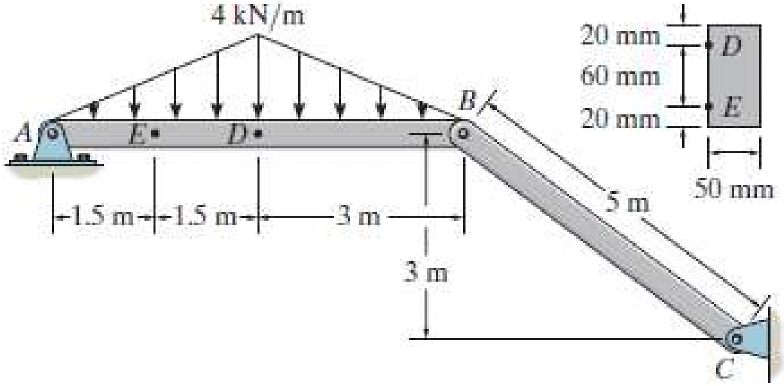
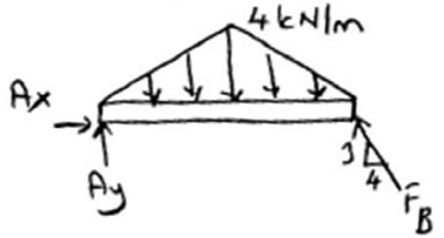
The frame supports the distributed load shown. Determine the bending stress at point E.



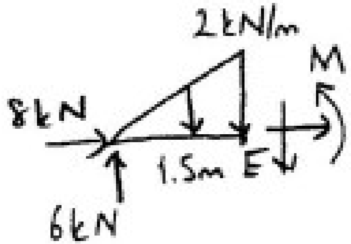
FBD of AB:



$\circlearrowleft + \Sigma M_B = 0 \qquad (4)(6)\left(\frac{1}{2}\right)(3) - A_y(6) = 0 \qquad A_y = 6\,kN$

$\uparrow + \Sigma F_y = 0 \qquad 6 - (4)(6)\left(\frac{1}{2}\right) + F_B \frac{3}{5} = 0 \qquad F_B = 10\,kN$

$\rightarrow \Sigma F_x = 0 \qquad A_x - 10\left(\frac{4}{5}\right) = 0 \qquad A_x = 8\,kN$

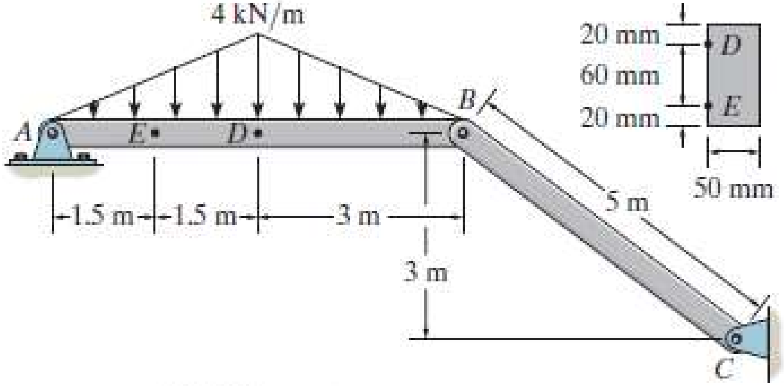


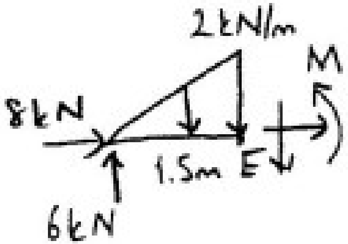
$\circlearrowleft + \Sigma M_E = 0$

$-(6)(1.5) + (1.5)(2)\left(\frac{1}{2}\right)(0.5) + M = 0$

$M = 8.25\,kN.m$

The frame supports the distributed load shown. Determine the bending stress at point E.





