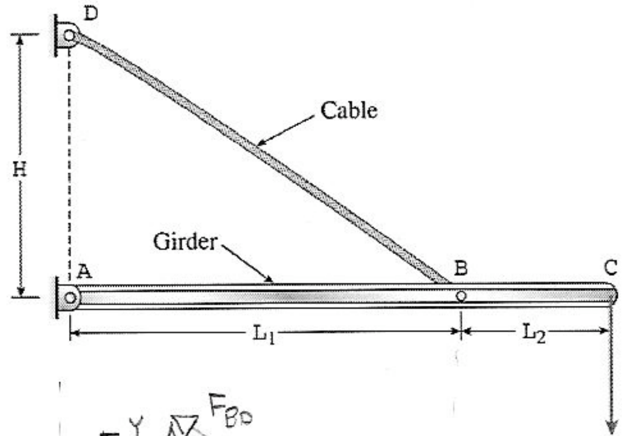
MULTIPLE CHOICE PROBLEMS (10 Points each)

1. A loading crane consisting of a steel girder *ABC* supported by a cable *BD* is subjected to a load $P = 9000$ 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



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

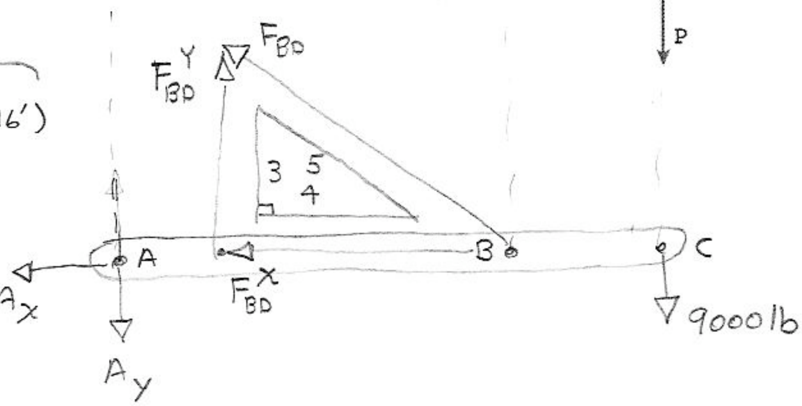
(a) 19.11 ksi
(b) 14.33 ksi
(c) 31.8 ksi
(d) 42.5 ksi
(e) 75.2 ksi

$F_{BD} = 20{,}000$ lb

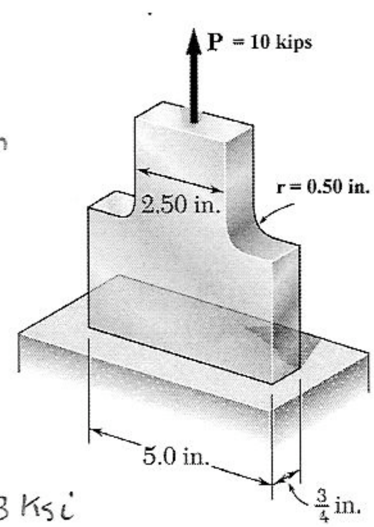
$\circlearrowleft + \sum M_{@A} = 0 = \frac{3}{5} F_{BD} \cdot (12') - 9000\,(16')$

$\sigma_{BD} = F_{BD}/A = \dfrac{20{,}000 \text{ lb}}{0.471 \text{ in}^2}$

$\boxed{\sigma_{BD} = 42.5 \text{ Ksi}}$



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

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

$d = 2.5 \text{ in}$

$\frac{D}{d} = 2 \; , \; \frac{r}{d} = 0.2$

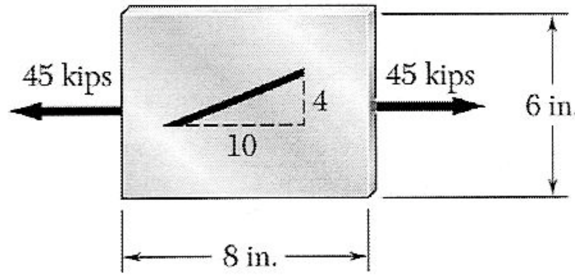
$K \tilde{=} 1.94$

$\sigma_{ave} = \dfrac{P}{A} = \dfrac{10{,}000 \text{ lb}}{(2.5)(0.75) \text{ in}^2} = 5.33 \text{ Ksi}$

