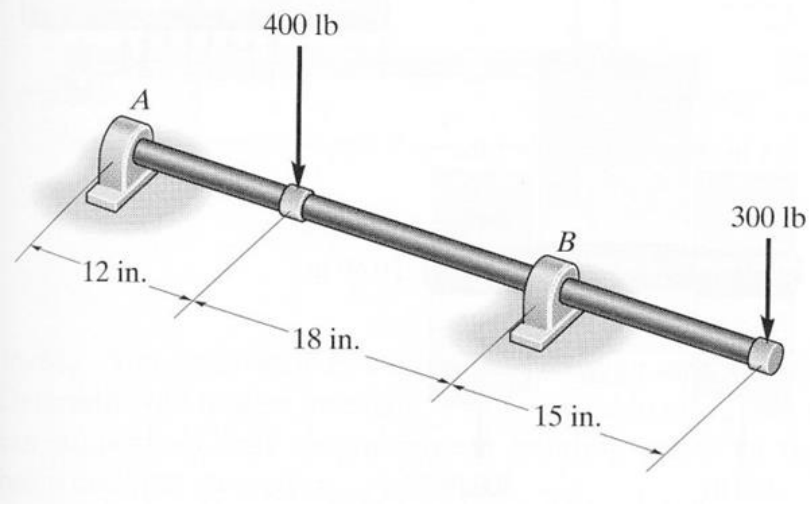
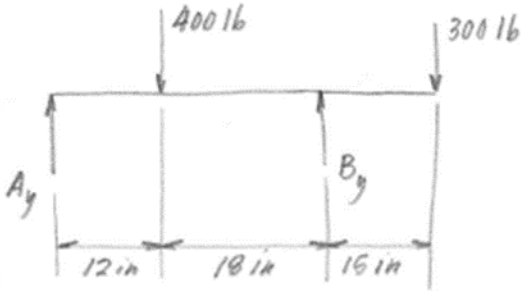
CME 260 – Mechanics of Materials
Exam #6 (04/03/2024)

StarID or TechID (no names) ___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. Determine the maximum bending stress in the 1.5 inch diameter solid shaft which is subjected to the concentrated forces shown. The supports at A and B exert only vertical reactions on the shaft.



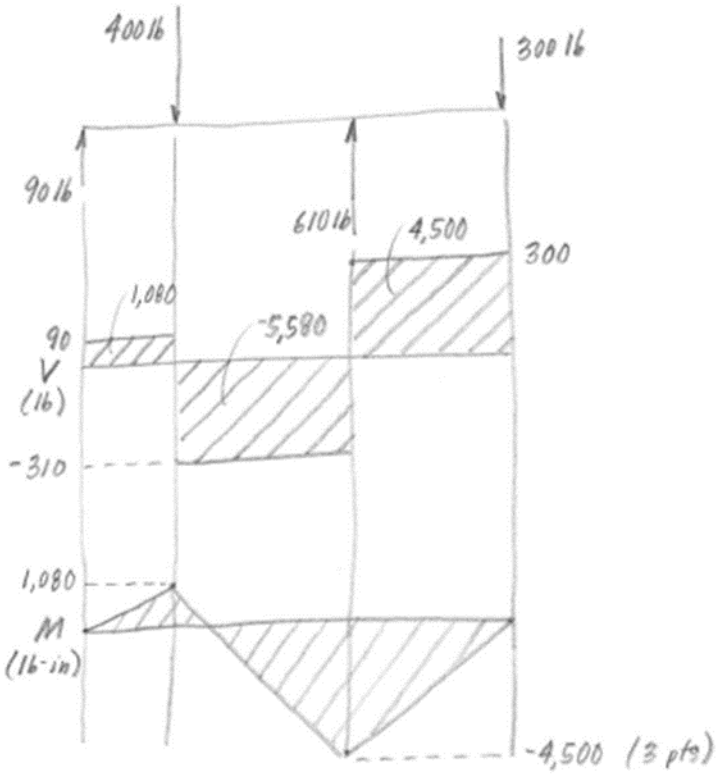


$M_A = 0, \; -(12\text{in})(400\text{lb}) + (30\text{in})B_y - (45\text{in})(300\text{lb}) = 0$

$B_y = 610\text{ lb}$ (1 pt)

$F_y = 0, \; A_y - 400\text{lb} + 610\text{lb} - 300\text{lb} = 0$

$A_y = 90\text{ lb}$ (1 pt)



$\sigma_{max} = \dfrac{Mc}{I}$

$c = 0.75\text{ in}$ (1 pt)