$M = 8.25 \text{ kN.m}$

$I = \frac{1}{12}(0.05)(0.1)^3 = 4.167 \times 10^{-6} \text{ m}^4$

$\sigma = \frac{My}{I}$

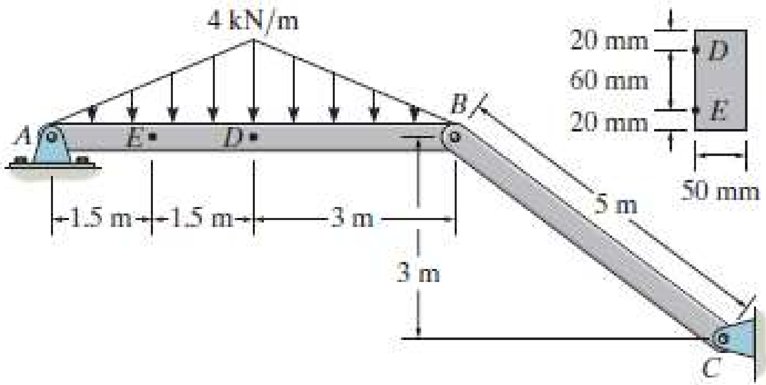
$\sigma = \frac{My}{I} = \frac{(8.25 \times 10^3)(0.03)}{4.167 \times 10^{-6}}$

$= 59.4 \times 10^6 \text{ Pa}$

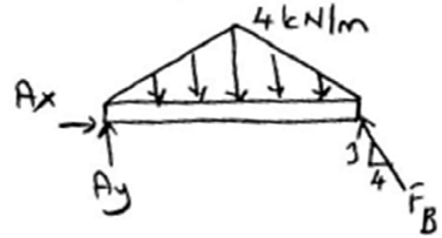
$= 59.4 \text{ MPa (T)}$

The frame supports the distributed load shown.

Determine the bending stress at point *D*.



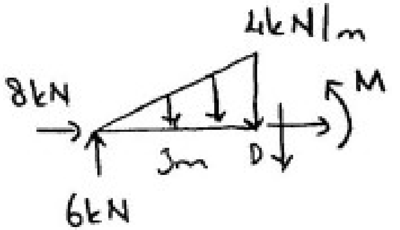
FBD of AB:



$A_y = 6\,kN$

$F_B = 10\,kN$

$A_x = 8\,kN$

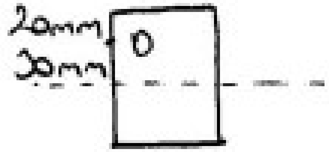


$\circlearrowleft + \Sigma M_D = 0$

$-(6)(3) + (4)(3)\left(\frac{1}{2}\right)(1) + M = 0$

$M = 12\,kN.m$

$I = \frac{1}{12}(0.05)(0.1)^3 = 4.167\times10^{-6}\,m^4$

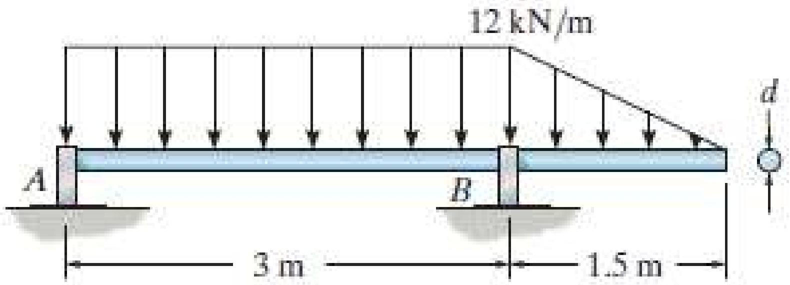


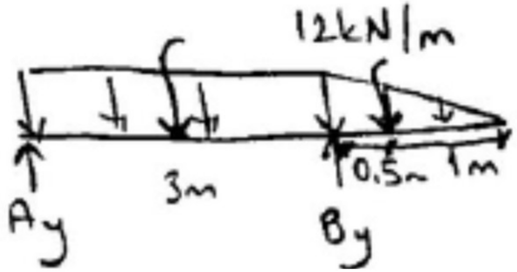
$\sigma = -\frac{(12\times10^3)(0.03)}{4.167\times10^{-6}}$

$= -86.393\times10^6\,Pa$

$= 86.39\,MPa\ (C)$

The shaft is supported by smooth journal bearings at A and B that only exert vertical reactions on the shaft.
If $d = 90$ mm, determine the absolute maximum bending stress in the beam, and sketch the stress distribution acting over the cross section.



