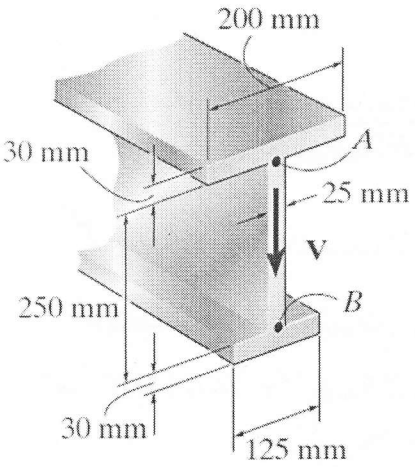
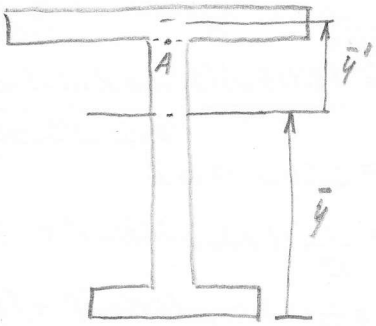
CME 260 – Mechanics of Materials
Exam #7 (04/06/2022)

Tech ID or Star ID: Grading

Do one of the two problems shown below (the second problem is on the back).
Show your work (you will not receive any credit if all you have is a final answer, right or wrong).

(1) The beam is subjected to a shear of V = 15 kN. Determine the shear stress in the web at point A (point A is located right where the web meets the upper flange). Point B is ignored in this problem.





$$\bar{y} = \frac{(0.295\,m)(0.200\,m)(0.030\,m) + (0.155\,m)(0.025\,m)(0.250\,m) + (0.015\,m)(0.125\,m)(0.030\,m)}{(0.200\,m)(0.030\,m) + (0.025\,m)(0.250\,m) + (0.125\,m)(0.030\,m)}$$

$$= \frac{0.002795\,m^3}{0.016\,m^2} = 0.1747\,m \quad (2\,pt)$$

$$Q = \bar{y}' A'$$

$$\bar{y}' = 0.310\,m - 0.1747\,m - \frac{0.030\,m}{2} = 0.1203\,m \quad (1\,pt)$$

$$A' = (0.200\,m)(0.030\,m) = 0.006\,m^2 \quad (1\,pt)$$

$$Q = (0.1203\,m)(0.006\,m^2) = 0.0007218\,m^3 \quad (1\,pt)$$

$$I = \frac{1}{12}(0.200\,m)(0.030\,m)^3 + (0.200\,m)(0.030\,m)\underbrace{(0.1203\,m)^2}_{\text{same as } \bar{y}'}$$
$$+ \frac{1}{12}(0.025\,m)(0.250\,m)^3 + (0.025\,m)(0.250\,m)(0.155\,m - 0.1747\,m)^2$$
$$+ \frac{1}{12}(0.125\,m)(0.030\,m)^3 + (0.125\,m)(0.030\,m)(0.015\,m - 0.1747\,m)^2$$

$$= 4.5\times10^{-7} + 868.3\times10^{-7} + 325.5\times10^{-7} + 24.26\times10^{-7} + 2.813\times10^{-7} + 956.4\times10^{-7}\,(m^4)$$

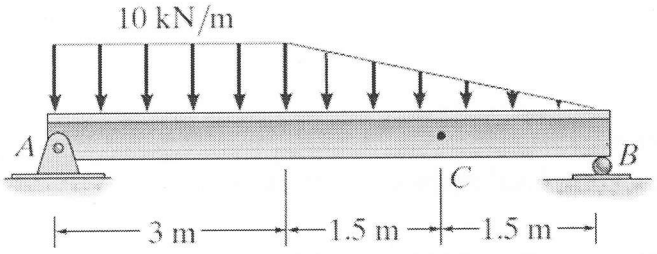
$$= 2.182\times10^{-4}\,m^4 \quad (3\,pts)$$

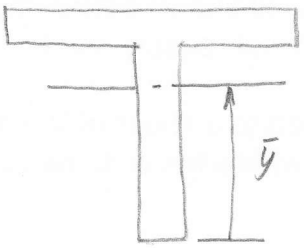
@ web, $t = 0.025\,m$ (1 pt)

