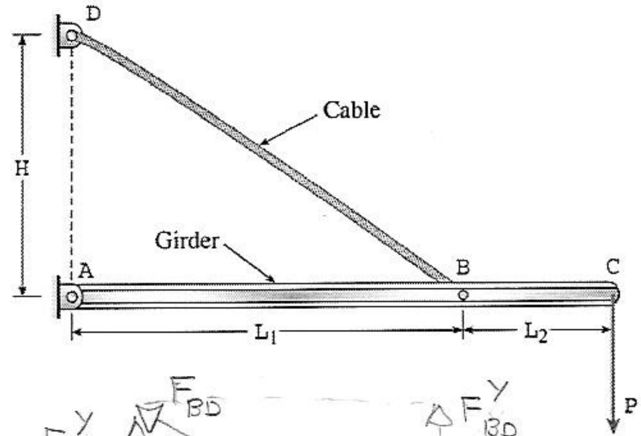
makeup

MULTIPLE CHOICE PROBLEMS (10 Points each)

1. A loading crane consisting of a steel girder ABC supported by a cable BD is subjected to a load $P = 4050$ lb. as shown. The cable has a cross sectional area $A = 0.471$ in^2. The dimensions of the crane are $H = 9$ ft, $L_1 = 12$ ft, and $L_2 = 4$ ft. The average tensile stress in the cable is most nearly

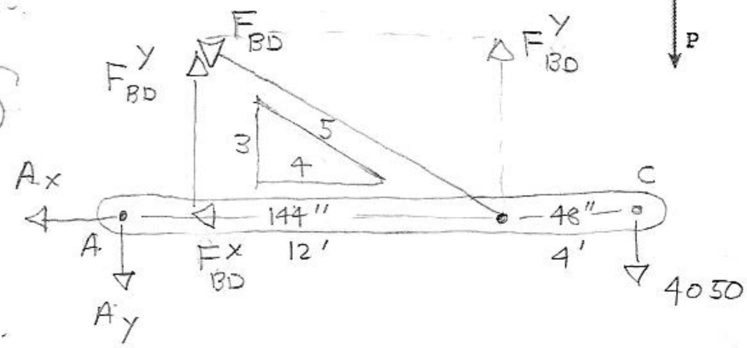


(a) 19.11 ksi
(b) 14.33 ksi
(c) 31.8 ksi
(d) 42.5 ksi
(e) 75.2 ksi

$A = 0.471 \text{ in}^2$

$F_{BD} = 9{,}000 \text{ lb}$

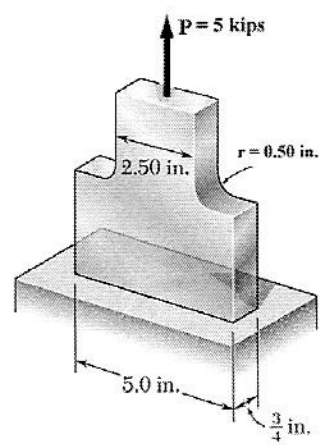
$\circlearrowleft \sum M_{@A} = 0 = \frac{3}{5} F_{BD} \cdot (12') - 4050 \cdot (16')$



$\sigma_{BD} = F_{BD}/A = \frac{19{,}000}{0.471 \text{ in}^2}$

$\boxed{\sigma_{BD} = 19.11 \text{ ksi}}$

2. A flat bar is loaded as shown. The maximum stress in the member is most nearly



(a) 10.35 ksi
(b) 5.33 ksi
(c) 2.67 ksi
(d) 5.17 ksi
(e) 17.06 ksi

$D = 5 \text{ in} \quad r = 0.5 \text{ in}$

$d = 2.5 \text{ in}$

$D/d = 2, \; r/d = 0.2$

$K \cong 1.94$

$\sigma_{ave} = \frac{5000 \text{ lb}}{(2.5)(0.75)}$

$\sigma_{ave} = 2.67 \text{ ksi}$

$\sigma_{max} = K \sigma_{ave} \Rightarrow \boxed{\sigma_{max} = 5.17 \text{ ksi}}$

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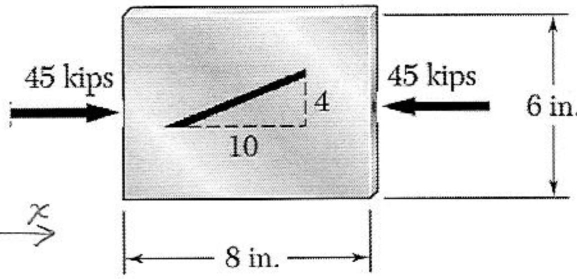
3. A line of slope 4:10 has been scribed on a cold-rolled yellow-brass plate, 6 in. wide and 0.25 in. thick. For this material, $E = 15\times10^6$ psi and $\nu = 0.34$. The slope of the line when a 45-kip compressive centric axial load is applied is most nearly