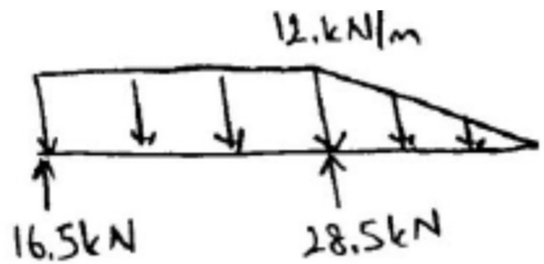


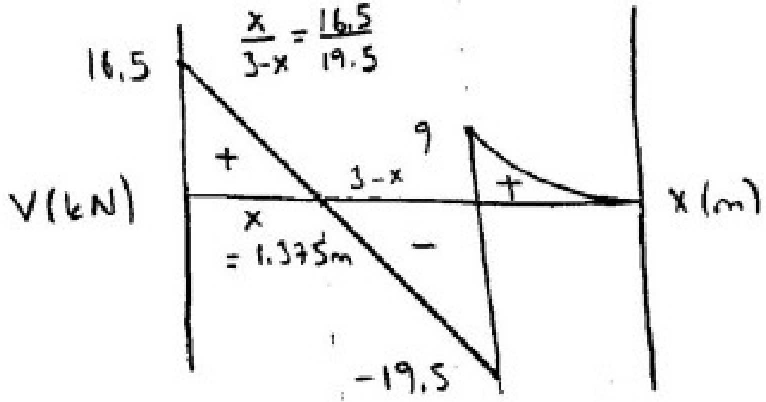
$$\circlearrowleft + \Sigma M_A = 0: \quad B_y \cdot 3 - (12)(3)(1.5) - (12)(1.5)\left(\frac{1}{2}\right)(3.5) = 0$$

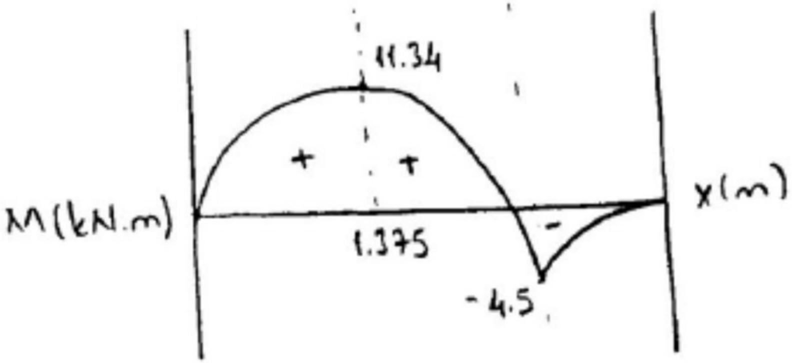
$$B_y = 28.5 \text{ kN}$$

$$+\uparrow \Sigma F_y = 0: \quad A_y + 28.5 - (12)(3) - (12)(1.5)\left(\frac{1}{2}\right) = 0$$

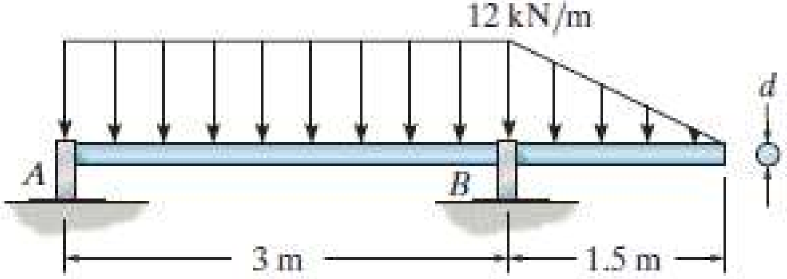
$$A_y = 16.5 \text{ kN}$$







The shaft is supported by smooth journal bearings at A and B that only exert vertical reactions on the shaft.
If $d = 90$ mm, determine the absolute maximum bending stress in the beam, and sketch the stress distribution acting over the cross section.

