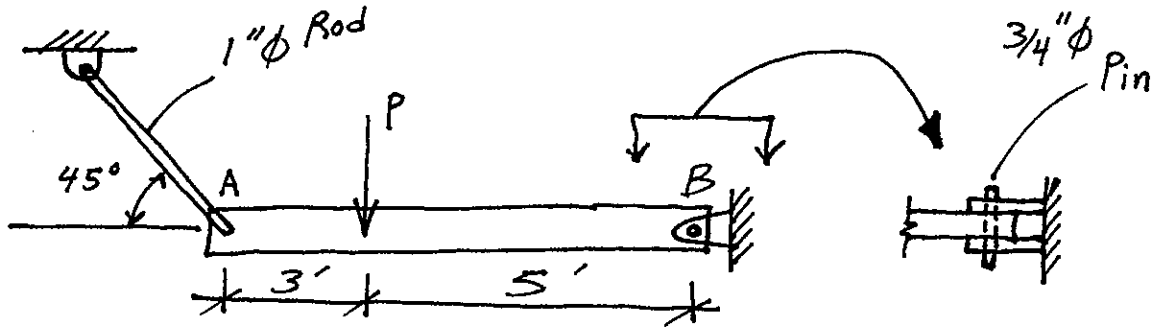
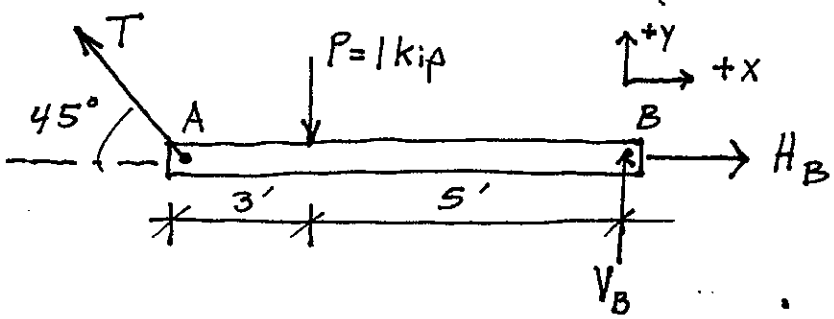
Example Problem

What value of P can be applied to the beam so that the rod stress does not exceed $\sigma_a = 20$ ksi and the pin stress does not exceed $\tau_a = 14$ ksi ?



Solution:

- Draw FBD of Beam (Let P=1 kip for now)



- Determine Unknowns - Use equilibrium Equations

$\overset{+}{\rightarrow} \Sigma F_X = 0; \rightarrow -T\cos 45 + H_B = 0$

$+\uparrow \Sigma F_Y = 0; \rightarrow T\sin 45 - 1 + V_B = 0$

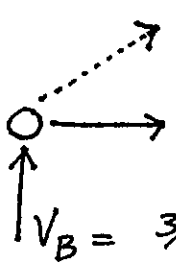
$\circlearrowleft^{+} \Sigma M_A = 0; \rightarrow -3(1) + 8V_B = 0 \Rightarrow V_B = \frac{3}{8}$ kips

$\rightarrow T = \frac{1 - 3/8}{\sin 45} = 0.8839$ kips

$\rightarrow H_B = 0.8839\cos 45 = 0.6250$ kips

→

- Determine Resultant force at the pin.



- Determine Rod stress and pin stress

Area Rod = $\frac{\pi (1)^2}{4}$ = 0.7854 in^2 = A_r

Area Pin = $\frac{\pi (0.75)^2}{4}$ = 0.4418 in^2 = A_p

Rod Stress = $\sigma = \frac{T}{A_r} = \frac{0.8839 \text{ kips}}{0.7854 \text{ in}^2}$ = 1.125 Ksi

Pin Stress = $\tau = \frac{V}{2A_p} = \frac{0.7289 \text{ kips}}{2(0.4418) \text{ in}^2}$ = 0.8249 Ksi

(Notice pin is in double shear) →

- By proportions determine the allowed value of P.

→ Consider the rod first

$$\frac{P}{\sigma} = \frac{1 \text{ kips}}{1.125 \text{ Ksi}} = \frac{P_a}{\sigma_a} = \frac{P_a}{20 \text{ Ksi}} \quad (\sigma_a \text{ given}) \Rightarrow P_a = \frac{20 \text{ Ksi} \cdot \text{kips}}{1.125 \text{ Ksi}} = 17.8 \text{ kips}$$

→ Consider the pin

$$\frac{P}{\tau} = \frac{1 \text{ kips}}{0.8249 \text{ Ksi}} = \frac{P_a}{\tau_a} = \frac{P_a}{14 \text{ Ksi}} \quad (\tau_a \text{ given}) \Rightarrow P_a = \frac{14 \text{ Ksi} \cdot \text{kips}}{0.8249 \text{ Ksi}} = 17.0 \text{ kips}$$

- Conclusion

The pin limits the load P that can be applied to the beam. The limiting value is $\boxed{P = 17.0 \text{ kips}}$ ←

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