\frac{60}{208}\uparrow - F_{BC}\frac{200}{208}$$

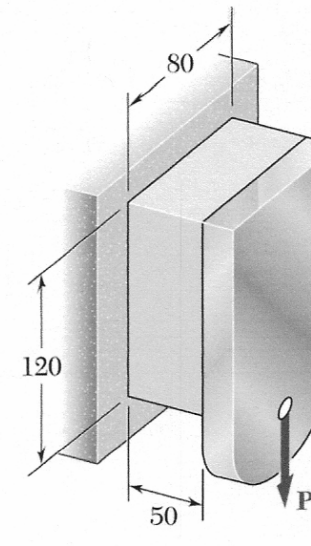
$$\circlearrowleft \Sigma M_A = 0 = -M + F_{BC}\frac{60}{208}(0.08\text{m}) + F_{BC}\frac{200}{208}(0.06\text{m})$$

$$F_{BC} = 18.64\text{ kN}$$



$$\sigma_{BC} = -\frac{F_{BC}}{A_{BC}} = -\frac{18.64\text{kN}}{450\text{mm}^2} = -41.4\text{ MPa}$$

3. The plastic block shown is bonded to a rigid support and to a vertical plate to which a 240-kN load **P** is applied. If the plastic has a shear modulus of 1050 MPa, the deflection of the plate is most nearly



Dimensions in mm

(a) 18.29 mm
(b) 6.86 mm
(c) 11.43 mm
(d) 2.86 mm
(e) 1.190 mm

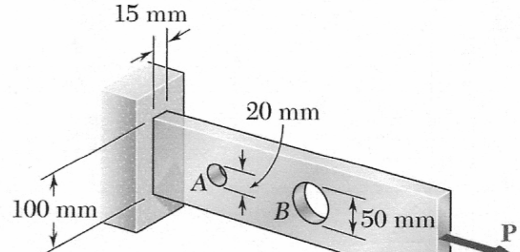
$$\tau = \frac{P}{(80mm)(120mm)} = \frac{240\times10^3 N}{9600 mm^2} = \underline{25 MPa}$$

50 mm, δ, γ

$$\gamma = \frac{\tau}{G} = \frac{\delta}{50mm}$$

$$\delta = \frac{\tau}{G}(50mm) = \frac{25MPa}{1050 MPa}(50mm) = \underline{\underline{1.190mm}}$$

4. Knowing that σ_{ult} = 240 MPa, and that a factor of safety of 2.0 is required, the maximum allowable value of the centric axial load **P** is most nearly



(a) 54.3 kN
(b) 41.7 kN
(c) 143.9 kN
(d) 90.0 kN
(e) 35.3 kN

@A $d = 80mm$

$r = 10 mm$

$\frac{r}{d} = 0.125$

$K = 2.65$

$$P_{all} = \frac{(120 N/mm^2)(15mm)(80mm)}{2.65} = \underline{54.3kN}$$

$$\sigma_{all} = \sigma_{ult}/FS = 240/2 = \underline{120 MPa}$$

$$\sigma_{max} = K\frac{P}{td} = \sigma_{all}$$

$$P_{all} = \frac{\sigma_{all}\,td}{K}$$

@ B $d = 50mm$

$r = 25mm$

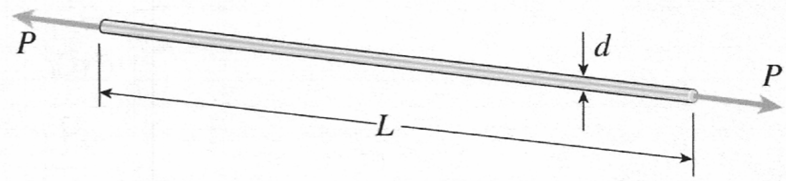
$\frac{r}{d} = 1/2$

$K = 2.16$

$$P_{all} = \frac{(120 N/mm^2)(15mm)(50mm)}{2.16} = \underline{\underline{41.7 kN}}$$

5. An aluminum wire having a diameter $d = 2$ mm and length $L = 3.8$ m is subjected to a tensile load P (see figure). The aluminum has a modulus of elasticity $E = 75$ GPa. If the maximum permissible elongation of the wire is 3.0 mm and the allowable stress in tension is 60 MPa, the allowable load P_{max} is most nearly

(a) 189 N
(b) 186 N
(c) 183 N
(d) 180 N
(e) 177 N



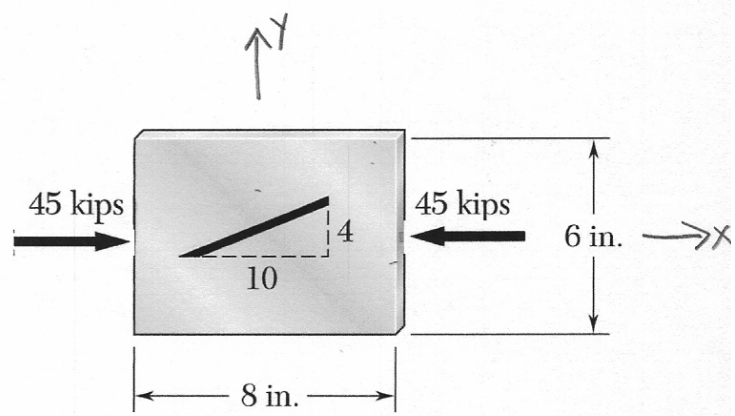
$$\delta = \frac{PL}{AE}$$

$$P_{max} = \frac{\delta AE}{L} = \frac{(0.003\,m)\frac{\pi}{4}(0.002\,m)^2(75\times10^9\,N/m^2)}{3.8\,m} = \underline{\underline{186N}}$$

