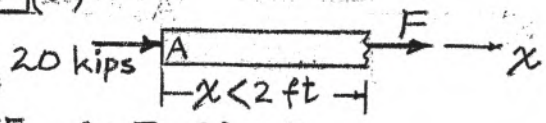
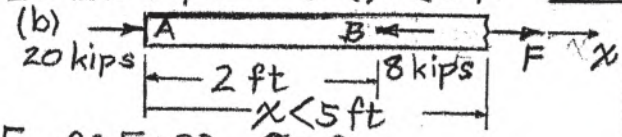
1.1 (a)



$\Sigma F_x = 0: F + 20 = 0$

$F = -20$ kips ... $0 < x < 2$ ft ANS.

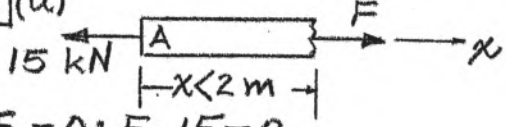
(b)



$\Sigma F_x = 0: F + 20 - 8 = 0$

$F = -12$ kips ... $2 < x < 5$ ft ANS.

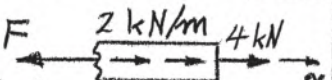
1.2 (a)



$\Sigma F_x = 0: F - 15 = 0$

$F = 15$ kN ... $0 < x < 2$ m ANS.

(b)

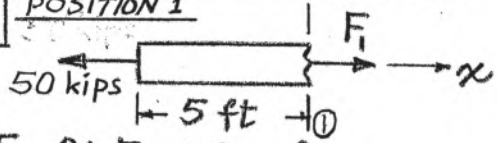


$\Sigma F_x = 0: 4 + 2(5-x) - F = 0$

$F = 14 - 2x$ ... $2 < x < 5$ m

$F_{x=4m} = 6$ kN ANS.

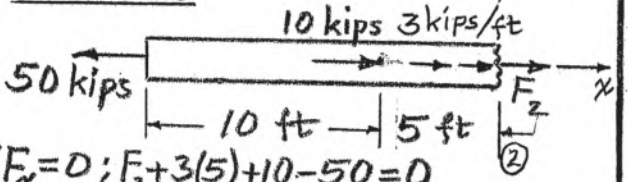
1.3 POSITION 1



$\Sigma F_x = 0: F_1 - 50 = 0$

$F_1 = 50$ kips ANS.

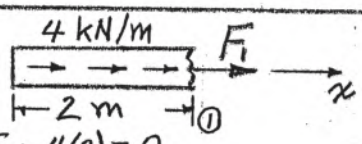
POSITION 2



$\Sigma F_x = 0; F_2 + 3(5) + 10 - 50 = 0$

$F_2 = 25$ kips ANS.

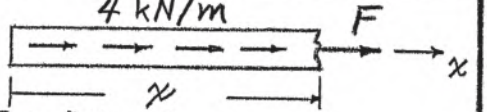
1.4



$\Sigma F_x = 0: F_1 + 4(2) = 0$

$F_1 = -8$ kN ANS.

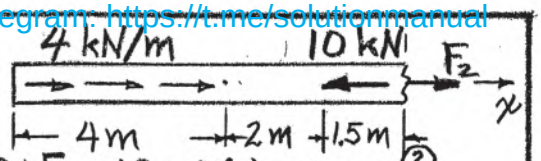
1.5



$\Sigma F_x = 0: F + 4x = 0$

$F = -4x$ kN ... $0 < x < 4$ m ANS.

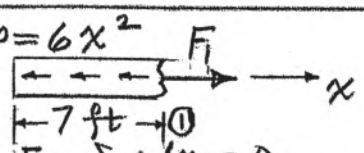
1.6



$\Sigma F_x = 0; F_2 - 10 + 4(4) = 0$

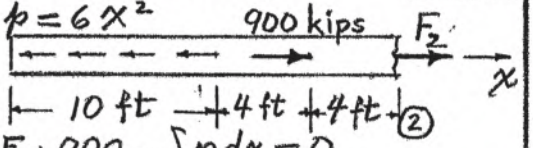
$F_2 = -6$ kN ANS.

1.7



$\Sigma F_x = 0: F_1 - \int p\,dx = 0$

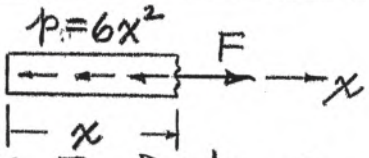
$F_1 = \int_0^7 6x^2\,dx = 686$ kips ANS.



$\Sigma F_x = 0: F_2 + 900 - \int p\,dx = 0$

$F_2 = \int_0^{10} 6x^2\,dx - 900 = 1100$ kips ANS.

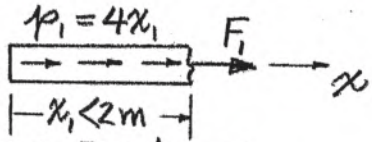
1.8



$\Sigma F_x = 0: F - \int p\,dx = 0$

$F = \int_0^x 6x^2\,dx = 2x^3$ ANS.

1.9

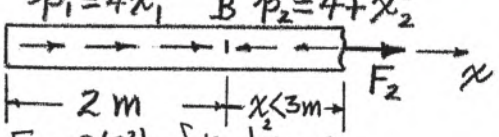


$\Sigma F_x = 0: F_1 + \int p_1\,dx_1 = 0$

$F_1 = -\int_0^{x_1} 4x_1\,dx_1 = -2x_1^2$ kN ANS.

$F_{B-} = -2(2^2) = -8$ kN ANS.

1.10



$\Sigma F_x = 0: F_2 + 2(2^2) - \int p_2\,dx = 0$

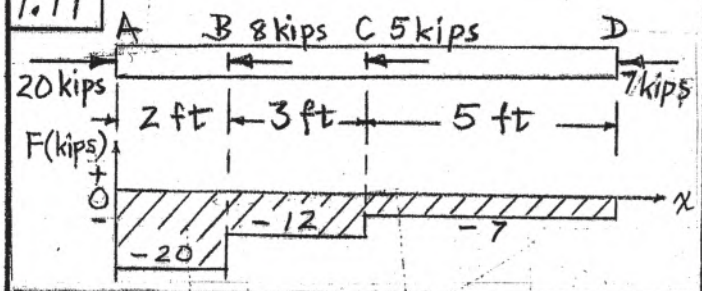
$F_2 = \int_0^{x_2} (4 + x_2^3)\,dx_2 - 8$

$F_2 = 4x_2 + x_2^4/4 - 8$ ANS.

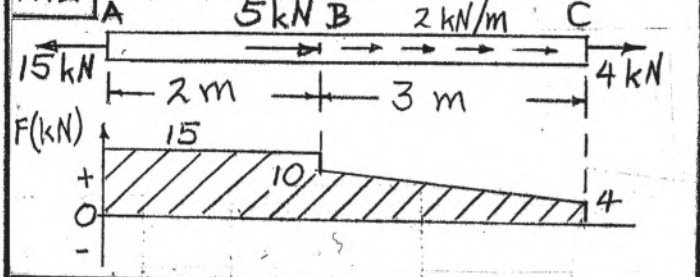
$F_{2\,AT\,x_2=2m} = 4$ kN ANS.

$F_{2\,AT\,x_2=3m} = 24.25$ kN ANS.

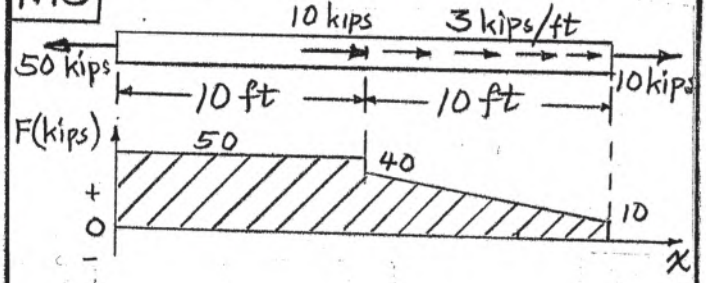
1.11



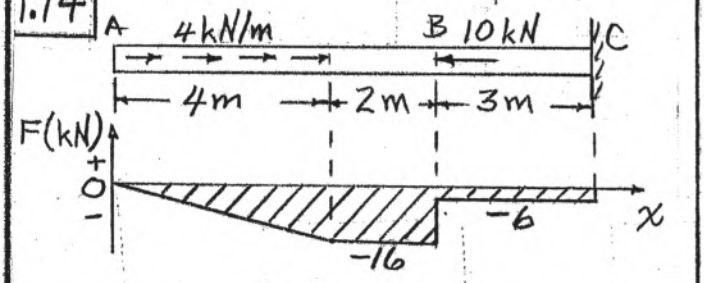
1.12



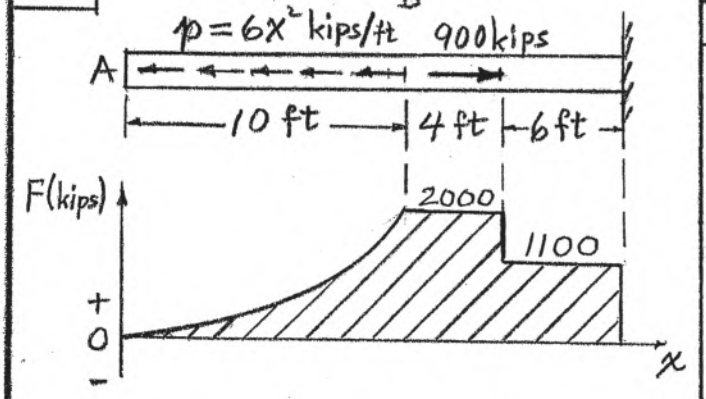
1.13



1.14



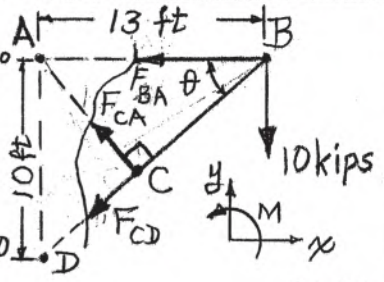
1.15



1.16 (a)

$\theta = \tan^{-1}\left(\frac{10}{13}\right) = 37.569°$

TRANSMIT F_{CD} TO POINT D.



$\Sigma M_A = 0$

$-10(13) - (F_{CD}\cos\theta)(10) = 0$

$F_{CD} = -16.4$ kips ANS.

$\Sigma M_D = 0: F_{BA}(13\cos\theta)(\sin\theta) - 10(13\cos\theta)(\cos\theta) = 0$

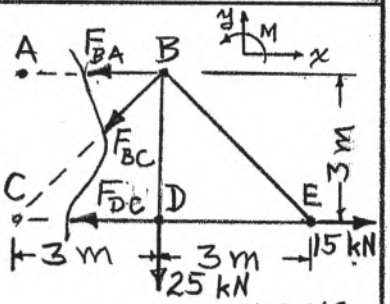
$F_{BA} = 13.0$ kips ANS.