$I = \frac{1}{4}\pi r^4 = \frac{1}{4}\pi (0.75\text{in})^4$

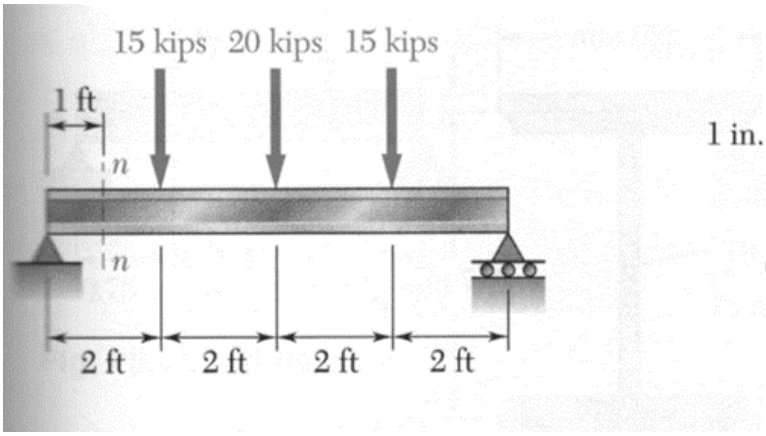
$= 0.2485\text{ in}^4$ (2 pts)

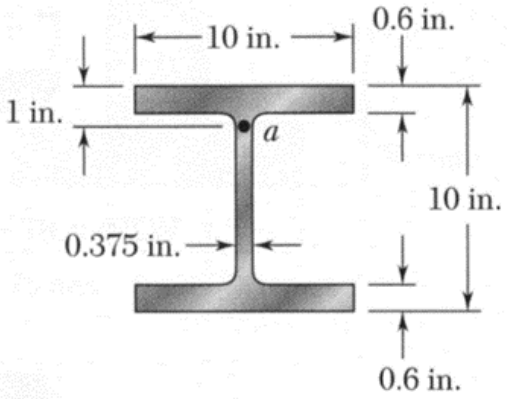
$\sigma_{max} = \dfrac{(4{,}500\text{ lb-in})(0.75\text{ in})}{0.2485\text{ in}^4}$

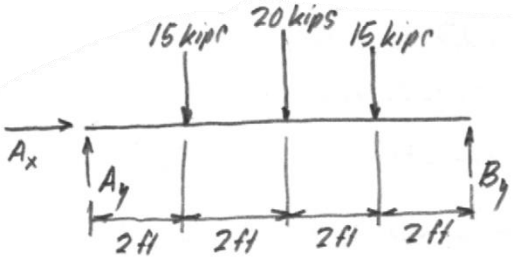
$= 13{,}581.2\text{ psi}$ or $\boxed{13.6\text{ ksi}}$

(2 pts)

2. For section n-n (1 ft from the left end of the beam), determine the shearing stress in the beam at point a (1 inch from the top of the beam). (a pin support is shown on the left end of the beam and a roller support is shown on the right end of the beam)

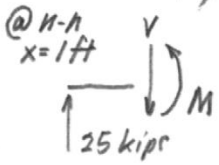




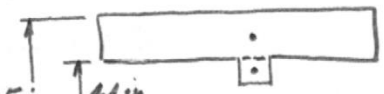


$\Sigma M_B = 0$, $(2\text{ ft})(15\text{ kips}) + (4\text{ ft})(20\text{ kips}) + (6\text{ ft})(15\text{ kips}) - (8\text{ ft})A_y = 0$

$A_y = 25$ kips



$V = 25$ kips (2 pts)



$Q = \bar{y}'A'$: $\bar{y}' = \dfrac{(4.2\text{ in})(0.375\text{ in})(0.4\text{ in}) + (4.7\text{ in})(10\text{ in})(0.6\text{ in})}{(0.375\text{ in})(0.4\text{ in}) + (10\text{ in})(0.6\text{ in})}$

$= 4.6878$ in (2 pts)

$A' = (0.375\text{ in})(0.4\text{ in}) + (10\text{ in})(0.6\text{ in}) = 6.15\text{ in}^2$ (1 pt)

$Q = (4.6878\text{ in})(6.15\text{ in}^2) = 28.83\text{ in}^3$ (1 pt)

$I = \frac{1}{12}(10\text{ in})(10\text{ in})^3 - \frac{1}{12}(10\text{ in} - 0.375\text{ in})(10\text{ in} - 1.2\text{ in})^3$

$= 833.33\text{ in}^4 - 546.60\text{ in}^4 = 286.73\text{ in}^4$ (2 pts)

$t = 0.375$ in (1 pt)

@ n-n, x = 1 ft: $\tau_a = \dfrac{VQ}{It} = \dfrac{(25\text{ kips})(28.83\text{ in}^3)}{(286.73\text{ in}^4)(0.375\text{ in})}$

$= 6.703$ ksi $\rightarrow$ **6.70 ksi** (1 pt)