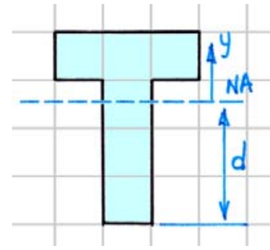
7-22

$$d = \frac{M_x}{A} = \frac{(140)\left[(120)(40)\right]+(60)\left[(40)(120)\right]}{\left[(120)(40)\right]+\left[(40)(120)\right]} = 100 \text{ mm}$$

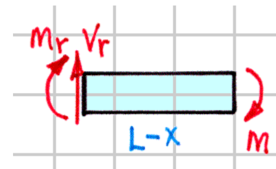


$$I = \frac{(120)(60)^3}{3} - \frac{(80)(20)^3}{3} + \frac{(40)(100)^3}{3}$$

$$= 21.76\left(10^6\right) \text{ mm}^4$$

$$\circlearrowleft \Sigma M_{cut} = 0: \qquad -M_r - M = 0$$

$$M_r = -M$$



(The internal resisting moment is the same over the entire length of the beam.)

At the top of the beam $(\sigma = 90 \text{ MPa T})$

$$M = -M_r = \frac{\sigma I}{y} = \frac{\left(90\times 10^6\right)\left(21.76\times 10^{-6}\right)}{(0.060)} = +32.6 \text{ kN}\cdot\text{m}$$

At the bottom of the beam $(\sigma = 140 \text{ MPa C})$

$$M = -M_r = \frac{\sigma I}{y} = \frac{\left(-140\times 10^6\right)\left(21.76\times 10^{-6}\right)}{(-0.100)} = +30.5 \text{ kN}\cdot\text{m}$$

$M_{max} = 30.5 \text{ kN}\cdot\text{m}$ ↻ .... **Ans.**

7-39

$\circlearrowleft \Sigma M_B = 0: \quad [(500)(6)](7) + [(800)(5)](2.5) - 10R_A = 0 \qquad R_A = 1100 \text{ lb}$

$\circlearrowleft \Sigma M_A = 0: \quad 10R_B - [(500)(6)](3) - [(800)(5)](12.5) = 0 \qquad R_B = 5900 \text{ lb}$

(a) $V_r = 1100 - (500)(6) = (-1900) \text{ lb}$ .... **Ans.**

$M_r = 1100x - [(500)(6)](x-3) = [-1900x + 9000] \text{ lb}\cdot\text{ft}$ .... **Ans.**

(b) From Table B-3 for an $S8\times 23$ section $\quad d = 2c = 8.00 \text{ in.}$

$I = 64.9 \text{ in.}^4 \qquad S = 16.2(10^3) \text{ in.}^3$

$M_3 = 1100(3) - [(500)(3)](1.5) = 1050 \text{ lb}\cdot\text{ft} \qquad y = c - 1 = 4 - 1 = +3 \text{ in.}$

$\sigma = \dfrac{-M_r y}{I} = \dfrac{-(1050\times 12)(3)}{(64.9)} = -582 \text{ psi} = 582 \text{ psi (C)}$ .... **Ans.**

(c) $\sigma_{\max} = \dfrac{M_r}{S} = \dfrac{(1050\times 12)}{(16.2)} = 778 \text{ psi (C, top; T bottom)}$ .... **Ans.**

7-41*

$$R_A = R_B = \frac{1}{2}\int_0^{10} 1000\sin\left(\frac{\pi s}{10}\right)ds = \left[\frac{-5000}{\pi}\cos\left(\frac{\pi s}{10}\right)\right]_0^{10} = \left(\frac{10,000}{\pi}\right)\text{ lb}$$

