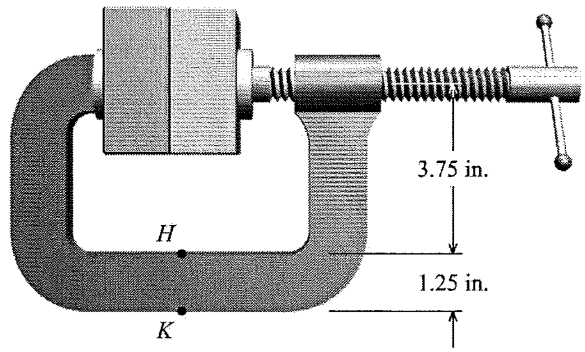
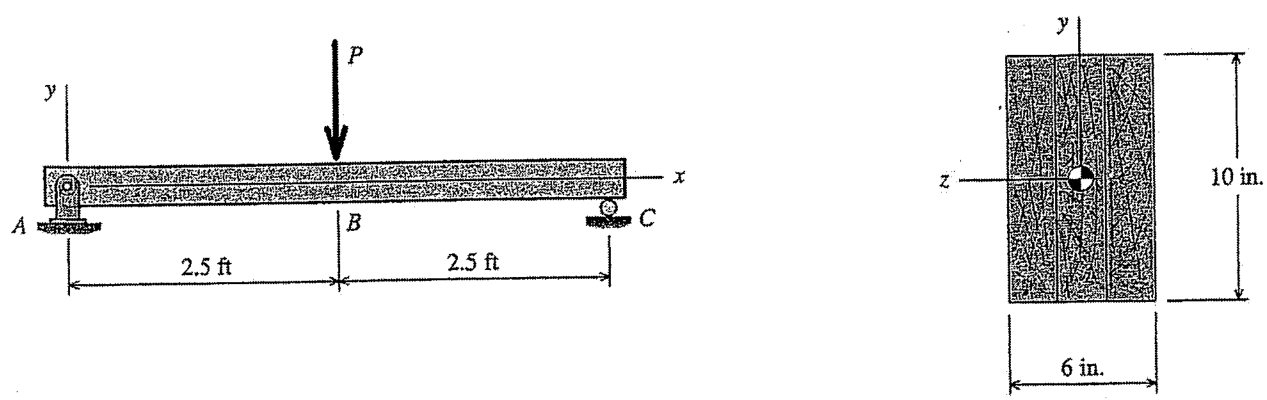
Exam 3 – Mechanics of Materials, ENGR 350
Wednesday, December 3, 2014

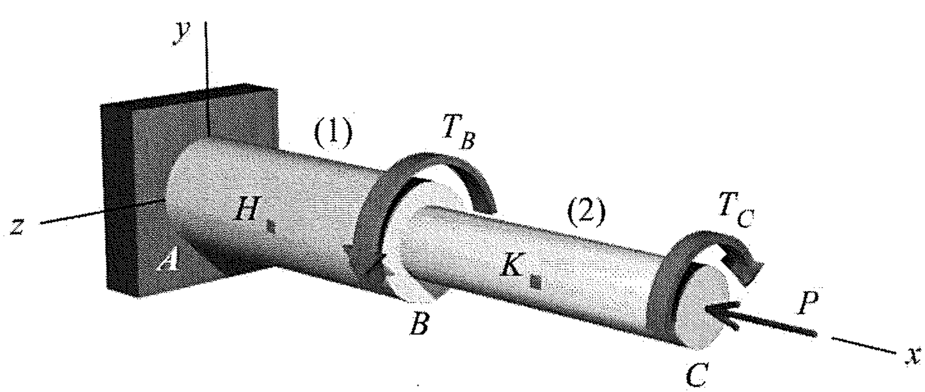
1) The screw of a clamp exerts a compressive force of 350 lb on the wood blocks. Determine the normal stresses produced at points H and K. The clamp cross-sectional dimensions at the section of interest are 1.25 in. by 0.375 in. thick.



2) A 5-ft-long simply supported wood beam carries a concentrated load P at midspan. The cross-sectional dimensions are also shown. If the maximum allowable shear stress in the beam is 80 psi, determine the maximum load P that may be applied at midspan.



3) A solid compound shaft consists of segment (1), which has a diameter of 1.5 in., and segment (2), which has a diameter of 1.0 in. The shaft is subjected to an axial compression load of P = 7 kips and torques TB = 5 kip-in. and TC = 1.5 kip-in., which act in the directions shown in figure. Determine the normal and shear stresses at (a) point H and (b) point K. For each point, show the stresses on a stress element.



(1) $A = (0.375\text{ in})(1.25\text{ in}) = 0.469\text{ in}^2$

$$I_z = \frac{0.375\text{ in}\,(1.25\text{ in})^3}{12} = 0.061\text{ in}^4$$

$F = 350\text{ lb}$

$M = 350\text{ lb}\,(3.75\text{ in} + 0.625\text{ in}) = 1{,}531\text{ lb-in}$

Stresses:

$$\sigma_{axial} = \frac{F}{A} = \frac{350\text{ lb}}{0.469\text{ in}^2} = 747\text{ psi}$$

$$\sigma_{bending} = \frac{Mc}{I} = \frac{1{,}531\text{ lb-in}\,(0.625\text{ in})}{0.061\text{ in}^4} = \pm 15{,}680\text{ psi}$$