(b) $A = \pi(1^2)/4 = 0.785$ in.²

$\sigma_{AB} = \frac{13.0}{0.785} = 16.6$ ksi ANS.

$\sigma_{CD} = \frac{-16.4}{0.785} = -20.9$ ksi ANS.

1.17 (a)



$\Sigma M_C = 0$

$F_{BA}(3) - 25(3) = 0$

$F_{BA} = 25.0$ kN ANS.

$\Sigma M_B = 0: 15(3) - F_{DC}(3) = 0$

$F_{DC} = 15.0$ kN ANS.

$\Sigma F_y = 0: -25 - F_{BC}\cos 45° = 0$

$F_{BC} = -35.4$ kN ANS.

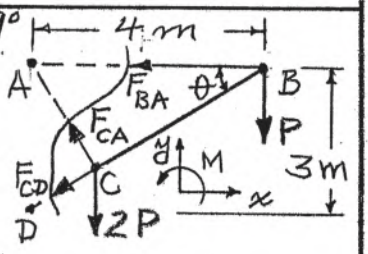
(b)

$\sigma_{BA} = \frac{25.0(10^3)}{(\pi/4)(0.02^2)} = 79.6$ MPa ANS.

$\sigma_{DC} = \frac{15.0(10^3)}{(\pi/4)(0.025^2)} = 30.6$ MPa ANS.

$\sigma_{BC} = \frac{-35.4(10^3)}{(\pi/4)(0.03^2)} = -50.1$ MPa ANS.

1.18 $\theta = \tan^{-1}(3/4) = 36.9°$



$F_{CA} = 75\times10^6(5\times10^{-4}) = 37.5$ kN

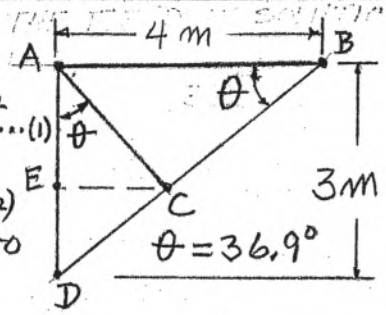
$\Sigma M_B = 0$

$2P(4\cos\theta)\cos\theta - F_{CA}(4\cos\theta) = 0$

$P = \frac{F_{CA}}{2\cos\theta} = \frac{37.5}{2\cos 36.9°}$

$P = 23.4$ kN ANS.

1.19 $BD = 5\ m$



$AC^2 = AB^2 - BC^2$

$AC^2 = 4^2 - (5-DC)^2 \quad \cdots (1)$

ALSO

$AC^2 = 3^2 - DC^2 \quad \cdots (2)$

SOLVE (1) AND (2) TO OBTAIN:

$DC = 1.8\ m$

$AC = 2.4\ m$

$CE = 2.4 \sin\theta = 1.44\ m$

REFER TO F.B.D. IN SOLUTION OF PROB. 1.18.

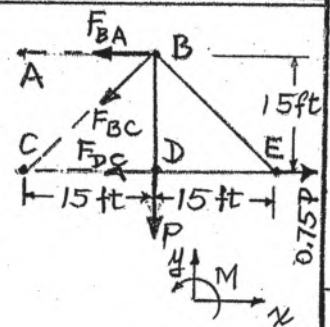
$\Sigma M_A = 0: -P(4) - 2P(1.44) - F_{CD}(2.4) = 0$

$F_{CD} = -2.867P = V_D = \tau_D A_D$

$\tau_D = 50 \times 10^6 = \dfrac{|-2.867P|}{2(\pi/4)(0.015^2)}$

$P = 6164\ N = 6.2\ kN$ ANS.

1.20 $\Sigma M_C = 0$



$F_{BA}(15) - P(15) = 0$

$F_{BA} = P = V_A = \tau_A A_A$

$\tau_A = 10 = \dfrac{P}{(\pi/4)(1.25^2)}$

$P = 12.3$ kips ANS.

1.21 REFER TO F.B.D. IN SOLUTION OF PROB. 1.20.

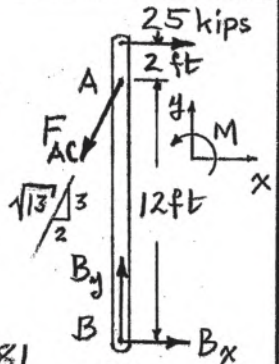
$\Sigma F_y = 0: -F_{BC}\sin 45° - P = 0$

$F_{BC} = -P/\sin 45° = -\sigma_{BC} A_{BC}$

$P = \sigma_{BC} A_{BC} \sin 45° = 50(2.5)\sin 45°$

$P = 88.4$ kips ANS.

1.22 $\Sigma M_B = 0$



$\left(\dfrac{2}{\sqrt{13}}\right)F_{AC}(12) - 25(14) = 0$

$F_{AC} = 52.581$ kips

$\sigma_{AC} = \dfrac{F_{AC}}{A_{AC}} = \dfrac{52.581}{(\pi/4)(1.5^2)} = 29.755$

$\sigma_{AC} \approx 29.8$ ksi ANS.

1.23 REFER TO THE F.B.D. IN PROB. 1.22.

$\Sigma F_x = 0: B_x - \dfrac{2}{\sqrt{13}}(52.581) + 25 = 0$

$B_x = 4.167$ kips

$\Sigma F_y = 0: B_y - \dfrac{3}{\sqrt{13}}(52.581) = 0$

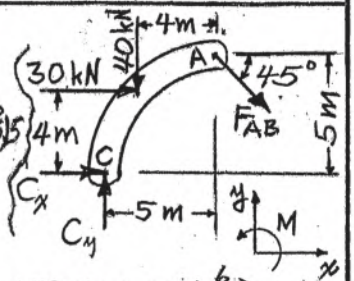
$B_y = 43.750$ kips

$B = \sqrt{4.167^2 + 43.750^2} = 43.948$ kips

$\tau_{AVE} = \dfrac{B}{A} = \dfrac{43.948}{(\pi/4)(1.5^2)} = 24.869$

$\tau_{AVE} \approx 24.9$ ksi ANS.

1.24 (a)



$\Sigma M_C = 0$

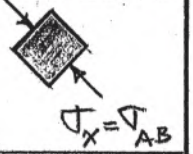
$-(F_{AB}\cos 45°)5 - (F_{AB}\sin 45°)5 - 40(1) - 30(4) = 0$

$F_{AB} = -22.627$ kN

$\sigma_{AB} = \dfrac{22.627(10^3)}{(0.03)(0.02)} = -37.712 \times 10^6\ Pa$

≈ -37.7 MPa ANS.

(b)



1.25 REFER TO THE F.B.D. IN PROB. 1.24.

$\Sigma F_x = 0: C_x + 30 - 22.627\cos 45° = 0$

$C_x = -14.0$ kN

$\Sigma F_y = 0: C_y - 40 + 22.627\sin 45° = 0$

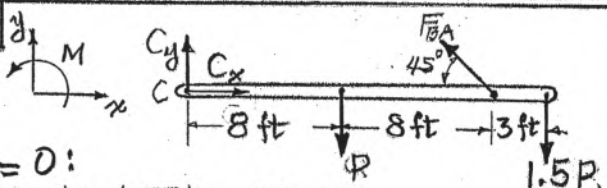
$C_y = 24.0$ kN

$C = \sqrt{14.0^2 + 24.0^2} = 27.784$ kN

$\tau_{AVE} = \dfrac{C}{A} = \dfrac{27.784(10^3)}{(\pi/4)(0.03^2)} = 39,306.3 \times 10^3\ Pa$

≈ 39.3 MPa ANS.

1.26



$\Sigma M_C = 0:$

$(F_{BA}\sin 45°)16 - (1.5R)19 - 8R = 0$

$F_{BA} = 3.226R$

$F_{BA} = 30(\pi/4)(3/8)^2 = 3.313$ kips

$3.226R = 3.313$

$R = 1.027$ kips ≈ 1.0 kips ANS.

1.27 REFER TO THE F.B.D. IN PROB. 1.26.

$\Sigma F_x = 0$: $C_x - (3.226P)\cos 45^\circ = 0$

$C_x = 2.281P$

$\Sigma F_y = 0$: $C_y - P - 1.5Q + (3.226P)\sin 45^\circ = 0$

$C_y = 0.219P$

$C = \sqrt{(2.281P)^2 + (0.219P)^2} = 2.291P$

$\tau_{AVE} = 10 = \dfrac{2.291P}{(\pi/4)(1^2)}$

$P = 3.428 \text{ kips} \approx 3.4 \text{ kips}$ ANS.

1.28 $F_{BC} = 75\times10^6(0.02)(0.025)$

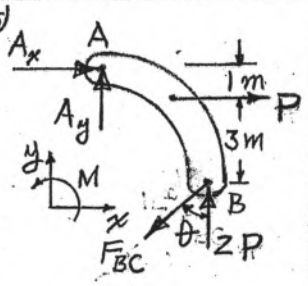
$F_{BC} = 37.5 \text{ kN}$

$\theta = \tan^{-1}\left(\dfrac{6.5}{6.0}\right) = 47.291^\circ$

$\Sigma M_A = 0$:

$P(1) + 2P(4) - F_{BC}\cos\theta(4) - F_{BC}\sin\theta(4) = 0$

$P = 23.551 \text{ kN} \approx 23.6 \text{ kN}$ ANS.



1.29 $F_{BC} = V_C = 25\times10^6(\pi/4)(0.03^2)$

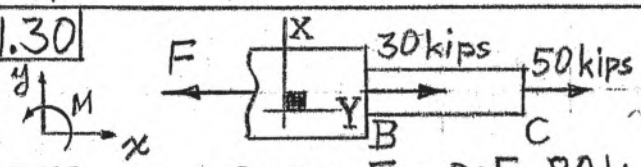
$= 17.671 \text{ kN}$

REFER TO THE F.B.D. IN PROB. 1.28.

$\Sigma M_A = 0$: $P(1) + 2P(4) - F_{BC}\cos\theta(4) - F_{BC}\sin\theta(4) = 0$

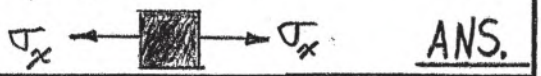
$P = 11.098 \text{ kN} \approx 11.1 \text{ kN}$ ANS.

1.30



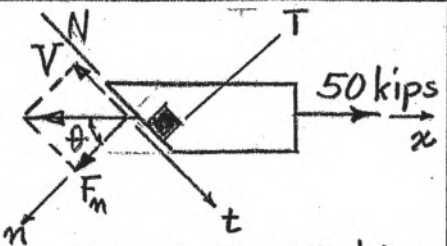
$\Sigma F_x = 0$: $50 + 30 - F = 0$; $F = 80$ kips

$\sigma_x = \dfrac{80}{(\pi/4)(5^2)} = 4.074 \text{ ksi} \approx 4.1 \text{ ksi}$



ANS.

