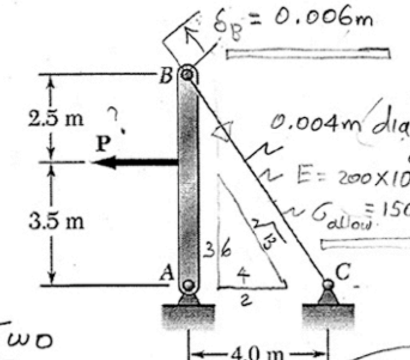
$\sqrt{2^2+3^2} = \sqrt{13}$

$l_{BC} = \sqrt{6^2+4^2} = \sqrt{52} \quad l_{BC} = 7.21$

MULTIPLE CHOICE PROBLEMS (10 Points each)

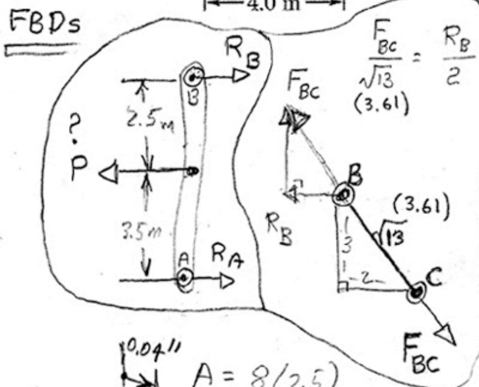
1. The 4-mm diameter cable *BC* is made of a steel with $E = 200$ GPa. Knowing that the maximum stress in the cable must not exceed 150 MPa and that the elongation of the cable must not exceed 6 mm, the maximum load **P** that can be applied as shown is most nearly
   (a) 1884 N
   (b) 2091 N
   (c) 1989 N
   (d) 1792 N
   (e) 2677 N



$\overset{+}{\curvearrowleft}\sum M_{@A} = 0 = +3.5P - 6.0\,R_B$

$R_B = 0.583\,P$

Two FBDs



$0.006_m = \delta_{BC} = \dfrac{F_{BC}L_{BC}}{E_{BC}A_{BC}} = 0.006\,m = \dfrac{\frac{3.61}{2}(0.583)P(7.21)}{200\times10^9\,\frac{\pi}{4}(0.004)^2}$

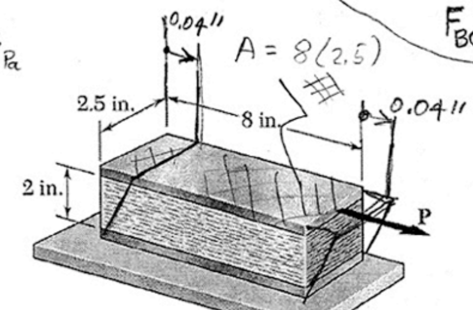
Solve for P

$\delta \quad P = \dfrac{0.006(200\times10^9)\pi(0.004)^2}{2(3.61)(0.583)(7.21)}, \quad \boxed{P = 1988\,N}$ For $\delta = 6\,mm$

$\sigma_{allow} \quad \sigma_{BC}^{allow} = 150\times10^6 = \dfrac{F_{BC}}{A_{BC}} = \dfrac{\frac{3.61}{2}(0.583)P}{\frac{\pi}{4}(0.004)^2}, \quad P = \dfrac{150\times10^6(0.004)^2\pi}{2(3.61)(0.583)}$

Pick smallest: $\boxed{P = 1791\,N}$ For $\sigma = 150\times10^6$ Pa

2. A rectangular block of a material with a modulus of rigidity $G = 90$ ksi is bonded to two rigid horizontal plates. The lower plate is fixed, with the upper plate is subjected to a horizontal force **P**. Knowing that the upper plate moves through 0.04 in. under the action of the force, the force **P** exerted on the upper plate is most nearly
   (a) 2.25 kips
   (b) 36.0 kips
   (c) 23.0 kips
   (d) 9.0 kips
   (e) 19.0 kips



(Example 2.10)

$\tau = G\gamma \qquad \gamma \cong \tan\gamma = \dfrac{0.04''}{2''} = 0.02\,rad$

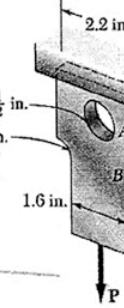
$\tau = P/A = 90\times10^3(0.02) = P/(8)(2.5)$