(a) $$V_r = R_A - \int_0^x w\,ds = \left(\frac{10,000}{\pi}\right) - \int_0^x 1000\sin\left(\frac{\pi s}{10}\right)ds$$

$$V_r = \left(\frac{10,000}{\pi}\right) + \left[\frac{10,000}{\pi}\cos\left(\frac{\pi s}{10}\right)\right]_0^x = \left[\frac{10,000}{\pi}\cos\left(\frac{\pi x}{10}\right)\right]\text{ lb}$$ .... **Ans.**

$$M_r = R_A x - \int_0^x w(x-s)\,ds = \left(\frac{10,000x}{\pi}\right) - \int_0^x 1000(x-s)\sin\left(\frac{\pi s}{10}\right)ds$$

$$= \left(\frac{10,000x}{\pi}\right) + \left[\frac{10,000x}{\pi}\cos\left(\frac{\pi s}{10}\right)\right]_0^x + \left[\frac{100,000}{\pi^2}\sin\left(\frac{\pi s}{10}\right)\right]_0^x - \left[\frac{10,000s}{\pi}\cos\left(\frac{\pi s}{10}\right)\right]_0^x$$

$$M_r = \left[\frac{100,000}{\pi^2}\sin\left(\frac{\pi x}{10}\right)\right]\text{ lb}\cdot\text{ft} = \left[10.13\sin\left(\frac{\pi x}{10}\right)\right]\text{ kip}\cdot\text{ft}$$ .... **Ans.**

(b) $$V_{\max} = V_{x=0} = V_{x=10} = \frac{10,000}{\pi} = 3183\text{ lb} \cong 3.18\text{ kip}$$ .... **Ans.**

$$M_{\max} = M_{x=5} = \frac{100,000}{\pi^2} = 10,132\text{ lb}\cdot\text{ft} \cong 10.13\text{ kip}\cdot\text{ft}$$ .... **Ans.**

7-58*

$\circlearrowleft \Sigma M_E = 0:$

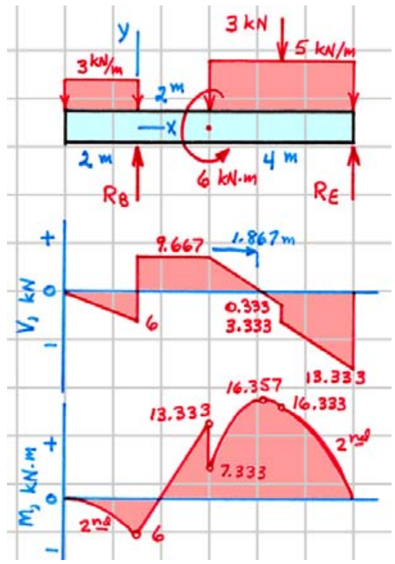
$$(3\times 2)(7)+(6)+(5\times 4)(2)+(3)(2)-6R_B = 0$$

$$R_B = 15.667 \text{ kN} \uparrow$$

$\circlearrowleft \Sigma M_B = 0:$

$$6R_E + (3\times 2)(1)+(6)-(5\times 4)(4)-(3)(4) = 0$$

$$R_E = 13.333 \text{ kN} \uparrow$$



From the moment diagram: $M_{max} = +16.357 \text{ kN}\cdot\text{m},\ -6 \text{ kN}\cdot\text{m}$

From Table B-2 for a W102×19 section : $S = 89.5(10^3) \text{ mm}^3$

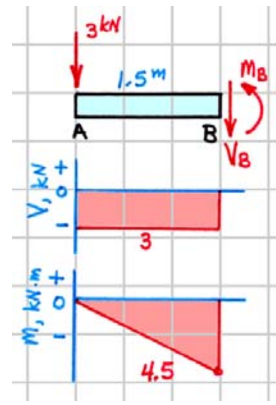
$$\sigma = \frac{M_r}{S} = \frac{(16.357)}{(89.5\times 10^{-6})} = +182.8(10^6) \text{ N/m}^2$$

$\sigma = 182.8$ MPa (T, bottom; C, top) .... **Ans.**

Both stresses would be less at the section where $M = -6 \text{ kN}\cdot\text{m}$.

此題答案有誤，1.867m 應修正為1.934 m
Maximum moment 為 + 16.680 kN · m
所以maximum stress 為 + 186.4 (10^6) N/m^2