$\sigma_{max} = K\,\sigma_{ave} = 1.94\,(5.33)$

$\boxed{\sigma_{max} = 10.35 \text{ Ksi}}$

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, $E = 15 \times 10^6$ psi and $\nu = 0.34$. The slope of the line when a 45-kip centric axial load is applied is most nearly

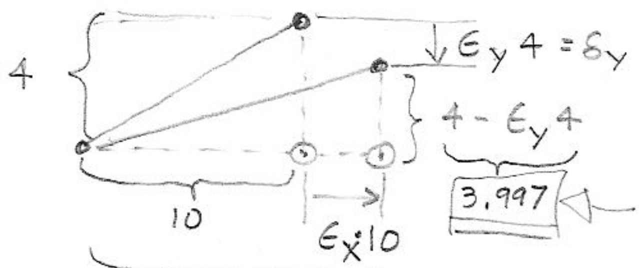


(a) 3.99728:10.02 (0.39893) ← (a)
(b) 6:8 (0.75)
(c) 4.99592:8.016 (0.62324)
(d) 4.00272:10.02 (0.39947)
(e) 4.00272:9.98 (0.40107)

$$\sigma_x = \frac{P}{A} = \frac{45{,}000}{(6)(0.25)} = 30\text{ ksi}$$

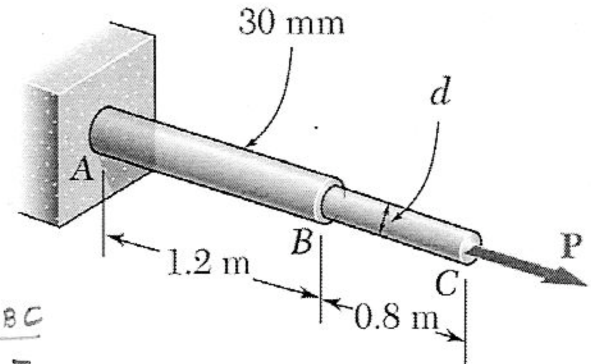
$$\epsilon_x = \frac{+30 \times 10^3}{15 \times 10^6} = +0.002$$

$$\epsilon_y = -\nu \epsilon = -6.8 \times 10^{-4}$$



$$10 + \epsilon_x \cdot 10 = \boxed{10.02} \leftarrow$$

4. A single axial load of magnitude $P = 58$ 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 ← (b)
(c) 13.69 mm
(d) 19.35 mm
(e) 10.86 mm

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

Solve for $A_{BC} = \dfrac{P L_{BC}}{\left(\delta_c - \dfrac{P L_{AB}}{A_{AB} E}\right) E}$

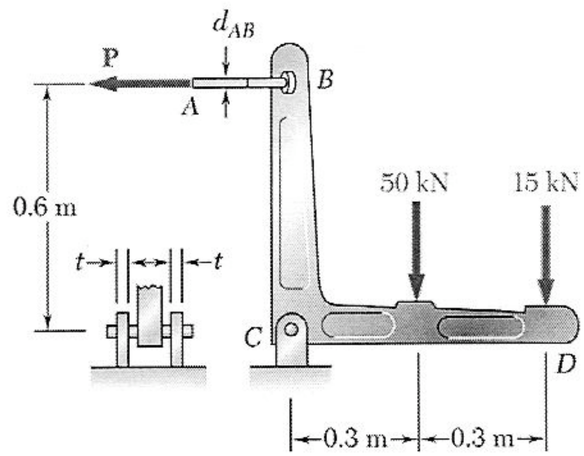
$$A_{BC} = \frac{(58 \times 10^3)(0.8)}{\left[0.003 - \dfrac{58 \times 10^3 \cdot (1.2)}{\frac{\pi}{4}(0.03)(105 \times 10^9)}\right] 105 \times 10^9}$$

$$A_{BC} = 2.14 \times 10^{-4}\ \text{m}^2$$

$$d_{BC} = \sqrt{4 A_{BC}/\pi} = \sqrt{4(2.14 \times 10^{-4})/\pi} = 0.01652\text{m}$$

