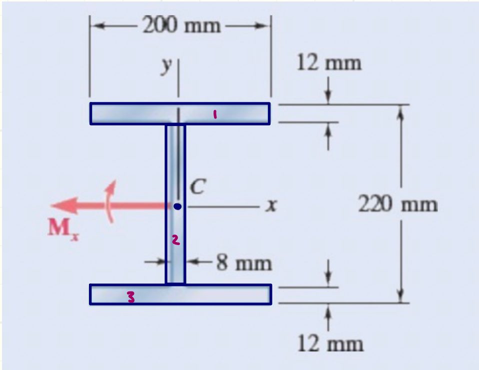
ANANYA VARMA | HOMEWORK 10 | 4.5.2024

P 11.3



f (ALLOWABLE) $= 155$ MPa

$I_{xx} = I_1 + I_2 + I_3$

CENTROID:

$$\bar{x} = \bar{y} = \frac{200}{2} = 100 \text{ mm}$$

HEIGHT FROM CENTROID

$$I_1 = \frac{bd^3}{12} + Ah^2$$

$$= \frac{(200)(12)^3}{12} + (200)(12)(214-110)^2 = 25987200 \text{ mm}^4$$

$$I_2 = \frac{bd^3}{12} + Ah^2$$

$$= \frac{(8)(196)^3}{12} + (8)(196)(0)^2 = 5019690.667 \text{ mm}^4$$

$$I_3 = \frac{bd^3}{12} + Ah^2$$

$$= \frac{(200)(12)^3}{12} + (200)(12)(110-6)^2 = 25987200 \text{ mm}^4$$

$$I_{xx} = I_1 + I_2 + I_3$$

$$= 56994090.67 \text{ mm}^4 \longrightarrow 56.99 \times 10^6 \text{ mm}^4$$

BENDING MOMENT

$$\frac{M}{I} = \frac{f}{y}$$

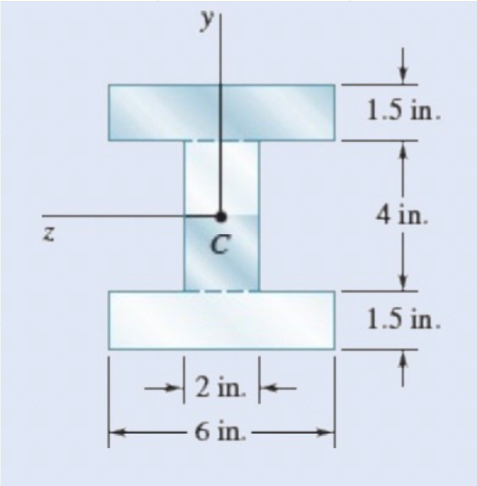
ALLOWABLE STRESS

CENTROID

MOMENT OF INERTIA

$$M = \frac{f \cdot I}{y} \longrightarrow \frac{(155)(56.99 \times 10^6)}{110} = \boxed{80.31 \text{ kN}\cdot\text{m}} \longrightarrow \text{LARGEST BENDING MOMENT}$$

P11.13



BENT ALONG HORIZONTAL AXIS

BENDING MOMENT IS 50 kip·in

BENDING STRESS:

$$\left.\begin{array}{l}\sigma_x = \dfrac{My}{I} \\ \sigma = \dfrac{F}{A}\end{array}\right\} F = \frac{M \cdot y \cdot A}{I}$$

$$I_1 = I_3 = \frac{(6)(1.5)^3}{12} + (6)(1.5)(2+0.75)^2 = 69.75 \text{ in}^4$$

$$I_2 = \frac{(2)(4)^3}{12} = 10.667 \text{ in}^4$$

$$I = I_1 + I_2 + I_3$$
$$= 2(69.75) + 10.667 = 150.1667 \text{ in}^4$$

a) TOTAL FORCE ON TOP OF FLANGE:

$A = 6 \cdot 1.5 = 9 \text{ in}^2$

$y = 2 + 0.75 = 2.75 \text{ in}$

$$F = \frac{(50\times10^3)(2.75)(9)}{150.1667} = 8240.84 \text{ lb}$$

$$\boxed{F = 8.240 \text{ kips}}$$

b) TOTAL FORCE ON SHADED PORTION OF WEB:

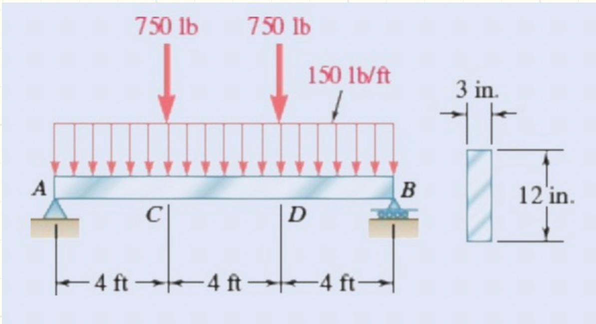
$A = 2\times2 = 4 \text{ in}^2$

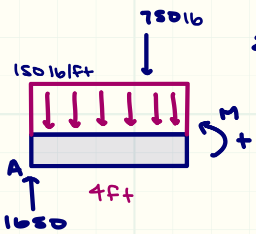
$y = 1 \text{ in}$

$$F = \frac{(50\times10^3)(1)(4)}{150.1667} = 1331.85 \text{ lb}$$

$$\boxed{F = 1.331 \text{ kips}}$$

P12.13





$\Sigma F_y = 0$

A = C BY SYMMETRY

$A + C - (2)(750) - (12)(150) = 0$

$A + C = 3300 \longrightarrow A = C = 1650 \text{ lb}$

$+\circlearrowright \Sigma M_C = 0$

$-1650(4) + 150(4)(2) + M = 0$

$M = 5400 \text{ lb} \cdot \text{ft}$

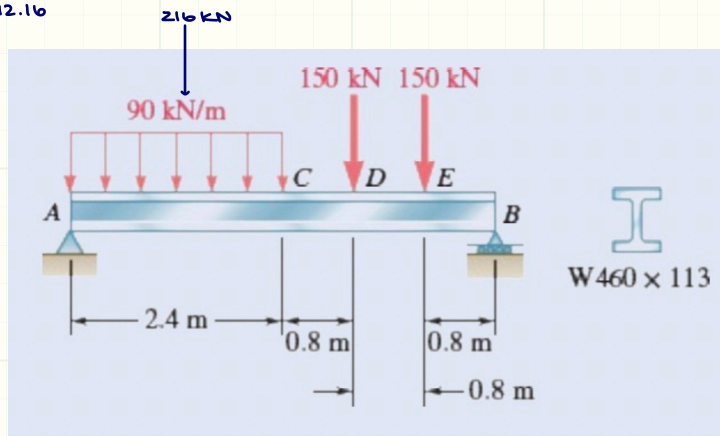
$\hookrightarrow 64800 \text{ lb} \cdot \text{in}$

$S = \frac{1}{6} bh^2 \longrightarrow \frac{1}{6}(3)(12)^2 = 72 \text{ in}^3$

NORMAL STRESS:

$\sigma = \frac{M}{S} = \frac{64800 \text{ lb} \cdot \text{in}}{72 \text{ in}^3} = 900 \text{ lb}/\text{in}^2 \longrightarrow \boxed{900 \text{ psi}}$

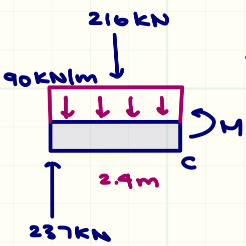
P 12.16



$+\circlearrowleft \Sigma M_B = 0$

$-48 \cdot A + (3.6)(216) + (1.6)(150) + (0.8)(150) = 0$

$A = 237 \text{ kN}$



$+\circlearrowleft \Sigma M_C = 0$

$M - (2.4)(237) + (1.2)(216) = 0$

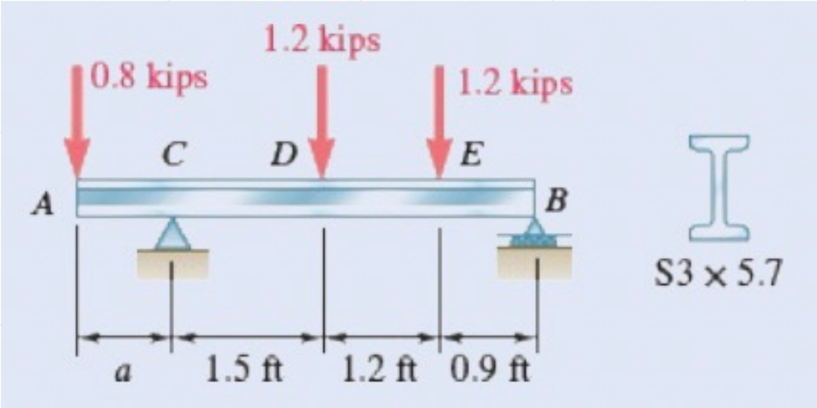
$M = 309.6 \text{ kN} \cdot \text{m}$

$S = 2390 \times 10^6 \text{ mm}^3$ (FROM APPENDIX)

NORMAL STRESS:

$$\sigma = \frac{M}{S} = \frac{(309.6 \text{ kN} \cdot \text{m})}{(2390 \times 10^{-6} \text{ m}^3)} = \boxed{129.5 \times 10^6 \text{ Pa}}$$

P12.27



$\sum F_y = 0$

$C + D - 0.8 - 1.2 - 1.2 = 0$

$C + D = 3.2$

$\sum M_C = \sum M_B = 0$

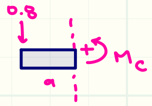
$-0.8a + 1.2(1.5) + 1.2(2.7) - B(3.6) = 0$

$B = 1.4 - 0.222a$

$C = 3.2 - 1.4 - 0.222a \longrightarrow 1.8 + 0.222a$

a)

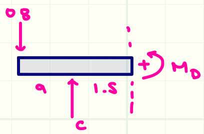
BENDING MOMENT AT C:



$-M_C - 0.8a = 0$

$M_C = -0.8a$

BENDING MOMENT AT D:

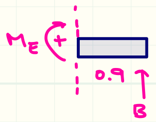


$-0.8(a+1.5) + C(1.5) - M_D = 0$

$M_D = -0.8a - 1.2 + (1.8 + 0.222a)\,1.5$

$M_D = 1.5 - 0.467a$

BENDING MOMENT AT E:



$-B(0.9) + M_E = 0$

$M_E = 0.9(1.4 - 0.222a)$

$M_E = 1.26 - 0.2a$

ASSUME $M_E = -M_C$:

$0.8a = 1.26 - 0.2a$

$\boxed{a = 1.260 \text{ ft}}$

$|M_C| = M_E$

$|M_C| = M_D \rightarrow 1.5 - 0.4667a = 0.8a$

$a = 1.20 \text{ ft}.$

b) $M_C = -0.8(1.26) = -1.008 \text{ kip}\cdot\text{ft}$

$M_D = 1.5 - 0.467(1.26) = 0.91158 \text{ kip}\cdot\text{ft}$

$M_E = 1.26 - 0.2(1.26) = 1.008 \text{ kip}\cdot\text{ft} \longrightarrow$ MAX VALUE

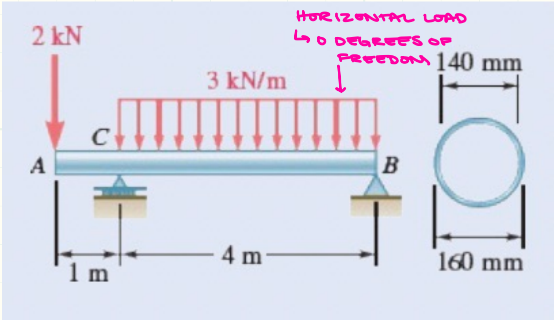
$\hookrightarrow 12.096 \text{ kip}\cdot\text{in}$

$S = 1.67 \text{ in}^3$ (FROM APPENDIX)

NORMAL STRESS:

$\sigma = \dfrac{M}{S} = \dfrac{(12.096)}{1.67} = \boxed{7.243 \text{ ksi}}$

P12.53



$+\circlearrowleft \sum M_C = 0$

$2(1) + B(4) - 12(2) = 0$

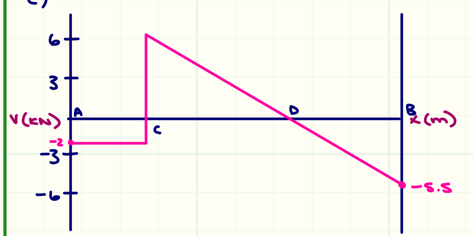
$B = 5.5\text{ kN}$

$\sum F_y = 0$

$-2 + C - 12 + 5.5 = 0$

$C = 8.5\text{ kN}$

i)



SHEAR FORCE,

A to C $\longrightarrow V = -2\text{ kN}$

RIGHT NEXT TO POINT C $\rightarrow C' \longrightarrow V = -2 + 8.5 = 6.5\text{ kN}$

C' to B $\longrightarrow 6.5 - 3(4) = -5.5\text{ kN}$

AREA OF SHEAR:

A to C $= \int V dx = (-2)(1) = -2$

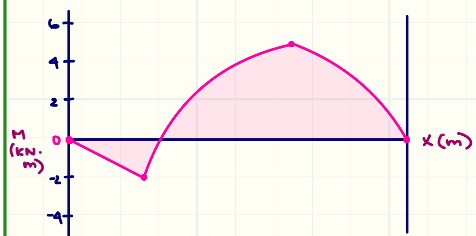
C to D $= \int V dx = \frac{1}{2}(2.1667)(6.5) = 7.0417$

D to B $= \int V dx = \frac{1}{2}(-5.5)(3.833) = -5.0417$

SIMILAR TRIANGLES:

$\frac{d}{6.5} = \frac{4-d}{5.5} \longrightarrow d = 2.1667\text{ m}$

$4 - d = 3.833\text{ m}$



BENDING MOMENT:

$M_A = 0$

$M_C = M_A + -2 = -2\text{ kN}\cdot\text{m}$

$M_D = M_C + 7.0417 = 5.0417\text{ kN}\cdot\text{m}$

$M_B = -2 + 7.0417 - 5.0417 = 0$

ii) $\sigma = \frac{|M|}{S} \longrightarrow \frac{5.0417\times10^3}{166\ 406\times10^{-6}} = 30.3\times10^3\text{ Pa} \longrightarrow \boxed{\sigma_{max} = 30.3\text{ MPa}}$

$S = \frac{I}{c} \longrightarrow \frac{13\ 312\times10^6}{80} = 166.406\times10^{-6}\text{ m}^3$

$I = \frac{\pi}{4}(d_o^4 - d_i^4)$

$I = \frac{\pi}{4}(80^4 - 70^4)$

$I = 13.3125\times10^6\text{ mm}^4$