1.31



$\theta = 45^\circ$

$A_i = \dfrac{(\pi/4)(2^2)}{\cos\theta} = 4.443 \text{ in.}^2$

$\Sigma F_x = 0$: $50 - F = 0$; $F = 50$ kips

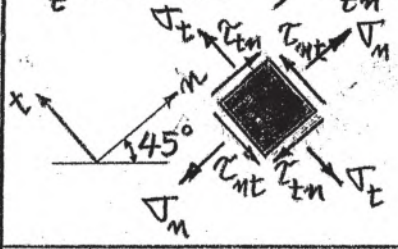
$\sigma_n = \dfrac{F_n}{A_i} = \dfrac{F\cos\theta}{A_i} = 7.958 \text{ ksi} \approx 8.0 \text{ ksi}$

1.31 CONT'D

$\tau_{nt} = \dfrac{V}{A_i} = \dfrac{F\sin\theta}{A_i} = 7.958 \text{ ksi} \approx 8.0 \text{ ksi}$

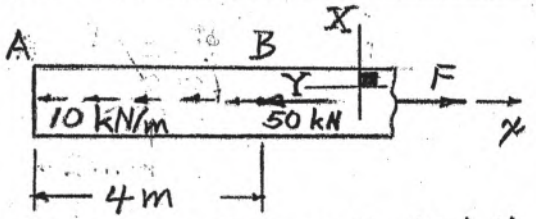
SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t \approx 8.0 \text{ ksi}$; $\tau_{tn} \approx 8.0 \text{ ksi}$



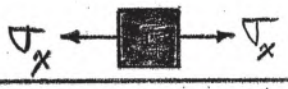
ANS.

1.32



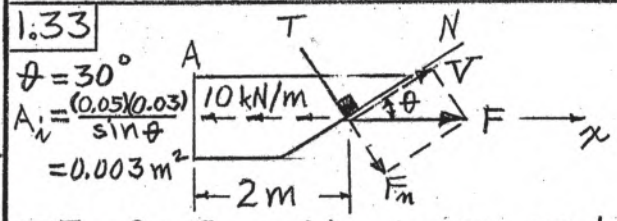
$\Sigma F_x = 0$: $F - 50 - 10(4) = 0$; $F = 90 \text{ kN}$

$\sigma_x = \dfrac{90(10^3)}{(\pi/4)(0.06^2)} = 31.831\times10^6 \text{ N} \approx 31.8 \text{ MPa}$



ANS.

1.33



$\theta = 30^\circ$

$A_i = \dfrac{(0.05)(0.03)}{\sin\theta} = 0.003 \text{ m}^2$

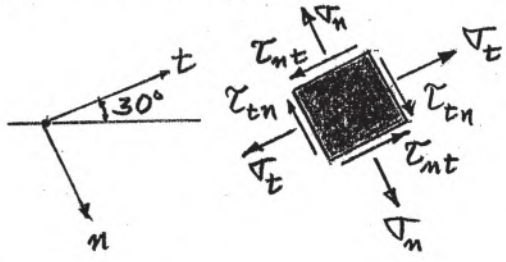
$\Sigma F_x = 0$: $F - 10(2) = 0$; $F = 20 \text{ kN}$

$\sigma_n = \dfrac{F_n}{A_i} = \dfrac{F\sin\theta}{A_i} = 3.333 \text{ MPa} \approx 3.3 \text{ MPa}$

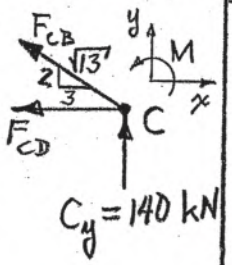
$\tau_{nt} = \dfrac{V}{A_i} = \dfrac{F\cos\theta}{A_i} = 5.774 \text{ MPa} \approx 5.8 \text{ MPa}$

SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t = 10.0 \text{ MPa}$; $\tau_{tn} = 5.774 \text{ MPa} \approx 5.8 \text{ MPa}$



1.34 THE F.B.D. OF THE ENTIRE TRUSS YIELDS $C_y = 140$ kN.



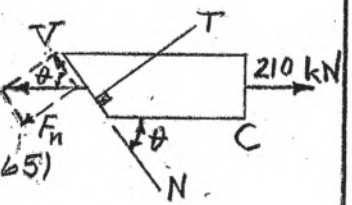
JOINT AT C

$\Sigma F_y = 0: 140 + \frac{2}{\sqrt{13}} F_{CB} = 0$

$F_{CB} = -252.389$ kN

$\Sigma F_x = 0: \frac{3}{\sqrt{13}}(252.389) - F_{CD} = 0$

$F_{CD} = 210.0$ kN



$\theta = 60°$

$A = (0.04)(0.08) - (0.025)(0.065)$

$= 0.001575$ m^2

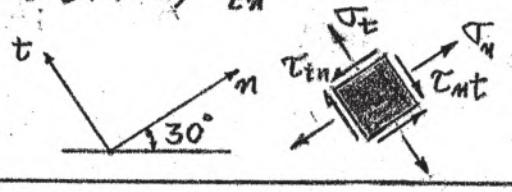
$A_i = \frac{A}{\sin\theta}$

$\sigma_n = \frac{F_n}{A_i} = \frac{F\sin^2\theta}{A} = 100.0$ MPa

$\tau_{nt} = \frac{V}{A_i} = \frac{F\sin\theta\cos\theta}{A} = 57.7$ MPa

SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t = 33.3$ MPa; $\tau_{tn} = 57.7$ MPa



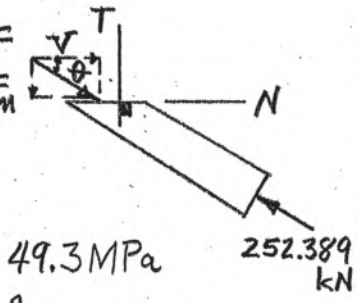
1.35 FROM PROB. 1.34, $F_{BC} = -252.389$ kN

$\theta = \tan^{-1}(\frac{2}{3}) = 33.69°$

$F = -252.389$ kN

$A = 0.001575$ m^2

$A_i = \frac{A}{\sin\theta}$

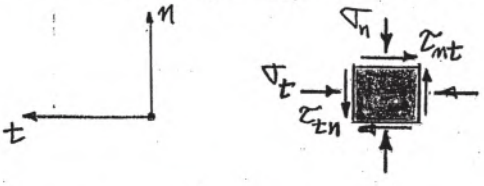


$\sigma_n = \frac{F_n}{A_i} = \frac{F\sin^2\theta}{A} = 49.3$ MPa

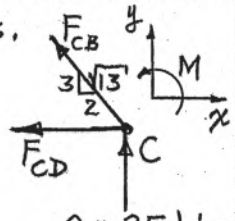
$\tau_{nt} = \frac{V}{A_i} = \frac{F\cos\theta\sin\theta}{A} = 74.0$ MPa

SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t = 110.9$ MPa; $\tau_{tn} = 74.0$ MPa



1.36 THE F.B.D. OF THE ENTIRE TRUSS YIELDS $C_y = 25$ kips.



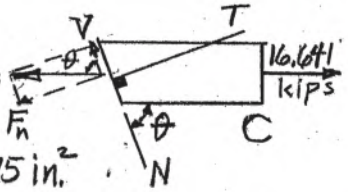
JOINT AT C

$\Sigma F_y = 0: 25 + \frac{3}{\sqrt{13}} F_{CB} = 0$

$F_{CB} = -30.0$ kips

$\Sigma F_x = 0: \frac{2}{\sqrt{13}}(30.0) - F_{CD} = 0$

$F_{CD} = 16.641$ kips



$\theta = 75°$

$A = (6)(8) - (5.5)(7.5) = 6.75$ in.^{2}

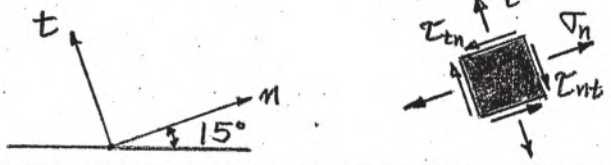
$A_i = \frac{A}{\sin\theta}$

$\sigma_n = \frac{F_n}{A_i} = \frac{F\sin^2\theta}{A} = 2.3$ ksi

$\tau_{nt} = \frac{V}{A_i} = \frac{F\cos\theta\sin\theta}{A} = 0.6$ ksi

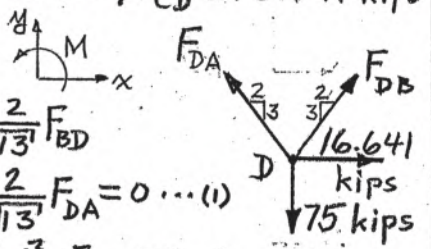
SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t = 0.2$ kips; $\tau_{tn} = 0.6$ ksi



1.37 FROM PROB. 1.36, $F_{CD} = 16.641$ kips

JOINT AT D



$\Sigma F_x = 0: 16.641 + \frac{2}{\sqrt{13}} F_{BD} - \frac{2}{\sqrt{13}} F_{DA} = 0 \ldots (1)$

$\Sigma F_y = 0: \frac{3}{\sqrt{13}} F_{DA} + \frac{3}{\sqrt{13}} F_{DB} - 75 = 0 \ldots (2)$

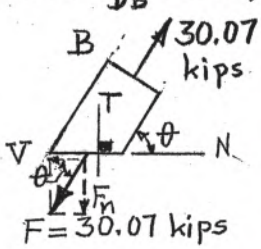
SOLVE SIMULTANEOUSLY TO GET $F_{DB} = 30.07$ kips

$\theta = \tan^{-1}(\frac{3}{2}) = 56.310°$

$A = 6.75$ in.^{2}; $A_i = \frac{A}{\sin\theta}$

$\sigma_n = \frac{F}{A_i} = \frac{F\sin^2\theta}{A} = 3.1$ ksi

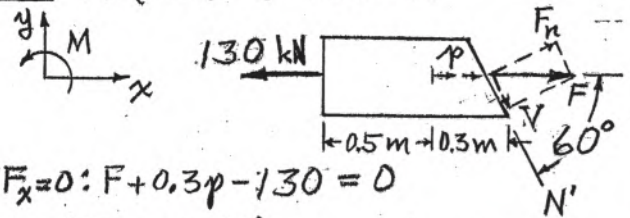
$\tau_{nt} = \frac{V}{A_i} = \frac{F\cos\theta\sin\theta}{A} = 2.1$ ksi



SIMILARLY, A F.B.D. SHOWING THE T PLANE YIELDS THE FOLLOWING:

$\sigma_t = 1.4$ ksi; $\tau_{tn} = 2.1$ ksi

1.38 $A=(0.03)(0.04)=0.0012\ m^2$



$\Sigma F_x=0: F+0.3p-130=0$

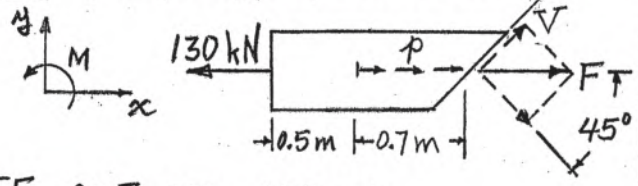
$F=130-0.3p$

$\sigma_n=80\times10^6=\frac{F_n}{A_i}=\frac{(130-0.3p)(10^3)\sin^2 60°}{A}$

$(130-0.3p)(10^3)=\frac{80\times10^6(0.0012)}{\sin^2 60°}$

$p=6.667\approx6.7\ kN/m$ ANS.