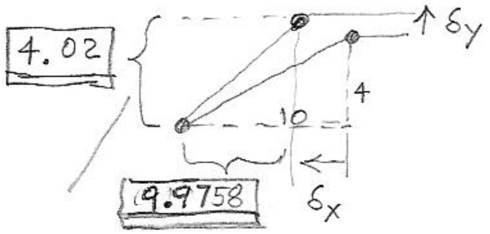


(a) 3.99728:10.02 (0.39893)
(b) 6:8 (0.75)
(c) 4.99592:8.016 (0.62324)
(d) 4.00272:10.02 (0.39947)
(e) 4.00272:9.98 (0.40107) ← (e)

$$\sigma_x = \frac{P}{A} = \frac{-45{,}000\,\text{lb}}{(6)(0.25)\,\text{in}^2} = -30\,\text{ksi}$$

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

$$\epsilon_y = -\nu\epsilon_x = +6.8\times10^{-4}$$

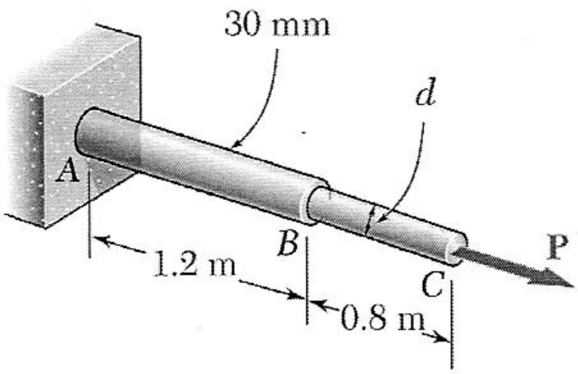


$$\delta_x = \epsilon_x \cdot 10 = -0.02$$

$$\delta_y = \epsilon_y \cdot 4 = +0.00242$$

$$\begin{array}{r} 10.00000 \\ -.00242 \\ \hline 0.99758 \end{array}$$

4. A single axial load of magnitude $P = 44$ kN is applied at the end C of the brass rod ABC. Knowing that $E =$ 105 GPa, the diameter d of portion BC for which the deflection of point C is 3 mm is most nearly



(a) 25.2 mm
(b) 16.52 mm
(c) 13.69 mm ← (c)
(d) 19.35 mm
(e) 10.86 mm

$$\delta_c = \frac{PL_{AB}}{A_{AB}E} + \frac{PL_{BC}}{A_{BC}E}$$

$$A_{BC} = \frac{PL_{BC}}{\left(\delta_c - \frac{PL_{AB}}{A_{AB}E}\right)E}$$

$$= \frac{44{,}000\,(0.8\,\text{m})}{\left(0.003\,\text{m} - \underbrace{\frac{(44\times10^3\,\text{N})(1.2\,\text{m})}{\frac{\pi}{4}(0.03\,\text{m})^2(105\times10^9\,\text{N/m}^2)}}_{7.113\times10^{-4}}\right)105\times10^9\,\text{N/m}^2}$$

$$A_{BC} = 146.4\times10^{-6}\,\text{m}^2$$

$$= \frac{44\times10^3\,(0.8)}{0.2403\times10^9}$$

$$d_{BC} = \sqrt{\frac{4}{\pi}A_{BC}}$$

$$d_{BC} = \sqrt{0.1864\times10^{-3}}$$

$$d_{BC} = 0.01365\,\text{m}$$

$$\boxed{d_{BC} = 13.65\,\text{mm}}$$

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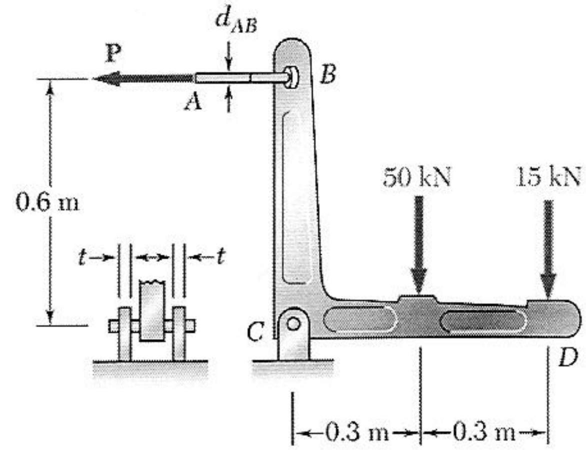
5. Two forces are applied to the bracket *BCD* as shown. The pin at *C* is to be made of a steel having an ultimate shearing stress of 350 MPa, and a factor of safety of 3.3 will be required. From static equilibrium, we know that the reaction components at *C* are C_x = 40 kN and C_x = 65 kN (as shown on the free-body diagram). The required area of the pin at C is most nearly



