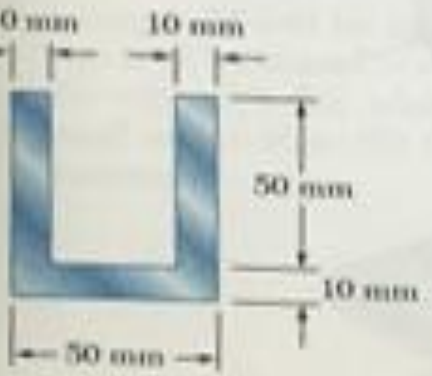
11.97 Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion *BC* of the beam.



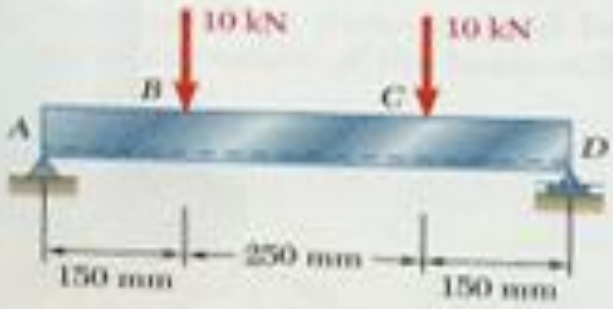
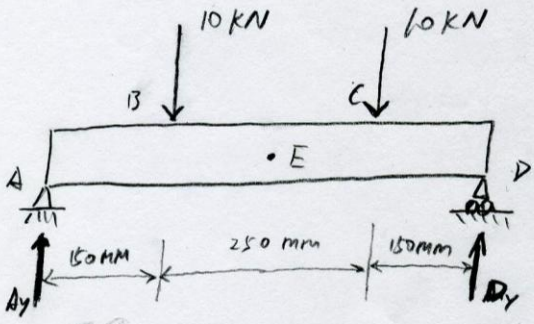
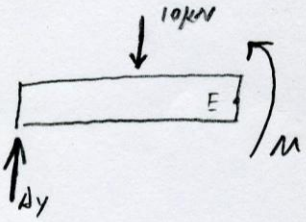


Fig. P11.97

Since the loading is symmetric, maximum bending moment occur at the middle of the beam, E.



$A_y = D_y = 10\,kN$



$\Sigma M_E = 0$

$\Rightarrow -A_y(0.15m + 0.125m) + 10kN(0.125m) + M = 0$

$-10\,kN(0.275m) + 10\,kN(0.125m) + M = 0$

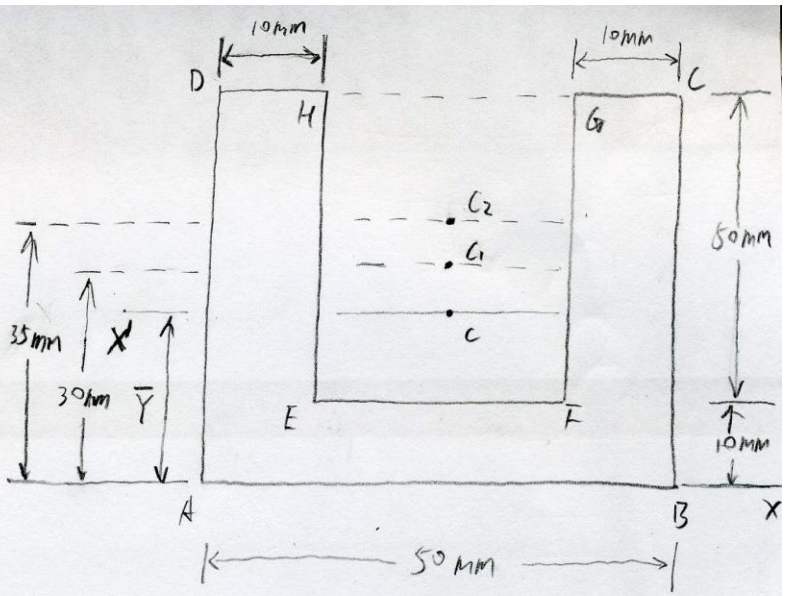
$\Rightarrow M = 1.5\ kN\text{-}m$

$= 1500\ N\text{-}m$

11.97]