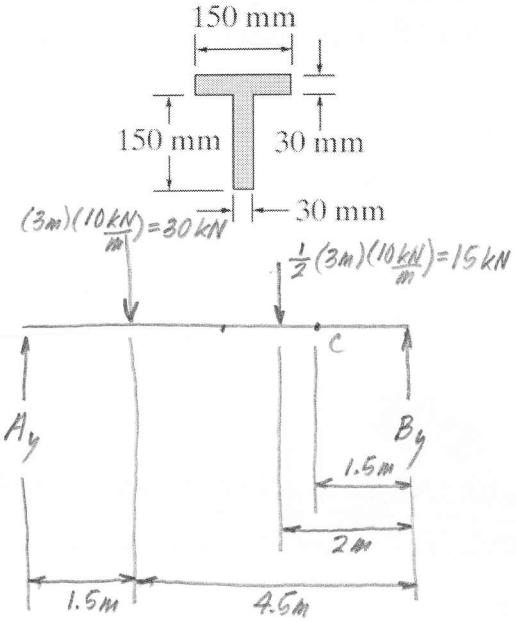
$$\tau_A = \frac{VQ}{It} = \frac{(15\,kN)(7.218\times10^{-4}\,m^3)}{(2.182\times10^{-4}\,m^4)(0.025\,m)}$$

$$= \boxed{1,985\,\frac{kN}{m^2} \text{ or } 1.99\,MPa} \quad (1\,pt)$$

(2) Determine the maximum shear stress in the beam at point C.







$\bar{y} = \dfrac{(0.165\,m)(0.150\,m)(0.030\,m) + (0.075\,m)(0.030\,m)(0.150\,m)}{(0.150\,m)(0.030\,m) + (0.030\,m)(0.150\,m)}$

$= 0.120\,m$ (2 pts)

$I = \frac{1}{12}(0.150\,m)(0.030\,m)^3 + (0.150\,m)(0.030\,m)(0.165\,m - 0.120\,m)^2$

$+ \frac{1}{12}(0.030\,m)(0.150\,m)^3 + (0.030\,m)(0.150\,m)(0.075\,m - 0.120\,m)^2$

$= 3.375\times10^{-7} + 91.125\times10^{-7} + 84.375\times10^{-7} + 91.125\times10^{-7}\,m^4$

$= 2.7\times10^{-5}\,m^4$ (2 pts)

$Q = \bar{y}'A'$ (used area below neutral axis)

$\bar{y}' = 0.060\,m$ (1 pt)

$A' = (0.030\,m)(0.120\,m) = 0.0036\,m^2$ (1 pt)

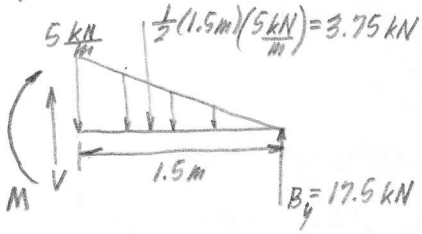
$Q = (0.060\,m)(0.0036\,m^2) = 0.000216\,m^3$ (1 pt)

$t = 0.030\,m$ (1 pt)

$\sum M_A = 0,\ -(1.5\,m)(30\,kN) - (4\,m)(15\,kN) + (6\,m)B_y = 0$

$B_y = 17.5\,kN$

V @ point B:



$\sum F_y = 0,\ V - 3.75\,kN + 17.5\,kN = 0$

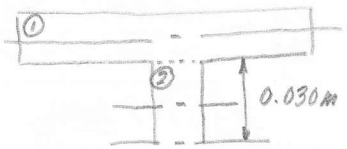
$V = -13.75\,kN$ (1 pt)

$\tau_{max\,@\,C} = \dfrac{VQ}{It} = \dfrac{(13.75\,kN)(0.000216\,m^3)}{(2.7\times10^{-5}\,m^4)(0.030\,m)}$

$= \boxed{3,666.7\ \frac{kN}{m^2}\ \text{or}\ 3.67\,MPa}$

(1 pt)

Q (for area above neutral axis)



for area ①: $\bar{y}' = 0.045\,m$, $A' = (0.150\,m)(0.030\,m) = 0.0045\,m^2$ (1 pt)

for area ②: $\bar{y}' = 0.015\,m$, $A' = (0.030\,m)(0.030\,m) = 0.0009\,m^2$

$Q = (0.045\,m)(0.0045\,m^2) + (0.015\,m)(0.0009\,m^2)$ (1 pt)

$= 0.000216\,m^3$ (1 pt)