1.39 $A=(0.03)(0.04)=0.0012\ m^2$



$\Sigma F_x=0: F+0.7p-130=0$

$F=130-0.7p$

$\tau_{nt}=50\times10^6=\frac{V}{A_i}=\frac{(130-0.7p)(10^3)\sin^2 45°}{A}$

$(130-0.7p)(10^3)=\frac{50\times10^6(0.0012)}{\sin^2 45°}$

$p=14.286\approx14.3\ kN/m$ ANS.

1.40

(a) $P_{MAX}=-45{,}000(\pi/4)(3^2)=-318{,}086\ lb$

$P_{MAX}\approx-318.1\ kips$ ANS.

(b) $\delta=\frac{FL}{AE}=\frac{-318{,}086(5)}{(\pi/4)(3^2)(30\times10^6)}=-0.007499\ in.$

$\delta=-0.00750\ in.$ ANS.

$\epsilon_T=-\mu\epsilon_L=-0.3\left(\frac{-0.007499}{5}\right)$

$=4.4994\times10^{-4}$

$\Delta D=\epsilon_T D$

$=4.4994\times10^{-4}(3)=0.0013498\ in$

$\Delta D\approx0.00135\ in.$ ANS.

1.41

(a) $u_R=\frac{1}{2}\epsilon_p\sigma_p=\frac{\sigma_p^2}{2E}$

$\sigma_p=\sqrt{2u_R(E)}=\sqrt{2(4\times10^5)(120\times10^9)}$

$=30.984\times10^7\ Pa\approx309.8\ MPa$ ANS.

$\epsilon_p=\sigma_p/E=309.8\times10^6/120\times10^9=0.00258$ ANS.

(b) $P=\sigma_p A=30.984\times10^7(10\times10^{-4})$

$=309.84\times10^3\ N\approx309.8\ kN$ ANS.

1.42

(a) $E=\frac{\sigma_p}{\epsilon_p}=\frac{(8{,}800/(\pi/4)(0.5^2))}{(0.003/2)}$

$=29.879\times10^6\approx29.9\times10^6\ psi$ ANS.

(b) $\mu=\left|\frac{\epsilon_T}{\epsilon_L}\right|=\left|\frac{-(0.00025/0.5)}{(0.003/2)}\right|$

$=0.33333=\frac{1}{3}$ ANS.

(c) $u_R=\frac{\sigma_p^2}{2E}=\frac{[(8{,}800/(\pi/4)(0.5^2)]^2}{2(29.879\times10^6)}$

$=33.613\approx33.6\ lb.in./in.^3$ ANS.

1.43

(a) $\mu=\left|\frac{\epsilon_T}{\epsilon_L}\right|=\left|\frac{(0.1/60)}{-(1.3/200)}\right|$

$=0.25641\approx0.256$ ANS.

(b) $D_2=D_1+\epsilon_T(D_1)=40+\frac{0.1}{60}(40)$

$=40.06666\approx40.0667\ mm$ ANS.

(c) $E=\frac{\sigma}{\epsilon_L}=\frac{(600\times10^3)/(0.04)(0.06)}{(1.3/200)}$

$=38.462\times10^9\ Pa\approx38.5\ GPa$ ANS.

1.44 (a) $\sigma_p=\epsilon_p E=(0.0045/3.5)(30\times10^3)$

$=38.571\approx38.6\ ksi$ ANS.

(b) $u_R=\frac{\sigma_p^2}{2E}=\frac{38.571^2}{2(30\times10^3)}$

$=24.795\times10^{-3}\approx24.8\times10^{-3}\ kip.in/in.^3$ ANS.

1.45

(a) $\mu = \left|\frac{\epsilon_T}{\epsilon_L}\right| = \left|\frac{(-0.04/30)}{(1.2/300)}\right|$

$= 0.33333 = \frac{1}{3}$ ANS.

(b) $W_2 = W_1 + \epsilon_T W_1 = 15 + \frac{0.04}{30}(15)$

$= 14.98$ mm ANS.

(c) $\sigma = \frac{F}{A} = \frac{130\times10^3}{(0.015)(0.030)}$

$= 288.889\times10^6 \approx 288.9$ MPa ANS.

(d) $E = \frac{\sigma}{\epsilon_L} = \frac{288.889\times10^6}{(1.2/300)}$

$= 72.222\times10^9 \approx 72.2$ GPa ANS.

1.46

(a) $\mu = \left|\frac{\epsilon_T}{\epsilon_L}\right| = \left|\frac{(0.03/25)}{-(0.60/100)}\right|$

$= 0.2$ ANS.

(b) $W_2 = W_1 + \epsilon_T W_1 = 35 + \frac{0.03}{25}(35)$

$= 35.042$ mm ANS.

(c) $E = \frac{\sigma}{\epsilon_L} = \frac{(600\times10^3/(0.025)(0.035)}{(0.60/100)}$

$= 114.286\times10^9 \approx 114.3$ GPa ANS.

1.47 $A_i = 2.54469\times10^{-4}\ m^2$; $A_f = 2.51368\times10^{-4}\ m^2$

σ (MPa)	$\epsilon\times10^4$	σ (MPa)	$\epsilon\times10^4$
0	0	69.557	24.58
6.956	1.192	73.034	30.52
13.911	2.383	76.512	38.54
20.867	3.575	79.912	48.78
27.823	4.758	82.077	62.52
34.778	5.950	82.077	75.13
41.734	7.142	79.990	104.58
48.690	8.333	74.783	125.33
55.645	11.00	66.413	142.23
62.601	15.27	51.480	162.25
66.079	20.09		

(a) $\sigma_U = 82.5$ MPa ANS.

(b) $\sigma_f = 51.5$ MPa ANS.

(c) %EL $= (1.95\times100)/120 = 1.625$ ANS.

%ROA $= \frac{(2.54469-2.51368)(100)}{2.54469} = 1.219$ ANS.

1.48 PLOT INITIAL PART OF DATA GIVEN IN PROB. 1.48 TO GET:

(a) $\sigma_p = 51$ MPa ANS.

(b) $\sigma_y = 74$ MPa ANS.

(c) $E = \left(\frac{\sigma}{\epsilon}\right)_p = \frac{51\times10^6}{9\times10^{-4}}$

$E = 56.7$ GPa ANS.

1.49 REFER TO PLOTS OF PROBS. 1.47 AND 1.48 TO GET:

(a) $u_T \approx \sigma_{ave}(\epsilon_f)$

$\approx 70\times10^6(162.25\times10^{-4})$

≈ 1135.8 kN·m/m³ ANS.

(b) $u_R = \frac{\sigma_p^2}{2E} = \frac{(51\times10^6)^2}{2(56.7\times10^9)}$

$= 22.937$ kN·m/m³ ANS.

1.50 $A_i = 0.19635\ in^2$

σ (ksi)	$\epsilon\times10^4$	σ (ksi)	$\epsilon\times10^4$
0	0	63.153	85.0
8.149	2.0	62.643	100.0
16.297	4.5	66.208	135.0
24.446	7.5	71.301	165.0
32.595	10.5	76.394	200.0
40.744	13.0	81.487	245.0
48.892	15.5	89.127	335.0
57.041	17.5	96.766	502.5
61.115	20.0	99.313	750.0
63.153	25.0	101.859	1000.0
64.171	35.0	101.859	1250.0
65.190	50.0	94.729	1600.0
65.190	65.0	86.580	2000.0
64.171	75.0	84.034	2250.0

(a) $\sigma_U = 101$ ksi ANS.

(b) $\sigma_f = 83$ ksi ANS.

1.51 PLOT INITIAL PART OF DATA GIVEN IN PROB. 1.50 TO GET:

(a) $E = \left(\frac{\sigma}{\epsilon}\right)_p = \frac{57\times10^3}{17.5\times10^{-4}}$

$= 32.6\times10^3$ ksi ANS.

(b) $\sigma_{uy} = 65.5$ ksi ANS.

(c) $\sigma_{ly} = 61.5$ ksi ANS.

(d) $\sigma_p = 57.0$ ksi ANS.

1.52 $A_i = 0.19635\ in^2$; $A_f = 0.08296$

(a) $\%EL = \left(\frac{0.45}{2.0}\right)100 = 22.5$ ANS.

(b) $\%ROA = \left(\frac{0.19635-0.08296}{0.19635}\right)100$

$= 57.7$ ANS.

1.53 REFER TO PLOTS OF PROBS. 1.50 AND 1.51 TO GET:

(a) $u_R = \frac{\sigma_p^2}{2E} = \frac{57.0^2}{2(32.6\times10^3)}$

≈ 0.05 kip·in./in.^{3} ANS.

(b) $u_T \approx \sigma_{ave}(\epsilon_f)$

$\approx 92(0.225)$

≈ 20.7 kip·in./in.^{3} ANS.

1.54 $A_i = 28.274\ in^2$

σ (psi)	$\epsilon\times10^4$	σ (psi)	$\epsilon\times10^4$
0	0	3996.6	12.5
1000.9	2.5	4498.8	15.0
1998.3	5.0	5001.1	25.0
2999.2	8.0	4799.5	30.0
3501.5	10.0	4000.1	35.0

(a) $\sigma_u = 5{,}050$ psi ANS.

(b) $\epsilon_u = 23.75\times10^{-4}$ ANS.

1.55 * GIVEN VALUES

$$\sigma = \sigma_u\left[\frac{2\epsilon}{\epsilon_u} - \left(\frac{\epsilon}{\epsilon_u}\right)^2\right]$$

$\epsilon\times10^4$	σ (psi)	$\epsilon\times10^4$	σ (psi)
0	0	20	5188
5	2181	21	5200*
10	3773	25	5011
15	4776	30	4245
		35	2889

$E_{SEC.} = 4.1\times10^6$ psi ANS.

