H. Indeterminate Problems

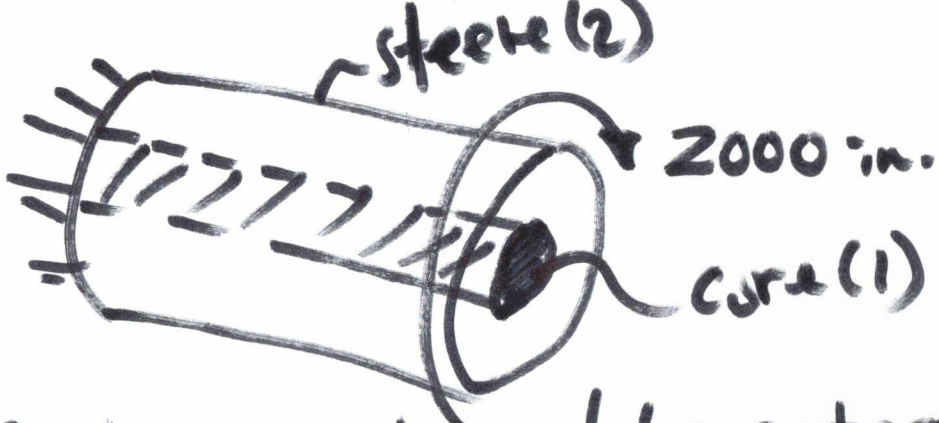
ΣT +

① Statics

② Load - Deformation eqn. $\phi = \frac{TL}{JpG}$

③ Geometry of deformation

series, parallel



$d_1 = 0.5$ in

$do_2 = 1.0$ in

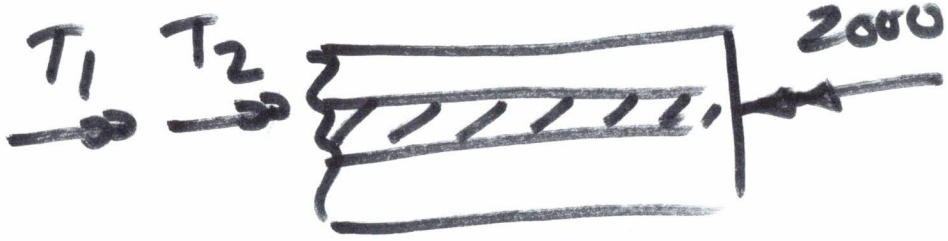
$di_2 = 0.5$ in

DRAW FBD that relates internal torques T_1 & T_2 to 2000 in. lb external torque.

$G_1 = 8 \times 10^3$ ksi $\quad L_1 = L_2 = 15$ in

$G_2 = 12 \times 10^3$ ksi

$I_p = \pi/32 d^4$



ΣT

$T_2 + T_1 - 2000 = 0$

$T_1 + T_2 = 2000$

$\phi_1 = \phi_2$

$\frac{T_1 L_1}{I_{p_1} G_1} = \frac{T_2 L_2}{I_{p_2} G_2}$

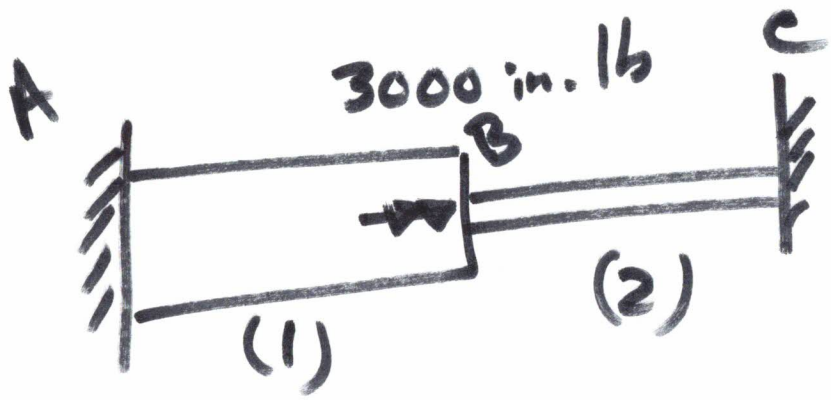
$T_1 = T_2 \frac{L_2}{L_1} \frac{I_{p_1}}{I_{p_2}} \frac{G_1}{G_2}$

