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Mechanics of Materials 2

Name:

MEN 302
EXAM 2
SPRING 2004

40

1) (20 pts) A shaft AB is attached to member $CDFH$ at A and fixed to a wall at B. The shaft has a diameter of $60\,mm$ and the parts CD and FH have square cross sections of $40\,mm$ by $40\,mm$. The massive hub DF may be considered rigid. A torque of magnitude $3\,kN.m$ is applied to the midsection of the shaft. All members are made of steel ($E = 200\,GPa$ and $G = 77.5\,GPa$). Determine the maximum shear stress in the shaft.

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old edition
p.184

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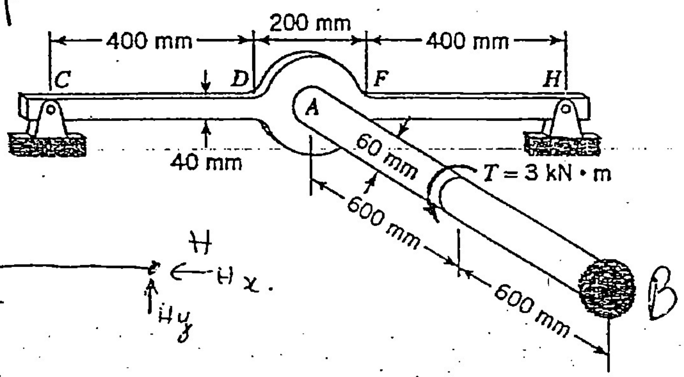
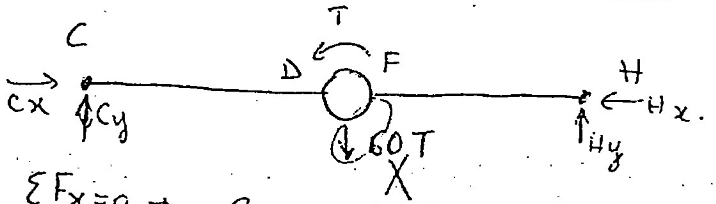




let $T = Q$.
$T_B = Y$

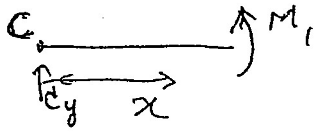
$\Sigma F_x = 0 \Rightarrow C_x = H_x$

$\Sigma F_y = 0 \Rightarrow C_y + H_y = 60T$

$\Sigma M_c = 0 \Rightarrow H_y \times 1000 + T + 60T \times 500 = 0 \Rightarrow \boxed{H_y = 30.001\,Q}$

$\Rightarrow C_y = 60Q - H_y = 60Q - 30Q \Rightarrow \boxed{C_y = 30Q}$ X

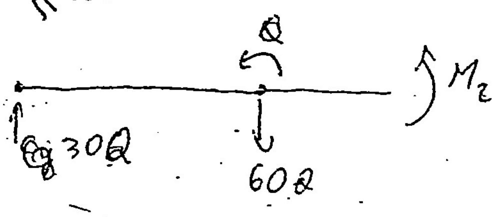
cut: $Q\ 0 \le x < 400$



$\boxed{M_1 = C_y x} \Rightarrow \boxed{M_1 = 30Qx}$ ✓

$\Rightarrow \boxed{\dfrac{\partial M_1}{\partial Q} = 30x}$

cut $600 \le x \le 1000$



$\boxed{M_2 = 30Qx - 61Q}$

$\boxed{\dfrac{\partial M_2}{\partial Q} = 30x - 61}$

$M_2 = -Q - 60Q + 30Qx$
$= -61Q + 30Qx$

$$\frac{1}{EI}\left[\int_0^{0.4}(30Qx)(30x)\,dx + \int_{0.6}^{1}(30Qx-61Q)(30x-61)\,dx\right]$$

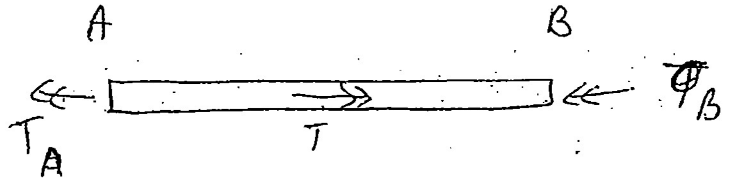
$$= \frac{1}{EI}\left[\left(900Q\frac{x^3}{3}\right)_0^{0.4} + \left(\frac{30Qx^3}{3} - \frac{1830Qx^3}{3} - \frac{1830Qx^2}{2} + 3721Q\ldots\right.\right.$$

$$= \frac{1}{EI}\left[19.2Q + 432.4Q\right] = \frac{1}{EI}\left[451.6Q\right]$$

$$= \frac{1}{200\times10^9 \times \frac{1}{12} \times 0.04^4}\left[451.6 \times 3000\right]$$

$$= \boxed{31.753125.} \quad (1)$$

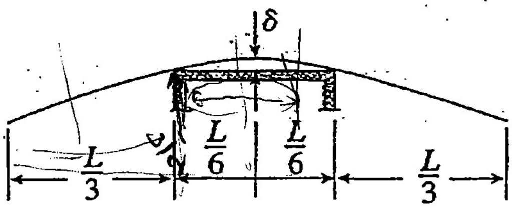
Shaft

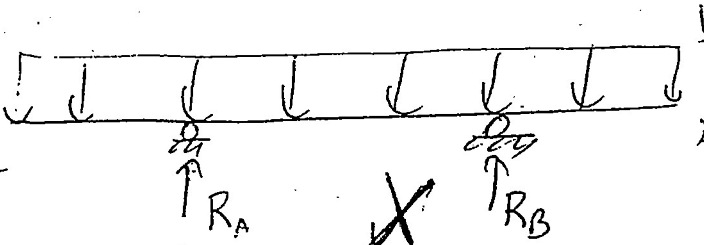


let $Q = T_A$

$\Rightarrow$

2) (15 pts) A thin metal strip of total weight W and length L is placed across the top of a flat table of width $\frac{L}{3}$ as shown in the figure. What is the clearance δ between the strip and the middle of the table. The strip of metal has a flexural rigidity EI.