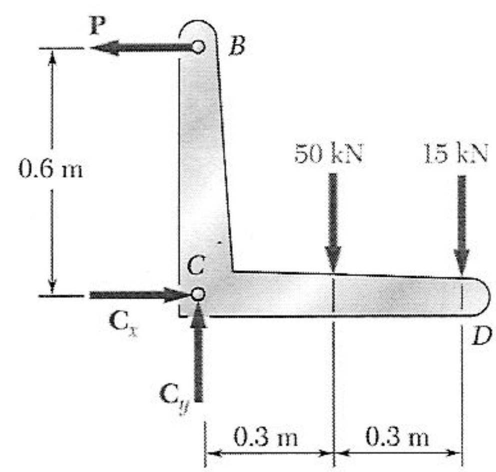
$$\boxed{d_{BC} = 16.52\text{mm}} \leftarrow$$

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 mm^2
(b) 720 mm^2
(c) 306 mm^2
(d) 188.5 mm^2
(e) 613 mm^2

$$C = \sqrt{C_x^2 + C_y^2}$$
$$= \sqrt{(40)^2 + (65)^2}$$
$$C = 76.3 \text{ kN}$$



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

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

Double Shear $\quad \tau = \frac{C/2}{A_{pin}}$, $\quad A_{pin} = \frac{C/2}{\tau_{allow}} = \frac{(76.3 \times 10^3)/2}{106.1 \times 10^9}$

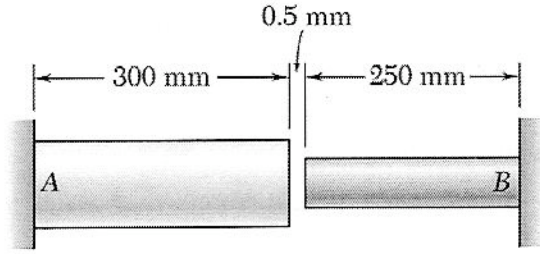
$$\boxed{A_{pin} = 360 \text{mm}^2}$$

WORK OUT PROBLEM (50 Points) $\Delta T = 120^\circ C$

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

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 140°C, determine
   (a) the normal stress in the aluminum rod,
   (b) the change in length of the aluminum rod.

0.0005m



Aluminum (A)	Stainless steel (S)
$A = 2000\ mm^2$	$A = 800\ mm^2$
$E = 75$ GPa	$E = 190$ GPa
$\alpha = 23 \times 10^{-6}/^\circ C$	$\alpha = 17.3 \times 10^{-6}/^\circ C$

Thermal only (ΔT)

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

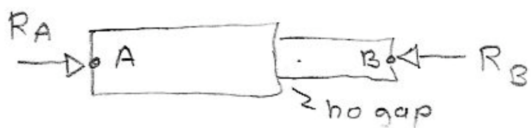
Mechanical only (P)

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

Kinematics (geometry)

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

Equilibrium (Kinetics)



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

$F_A = F_S = -R$

Substitute δ_T & δ_P into (1)

$$(\alpha_A L_A + \alpha_S L_S)\Delta T = \delta_{gap} + R\left(\frac{L_A}{E_A A_A} + \frac{L_S}{E_S A_S}\right)$$

$$\left[(23 \times 10^{-6})0.3 + (17.3 \times 10^{-6})0.25\right]120 = 0.5 \times 10^{-3} + R\left(\frac{0.30}{75 \times 10^9 (0.002)} + \frac{0.25}{190 \times 10^9 (0.0008)}\right)$$

$$\left[6.9 \times 10^{-6} + 4.3 \times 10^{-6}\right]120 = 0.5 \times 10^{-3} + R\,(2.0 \times 10^{-9} + 1.645 \times 10^{-9})$$

$$1.344 \times 10^{-3} = 0.5 \times 10^{-3} + 3.645 \times 10^{-9} R \quad ; \quad R = \frac{0.844 \times 10^{-3}}{3.645 \times 10^{-9}}$$

$R = 232$ kN

(a) $\sigma_A = F_A / A_A = \dfrac{-232 \times 10^3}{0.002}$ $\boxed{\sigma_A = -115.7\ MPa}$

(b) $\delta_A = \dfrac{F_A L_A}{E_A A_A} + \alpha_A L_A \Delta T = \dfrac{-232 \times 10^3 (0.3)}{75 \times 10^9 (0.002)} + (23 \times 10^{-6})(0.3)120$

$\delta_A = -0.464 \times 10^{-3} + 0.828 \times 10^{-3}$

$-.464$

$\boxed{\delta_A = +0.364\ mm}$