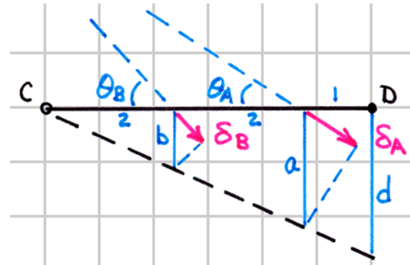
5-32

$$\delta_A = \varepsilon_A L_A = \left(625\times 10^{-6}\right)\left(5000\right) = 3.12500 \text{ mm}$$

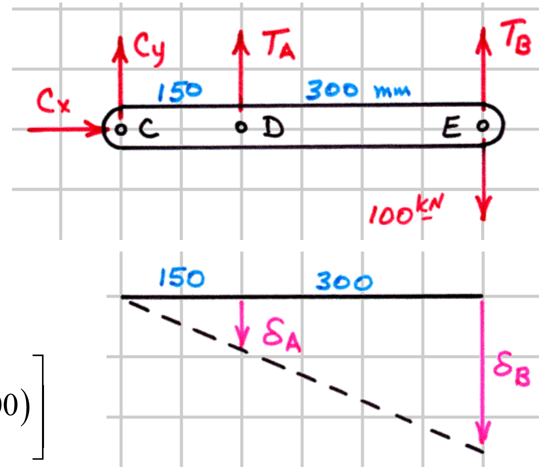
$$\delta_A = a\sin\theta_A = \left(3/5\right)a$$

$$a = 5.20833 \text{ mm}$$



$d = \left(5/4\right)a = 6.51 \text{ mm} \downarrow$ .... **Ans.**

5-66*



$\rightarrow \Sigma F_x = 0: \qquad C_x = 0$

$\uparrow \Sigma F_y = 0: \qquad C_y + T_A + T_B - 100 = 0$

$\circlearrowleft \Sigma M_C = 0: \qquad 150T_A + 450T_B - 450(100) = 0$

$$T_A + 3T_B = 300 \text{ kN} \qquad \text{(a)}$$

$$\delta_B = (450/150)\delta_A$$

$$\left[\frac{T_B(500)}{(300\times10^{-6})(70\times10^{9})} + (22.5\times10^{-6})(-25)(500)\right]$$

$$= \left(\frac{450}{150}\right)\left[\frac{T_A(250)}{(1200\times10^{-6})(210\times10^{9})} + (11.9\times10^{-6})(-25)(250)\right]$$

$$T_A - 8T_B = -19{,}530 \text{ N} = -19.530 \text{ kN} \qquad \text{(b)}$$

$T_A = 212.8555$ kN $\qquad T_B = 29.0482$ kN

$C_x = 0$ kN $\qquad C_y = -141.904$ kN $\qquad C = \sqrt{C_x^2 + C_y^2} = 141.904$ kN

(a) $\sigma_A = \dfrac{212.8555(10^3)}{1200(10^{-6})} = 177.4(10^6)\ \text{N/m}^2 = 177.4$ MPa (T) .... **Ans.**

$\sigma_B = \dfrac{29.0482(10^3)}{300(10^{-6})} = 96.8(10^6)\ \text{N/m}^2 = 96.8$ MPa (T) .... **Ans.**

(b) $\tau_{\max A} = \sigma_{\max A}/2 = 88.7$ MPa .... **Ans.**

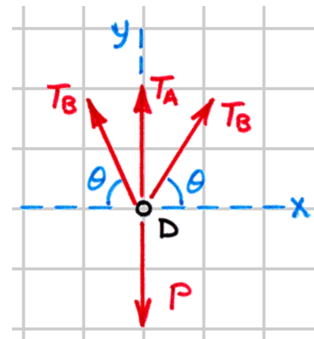
$\tau_{\max B} = \sigma_{\max B}/2 = 48.4$ MPa .... **Ans.**