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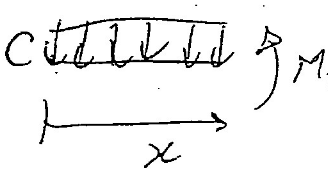
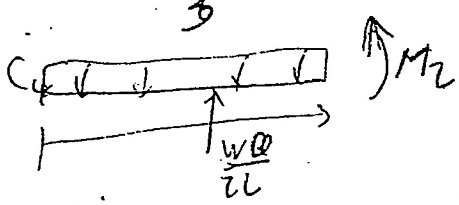
$$\boxed{R_A + R_B = \frac{W}{L}} \Rightarrow \boxed{R_A = R_B = \frac{W}{2L}}$$

Cut $0 \leq x < \frac{L}{3}$



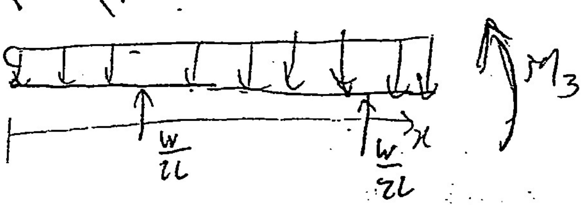
$$\boxed{M_1 = - \frac{W}{L} \times x}$$

cut $\frac{L}{3} < x < \frac{2L}{3}$



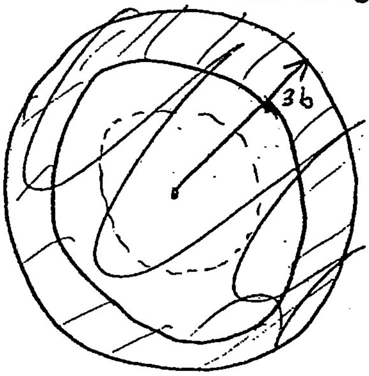
$$\boxed{M_2 = - \frac{W}{L} x + \frac{W}{2L}\left(x - \frac{L}{3}\right)}$$

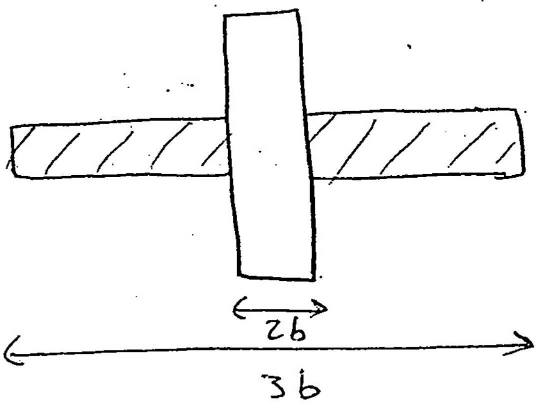
Cut $\frac{2L}{3} < x \leq L$

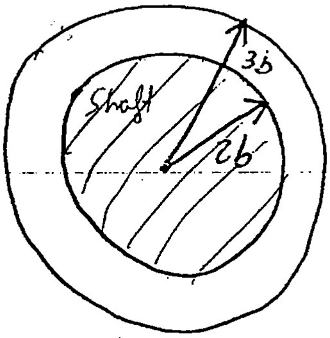


$$M_1 = - \frac{W}{2L} x + \frac{W}{2L}\left(x - \frac{L}{3}\right) + \frac{W}{2L}\left(x - \right.$$

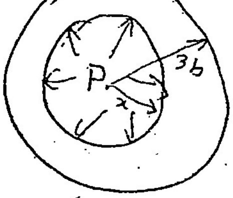
3) (15 pts) A steel tube of external diameter $3b$ is shrunk onto a solid steel shaft of diameter $2b$. The internal diameter of the tube is increased by an amount δ_o. Assuming that $\nu = \frac{1}{3}$, determine the reduction of the diameter of the shaft.







internal d of the tube increa[sed]
by δ_o



$\Rightarrow \delta_o = 2u$ & let x be the initial internal radius of the tu[be]

we have $u_{tube} - u_{Shaft} = \delta_{allowance}$

but $\delta_o = 2u_t \Rightarrow u_t = \frac{\delta_o}{2}$

$$\Rightarrow \boxed{u_s = \frac{\delta_o}{2} - \delta}$$

$$\delta = \frac{2bP}{E}\left(\frac{4b^2 + 9b^2}{9b^2 - 4b^2} + \nu\right) + \frac{2bP}{E}\left(\frac{0 + 4b^2}{4b^2 - 0} - \nu\right)$$

$$= \frac{2bP}{E}\left[\left(\frac{13}{5} + \frac{1}{3}\right) + \left(1 - \frac{1}{3}\right)\right] = \frac{2bP}{E} \cdot \frac{52}{15}$$

$$\Rightarrow \boxed{\delta = \frac{104\, bP}{15E}} \quad P = ?$$