Let C_1 be the centroid of the rectangle ABCD

C_2 be the centroid of the hole EFDH

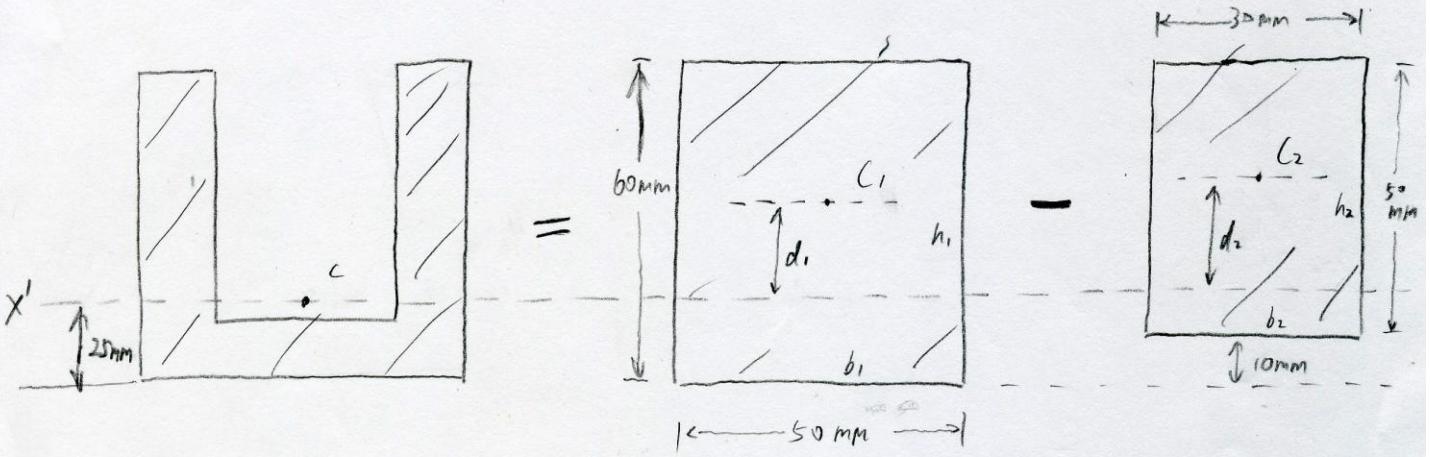


	Area, mm^2	$\bar{y}$, mm	$\bar{y}A$, mm^3
ABCD:	50(60) = 3000	30	90000
EFDH:	-[30(50)] = -1500	35	-52500
total:	1500		37500

$\bar{Y}\Sigma A = \Sigma \bar{y}A$

$\Rightarrow \bar{Y}(1500\ mm^2) = 37500\ mm^3$

$\Rightarrow \bar{Y} = 25\ mm$



$$I_{C_1,X'} = I_{C_1,X'} - I_{C_2,X'}$$

$$= \left(\frac{1}{12} b_1 h_1^3 + A_1 d_1^2\right) - \left(\frac{1}{12} b_2 h_2^3 + A_2 d_2^2\right)$$

$$= \left[\frac{1}{12}(0.05m)(0.06m)^3 + (0.05m)(0.06m)\left(\frac{0.06m}{2} - 0.025m\right)^2\right]$$

$$- \left[\frac{1}{12}(0.03m)(0.05m)^3 + (0.03m)(0.05m)\left(\frac{0.05m}{2} + 0.01m - 0.025m\right)^2\right]$$

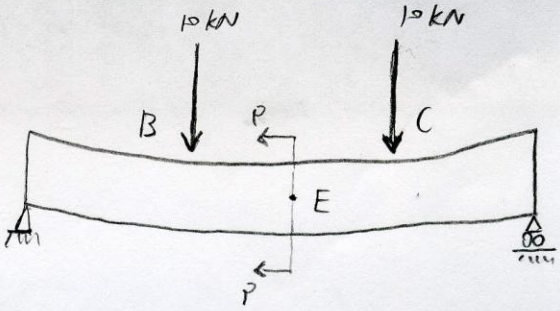
$$= 5.13 \times 10^{-7}\ m^4$$

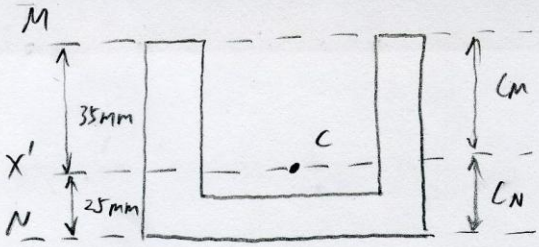
(smiling)

Since the beam is bent downwards ∩

maximum tension occurs at line N (bottom)

maximum compression occurs at line M (top)





P-P

$$\sigma_{max,T} = -\frac{M c_M}{I_c}$$

$$= -\frac{(1500\ N\text{-}m)(0.035\ m)}{5.13\times10^{-7}\ m^4}$$

$$= -1.024\times10^{8}\ Pa$$

$$= -102.4\ MPa$$ max compression

$$\sigma_{max,T} = \frac{-M c_L}{I_c}$$ y at bottom rel. to neutral axis

$$= \frac{-(1500\ N\text{-}m)(-0.025\ m)}{5.13\times10^{-7}\ m^4}$$

$$= 7.31\times10^{7}\ Pa$$

$$= 73.1\ MPa$$ max tension