1.56

(a) $E = 32\times10^3$ ksi ANS.

(b) $\sigma_p = 195$ ksi ANS.

(c) $\epsilon_u = \epsilon_f = 0.050$ ANS.

(d) $u_T = \sigma_{ave}(\epsilon_f) = 230\times0.050$

$= 11.5$ kip·in./in.^{3} ANS.

1.57 $\sigma_{ALL} = \frac{P}{A}$

$A = \frac{P}{\sigma_{ALL}} = \frac{20}{5} = 4.0\ in^2$ ANS.

1.58 $\sigma_{ALL} = \frac{P}{A}$

$P = \sigma_{ALL}A = \left(\frac{150\times10^6}{2.5}\right)(0.03)(0.04)$

$= 72.0$ kN ANS.

1.59 $\sigma = \frac{P}{A} = \frac{400\times10^3}{(\pi/4)(0.06^2)} = 141.5$ MPa

$F.S. = \frac{\sigma_y}{\sigma} = \frac{250}{141.5} = 1.767$ ANS.

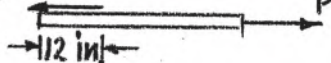
$\sigma_{ALL} = 141.5$ MPa ANS.

1.60 $\sigma = \frac{P}{A} = \frac{100}{(1.5)(2.0)} = 33.333$ ksi

$F.S. = \frac{\sigma_U}{\sigma} = \frac{60}{33.333} = 1.80$ ANS.

$\sigma_{ALL} = 33.333 \approx 33.3$ ksi ANS.

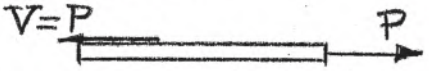
1.61



$P = V = \tau_{ALL}(A) = 70(12\times8)$

$= 6720$ lb ≈ 6.7 kips ANS.

1.62 THREE POSSIBILITIES:

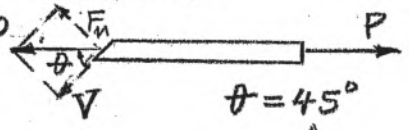


GLUE

$P_1 = V = \tau_{ALL}(A) = 0.45\times10^6(0.3)(0.5)$

$= 67.5$ kN

GRAIN $F = P$



$\theta = 45°$

$V = P_2\cos\theta$

$F_n = P_3\sin\theta$

$A_i = \frac{A}{\sin\theta}$

$P_2 = \frac{V}{\cos\theta} = \frac{\tau_{ALL}(A_i)}{\cos\theta} = \frac{\tau_{ALL}(A)}{\sin\theta\cos\theta}$

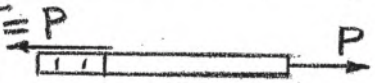
$P_2 = \frac{0.25\times10^6(0.3)(0.5)}{\sin45°\cos45°} = 75.0$ kN

$P_3 = \frac{F_n}{\sin\theta} = \frac{\sigma_{ALL}(A_i)}{\sin\theta} = \frac{\sigma_{ALL}(A)}{\sin^2\theta}$

$P_3 = \frac{0.3\times10^6(0.3)(0.5)}{\sin^2 45°} = 90.0$ kN

$P_{MAX} = P_1 = 67.5$ kN ANS.

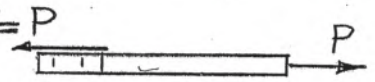
1.63



$P = V = \tau_{ALL}(A) = 75(\pi/4)(0.375^2)$

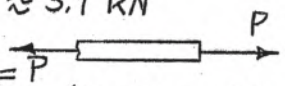
$= 8.283 \approx 8.3$ kips ANS.

1.64



$P_1 = V = \tau_{ALL}(A_P) = 50\times10^6(\pi/4)(0.01^2)$

$= 3.927 \approx 3.9$ kN

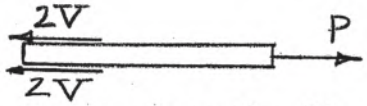


$P_2 = F = \sigma_{ALL}(A_B) = 25\times10^6(\pi/4)(0.015^2)$

$= 4.418 \approx 4.4$ kN

$P_{MAX} = P_1 = 3.9$ kN ANS.

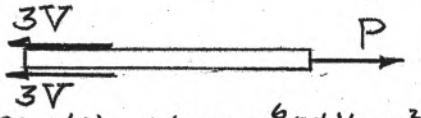
1.65



$P = 4V = 4\tau_{ALL}(A) = 4(25)(\pi/4)(0.75^2)$

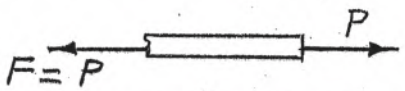
$= 44.179 \approx 44.2$ kips ANS.

1.66



$P_1 = 6V = 6\tau_{ALL}(A) = 6(150\times10^6(\pi/4)(0.03^2)$

$= 636.173 \approx 636.2$ kN

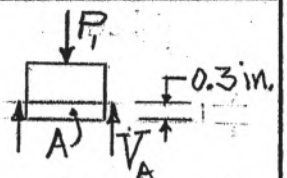


$P_2 = F = \sigma_{ALL}(A) = 100\times10^6(0.02)(0.40)$

$= 800.0$ kN

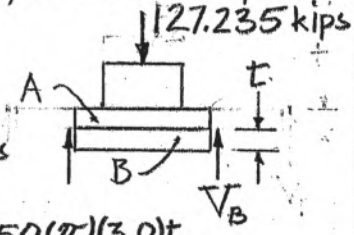
$P_{MAX} = 636.2$ kN ANS.

1.67



$P_A = V_A = (\tau_{ALL})_A(\pi d_A)t_A$

$= 90(\pi)(1.5)(0.3) = 127.235$ kips



THEREFORE

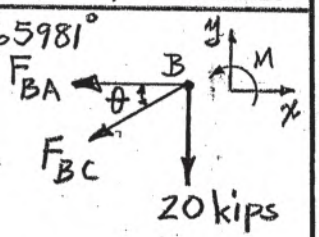
$V_B = V_A = 127.235$ kips

$= (\tau_{ALL})_B(\pi d_B)t = 50(\pi)(3.0)t$

$t = \frac{127.235}{50(\pi)(3.0)} = 0.270$ in. ANS.

$P_{MIN} = 127.235 \approx 127.0$ kips ANS.

1.68 $\theta = \tan^{-1}(\frac{12}{15}) = 38.65981°$



$\Sigma F_y = 0$:

$-20 - F_{BC}\sin\theta = 0$

$F_{BC} = -32.016$ kips

$\Sigma F_x = 0$: $-(-32.016)\cos\theta - F_{BA} = 0$

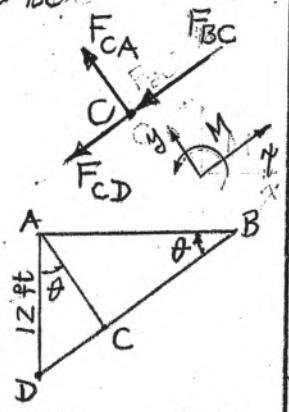
$F_{BA} = 25.0$ kips

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

$\delta_{AB} = \frac{25.0(15\times12)}{1.5(30\times10^3)}$

$= 0.10$ in. ANS.

1.69 FROM PROB. 1.68, $F_{BC} = -32.016$ kips AND $\theta = 38.65981°$



$\Sigma F_x = 0$:

$-32.016 - F_{CD} = 0$

$F_{CD} = -32.016$ kips

$L_{CD} = 12 \sin\theta$

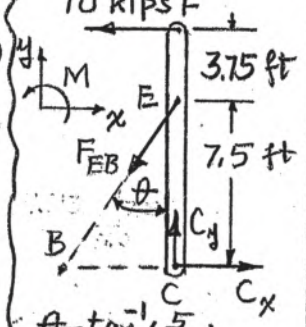
$= 7.49634$ ft

$\delta_{CD} = \dfrac{-32.016(7.49634 \times 12)}{15\times10^3(1.5)(3.0)}$

$= -0.0427 \approx -0.04$ in. ANS.

1.70 $\Sigma M_C = 0$:

$10(11.25) + F_{EB}\sin\theta(7.5) = 0$



$F_{EB} = -27.042$ kips

$L_{EB} = \dfrac{7.5}{\cos\theta}$

$= 9.01388$ ft

$\theta = \tan^{-1}\left(\dfrac{5}{7.5}\right)$

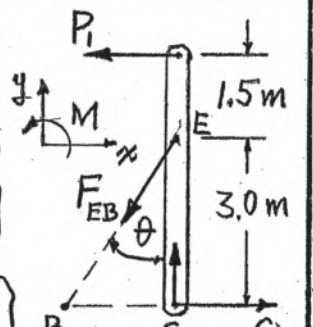
$= 33.69007°$

$\delta_{EB} = \dfrac{-27.042(9.01388\times12)}{2.5(30\times10^3)}$

$= -0.0390 \approx -0.04$ in. ANS.

1.71 $\Sigma M_C = 0$:

$P_1(4.5) + F_{EB}\sin\theta(3) = 0$



$F_{EB} = -2.70416 P_1$

$L_{EB} = \dfrac{3.0}{\cos\theta}$

$= 3.60555$ m

$\theta = \tan^{-1}\left(\dfrac{2}{3}\right)$

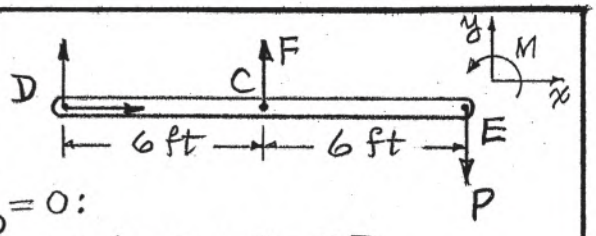
$= 33.69007°$

$\delta_{EB} = -0.003 = \dfrac{-2.70416 P_1 (3.60555)}{(0.025)(0.040)(70\times10^9)}$

$P_1 = 21538$ N

≈ 21.5 kN ANS.

1.72



$\Sigma M_D = 0$:

$F(6) - P(12) = 0$; $F = 2P$

$\delta_C = 0.25 = \dfrac{2P(5\times12)}{0.75(30\times10^3)} + \dfrac{2P(5\times12)}{0.35(30\times10^3)}$

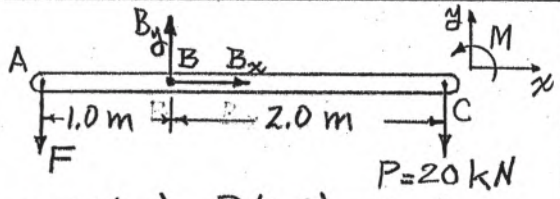
$P = 14.915 \approx 14.9$ kips ANS.