(c) $\tau_C = \dfrac{V}{A} = \dfrac{141.904(10^3)}{2\left[\pi(0.020)^2/4\right]} = 226(10^6)\ \text{N/m}^2 = 226$ MPa .... **Ans.**

(d) $v_E = \delta_B = \dfrac{(29.0482)(500)}{(300\times10^{-6})(70\times10^{9})} + (22.5\times10^{-6})(-25)(500)$

$v_E = 0.410$ mm $\downarrow$ .... **Ans.**

5-71*



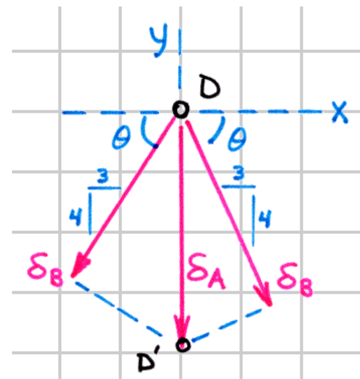
$\sin\theta = 4/5 \qquad P = 200 \text{ kip}$

$$T_A + 2(4/5)T_B = 200 \text{ kip} \qquad \text{(a)}$$

$$\delta_B = (4/5)\delta_A$$

$$\frac{T_B(5\times 12)}{(2.5)(30{,}000)} + (6.6\times 10^{-6})(30)(5\times 12) = \left(\frac{4}{5}\right)\left[\frac{T_A(4\times 12)}{(3)(15{,}000)} + (9.4\times 10^{-6})(-50)(4\times 12)\right]$$

$$T_B = 1.06667T_A - 37.41000 \text{ kip} \qquad \text{(b)}$$



$T_A = 96.0055 \text{ kip (T)} \qquad T_B = 64.9966 \text{ kip (T)}$

(a) $\sigma_A = \dfrac{96.0055}{3} = 32.0 \text{ ksi}$ .... **Ans.**

$\sigma_B = \dfrac{64.9966}{2.5} = 26.0 \text{ ksi}$ .... **Ans.**

(b) $v_C = \delta_A = \dfrac{(96.0055)(4\times 12)}{(3)(15{,}000)} + (9.4\times 10^{-6})(-50)(4\times 12)$

$v_C = 0.0799 \text{ in.}$ .... **Ans.**

5-89*

$2T_S + T_A = P$ $\qquad 2(1.6\sigma_S) + (3.2\sigma_A) = P$ (a)

$\delta_S = \delta_A$

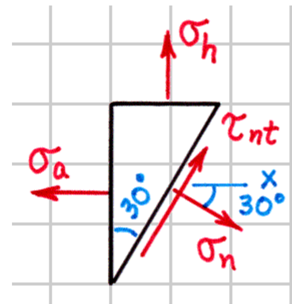
$\dfrac{\sigma_S(8)}{(29{,}000)} = \dfrac{\sigma_A(10)}{(10{,}600)}$ $\qquad \sigma_S = 3.41981\sigma_A$ (b)

$\sigma_S = 100$ ksi $\qquad \sigma_A = 29.2414$ ksi

$T_S = 100(1.6) = 160$ kip (T) $\qquad T_A = 29.2414(3.2) = 93.572$ kip (T)

$P_{max} = 93.572 + 2(160) = 414$ kip .... **Ans.**

5-100*



$$\sigma_x = \sigma_a = \frac{pr}{2t} = \frac{(950)(500-50)}{2(50)} = 4275 \text{ kPa} = 4.275 \text{ MPa}$$

$$\sigma_y = \sigma_h = \frac{pr}{t} = \frac{(950)(500-50)}{(50)} = 8550 \text{ kPa} = 8.550 \text{ MPa}$$

$$\tau_{xy} = 0 \text{ MPa} \qquad \theta = -30°$$

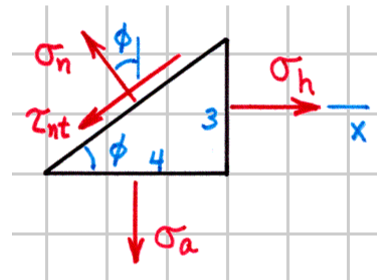
$$\sigma_n = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + 2\tau_{xy}\sin\theta\cos\theta$$
$$= 4.275\cos^2(-30°) + 8.55\sin^2(-30°) + 0$$