(a) 360 mm² ← (a)
(b) 720 mm²
(c) 306 mm²
(d) 188.5 mm²
(e) 613 mm²

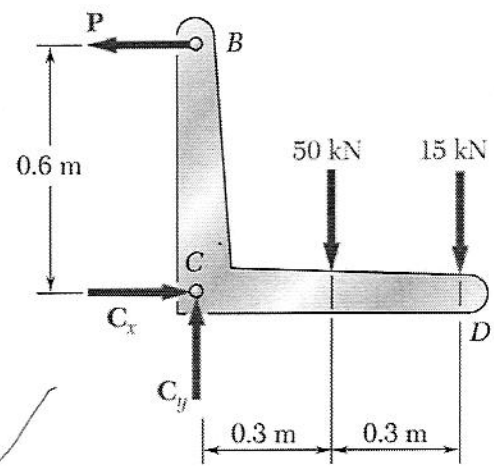
Double Shear

$$\tau_{allow} = \tau = \frac{C/2}{A_{pin}}$$

$$A_{pin} = \frac{C/2}{\tau_{allow}} = \frac{(76.3\times10^3)/2\ \text{N}}{106.1\times10^6\ \text{N/m}^2}$$

$$A_{pin} = 359.5\times10^{-6}\ \text{m}^2$$

$$\boxed{A_{pin} = 359.5\ \text{mm}^2}$$



$$C = \sqrt{C_x^2 + C_y^2}$$

$$= \sqrt{(40\ \text{kN})^2 + (65\ \text{kN})^2}$$

$$C = 76.3\ \text{kN}$$

$$\tau_{allow} = \frac{\tau_{ult}}{F.S.} = \frac{350\ \text{MPa}}{3.3}$$

$$\tau_{allow} = 106.1\ \text{MPa}$$

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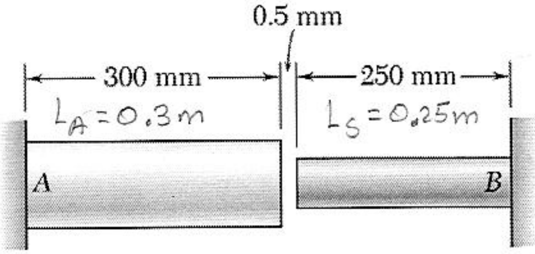
WORK OUT PROBLEM (50 Points) $\Delta T = 140°C$

$\delta_{gap} = 0.5 \times 10^{-3}\,m$
$0.0005\,m$

6. At room temperature (20°C) a 0.5mm gap exists between the ends of the rods shown. At a later time when the temperature has reached 160°C, determine
   (a) the normal stress in the aluminum rod,
   (b) the change in length of the aluminum rod.



Aluminum (A)
$A = 2000\ mm^2$
$E = 75$ GPa
$\alpha = 23 \times 10^{-6}/°C$

Stainless steel (S)
$A = 800\ mm^2$
$E = 190$ GPa
$\alpha = 17.3 \times 10^{-6}/°C$

Thermal only (ΔT)

$$\alpha_A L_A \Delta T + \alpha_S L_S \Delta T = \delta_T$$

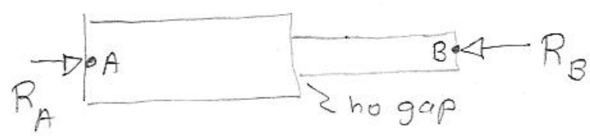
Mechanical only (P)

$$\frac{P_A L_A}{E_A A_A} + \frac{P_S L_S}{E_S A_S} = \delta_P$$

Kinematics (Geometry)

Magnitudes: $\underline{\delta_T = \delta_{gap} + \delta_P}$ (1)

Equlibrium (Kinetics)



$\xrightarrow{+} \sum F_x = 0 = +R_A - R_B$; $\underline{R_A = R_B = R}$ (2)

$\underline{F_A = F_S = -R}$

Substitute δ_T & δ_P into (1) and use (2)

$$(\alpha_A L_A + \alpha_S L_S)\Delta T = +0.5 \times 10^{-3} + R\left(\frac{L_A}{E_A A_A} + \frac{L_S}{E_S A_S}\right) = 0.5 \times 10^{-3}\,m$$

$$\left[(23 \times 10^{-6})\,0.3 + (17.3 \times 10^{-6})\,0.25\right] 140 = R\left(\frac{0.30}{75 \times 10^9\,(0.002)} + \frac{0.25}{190 \times 10^9\,(0.0008)}\right) + 0.5 \times 10^{-3}\,m$$

$$\left[6.9 \times 10^{-6} + 4.325 \times 10^{-6}\right] 140$$

$$1.572 \times 10^{-3} = 0.5 \times 10^{-3} + R\,(2.0 \times 10^{-9} + 1.645 \times 10^{-9})$$

$$\frac{1.072 \times 10^{-3}}{3.645 \times 10^{-9}} = R$$

$\underline{R = 294\ kN}$

(a) $\sigma_A = \dfrac{F_A}{A_A} = \dfrac{-294 \times 10^3}{0.002}$ $\boxed{\sigma_A = -147\,MPa}$

(b) $\delta_A = \dfrac{F_A L_A}{E_A A_A} + \alpha_A L_A \Delta T$

$$\delta_A = \frac{(-294 \times 10^3)(0.3)}{75 \times 10^9\,(0.002)} + (23 \times 10^{-6})(0.3)\,140$$

$$\delta_A = -0.588 \times 10^{-3}\,m + 0.966 \times 10^{-3}\,m$$

$-.588$
$.378 \times 10^{-3}\,m$

$\boxed{\delta_A = +0.378\,mm}$ To the $\rightarrow$ right