1.73 REFER TO SOLUTION OF PROB. 1.72. LEADING TO $F = 2P = 2(25) = 50$ kips

$\delta_C = \dfrac{50(5\times12)}{(0.8)(1.0)(16\times10^3)} + \dfrac{50(5\times12)}{(0.24)(22\times10^3)}$

$= 0.803 \approx 0.80$ in. ANS.

1.74



(a)

$\Sigma M_B = 0$: $F(1.0) - P(2.0) = 0$

$F = 2P = 2(20) = 40$ kN

$\delta_A = \delta_{ROD} + \delta_{SPRING}$

$= \dfrac{40\times10^3(3.0)}{(\pi/4)(0.015^2)(200\times10^9)} + \dfrac{40}{500}$

$= 0.003395 + 0.080$

$\delta_A = 0.083395$ m ≈ 83.4 mm ANS.

(b) $\delta_{SPRING} = 0.080 = 80.0$ mm ANS.

1.75 AS IN PROB. 1.74, $F = 2P$ AND

(a) $\delta_A = \delta_{ROD} + \delta_{SPRING}$

$0.010 = \dfrac{2P(3.0)}{(\pi/4)(0.025^2)(70\times10^9)} + \dfrac{2P}{1200\times10^3}$

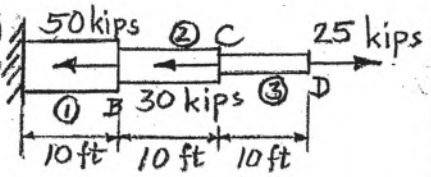
$P = 5431$ N ≈ 5.4 kN ANS

(b) $\delta_{ROD} = \dfrac{2(5431)(3.0)}{(\pi/4)(0.025^2)(70\times10^9)}$

$= 0.000948$ m ≈ 0.95 mm ANS.

1.76

(a)



$D_1 = 2.0$ in.
$D_2 = 1.0$ in.
$D_3 = 0.5$ in.

$F_{AB} = -55$ kips; $F_{BC} = -5$ kips; $F_{CD} = 25$ kips

$\delta = \dfrac{FL}{AE}$

$\delta_C = \delta_{AB} + \delta_{BC} = \dfrac{-55(10\times12)}{(\pi/4)(2.0^2)(30\times10^3)} + \dfrac{-5(10\times12)}{(\pi/4)(1.0^2)(30\times10^3)}$

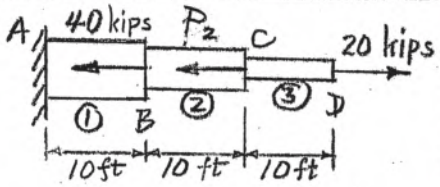
$= -95.493\times10^{-3} \approx -0.095$ in. ANS.

(b)

$\delta_D = \delta_{AB} + \delta_{BC} + \delta_{CD} = -95.493\times10^{-3} + \dfrac{25\times(10\times12)}{(\pi/4)(0.5^2)(30\times10^3)}$

$= 413.803\times10^{-3} \approx 0.414$ in. ANS.

1.77



$A_1 = 1.25$ in.^{2}
$A_2 = 0.90$ in.^{2}
$D_3 = 0.625$ in.

$F_{AB} = -(40 + P_2)$; $F_{BC} = 20 - P_2$; $F_{CD} = 20$ kips

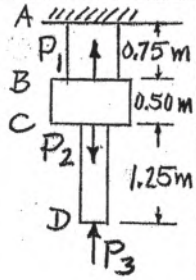
$\delta = \dfrac{FL}{AE}$

$\delta_C = \delta_{AB} + \delta_{BC} = \dfrac{-(40+P_2)(10\times12)}{1.25(10\times10^3)} + \dfrac{(20-P_2)(10\times12)}{0.90(10\times10^3)} = 0.25$

SOLVE FOR P_2 TO GET

$P_2 = -16.018 \approx -16.0$ kips → ANS.

1.78 $P_1 = 150$ kN; $P_2 = 100$ kN; $P_3 = 125$ kN;



$A_1 = 0.50A_2 = 0.75A_3$

$\therefore A_2 = 2.0A_1$; $A_3 = (\frac{4}{3})A_1$

$F_{AB} = -175$ kN; $F_{BC} = -25$ kN;

$F_{CD} = -125$ kN; $\delta = \dfrac{FL}{AE}$

$\delta_D = \delta_{AB} + \delta_{BC} + \delta_{CD} = 3.5$ mm

$\dfrac{-175(10^3)(0.75)}{A_1(120\times10^9)} + \dfrac{-25(10^3)(0.50)}{2.0A_1(120\times10^9)} + \dfrac{-125(10^3)(1.25)}{(4/3)A_1(120\times10^9)} = -0.0035$

$A_1 = 0.0006064\ m^2 = 606.4\ mm^2$ ANS.

$A_2 = 0.0012128\ m^2 = 1,212.8\ mm^2$ ANS.

$A_3 = 0.0008085\ m^2 = 808.5\ mm^2$ ANS.

1.79 REFER TO THE SKETCH IN PROB. 1.78.

$P_1 = 75$ kN; $P_2 = 150$ kN; $P_3 = 200$ kN

$A_1 = 1200\ mm^2$; $A_2 = 2000\ mm^2$; $A_3 = 450\ mm^2$

$E_1 = 75$ GPa; $E_2 = 100$ GPa; $E_3 = 150$ GPa

$F_{AB} = -125$ kN; $F_{BC} = -50$ kN; $F_{CD} = -200$ kN

$\delta = \dfrac{FL}{AE}$

$\delta_B = \dfrac{-125(10^3)(0.75)}{(0.0012)(75\times10^9)} = -0.001042$ m

$= -1.042$ mm ANS.

$\delta_C = \delta_B + \delta_{BC} = -0.001042 + \dfrac{-50(10^3)(0.50)}{(0.0020)(100\times10^9)}$

$= -0.001042 - 0.000125 = -0.001167$ m

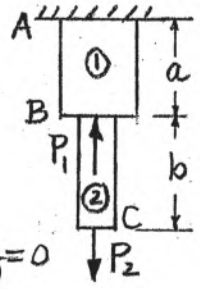
$= -1.167$ mm ANS.

$\delta_D = \delta_C + \delta_{CD} = -0.001167 + \dfrac{-200(10^3)(1.25)}{(0.00045)(150\times10^9)}$

$= -0.001167 - 0.003704 = -0.004871$ m

$= -4.871$ mm ANS.

1.80 $D_1 = 1.5$ in.; $D_2 = 0.75$ in.



$P_1 = 50$ kips; $P_2 = 20$ kips

$F_{AB} = -30$ kips; $F_{BC} = 20$ kips

$\delta_C = \delta_{AB} + \delta_{BC} = 0$

$\dfrac{-30a}{(\pi/4)(1.5^2)(15\times10^3)} + \dfrac{20b}{(\pi/4)(0.75^2)(25\times10^3)} = 0$

$\dfrac{a}{b} = 1.6$ ANS.

1.81 REFER TO SKETCH IN PROB. 1.80.

$P_1 = 50$ kips; $P_2 = 30$ kips

$E_1 = 10\times10^3$ ksi; $E_2 = 20\times10^3$

$a = 18$ in.; $b = 10$ in.

$F_{AB} = -20$ kips; $F_{BC} = 30$ kips

$\delta_C = \delta_{AB} + \delta_{BC} = 0$

$\dfrac{-20(18)}{(\pi/4)D_1^2(10\times10^3)} + \dfrac{30(10)}{(\pi/4)D_2^2(20\times10^3)} = 0$

$\dfrac{D_1^2}{D_2^2} = \dfrac{36}{15} = 2.4$

$\dfrac{D_1}{D_2} = 1.549$ ANS.

1.82 (a) $\delta_A = \delta_{SPRING} + \delta_{TUBE}$

$$\delta_A = \frac{P}{k} + \frac{FL}{AE} = \frac{75}{1200} + \frac{(75\times10^3)(0.25)}{\frac{\pi}{4}(0.045^2-0.043^2)(3.5\times10^9)}$$

$$= 0.0625 + 0.03876 = 0.10126\ \text{m} \approx 101.3\ \text{mm}$$ ANS.

(b) $\delta_B = \delta_{TUBE} = 0.03876\ \text{m} \approx 38.8\ \text{mm}$ ANS.

(c) $\delta_D = \delta_A + \delta_{ROD} = 0.10126 + \frac{FL}{AE}$

$$= 0.10126 + \frac{(75\times10^3)(0.9)}{\frac{\pi}{4}(0.015^2)(70\times10^9)}$$

$$= 0.10672\ \text{m} \approx 106.7\ \text{mm}$$ ANS.

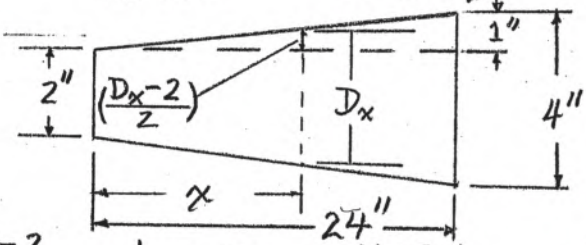
1.83 $\delta_D = \delta_{SPRING} + \delta_{TUBE} + \delta_{ROD}$

$$0.050 = \frac{P}{k} + \left(\frac{PL}{AE}\right)_{TUBE} + \left(\frac{PL}{AE}\right)_{ROD}$$

$$= \frac{P}{1200} + \frac{(P\times10^3)(0.25)}{\frac{\pi}{4}(0.045^2-0.043^2)(3.5\times10^9)} + \frac{(P\times10^3)(0.9)}{\frac{\pi}{4}(0.015^2)(70\times10^9)}$$

SOLVE TO GET $P \approx 35.1\ \text{kN}$ ANS.

1.84 $\delta = \int \frac{F}{AE}dx = \frac{F}{E}\int \frac{dx}{A_x}$



$$\frac{D_x-2}{2x} = \frac{1}{24};\quad D_x = \frac{x+24}{12}$$

$$A_x = \left(\frac{\pi}{4}\right)\left(\frac{x+24}{12}\right)^2 = \left(\frac{\pi}{576}\right)(x+24)^2$$

$$\delta = \frac{250}{20\times10^3}\left(\frac{576}{\pi}\right)\int_0^{24}\frac{dx}{(x+24)^2}$$

$$= 2.29183\left[-\frac{1}{(24+x)}\right]_0^{24}$$

$$= 0.04775 \approx 0.048\ \text{in.}$$ ANS.