7-66



For the complete structure:

$$\circlearrowleft \Sigma M_D = 0: \qquad 3R_C - (3)(1.5) - (1.5\times 3)(1.5) = 0$$

$$R_C = 3.75\text{ kN} = 3.75\text{ kN}\uparrow$$

$$\uparrow \Sigma F_y = 0: \qquad R_D - (3) - (1.5\times 3) + (3.75) = 0$$

$$R_D = 3.75\text{ kN} = 3.75\text{ kN}\uparrow$$

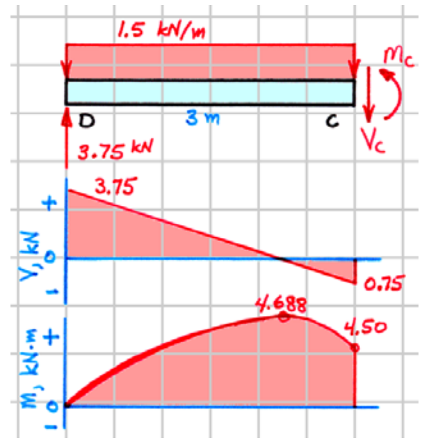
For the member *AB*:

$$\uparrow \Sigma F_y = 0: \qquad -(3) - V_B = 0$$

$$V_B = -3\text{ kN} = 3\text{ kN}\uparrow$$

$$\circlearrowleft \Sigma M_B = 0: \qquad M_B + (3)(1.5) = 0$$

$$M_B = -4.5\text{ kN}\cdot\text{m} = 4.5\text{ kN}\cdot\text{m}\circlearrowright$$



For the member *CD*:

$$\uparrow \Sigma F_y = 0: \qquad (3.75) - (1.5\times 3) - V_C = 0$$

$$V_C = -0.75\text{ kN} = 0.75\text{ kN}\uparrow$$

$$\circlearrowleft \Sigma M_C = 0: \qquad M_C + (1.5\times 3)(1.5) - (3.75)(3) = 0$$

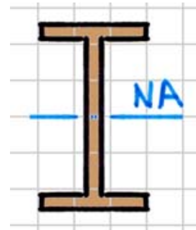
$$M_C = +4.5\text{ kN}\cdot\text{m} = 4.5\text{ kN}\cdot\text{m}\circlearrowleft$$

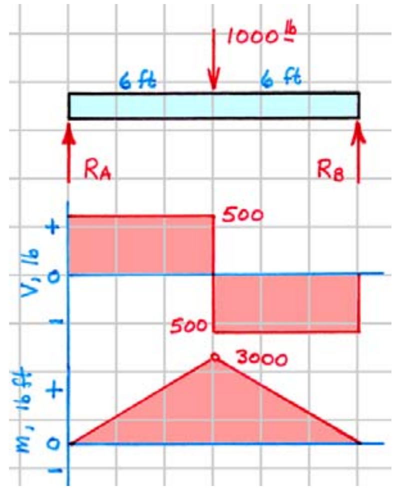
7-85*

$R_A = R_B = 1000/2 = 500 \text{ lb} = 500 \text{ lb} \uparrow$

$V = \text{constant} = 500 \text{ lb}$

$$I = \frac{(6)(12)^3}{12} - \frac{(4)(8)^3}{12} = 693.3 \text{ in.}^4$$





(a) $Q_J = y_C A = 5(6 \times 2) = 60.0 \text{ in}^3$

$$\tau_J = \frac{VQ}{It} = \frac{(500)(60.0)}{(693.3)(2)} = 21.636 \text{ psi}$$

$F_J = \tau_J A_J = (21.636)(12 \times 2) = 519.3 \text{ lb}$

$F_J \cong 519 \text{ lb}$ .... **Ans.**

(b) $N = F_J / F_N = 519.3/100 = 5.19 \text{ nails}$ $s = 12/5.19 = 2.13 \text{ in.}$

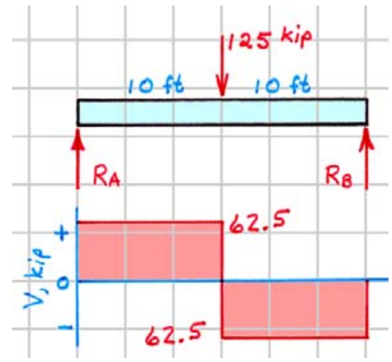
Use 6 nails spaced 2 in. apart in a 12-in. length. .... **Ans.**

7-89*

$$R_A = R_B = 125/2 = 62.5 \text{ kip} = 62.5 \text{ kip} \uparrow \qquad V = \text{constant} = 62.5 \text{ kip}$$

From Table B-1 for a $\text{W } 21 \times 101$ section: $I = 2420 \text{ in.}^4$

$$d = 2c = 21.36 \text{ in.} \qquad w_f = 12.290 \text{ in.}$$



For the beam:

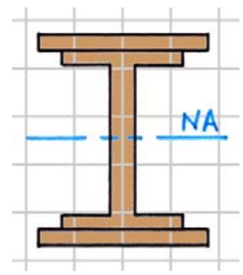
$$I = 2420 + 2\left[\frac{(16)(0.75)^3}{12} + (16 \times 0.75)(11.055)^2\right] = 5354 \text{ in.}^4$$

$$Q_J = y_C A = 11.055(16 \times 0.75) = 132.66 \text{ in}^3$$

$$\tau_J = \frac{VQ}{It} = \frac{(62{,}500)(132.66)}{(5354)(12.290)} = 126.01 \text{ psi}$$

$$F_J = \tau_J A_J = (126.01)(12.290s) = (1548.6s) \text{ lb}$$

$$F_B = \tau_B A_B = 2(17{,}500)\left[\pi(0.75)^2/4\right] = 15{,}463 \text{ lb}$$



Since $F_B = F_J$ $\qquad s = \dfrac{15{,}463}{1548.6} = 9.985 \text{ in.} \cong 10.00 \text{ in.}$ ....**Ans.**

7-197*

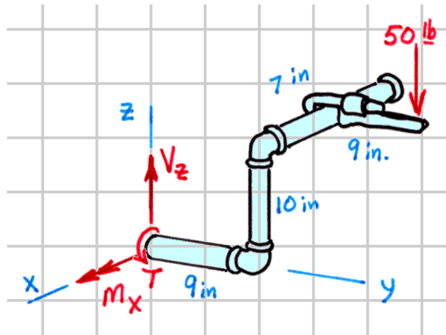
$$I = \frac{\pi(1)^4}{64} - \frac{\pi(0.75)^4}{64} = 0.03356 \text{ in.}^4 \qquad J = 2I = 0.06711 \text{ in.}^4$$

$$M_x = (50)(18) = 900 \text{ lb}\cdot\text{in.}$$

$$T = (50)(7) = 350 \text{ lb}\cdot\text{in.} \qquad V_z = 50 \text{ lb}$$

$$\sigma = \frac{Mc}{I} = \frac{(900)(0.5)}{0.003356} = 13{,}409 \text{ psi (T, top; C, bottom)}$$

$$\tau = \frac{Tc}{J} = \frac{(350)(0.50)}{0.06711} = 2608 \text{ psi}$$



On the top of the pipe:

$$\sigma_{p1,p2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \frac{13{,}409 + 0}{2} \pm \sqrt{\left(\frac{13{,}409 - 0}{2}\right)^2 + (2608)^2}$$

$\sigma_{p1} = 6705 + 7194 = +13{,}899 \text{ psi} \cong 13.90 \text{ ksi (T)}$ .... **Ans.**

$\sigma_{p2} = 6705 - 7194 = -489 \text{ psi} \cong 0.489 \text{ ksi (C)}$ .... **Ans.**

$\sigma_{p3} = 0 \text{ ksi}$ .... **Ans.**

$\tau_{max} = \tau_p = \dfrac{\sigma_{p1} - \sigma_{p2}}{2} = \dfrac{(13{,}899) - (-489)}{2} = 7194 \text{ psi} \cong 7.19 \text{ ksi}$ .... **Ans.**

On the bottom of the pipe:

$$\sigma_{p1,p2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \frac{-13{,}409 + 0}{2} \pm \sqrt{\left(\frac{-13{,}409 - 0}{2}\right)^2 + (2608)^2}$$

$\sigma_{p1} = -6705 + 7194 = +489 \text{ psi} \cong 0.489 \text{ ksi (T)}$ .... **Ans.**

$\sigma_{p2} = -6705 - 7194 = -13{,}899 \text{ psi} \cong 13.90 \text{ ksi (C)}$ .... **Ans.**

$\sigma_{p3} = 0 \text{ ksi}$ .... **Ans.**

$\tau_{max} = \tau_p = \dfrac{\sigma_{p1} - \sigma_{p2}}{2} = \dfrac{(489) - (-13{,}899)}{2} = 7194 \text{ psi} \cong 7.19 \text{ ksi}$ .... **Ans.**