$\sigma_n = 5.34$ MPa (T) .... **Ans.**

$$\tau_{nt} = -(\sigma_x - \sigma_y)\sin\theta\cos\theta + \tau_{xy}(\cos^2\theta - \sin^2\theta)$$
$$= -(4.275 - 8.55)\sin(-30°)\cos(-30°) + 0$$

$\tau_{nt} = -1.851$ MPa .... **Ans.**

5-104*



(a) $$\sigma_x = \sigma_h = \frac{pr}{t} = \frac{\left(2800\times 10^3\right)(600)}{(20)}$$

$$= 84.00\left(10^6\right)\text{ N/m}^2 = 84.00\text{ MPa}$$

$$\sigma_y = \sigma_a = \frac{pr}{2t} = \frac{\left(2800\times 10^3\right)(600)}{2(20)}$$

$$= 42.00\left(10^6\right)\text{ N/m}^2 = 42.00\text{ MPa}$$

$$\tau_{xy} = 0\text{ MPa} \qquad \phi = \tan^{-1}\frac{3}{4} = 36.870° \qquad \theta = 90° + \phi = 126.870°$$

$$\sigma_n = \sigma_x\cos^2\theta + \sigma_y\sin^2\theta + 2\tau_{xy}\sin\theta\cos\theta$$

$$= 84\cos^2(126.870°) + 42\sin^2(126.870°) + 0$$

$\sigma_n = 57.1$ MPa (T) .... **Ans.**

$$\tau_{nt} = -\left(\sigma_x - \sigma_y\right)\sin\theta\cos\theta + \tau_{xy}\left(\cos^2\theta - \sin^2\theta\right)$$

$$= -(84-42)\sin(126.870°)\cos(126.870°) + 0$$

$\tau_{nt} = +20.2$ MPa .... **Ans.**

(b) $$E = 2(1+\nu)G \qquad \nu = \frac{200}{2(76)} - 1 = 0.31579$$

$\varepsilon_a = \dfrac{\sigma_a - \nu\sigma_h}{E} = \dfrac{\left[42 - 0.31579(84)\right]\left(10^6\right)}{200\left(10^9\right)} = 77.4\left(10^{-6}\right) = 77.4\ \mu\text{m/m}$ .... **Ans.**

$\varepsilon_h = \dfrac{\sigma_h - \nu\sigma_a}{E} = \dfrac{\left[84 - 0.31579(42)\right]\left(10^6\right)}{200\left(10^9\right)} = 354\left(10^{-6}\right) = 354\ \mu\text{m/m}$ .... **Ans.**

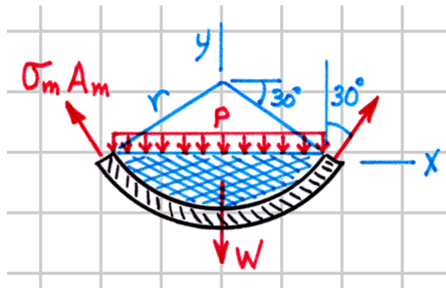
(c) $$\sigma_{max} = \sigma_h = 84.00\text{ MPa} \qquad \sigma_{min} = \sigma_z = 0\text{ MPa}$$

$\tau_{max} = \dfrac{\sigma_{max} - \sigma_{min}}{2} = \dfrac{84.00 - 0}{2} = 42.0$ MPa .... **Ans.**

(d) $$\sigma_{max} = \sigma_h = 84.00\text{ MPa} \qquad \sigma_{min} = \sigma_z = -2.800\text{ MPa}$$

$\tau_{max} = \dfrac{\sigma_{max} - \sigma_{min}}{2} = \dfrac{84.00 - (-2.800)}{2} = 43.4$ MPa .... **Ans.**