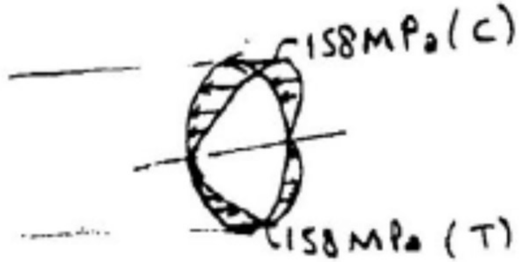


$$|M_{max}| = 11.34 \text{ kN.m}$$

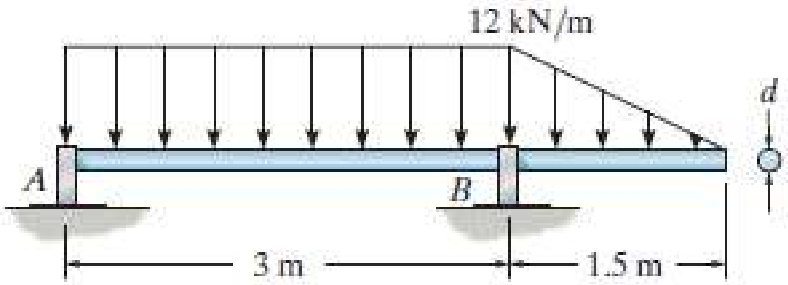
$$\sigma_{max} = \frac{M_{max} \cdot c}{I_x}$$

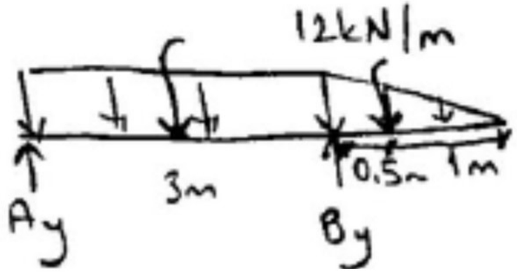
$$= \frac{(11.34 \times 10^3)(0.045)}{\frac{\pi}{4}(0.045)^4}$$

$$= 158 \text{ MPa}$$



The shaft is supported by smooth journal bearings at *A* and *B* that only exert vertical reactions on the shaft.
If *d* = 90 mm, determine the absolute maximum bending stress in the beam, and sketch the stress distribution acting over the cross section.



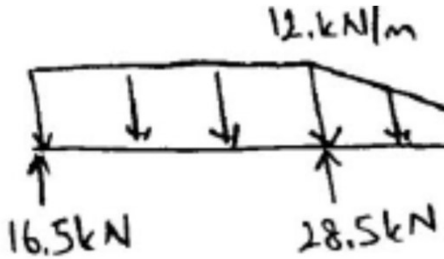


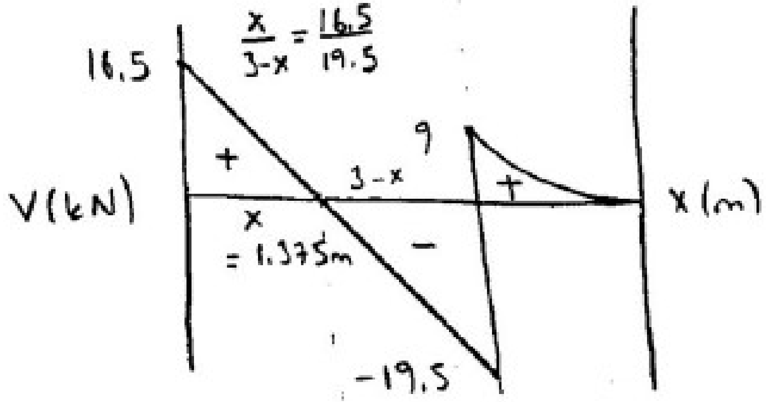
$\circlearrowleft + \Sigma M_A = 0$: $B_y \cdot 3 - (12)(3)(1.5) - (12)(1.5)\left(\frac{1}{2}\right)(3.5) = 0$

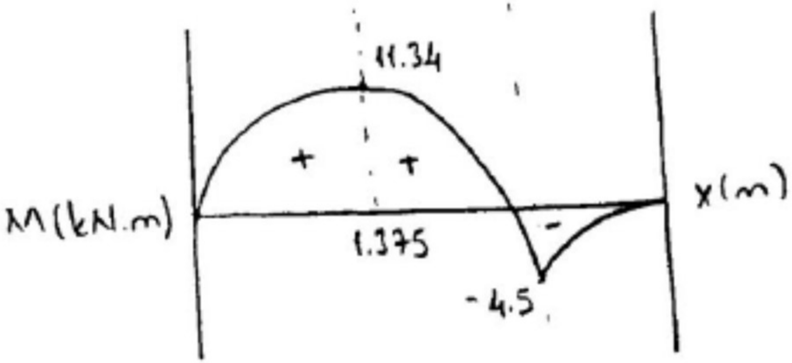
$B_y = 28.5\ \text{kN}$

$\uparrow + \Sigma F_y = 0$: $A_y + 28.5 - (12)(3) - (12)(1.5)\left(\frac{1}{2}\right) = 0$