$$\sigma = \frac{P}{A}$$

$$P_{max} = \sigma_{all} A = (60\times10^6\,N/m^2)\left(\frac{\pi}{4}\right)(0.002\,m)^2 = \underline{188.5\,N}$$

6. A line of slope 4:10 has been scribed on a cold-rolled yellow-brass plate, 6 in. wide and 0.25 in. thick. For this material, $E = 15\text{x}10^6$ psi and $\nu = 0.34$. The slope of the line when a 45-kip compressive centric axial load is applied is most nearly



(a) 3.99728:10.02 (0.39893)
(b) 6:8 (0.75)
(c) 4.99592:8.016 (0.62324)
(d) 4.00272:10.02 (0.39947)
(e) 4.00272:9.98 (0.40107)

$$\sigma_x = \frac{P}{A} = \frac{45\text{ kips}}{(6in)(0.25in)} = \underline{-30\text{ ksi}}$$

$$\varepsilon_x = \frac{1}{E}\sigma_x = \frac{-30\times10^3\,psi}{15\times10^6\,psi} = -0.002$$

$$\varepsilon_y = -\frac{\nu}{E}\sigma_x = -\frac{0.34}{15\times10^6\,psi}(-30\times10^3\,psi) = +6.8\times10^{-4}$$

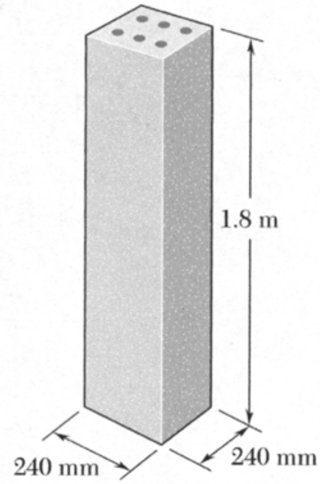
$$L_x' = L_x(1+\varepsilon_x) = 10(1-0.002) = 9.98$$

$$L_y' = L_y(1+\varepsilon_y) = 4(1+6.8\times10^{-4}) = 4.00272$$

WORK OUT PROBLEM (40 Points)

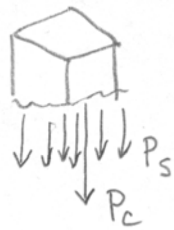
7. The concrete post ($E_c = 25$ GPa and $a_c = 9.9 \times 10^{-6}$ /°C) is reinforced with six steel bars, each of 22-mm diameter ($E_s = 200$ GPa and $a_s = 11.7 \times 10^{-6}$ /°C). If the temperature increases 35°C, determine

   (a) the normal stresses induced in the steel,
   (b) the normal stresses induced in the concrete.



Equilibrium

$$P_c + 6P_s = 0$$



Load-Temperature-Deformation

$$\delta_c = \frac{P_c L}{A_c E_c} + \alpha_c \Delta T L$$

$$\delta_s = \frac{P_s L}{A_s E_s} + \alpha_s \Delta T L$$

Kinematics

$$\delta_c = \delta_s$$

$$\frac{\overset{-6P_s}{\cancel{P_c}} \cancel{L}}{A_c E_c} + \alpha_c \Delta T \cancel{L} = \frac{P_s \cancel{L}}{A_s E_s} + \alpha_s \Delta T \cancel{L}$$

$$(\alpha_c - \alpha_s)\Delta T = \frac{P_s}{A_s E_s} + \frac{6P_s}{A_c E_c} = P_s\left(\frac{1}{A_s E_s} + \frac{6}{A_c E_c}\right)$$

$$P_s = \frac{(\alpha_c - \alpha_s)\Delta T}{\dfrac{1}{A_s E_s} + \dfrac{6}{A_c E_c}}$$

$$= \frac{(9.9\times10^{-6}/°C - 11.7\times10^{-6}/°C)(35°C)}{\dfrac{1}{\frac{\pi}{4}(22\,mm)^2(200\times10^3\,N/mm^2)} + \dfrac{6}{\left[(240\,mm)^2 - 6\cdot\frac{\pi}{4}(22\,mm)^2\right](25\times10^3\,N/mm^2)}}$$

$$= -3600\,N$$

(a) $$\sigma_s = \frac{P_s}{A_s} = \frac{-3600\,N}{\frac{\pi}{4}(22\,mm)^2} = -9.47\,MPa$$

(b) $$P_c = -6P_s = 21610\,N$$

$$\sigma_c = \frac{P_c}{A_c} = 0.391\,MPa$$