$T_1 = T_2 \frac{\pi/32\ 0.5^4}{\pi/32\ [1^4 - 0.5^4]} \frac{8}{12}$

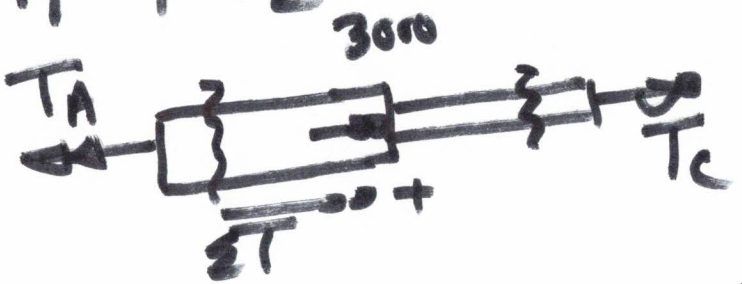
Solve for T_1 & T_2

$T_{MAX_1} = \frac{T_1 \frac{0.5}{2}}{\pi/32 (0.5)^4}$

$T_{MAX_2} = \frac{T_2 \frac{1.0}{2}}{\pi/32 (1^4 - 0.5^4)}$



- DRAW overall FBD
- DRAW FBD's to relate wall RXNs to internal torques T_1 & T_2



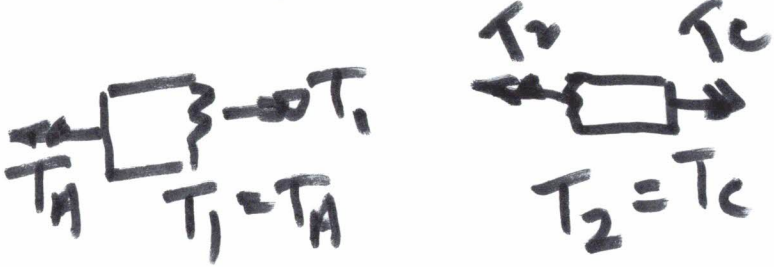
$L_1 = 10$ in $L_2 = 15$ in

$d_1 = 1.0$ in $d_2 = 0.75$ in

$G_1 = 10 \times 10^3$ ksi $G_2 = 5 \times 10^3$ ksi

Find τ_{max_1}, τ_{max_2}, ϕ_B

$$-T_A + 3000 + T_C = 0$$



$$-T_1 + 3000 + T_2 = 0$$

$$\phi_{total} = 0 = \phi_1 + \phi_2$$

$$\frac{T_1 L_1}{I_{p1} G_1} + \frac{T_2 L_2}{I_{p2} G_2} = 0$$

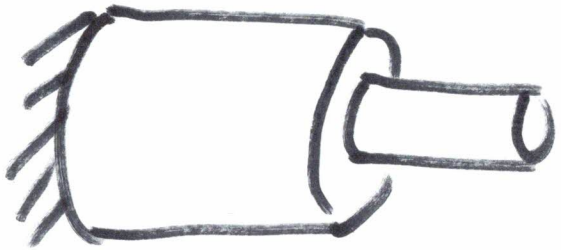
$$T_1 = -T_2 \frac{L_2}{L_1} \frac{I_{p1}}{I_{p2}} \frac{G_1}{G_2}$$

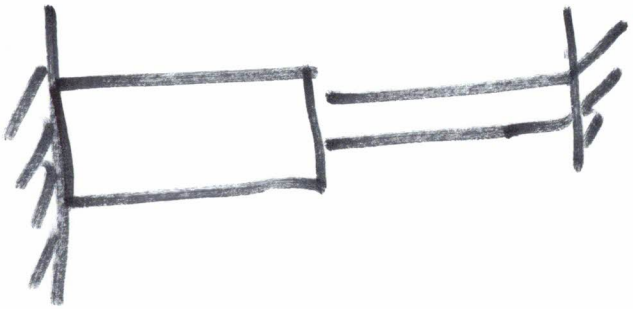
$$T_1 = -T_2 \frac{15}{10} \frac{\pi/32 \; 1^4}{\pi/32 \; 0.75^4} \frac{10}{5}$$

Solve for T_1 & T_2

$$T_{MAX_1} = \frac{T_1 d_1/2}{I_{p1}} \qquad T_{MAX_2} = \frac{T_2 d_2/2}{I_{p2}}$$

$$\phi_B = \phi_1 = \frac{T_1 L_1}{I_{p1} G_1}$$





$$e = \frac{FL}{AE} \quad , \sigma = \frac{F}{A}$$

$$\tau_{MAX} = \frac{Td/2}{I_p} \quad , \phi = \frac{TL}{J_p G}$$