$P = (8)(2.5)\,90\times10^3(0.02)$

$\boxed{P = 36\times10^3\,lbs}$

3. For $P = 8.5$ kips and an allowable stress of 18 ksi, the required plate thickness, t, is most nearly (2.97)

   (a) 0.655 in
   (b) 0.874 in
   (c) 1.123 in
   (d) 1.310 in
   (e) 0.604 in



Hole: $r_A/d_A = \frac{1/2}{1.2} = 0.417$ Fig Top. pg 6. $K = 2.22$

$K = \frac{\sigma_{max}}{\sigma_{ave}} = \frac{\sigma_{max}}{P/A_{net}}$, $A_{net} = (2.2-1.0)t = 1.2t$

$2.22 = \frac{18 \times 10^3}{8.5 \times 10^3 / 1.2t}$, $\boxed{t = 0.874 \text{ in}}$

Fillet: $D = 2.2''$, $d_B = 1.6''$, $D/d_B = \frac{2.2}{1.6} = 1.375$

$r_B = 0.375''$, $r_B/d_B = \frac{0.375}{1.6} = 0.2344$ Fig. Botton pg 6. $K = 1.70$

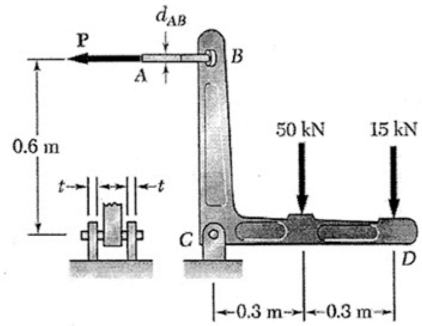
$K = \frac{\sigma_{max}}{\sigma_{ave}} = \frac{\sigma_{max}}{P/A_{net}}$, $A_{net} = d_B t = 1.6t$, $t = \frac{KP}{d_B \sigma_{max}} = \frac{1.70(8.5 \times 10^3)}{1.6(18 \times 10^3)}$

$\boxed{t = 0.502 \text{ in}}$

$\boxed{\text{Choose larger, } t = 0.874}$

4. 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 with a factor of safety of 3.3. The required diameter of the pin is most nearly

   (a) 19.75 mm
   (b) 15.50 mm
   (c) 25.1 mm
   (d) 17.32 mm
   (e) 21.4 mm



(Sample Problem 1.3)

$\circlearrowleft + \sum M_{@C} = 0 = +0.6P - 0.3(50) - 0.6(15)$

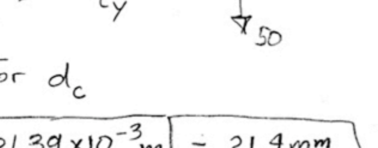
$\boxed{40 \text{ kN} = P}$

$\sum F_x = 0 \Rightarrow \boxed{C_x = P = 40 \text{ kN}}$

$\sum F_y = 0 \Rightarrow \boxed{C_y = 65 \text{ kN}}$

$C = \sqrt{C_x^2 + C_y^2}$ $\boxed{C = 76.3 \text{ kN}}$

Overall FBD



$F.S. = \frac{\tau_{ult}}{\tau_{all}} = \frac{350 \times 10^6}{\tau_{allow}} = 3.3$

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

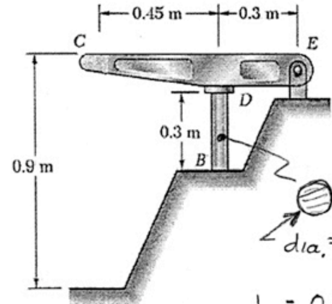
$\tau_{allow} = \frac{C/2}{A_{dia}} = 106.1 \times 10^6 = \frac{76.3 \times 10^3 / 2}{\pi/4 \, d_c^2}$ Solve for d_c

$d_c = \sqrt{\frac{76.3 \times 10^3 / 2}{106.1 \times 10^6 \, \pi/4}}$, $\boxed{d_c = 21.39 \times 10^{-3} \text{ m} = 21.4 \text{ mm}}$

5. The rigid bar *CDE* is attached to a pin support at *E* and rests horizontally on the 30-mm-diameter brass cylinder *BD* (E_{brass} = 105 GPa; $\alpha_{brass} = 20.9 \times 10^{-6}/°C$) when the temperature is 20°C. If the temperature increases to 50°C, the deflection of point C is most nearly:

(a) 0.1881 mm
(b) 0.470 mm
(c) 0.282 mm
(d) 0.564 mm
(e) 0.1411 mm

(Sample Problem 2.4)

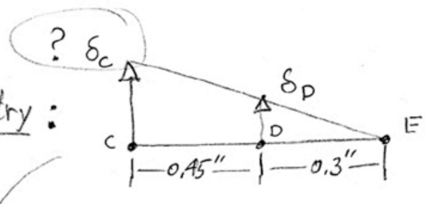


dia. = 0.03m

$L_b = 0.3$ m

$\Delta T = +30°C$

Geometry:



$\delta_D = \alpha_b (\Delta T) L_b$

$\delta_D = 20.9 \times 10^{-6} (+30)\, 0.3\text{m}$

$\delta_D = 188 \times 10^{-6}$ m

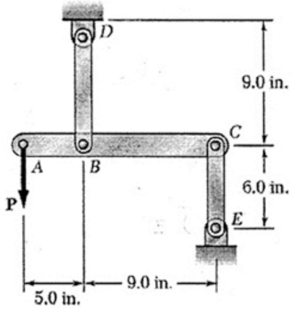
$$\frac{\delta_c}{(0.45 + 0.30)} = \frac{\delta_D}{0.3}$$

$\delta_c = \frac{0.75}{0.3}(188 \times 10^{-6})$, $\delta_c = 470.0 \times 10^{-6}$ m

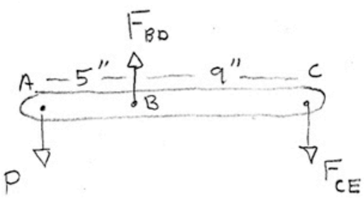
$\boxed{\delta_c = 0.470 \text{ mm}}$

WORK OUT PROBLEM (40 Points) (prob: 2.125)

(a) Link BD is made of brass ($E = 15 \times 10^6$ psi) and has a cross-sectional area of 0.50 in^2. Link CE is made of steel ($E = 29 \times 10^6$ psi) and has a cross-sectional area of 0.20 in^2. Determine the maximum force **P** that can be applied vertically at point A if the deflection of A is not to exceed 0.014 in.



FBD : Rigid Link ABC



(15 pnts)

$(+\circlearrowleft)\ \sum M_{@C} = 0 = +14P - 9F_{BD}$; $\boxed{F_{BD} = 1.556\,P}$

$(+\circlearrowleft)\ \sum M_{@B} = 0 = +5P - 9F_{CE}$; $\boxed{F_{CE} = 0.556\,P}$

(15 pnts)

$$\delta_B = \delta_{BD} = \frac{F_{BD} L_{BD}}{E_{BD} A_{BD}} = \frac{(1.556P)(9.0)}{(15\times10^6)(0.50)} = \overbrace{1.86672 \times 10^{-6}\,P}^{\delta_{BD}} \downarrow$$

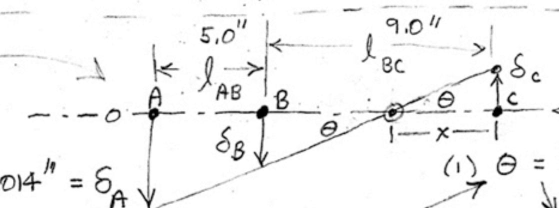
(3 pnts)

$$\delta_C = \delta_{CE} = \frac{F_{CE} L_{CE}}{E_{CE} A_{CE}} = \frac{(0.556\,P)(6.0)}{(29\times10^6)(0.20)} = \overbrace{0.374758 \times 10^{-6}\,P}^{\delta_{CE}} \uparrow$$

(10 pnts)

(3 pnts)

(8 pnts) Geometry :



(1) $\theta = \dfrac{\delta_B + \delta_C}{l_{BC}} = \dfrac{2.44147\times10^{-6}\,P}{9.0}$

$\theta = 0.271275 \times 10^{-6}\,P$

For small angles : (1) $\delta_B + \delta_C = l_{BC}\,\theta$ (1 pnt)

(2) $\delta_A - \delta_B = l_{AB}\,\theta$ (1 pnt)

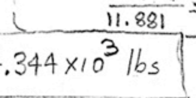
— OR —

$\overbrace{1.8667\times10^{-6}P}^{\delta_{BD}}$ $\overbrace{0.5748\times10^{-6}P}^{\delta_{CE}}$

$\dfrac{\delta_{BD}}{9-x} = \theta = \dfrac{\delta_{CE}}{x}$

$x = 9\,\delta_{CE}/\underbrace{(\delta_{BD}+\delta_{CE})}_{2.4415}$

$x = 2.119$



$\dfrac{0.014}{11.881} = \dfrac{1.8667\times10^{-6}P}{6.881}$

(4 pnts)

$\delta_A = \delta_B + l_{AB}\,\theta$

$\delta_A = 1.86672\times10^{-6}\,P + (5.0)(0.271275\times10^{-6})\,P$

$\delta_A = 3.22309 \times 10^{-6}\,P$

Displacement δ_A limit $= 0.014'' = 3.22309\times10^{-6}\,P$

Solve for $P = \dfrac{0.014}{3.22309\times10^{-6}}$

$\boxed{P = 4.344\times10^{3}\ \text{lbs}}$