1.85 AS IN PROB. 1.84, WE OBTAIN

$$A_x = \left(\frac{\pi}{576}\right)(x+18)^2$$

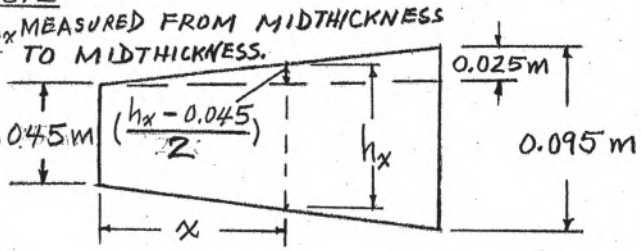
$$\delta = \frac{F}{E}\int\frac{dx}{A_x} = \frac{P}{15\times10^3}\left(\frac{576}{\pi}\right)\int_0^{24}\frac{dx}{(x+18)^2} = 0.05$$

$$0.12223P\left[-\frac{1}{(18+x)}\right]_0^{24} = 0.05$$

SOLVE TO GET $P = 128.85\ \text{kips} \approx 128.9\ \text{kips}$ ANS.

1.86 $\delta = \int\frac{F}{AE}dx = \frac{F}{E}\int\frac{dx}{A_x}$

NOTE h_x MEASURED FROM MIDTHICKNESS TO MIDTHICKNESS.



$$\frac{h_x-0.045}{2x} = \frac{0.025}{0.75} = \frac{1}{30}$$

$$h_x = 0.045 + \left(\frac{1}{15}\right)x$$

$$A_x = 4\left[0.045+\left(\frac{1}{15}\right)x\right](0.005) = 0.0009 + 0.00133x$$

$$\delta = \frac{200\times10^3}{30\times10^9}\int_0^{0.75}\frac{dx}{(0.0009+0.00133x)}$$

$$= 6.667\times10^{-6}\left(\frac{1}{0.00133}\right)\log(0.0009+0.00133x)\Big|_0^{0.75}$$

$$\delta = 5.013\times10^{-3}(-2.7218+3.0458)$$

$$= 0.00162\ \text{m} \approx 1.6\ \text{mm}$$ ANS.

1.87 AS IN PROB. 1.86, WE OBTAIN

$$h_x = 0.04 + 0.04x$$

$$A_x = 2(0.04+0.04x)(0.006) + 2(0.030)(0.006)$$

$$A_x = 0.00084 + 0.00048x$$

$$\delta = \frac{F}{E}\int\frac{dx}{A_x} = \frac{P}{110\times10^9}\int_0^{0.75}\frac{dx}{(0.00084+0.00048x)} = 0.0035$$

$$P\left(\frac{1}{0.00048}\right)\log(0.00084+0.00048x)\Big|_0^{0.75} = 3.85\times10^8$$

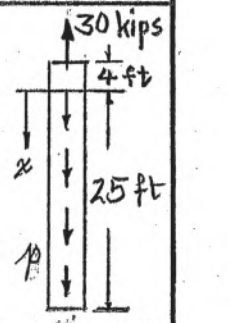
$$P[-2.92082+3.07572] = 1.848\times10^5$$

$$P = 1193\times10^3\ \text{N} = 1193\ \text{kN}$$ ANS.

1.88 (a) $\Sigma F_x = 0$

$$wp(25) - 30 = 0$$

$$wp = 1.2\ \text{kips/ft}$$ ANS.



(b) $\delta = \frac{FL}{AE} + \int\frac{F_x\,dx}{AE}$

$$\delta = \frac{1}{(61.8)(30\times10^3)}\left[30(4\times12) + \int_{4\times12}^{29\times12}(30-1.2x)\,dx\right]$$

$$\delta = 5.394\times10^{-4}(1440+4385-1325)$$

$$\delta = 2.427\ \text{in.}$$ ANS.

(c) AT $x = 15$ ft, $F_x = 30 - 1.2(15) = 12$ kips

$$\sigma = \frac{F_x}{A} = \frac{12}{61.8} = 0.194\ \text{ksi} = 194\ \text{psi}$$ ANS.

1.89 (a) $\sum F_x = 0$

$150(0.50) - P = 0$

$P = 75.0$ kN ANS.

(b) $\sum F_x = 0$

$F_2 + 150x - 75 = 0$

$F_2 = 75 - 150x$

$F_{MAX} = 75$ kN AT $x = 0$.

$\sigma_{MAX} = \frac{75\times10^3}{5\times10^{-4}} = 150$ MPa ANS.

(c) $\delta = \frac{FL}{AE} + \int \frac{F_2\,dx}{AE}$

$\delta = \frac{1}{5\times10^{-4}(70\times10^9)}\left[75\times10^3(0.10) + \int_0^{0.5}(75-150x)\,dx\right]$

$\approx 0.00075\text{ m} \approx 0.8$ mm ANS.

1.90 (a) BY EQ. (1.1): $F_2 - F_1 = \int_1^2 p\,dx$

$F_2 = P + \int_0^{0.3} 1000x\,dx$

$0 = P - 500x^2\Big|_0^{0.3}$

$P = 45$ N ANS.

(b) AT $x = 0.2$ m

$F_2 = 45 - 500(0.2)^2$

$= 25$ N ANS.

(c) $\delta = \int \frac{F\,dx}{AE} = \frac{1}{2\times10^{-5}(70\times10^9)}\int_0^{0.3}(45-500x^2)\,dx$

$= 6.429\times10^{-6}$ m ANS.

1.91 RETRACING THE STEPS USED IN PART II OF EXAMPLE 1.10, WE OBTAIN:

EQUILIBRIUM $\Rightarrow$

$120 - F_C + F_A = 0$ ——— (1)

DEFORMATION $\Rightarrow$

$F_A = -1.38616\,F_C$ ——— (2)

SOLVE SIMULTANEOUSLY TO GET:

$F_A = 69.710$ kN

$\sigma_{AB} = \left(\frac{F}{A}\right)_{AB} = \frac{69.710\times10^3}{\frac{\pi}{4}(0.06^2)} = 24.655$ MPa ANS.

$F_C = 50.290$ kN

$\sigma_{BC} = \left(\frac{F}{A}\right)_{BC} = \frac{50.290\times10^3}{\frac{\pi}{4}(0.08^2)} = 10.005$ MPa ANS.

1.92

$\sum F_y = 0$

$2F_B + F_S - P = 0$ ——— (1)

$\left(\frac{FL}{AE}\right)_B = \left(\frac{FL}{AE}\right)_S$; $\frac{F_B(1.5)}{600\times10^{-6}(100\times10^9)} = \frac{F_S(1.5)}{1500\times10^{-6}(200\times10^9)}$

$F_B = 0.2\,F_S$ ——— (2)

ASSUME BRASS CONTROLLS.

$F_B = 20\times10^6(600\times10^{-6}) = 12.0$ kN

(2) $\Rightarrow F_S = \frac{12.0}{0.2} = 60.0$ kN

$\sigma_S = \frac{60.0\times10^3}{1500\times10^{-6}} = 40.0\text{ MPa} < (\sigma_S)_{ALL}$. OK

(1) $\Rightarrow P = 2(12.0) + 60.0 = 84.0$ kN ANS.

1.93 $\sum F_y = 0$

$F_S + F_A - P = 0$ ——— (1)

$\delta_A = \delta_S$; $\frac{F_A(10)}{(0.4)(10\times10^3)} = \frac{F_S(10)}{(0.7)(30\times10^3)}$

$F_S = 5.25\,F_A$ ——— (2)

SOLVE SIMULTANEOUSLY TO GET

$F_A = 8.0$ kips

$\sigma_A = \left(\frac{F}{A}\right)_A = \frac{8.0}{0.4} = 20.0$ ksi ANS.

$F_S = 42.0$ kips

$\sigma_S = \left(\frac{F}{A}\right)_S = \frac{42.0}{0.7} = 60.0$ ksi ANS.

1.94 REFER TO F.B.D. IN PROB. 1.93.

$\sum F_x = 0$: $F_S + F_A - P = 0$ ——— (1)

$\delta_A = \delta_S$: $\frac{F_A(h)}{(0.35)(10\times10^3)} = \frac{F_S(h)}{(0.5)(30\times10^3)}$

$F_S = 4.286\,F_A$ ——— (2)

ASSUME STEEL CONTROLS.

$F_S = 40(0.5) = 20.0$ kips

(2) $\Rightarrow F_A = \frac{20.0}{4.286} = 4.666$ kips

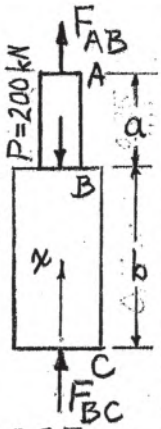
$\sigma_A = \left(\frac{F}{A}\right)_A = \frac{4.666}{0.35} = 13.331 < (\sigma_A)_{ALL}$. OK

(1) $\Rightarrow P = 20.0 + 4.666 \approx 24.7$ kips ANS.

$\delta_{PLATE} = \delta_S = \frac{20.0(15)}{(0.5)(30\times10^3)}$

$= 0.020$ in. ANS.

1.95 $\Sigma F_x = 0$



$F_{AB} - 200 + F_{BC} = 0$ ——(1)

$\delta_{AB} = \delta_{BC}$; $\left(\frac{FL}{AE}\right)_{AB} = \left(\frac{FL}{AE}\right)_{BC}$

$\frac{F_{AB}(0.25)}{(0.015)(0.03)(150\times10^9)} = \frac{F_{BC}(0.50)}{(0.05)(0.08)(150\times10^9)}$

$F_{AB} = 0.225 F_{BC}$ ——(2)

SOLVE (1) & (2) TO GET

$F_{BC} = 163.265$ kN

$F_{AB} = 36.735$ kN

$\{a = 0.25\text{ m}\}$ $\{b = 0.50\text{ m}\}$

(a) $\sigma_{AB} = \frac{36.735\times10^3}{(0.015)(0.03)} = 81.633$ MPa ANS.

$\sigma_{BC} = \frac{163.265\times10^3}{(0.05)(0.08)} = 40.816$ MPa ANS.

(b) $\delta_B = \delta_{BC} = \frac{163.265(10^3)(0.5)}{(0.05)(0.08)(150\times10^9)}$

$= 0.000136\text{m} = 0.136$ mm ANS.

1.96 REFER TO THE F.B.D. OF PROB. 1.95.

$\Sigma F_x = 0 \Rightarrow P = F_{AB} + F_{BC}$ ——(1)

$\delta_{AB} = \delta_{BC}$; $\left(\frac{FL}{AE}\right)_{AB} = \left(\frac{FL}{AE}\right)_{BC}$ $\{a = 0.3\text{ m}\}$ $\{b = 0.6\text{ m}\}$

$\frac{F_{AB}(0.3)}{(\pi/4)(0.035^2)(200\times10^9)} = \frac{F_{BC}(0.6)}{(\pi/4)(0.075^2)(70\times10^9)}$

$F_{AB} = 1.2444 F_{BC}$ ——(2)

ASSUME ALLOWABLE IN BC CONTROLS.