$A_y = 16.5\ \text{kN}$







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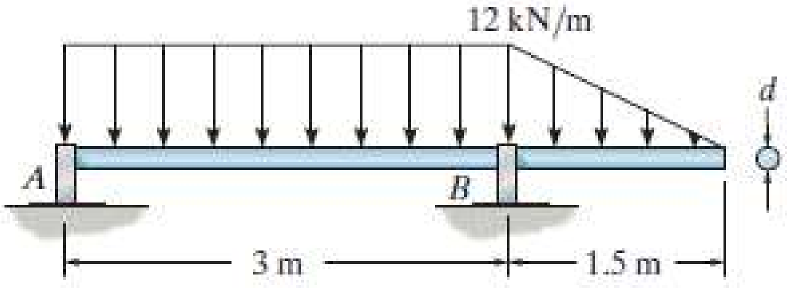
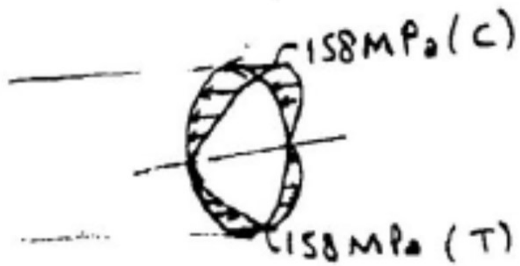


$$|M_{max}| = 11.34 \text{ kN.m}$$

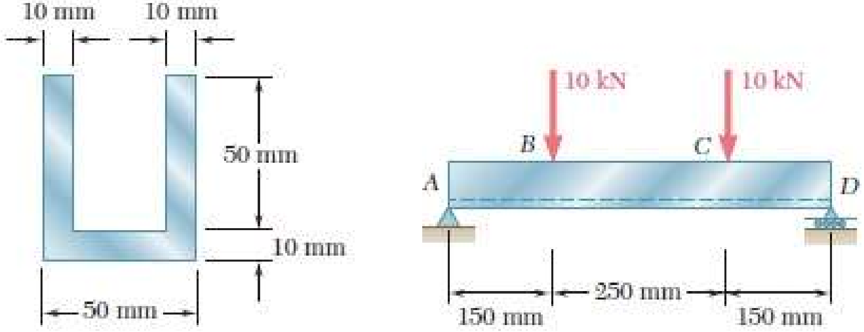
$$\sigma_{max} = \frac{M_{max} \cdot c}{I_x}$$

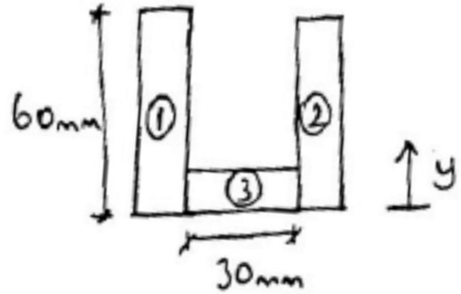
$$= \frac{(11.34 \times 10^3)(0.045)}{\frac{\pi}{4}(0.045)^4}$$

$$= 158 \text{ MPa}$$



Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion BC of the beam.





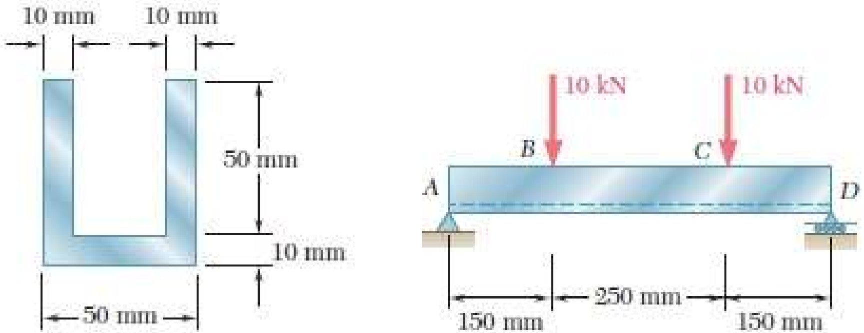
To find the centroid:

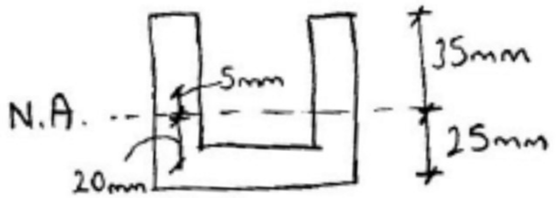
$$\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i}$$

$$\bar{y} = \frac{(10\times60)(30) + (10\times60)(30) + (10\times30)(5)}{10\times60 + 10\times60 + 10\times30}$$

$$\bar{y} = 25\text{mm}$$

Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion BC of the beam.





$$I_1 = \frac{1}{12}(10)(60^3) + (10\times 60)\,5^2$$

$$= 195\times 10^3\ mm^4$$

$$I_2 = I_1 = 195\times 10^3\ mm^4$$

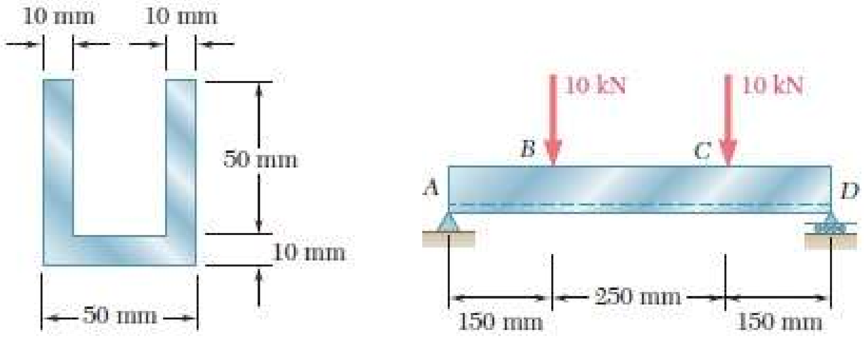
$$I_3 = \frac{1}{12}(30)(10^3) + (10\times 30)\,20^2$$

$$= 122.5\times 10^3\ mm^4$$

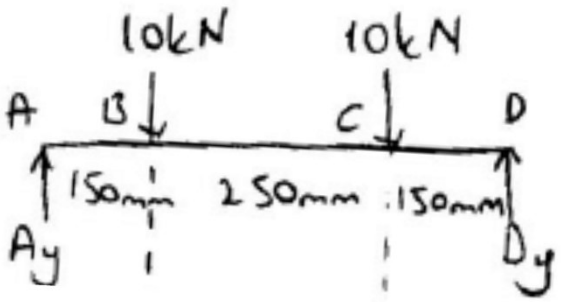
$$I = I_1 + I_2 + I_3 = 512.5\times 10^3\ mm^4$$

$$= 512.5\times 10^{-9}\ m^4$$

Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion BC of the beam.



FBD of the beam:



$\circlearrowleft + \Sigma M_A = 0$:

$$-(10)(0.15)-(10)(0.4)+D_y(0.55)=0$$

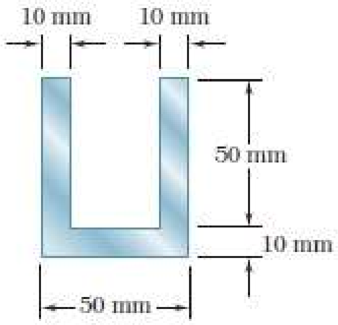
$$D_y = 10\,kN$$

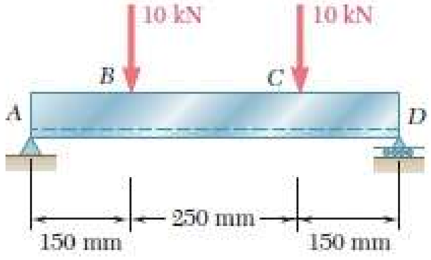
$\uparrow + \Sigma F_y = 0$:

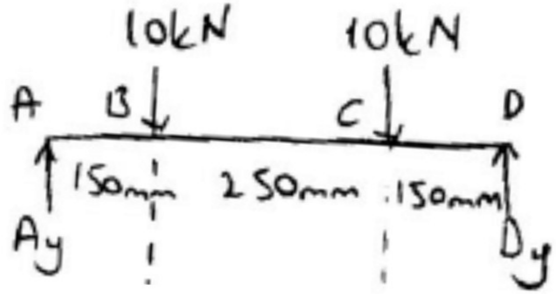
$$10-10-10+A_y=0$$

$$A_y = 10\,kN$$

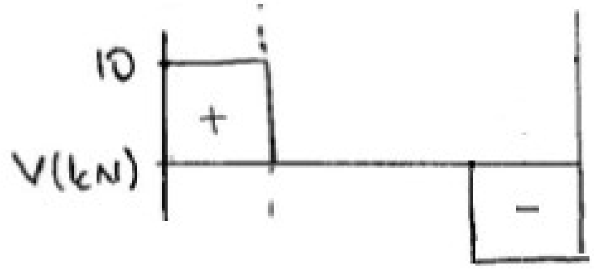
Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion BC of the beam.



