ME 325 – Homework #6
Due: Fri., Apr. 10, 2009

1. Problem 9-1
2. Problem 9-4
3. Problem 9-5
4. Problem 9-10
5. Problem 9-11
6. Problem 9-12

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(1) Problem 9-1

$$\tau = \frac{F}{2(0.707)h \cdot l} \Rightarrow F = 2 \cdot (0.707) h \cdot l =$$

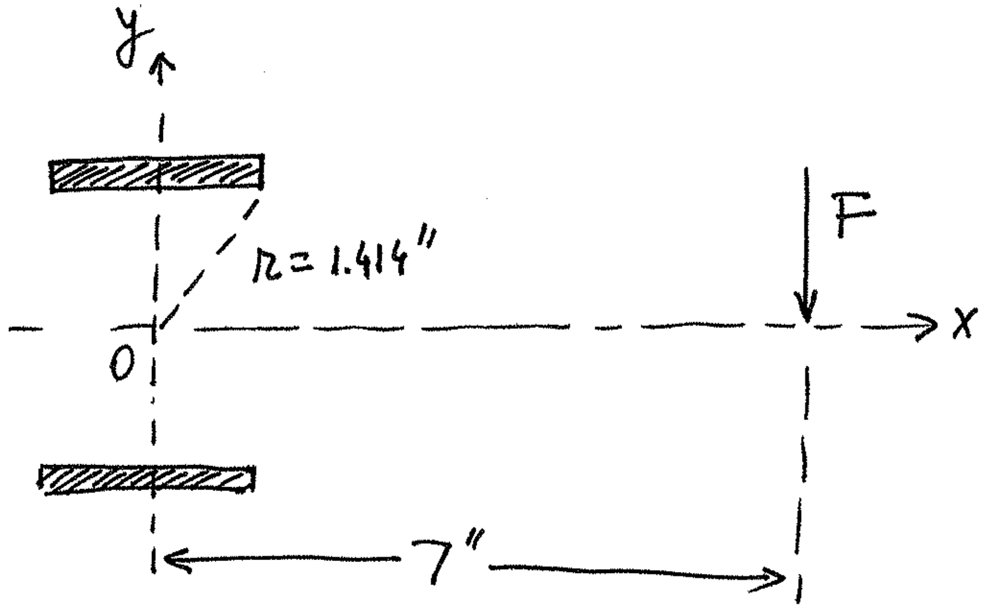
$$= 2(0.707)\frac{5}{16}(2) \cdot 20 =$$

$$= 17.7 \text{ Kip}$$

(2) Problem 9-4

$$\tau = \frac{F}{4(0.707)hl} = \frac{32}{4(0.707)\frac{5}{16} \cdot 2} = 18.1 \text{ Ksi}$$

(3) Problem 9-5



$$\tau' = \frac{F}{A} = \frac{F}{2(0.707)hl} = \frac{F}{1.414\left(\frac{5}{16}\right)2} = 1.13F \text{ Ksi}$$

$$J_u = \frac{d(3b^2+d^2)}{6} = \frac{2[3\cdot 4+4]}{6} = 5.33 \text{ in}^3$$

$$J = 0.707 h J_u = 0.707 \cdot \frac{5}{16} \cdot (5.33) = 1.18 \text{ in}^4$$

$$\tau_x'' = \tau_y'' = \frac{M r_y}{J} = \frac{7 \cdot F(1)}{1.18} = 5.93F \text{ ksi}$$

$$\tau_{max} = \sqrt{\tau_x^2 + \tau_y^2} = F \cdot \sqrt{(5.93)^2 + (1.13+5.93)^2} = 9.22F \text{ ksi}$$

$$F = \frac{20}{9.22} = 2.17 \text{ kip}$$

(4) <u>Problem 9-10</u>

$$A = 1.414 \cdot \pi \cdot h r = 1.414 \cdot \pi (0.5)(4) = 8.884 \text{ cm}^2$$

$$J_u = 2\pi r^3 = 2\pi \cdot 4^3 = 402 \text{ cm}^3$$

$$J = 0.707 \cdot h J_u = 0.707 \cdot (0.5) \cdot 402 = 142 \text{ cm}^4$$

$$M = (200+40)F = 240F \text{ N}\cdot\text{m} \quad (F \text{ in kN})$$

$$\tau' = \frac{F}{2 \cdot A} = \frac{F}{2 \cdot 8.884} = 0.056F \left(\frac{\text{kN}}{\text{cm}^2}\right) = 0.56F \text{ MPa}$$

$$\tau'' = \frac{Mr}{2J} = \frac{240F \cdot 4}{2 \cdot 142} = 3.38F \text{ MPa}$$

$$\tau_{all} = \tau' + \tau'' = (0.56+3.38)F = 4.94F \Rightarrow F = \frac{140}{4.94} = 28.34 \text{ kN}$$

(5) Problem 9-11

$$J_u = 2\pi r^3 = 2\pi \cdot 1^3 = 6.28 \text{ in}^3$$

$$J = 0.707 J_u = 0.707(0.25) \cdot 6.28 = 1.11 \text{ in}^4$$

$$\tau = \frac{Mr}{J} = \frac{Tr}{J} = \frac{20 \cdot 1}{1.11} = 18 \text{ Ksi}$$

(6) Problem 9-12

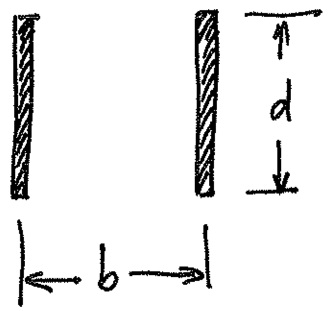


Table 9-3

$h = 0.375$ in

$d = 8$ in

$b = 1$ in

$$I_u = \frac{d^3}{6} = \frac{8^3}{6} = 85.3 \text{ in}^3$$

$$I = 0.707 h \cdot I_u = 0.707 \cdot (0.375)(85.3) = 22.6 \text{ in}^4$$

$$A = 1.414 h \cdot d = 1.414 \cdot (0.375)(8) = 4.24 \text{ in}^4$$

$$\tau = \frac{F}{A} = \frac{5}{4.24} = 1.18 \text{ Ksi}$$

$$M = 5 \cdot 6 = 30 \text{ kip}\cdot\text{in}$$

$$c = \frac{(1+8+1-2)}{2} = 4 \text{ in}$$

$$\sigma = \frac{Mc}{I} = \frac{30 \cdot 4}{22.6} = 5.31 \text{ Ksi}$$

Using Mohr's circle:

$$\tau_{max} = \sqrt{\frac{\sigma^2}{4} + \tau^2} = \sqrt{\frac{5.31^2}{4} + 1.18^2} = 2.9 \text{ ksi}$$

Largest principal stress:

$$\sigma_1 = \frac{\sigma}{2} + \sqrt{\frac{\sigma^2}{4} + \tau^2} = \frac{5.31}{2} + \sqrt{\frac{5.31^2}{4} + 1.18^2} = 5.56 \text{ ksi}$$

Comment: an alternate shear stress is to use the approach from example problem 9-2, and calculate an approximate maximum shear stress by equating

$$\left.\begin{aligned} \tau &= \tau' \\ \sigma &= \tau'' \end{aligned}\right\} \Rightarrow \tau_{max} = \sqrt{\tau'^2 + \tau''^2} = \sqrt{1.18^2 + (5.31)^2} =$$

$$= 5.44 \text{ ksi}$$