$$\sigma_H = \sigma_{axial} + \sigma_{bending}$$

$$= 747\text{ psi} + 15{,}680\text{ psi}$$

$$= \boxed{16{,}430\text{ psi (T)}}$$

$$\sigma_K = \sigma_{axial} - \sigma_{bending}$$

$$= 747\text{ psi} - 15{,}680\text{ psi}$$

$$= \boxed{14{,}930\text{ psi (C)}}$$

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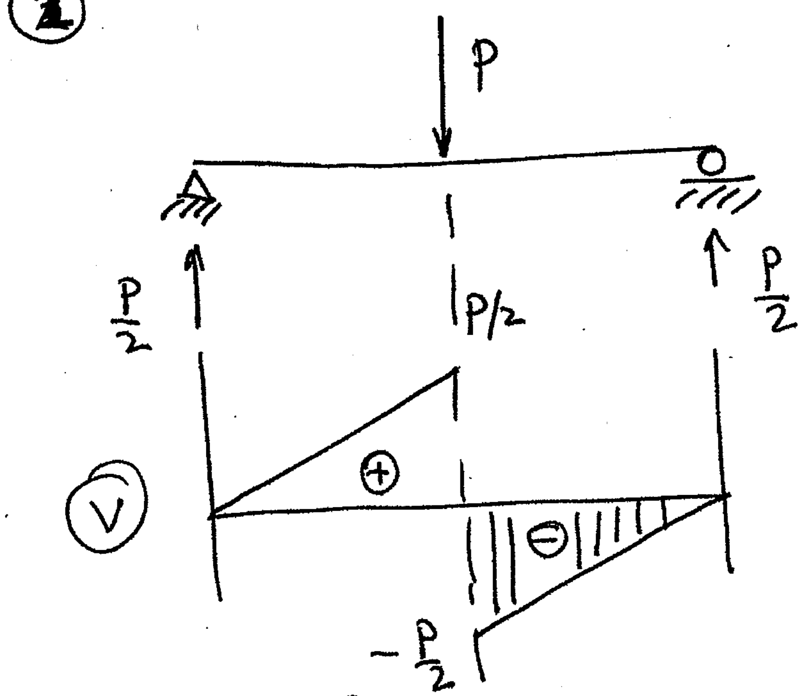
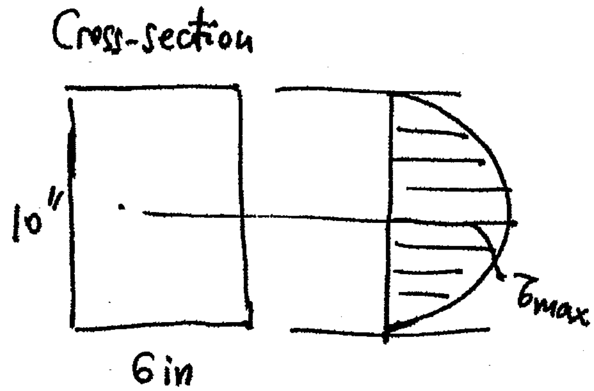




$$\tau_{max} = \frac{3V}{2A}$$

$$A = 10 \cdot 6 = 60 \text{ in}^2$$

$$V = \frac{P}{2}$$

$$\tau_{max} = \frac{3}{2}\,\frac{\frac{P}{2}}{60} = \frac{3P}{240}\,\frac{lb}{in^2} = 80 \text{ psi} \Rightarrow$$

$$\Rightarrow P = \frac{80 \cdot 240}{3} = 6400 \text{ lb.}$$

(3) Shaft (1) : $\Sigma M_x : 0 = -T_1 + 5\text{ Kip-in} - 1.5\text{ Kip-in}$

$T_1 = 3.5\text{ Kip-in}$

Shaft (2) : $\Sigma M_x : 0 = -T_2 - 1.5\text{ Kip-in}$

$T_2 = -1.5\text{ Kip-in}$

$A_1 = \frac{\pi}{4}(1.5\text{ in})^2 = 1.767\text{ in}^2$ $\qquad J_1 = \frac{\pi}{32}(1.5\text{ in})^4 = 0.497\text{ in}^4$

$A_2 = \frac{\pi}{4}(1.0\text{ in})^2 = 0.785\text{ in}^2$ $\qquad J_2 = \frac{\pi}{32}(1.0\text{ in})^4 = 0.098\text{ in}^4$

$$\sigma_1 = \frac{F_1}{A_1} = \frac{-7\text{ kips}}{1.767\text{ in}^2} = 3.961\text{ ksi (C)}$$

$$\sigma_2 = \frac{F_2}{A_2} = \frac{-7\text{ kips}}{0.785\text{ in}^2} = 8.913\text{ ksi (C)}$$

$$\tau_1 = \frac{T_1 c_1}{J_1} = \frac{3.5\text{ Kip-in}\,(0.75\text{ in})}{0.497\text{ in}^4} = 5.282\text{ ksi}$$

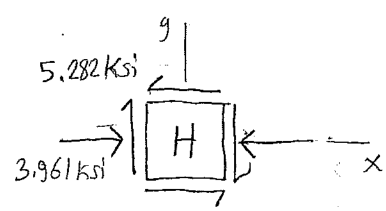
$$\tau_2 = \frac{T_2 c_2}{J_2} = \frac{1.5\text{ Kip-in}\,(0.5\text{ in})}{0.098\text{ in}^4} = 7.639\text{ ksi}$$

Stresses at H:

$\sigma_x = \boxed{-3.96\text{ ksi}}$

$\sigma_y = \boxed{0}$

$\tau_{xy} = \boxed{-5.28\text{ ksi}}$



Stresses at K:

$\sigma_x = \boxed{-8.91\text{ ksi}}$

$\sigma_y = \boxed{0}$

$\tau_{xy} = \boxed{7.64\text{ ksi}}$