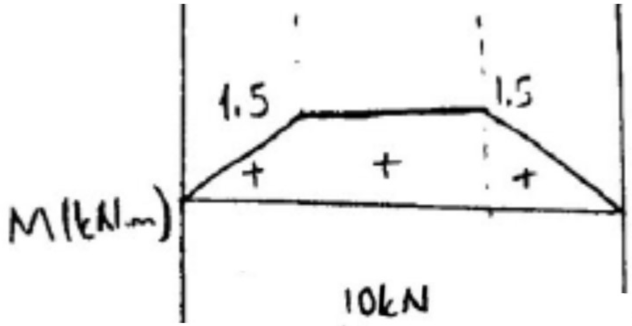




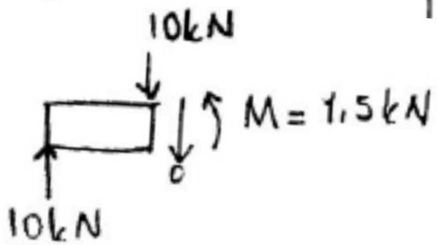
$$\sigma_{top} = -\frac{Mc}{I} = -\frac{(1.5\times10^{3})(0.035)}{512.5\times10^{-9}} = -102.4\times10^{6}\,Pa$$



$\sigma_{top} = -102.4$ MPa (compression)

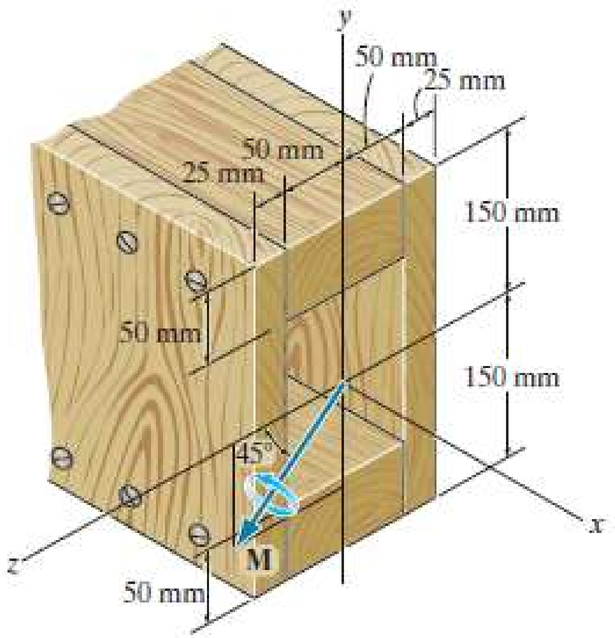


$$\sigma_{bottom} = -\frac{Mc}{I} = -\frac{(1.5\times10^{3})(-0.025)}{512.5\times10^{-9}} = 73.2\times10^{6}\,Pa$$



$\sigma_{bottom} = 73.2$ MPa (tension)

The box beam is subjected to the internal moment of $M = 4$ kN · m, which is directed as shown. Determine the maximum bending stress developed in the beam and the orientation of the neutral axis.

