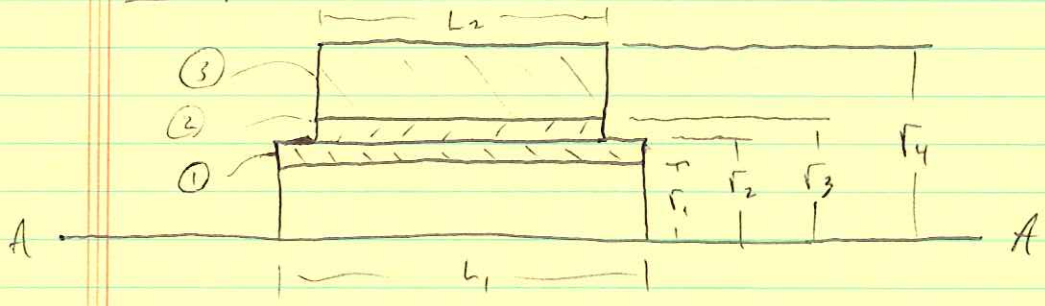
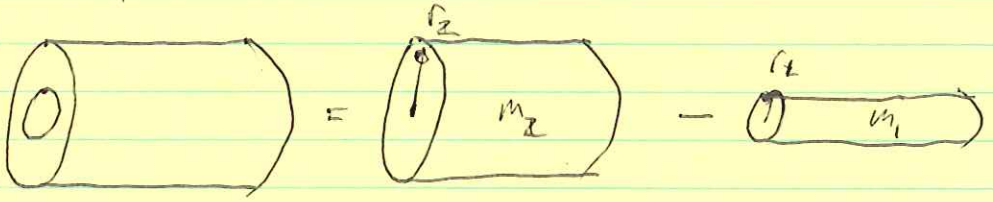
EX. PROB. 9.128



$\gamma_B = 0.310 \frac{LBF}{IN^3}$, $\gamma_A = 0.100 \frac{LBF}{IN^3}$, $\gamma_N = 0.0452 \frac{LBF}{IN^3}$

$I_{AA} = I_1 + I_2 + I_3$



$I_1 = \frac{1}{2} m_2 r_2^2 - \frac{1}{2} m_1 r_1^2$ $\qquad W = mg, \; m = \frac{W}{g}$

$= \frac{1}{2}\left(\gamma_B V_2 r_2^2 - \gamma_B V_1 r_1^2\right) \cdot \frac{1}{g}$

$= \frac{\frac{1}{2}\gamma_B}{g}\left(\pi r_2^2 L_1 \cdot r_2^2 - \pi r_1^2 L_1 \cdot r_1^2\right)$

$I_1 = \frac{\pi \gamma_B L_1}{2g}\left(r_2^4 - r_1^4\right)$

$= \frac{\pi}{2} \frac{\left(0.310 \frac{LBF}{IN^3}\right)\left(\frac{13}{16}\,IN\right)}{\left(32.2 \frac{ft}{s^2}\right)} \left[\left(\frac{3/8\,IN}{2}\right)^4 - \left(\frac{1/4\,IN}{2}\right)^4\right]\left(\frac{ft}{12\,IN}\right)$

$I_1 = 1.015 \times 10^{-6}\ LBF \cdot IN \cdot s^2$

$I_2 = \frac{\pi \gamma_A L_2}{2g}\left(r_3^4 - r_2^4\right)$

$= \frac{\pi}{2} \frac{\left(0.100\right)\left(\frac{11}{16}\right)}{\left(32.2\right)} \left[\left(\frac{1/2}{2}\right)^4 - \left(\frac{3/8}{2}\right)^4\right]\left(\frac{1}{12}\right)$

$I_2 = 7.463 \times 10^{-7}\ LBF \cdot IN \cdot s^2$

9.128 CONT.

$$I_3 = \frac{\pi \gamma_N L_2}{2g}\left(r_4^4 - r_3^4\right)$$

$$= \frac{\pi}{2}\frac{(0.0452)\left(\frac{11}{16}\right)}{(32.2)}\left[\left(\frac{1.125}{2}\right)^4 - \left(\frac{1/2}{2}\right)^4\right]\left(\frac{1}{12}\right)$$

$$I_3 = 1.215 \times 10^{-5} \text{ LBF}\cdot\text{IN}\cdot\text{S}^2$$

$$I_{AA} = 1.391 \times 10^{-5} \text{ LBF}\cdot\text{IN}\cdot\text{S}^2 = 1.16 \times 10^{-6} \text{ LBF}\cdot\text{FT}\cdot\text{S}^2$$

RADIUS OF GYRATION:

$$K = \sqrt{\frac{I}{m}} \qquad I = mK^2$$

$$m = m_1 + m_2 + m_3$$

$$m_1 = \frac{\gamma_B}{g}\left(\pi r_2^2 L_1 - \pi r_1^2 L_1\right)$$

$$= \frac{\pi \gamma_B L_1}{g}\left(r_2^2 - r_1^2\right)$$

$$= \frac{\pi\left(0.310 \frac{\text{LBF}}{\text{IN}^3}\right)\left(\frac{13}{16}\text{ IN}\right)}{\left(32.2 \frac{\text{FT}}{\text{S}^2}\right)}\left[\left(\frac{3/8\text{ IN}}{2}\right)^2 - \left(\frac{1/4\text{ IN}}{2}\right)^2\right]\left(\frac{\text{FT}}{12\text{ IN}}\right)$$

$$m_1 = 4.00 \times 10^{-5} \frac{\text{LBF}\cdot\text{S}^2}{\text{IN}}$$

$$m_2 = \frac{\pi \gamma_A L_2}{g}\left(r_3^2 - r_2^2\right)$$

$$= \frac{\pi(0.1)\left(\frac{11}{16}\right)}{(32.2)}\left[\left(\frac{1/2}{2}\right)^2 - \left(\frac{3/8}{2}\right)^2\right]\left(\frac{1}{12}\right)$$

$$m_2 = 1.528 \times 10^{-5} \frac{\text{LBF}\cdot\text{S}^2}{\text{IN}}$$

9.128 CONT.

$$M_3 = \frac{\pi \gamma_N L_2}{g}\left(r_4^2 - r_3^2\right)$$

$$= \frac{\pi (0.0452)\left(\frac{11}{16}\right)}{(32.2)}\left[\left(\frac{1.125}{2}\right)^2 - \left(\frac{1/2}{2}\right)^2\right]\left(\frac{1}{12}\right)$$

$$M_3 = 6.415 \times 10^{-5} \ \frac{LBF \cdot S^2}{IN}$$

$$M = 1.194 \times 10^{-4} \ \frac{LBF \cdot S^2}{IN}$$

$$K = \sqrt{\frac{\left(1.391 \times 10^{-5} \ LBF, IN \cdot S^2\right)}{\left(1.194 \times 10^{-4} \ \frac{LBF \cdot S^2}{IN}\right)}}$$

$$\boxed{K = 0.3413 \ IN}$$