$F_{AB} = 1.2444(120\times10^6)(\frac{\pi}{4})(0.075^2)$

$= 659,711$ N $= 659.711$ kN

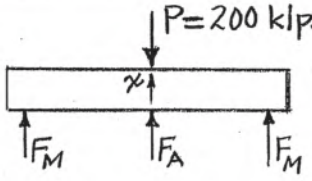
$\sigma_{AB} = \frac{659.711\times10^3}{(\pi/4)(0.035^2)}$

$= 685.690 < (\sigma_{ALL})_{AB}$. OK

(1) & (2) $\Rightarrow P = 659.711 + \frac{659.711}{1.2444}$

$= 1,189.855$ kN ANS.

1.97



$\Sigma F_x = 0$

$2F_M + F_A - 200 = 0$ —(1)

$\delta_M = \delta_A + 0.012$

$\frac{F_M(10)}{(3)(6.5\times10^3)} = \frac{F_A(10)}{(3)(10.0\times10^3)} + 0.012$

$F_M = 0.65 F_A + 23.4$ ——(2)

SOLVE (1) & (2) TO GET

$F_A = 66.609$ kips ; $F_M = 66.696$ kips

1.97 CONT'D

(a) $\sigma_A = \frac{66.609}{3} = 22.2$ ksi ANS.

$\sigma_M = \frac{66.696}{3} = 22.2$ ksi ANS.

(b) $\delta_M = \frac{66.609(10)}{(3)(10\times10^3)} + 0.012$

$= 0.022 + 0.012 = 0.034$ in. ANS.

1.98 REFER TO THE F.B.D. OF PROB. 1.97.

$\Sigma F_x = 0 \Rightarrow P = 2F_M + F_A$ ——(1)

$\delta_M = \delta_A + 0.01$; $F_M = F_A$

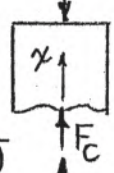
$\frac{F_A(10)}{(2.5)(6.5\times10^3)} = \frac{F_A(10)}{(2.5)(10\times10^3)} + 0.01$

$F_A = 46.429$ kips $= F_M$

(1) $\Rightarrow P = 3(46.429) = 139.3$ kips ANS.

$\delta_M = \frac{46.429(10)}{2.5(10\times10^3)} + 0.01 = 0.029$ in. ANS.

1.99 $\Sigma F_x = 0$



$5F_S + F_C - 2000 = 0$ ——(1)

$\delta_C = \delta_S$; $\left(\frac{FL}{AE}\right)_C = \left(\frac{FL}{AE}\right)_S$

$\frac{F_C(4)}{(0.12164)(30\times10^9)} = \frac{F_S(4)}{(0.00402)(200\times10^9)}$

$F_C = 4.537 F_S$ ——(2)

SOLVE (1) & (2) TO GET

$F_S = 209.710$ kN

$F_C = 951.452$ kN

$A_C = \frac{\pi}{4}[0.4^2 - 5(0.032^2)] = 0.12164\text{ m}^2$

$A_S = 5(\frac{\pi}{4})(0.032^2) = 0.00402\text{ m}^2$

$\sigma_S = \frac{F_S}{A_S} = 52.167\text{ MPa} \approx 52.2\text{MPa}$ ANS

$\sigma_C = \frac{F_C}{A_C} = 7.822\text{ MPa} \approx 7.8\text{MPa}$ ANS.

1.100 REFER TO THE F.B.D. OF PROB. 1.99.

$5F_S + F_C - P = 0$ ——(1)

$\delta_C = \delta_S$; $\left(\frac{FL}{AE}\right)_C = \left(\frac{FL}{AE}\right)_S$

$\frac{F_C(3.5)}{(0.15423)(30\times10^9)} = \frac{F_S(3.5)}{(0.00481)(210\times10^9)}$

$A_C = \frac{\pi}{4}[0.45^2 - 5(0.035^2)] = 0.15423\text{ m}^2$

$A_S = 5(\frac{\pi}{4})(0.035^2) = 0.00481\text{ m}^2$

$F_S = 0.20791 F_C = 0.20791[20\times10^6(0.15423)]$

$= 641.319$ kN (ASSUMING CONCRETE CONTROLS)

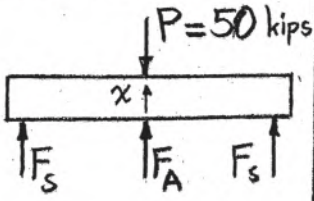
CHECK: $\sigma_S = \frac{F_S}{A_S} = 133.330\text{MPa} < (\sigma_{ALL})_S$ OK

$F_C = 4.8097 F_S = 3084.552$ kN

(1) $\Rightarrow P = 5(641.319) + 3084.552$

$= 6,291.147 \approx 6,291.1$ kN ANS.

1.101 $\Sigma F_x = 0$



$2F_S + F_A - 50 = 0$ —— (1)

$\delta_A = \delta_S + 0.001$

$\left(\frac{FL}{AE}\right)_A = \left(\frac{FL}{AE}\right)_S + 0.001$

$\frac{F_A(15)}{(2)(2.5)(10\times10^3)} = \frac{F_S(15)}{(2)(2.5)(30\times10^3)} + 0.001$

$3F_A = F_S + 10$ —— (2)

SOLVE (1) & (2) TO GET

$F_S = 20$ kips; $\sigma_S = \left(\frac{F}{A}\right)_S = 4.0$ ksi ANS.

$F_A = 10$ kips; $\sigma_A = \left(\frac{F}{A}\right)_A = 2.0$ ksi ANS.

1.102 REFER TO THE F.B.D. OF PROB. 1.101.

$2F_S + F_A - 60 = 0$ —— (1)

$\delta_A = \delta_S + e$; $\left(\frac{FL}{AE}\right)_A = \left(\frac{FL}{AE}\right)_S + e$

$\frac{F_A(15)}{(1.5)(3.0)(10\times10^3)} = \frac{F_S(15)}{(1.5)(3.0)(30\times10^3)} + e$

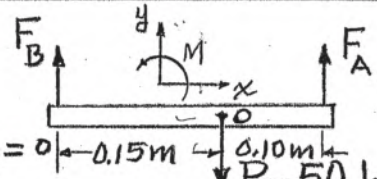
$3F_A = F_S + 9000e$ —— (2)

$\sigma_S = 2\sigma_A \Rightarrow F_S = 2F_A$ —— (3)

SOLVE SIMULTANEOUSLY TO GET

$F_S = 24$ kips; $F_A = 12$ kips; $e = 0.00133$ in. ANS.

1.103



$\Sigma M_O = 0$

$0.10F_A - 0.15F_B = 0$

$F_A = 1.5F_B$ —— (1)

$\Sigma F_y = 0$; $F_A + F_B - 50 = 0$ —— (2)

SOLVE (1) & (2) TO GET

$F_A = 30$ kN; $F_B = 20$ kN

$\delta_A = \delta_B$; $\left(\frac{FL}{AE}\right)_A = \left(\frac{FL}{AE}\right)_B$

$\frac{(30)(0.30)}{A_A(75\times10^9)} = \frac{(20)(0.20)}{A_B(100\times10^9)}$

$A_A = 3A_B$ —— (3)

$F_B = \sigma_B A_B$; $20\times10^3 = 15\times10^6 A_B$

$A_B = 1.333\times10^{-3}$ m^2 ANS.

(3) $\Rightarrow$

$A_A = 4.0\times10^{-3}$ m^2 ANS.

1.104 REFER TO THE F.B.D. OF PROB. 1.103.

$\Sigma M_O = 0$: $F_A b - F_B a = 0 \Rightarrow \frac{a}{b} = \frac{F_A}{F_B}$ —— (1)

$\Sigma F_y = 0$: $F_B + F_A - 60 = 0$ —— (2)

$\delta_A = \delta_B$; $\left(\frac{FL}{AE}\right)_A = \left(\frac{FL}{AE}\right)_B$

$\frac{F_A(0.3)}{(0.0065)(75\times10^9)} = \frac{F_B(0.2)}{(0.0130)(100\times10^9)}$

$F_A = 0.25F_B$ —— (3)

SOLVE (2) & (3) TO GET

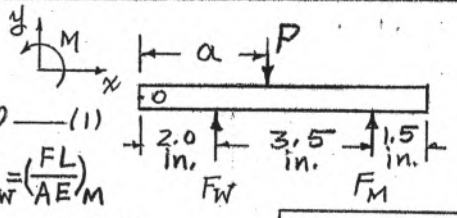
$F_A = 12$ kN; $F_B = 48$ kN

(1) $\Rightarrow \frac{a}{b} = \frac{12}{48} = \frac{1}{4}$ ANS.

$\sigma_A = \left(\frac{F}{A}\right)_A = \frac{12\times10^3}{0.0065} = 1,846 \approx 1.9$ MPa ANS.

$\sigma_B = \left(\frac{F}{A}\right)_B = \frac{48\times10^3}{0.0130} = 3.692 \approx 3.7$ MPa ANS.

1.105



P = 75 kips

$\Sigma F_y = 0$

$F_W + F_M - 75 = 0$ —— (1)

$\delta_W = \delta_M$; $\left(\frac{FL}{AE}\right)_W = \left(\frac{FL}{AE}\right)_M$

$\frac{F_W(10)}{(4)(5)(2\times10^6)} = \frac{F_M(10)}{(3)(5)(6.5\times10^6)}$

$F_W = 0.41026F_M$ —— (2)

SOLVE (1) & (2) TO GET

$F_W = 21.818$ kips; $F_M = 53.182$ kips

(a) $\Sigma M_O = 0$: $21.818(2.0) + 53.182(5.5) - 75a = 0$

$a = 4.482$ in. ANS.

(b) $\sigma_W = \left(\frac{F}{A}\right)_W = 1.091 \approx 1.1$ ksi ANS.

$\sigma_M = \left(\frac{F}{A}\right)_M = 3.545 \approx 3.5$ ksi ANS.

1.106 REFER TO THE F.B.D. OF PROB. 1.105.

P = 60 kips

$\Sigma F_y = 0$: $F_W + F_M - 60 = 0$ —— (1)

$\delta_W = \delta_M$; $\frac{F_W(12)}{(4d)(2\times10^6)} = \frac{F_M(12)}{(3d)(6.5\times10^6)}$

$F_W = 0.41026F_M$ —— (2)

SOLVE (1) & (2) TO GET: $F_W = 17.455$ kips; $F_M = 42.545$ kips

(a) $(\sigma_{ALL})_W = 7.5 = \frac{F_W}{4d}$

$d = \frac{17.455}{(7.5)(4)} = 0.582$ in. ANS.

CHECK: $\sigma_M = \frac{F_M}{3d} = \frac{42.545}{3(0.582)} = 24.4$ ksi $< (\sigma_{ALL})_M$ OK.

(b) $\Sigma M_O = 0$: $17.455(2.0) + 42.545(5.5) - 60a = 0$

$a = 4.482$ in ANS.