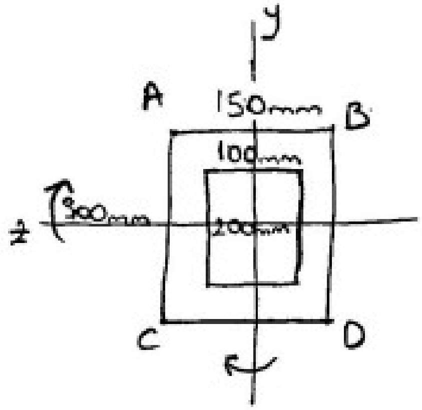


$$M_y = -4 \sin 45° = -2.828 \text{ kN.m}$$

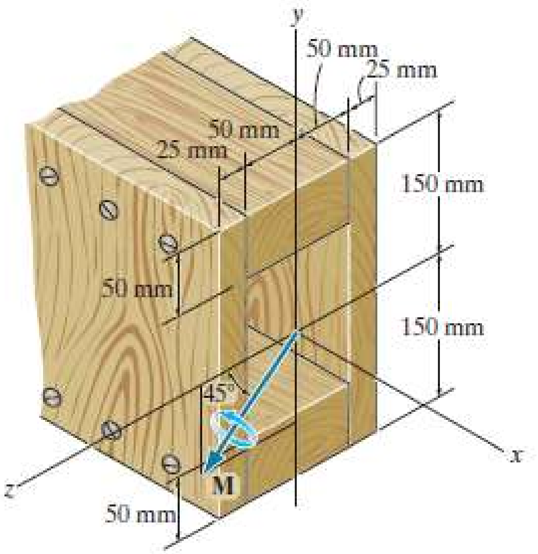
$$M_z = 4 \cos 45° = 2.828 \text{ kN.m}$$

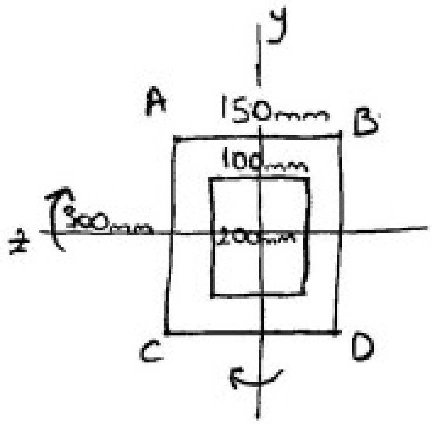
$$I_y = \frac{1}{12}(0.3)(0.15^3) - \frac{1}{12}(0.2)(0.1^3) = 67.71 \times 10^{-6} \text{ m}^4$$

$$I_z = \frac{1}{12}(0.15)(0.3^3) - \frac{1}{12}(0.1)(0.2^3) = 0.2708 \times 10^{-3} \text{ m}^4$$



The box beam is subjected to the internal moment of $M = 4\ \text{kN}\cdot\text{m}$, which is directed as shown. Determine the maximum bending stress developed in the beam and the orientation of the neutral axis.





$$\sigma = +\frac{M_z \cdot y}{I_z} + \frac{M_y z}{I_y}$$

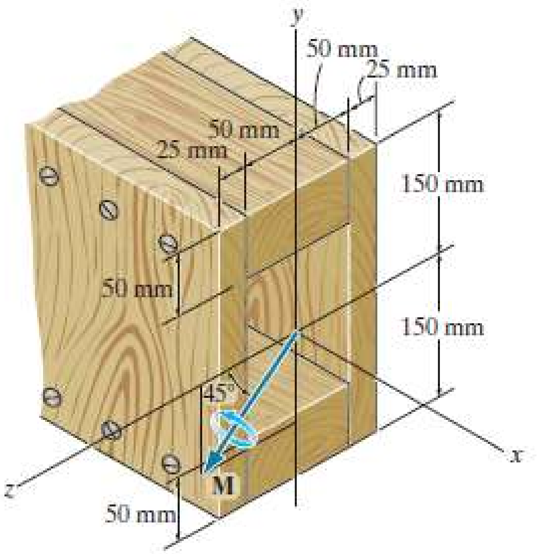
$$\sigma_{max} = \sigma_A = -\frac{(2.828\times10^3)(0.15)}{0.2708\times10^{-3}} - \frac{(2.828\times10^3)(0.075)}{67.7083\times10^{-6}}$$

$$\sigma_A = -4.7\ \text{MPa} = 4.7\ \text{MPa}\ (C)$$

$$\sigma_{max} = \sigma_D = +\frac{(2.828\times10^3)(0.15)}{(0.2708)(10^{-3})} + \frac{(2.828\times10^3)(0.075)}{67.7083\times10^{-6}}$$

$$\sigma_D = 4.7\ \text{MPa}\ (T)$$

The box beam is subjected to the internal moment of $M = 4$ kN · m, which is directed as shown. Determine the maximum bending stress developed in the beam and the orientation of the neutral axis.



Orientation of Neutral Axis:

$$\theta = -45^\circ$$

$$\tan\alpha = \frac{I_z}{I_y}\tan\theta$$

$$\tan\alpha = \frac{0.2708\times10^{-3}}{67.7083\times10^{-6}}\tan(-45^\circ)$$

$$\alpha = -76^\circ$$