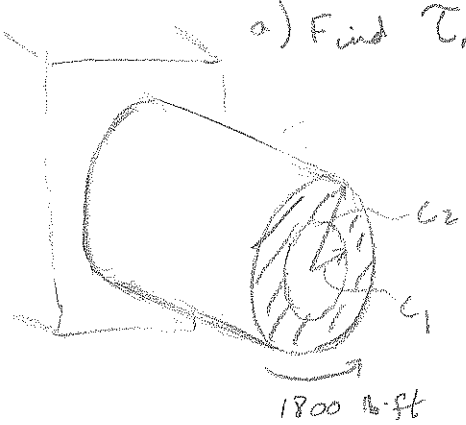
10.3

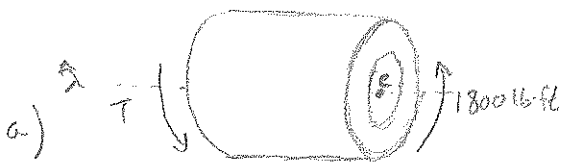
a) Find τ_{max}



$$c_1 = \frac{1.6\ in}{2}$$

$$c_2 = \frac{2.4\ in}{2}$$

FBD



$\Sigma M_{/C} : \Rightarrow T = 1800\ lb\cdot ft = 21600\ lb\cdot in$

$$\tau = \frac{Tc}{J} \Rightarrow \tau_{max} = \frac{Tc}{J}$$

$$J = \frac{\pi}{2}(c_2^4 - c_1^4) = \frac{\pi}{2}(1.2^4 - 0.8^4)\ in^4$$

$$= 2.61\ in^4$$

$$\tau_{max} = \frac{(21600\ lb\cdot in)(1.2\ in)}{2.61\ in^4}$$

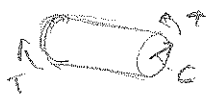
$$\boxed{\tau_{max} = 9.92\ ksi}$$

Note: Cross-sectional area of hollow shaft: $\pi(c_2^2 - c_1^2) = 2.51$

Cross-sectional area of solid shaft: $\pi c^2 = 3.91\ in$

Hollow shaft has similar radius that will withstand the same τ_{max} using less material

b) Determine the diameter of a solid shaft for same T and τ_{max}.



$$J = \frac{\pi}{2}c^4$$

$$\tau_{max} = \frac{Tc}{\frac{\pi}{2}c^4} \Rightarrow c = \left(\frac{2T}{\pi\tau_{max}}\right)^{1/3}$$

$$= \left[\frac{2(21600\ lb\cdot in)}{\pi(9.92\ ksi)}\right]^{1/3} = 1.115\ in$$

diameter, $d = 2c \Rightarrow$ $\boxed{d = 2.23\ in}$