5-107



$p = \gamma y \qquad \theta = \sin^{-1}\frac{r/2}{r} = 30°$

$$W = \int \gamma dV = \int_{r/2}^{r} \gamma\pi\left(r^2 - y^2\right)dy$$

$$= \gamma\pi\left[r^2 y - \frac{y^3}{3}\right]_{r/2}^{r} = \frac{5\gamma\pi r^3}{24}$$

$$x = \sqrt{r^2 - y^2} = \sqrt{r^2 - (r/2)^2} = \frac{r\sqrt{3}}{2}$$

$\uparrow \Sigma F_y = 0: \qquad \sigma_m A_m \cos 30° - W - pA_p = 0$

$$\sigma_m\left(2\pi x t\right)\cos 30° - W - p\left(\pi x^2\right) = 0$$

$$\sigma_m\left(2\pi t\right)\left(\frac{r\sqrt{3}}{2}\right)\cos 30° - \left(\frac{5\gamma\pi r^3}{24}\right) - \pi\left(\frac{\gamma r}{2}\right)\left(\frac{r\sqrt{3}}{2}\right)^2 = 0$$

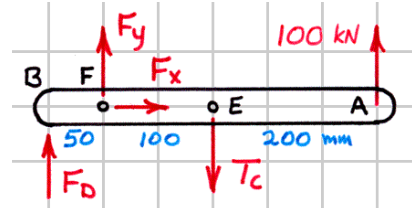
$\sigma_m = \dfrac{7\gamma r^2}{18t}$ .... **Ans.**

$\dfrac{\sigma_m}{r_m} + \dfrac{\sigma_t}{r_t} = \dfrac{p}{t} \qquad r_m = r_t = r$

$\dfrac{7\gamma r}{18t} + \dfrac{\sigma_t}{r} = \dfrac{\gamma r}{2t} \qquad \sigma_t = \dfrac{\gamma r^2}{9t}$ .... **Ans.**

5-142*

$$\circlearrowleft \Sigma M_F = 0: \quad 300(100) - 50F_D - 100T_C = 0$$

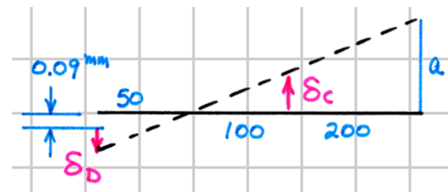


$$F_D + 2T_C = 600 \text{ kN}$$

$$\sigma_D\left(2000\times10^{-6}\right) + 2\sigma_C\left(600\times10^{-6}\right) = 600 \text{ kN}$$

$$5\sigma_D + 3\sigma_C = 1500\left(10^6\right) \text{ N/m}^2 = 1500 \text{ MPa} \qquad \text{(a)}$$

$$\delta_C = 2\left(\delta_D + 0.09\right) \text{ mm} \qquad \text{(b)}$$



Assume both bars elastic. Then

$$\frac{\sigma_C(300)}{\left(200\times10^9\right)} = 2\left[\frac{\sigma_D(150)}{\left(100\times10^9\right)} + 0.09\right]$$

$$\sigma_C = 2\sigma_D + 120\left(10^6\right) \text{ N/m}^2 = 2\sigma_D + 120 \text{ MPa} \qquad \text{(b)}$$

$$\sigma_C = 327.273 \text{ MPa} > 240 \text{ MPa (plastic)}$$

$$\sigma_D = 103.636 \text{ MPa} < 410 \text{ MPa (elastic)}$$

Therefore

(a) $\sigma_C = \sigma_y = 240.0 \text{ MPa}$ .... **Ans.**

and from Eq. (a) $\sigma_D = 156.0 \text{ MPa}$ .... **Ans.**

(b) $v_A = a = 6\left(\delta_D + 0.09\right) = 6\left[\frac{\left(156.0\times10^6\right)(150)}{\left(100\times10^9\right)} + 0.09\right] = 1.944 \text{ mm} \uparrow$ .... **Ans.**