

[9.5절]

9.142  $\rho = 7,850 \text{ kg/m}^3$

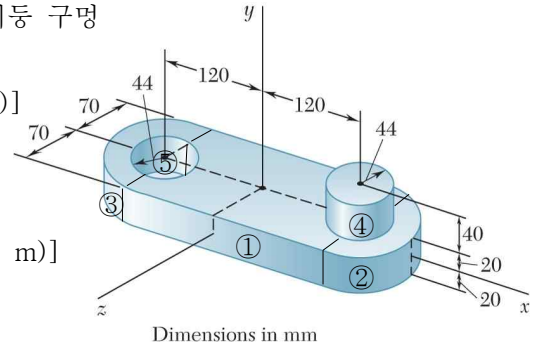
① 사각기둥, ②,③ 반원기둥, ④ 원기둥, ⑤ 원기둥 구멍

$$m = \rho V$$

$$\begin{aligned} m_1 &= (7,850 \text{ kg/m}^3) [(0.24 \text{ m})(0.14 \text{ m})(0.04 \text{ m})] \\ &= (7.85 \times 10^3 \text{ kg/m}^3) (1.344 \times 10^{-3} \text{ m}^3) \\ &= 10.550 \text{ kg} \end{aligned}$$

$$\begin{aligned} m_2 &= m_3 = (7,850 \text{ kg/m}^3) \left[ \frac{\pi}{2} (0.07 \text{ m})^2 (0.04 \text{ m}) \right] \\ &= (7.85 \times 10^3 \text{ kg/m}^3) (0.3079 \times 10^{-3} \text{ m}^3) \\ &= 2.417 \text{ kg} \end{aligned}$$

$$\begin{aligned} m_4 &= m_5 = (7,850 \text{ kg/m}^3) [\pi (0.044 \text{ m})^2 (0.04 \text{ m})] \\ &= (7.85 \times 10^3 \text{ kg/m}^3) (0.2433 \times 10^{-3} \text{ m}^3) = 1.9098 \text{ kg} \end{aligned}$$



(a)  $I_{x1} = \frac{1}{12} m_1 (b^2 + c^2)$

$$= \frac{1}{12} (10.550 \text{ kg}) [(0.14 \text{ m})^2 + (0.04 \text{ m})^2] = 18.638 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_{x2} = I_{x3} = \frac{1}{12} m_2 (3r_2^2 + L_2^2)$$

$$= \frac{1}{12} (2.417 \text{ kg}) [3 (0.07 \text{ m})^2 + (0.04 \text{ m})^2] = 3.283 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_{x4} = \frac{1}{12} m_4 (3r_4^2 + L_4^2) + m_4 d_4^2$$

$$= (1.9098 \text{ kg}) \left\{ \frac{1}{12} [3 (0.044 \text{ m})^2 + (0.04 \text{ m})^2] + (0.04)^2 \right\} = 4.234 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_{x5} = \frac{1}{12} m_5 (3r_5^2 + L_5^2)$$

$$= \frac{1}{12} (1.9098 \text{ kg}) [3 (0.044 \text{ m})^2 + (0.04 \text{ m})^2] = 1.179 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_x = I_{x1} + I_{x2} + I_{x3} + I_{x4} - I_{x5}$$

$$= [(18.638) + 2 (3.283) + (4.234) - (1.179)] \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$= 28.259 \times 10^{-3} \text{ kg} \cdot \text{m}^2 \quad \Rightarrow \quad I_x = 28.3 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

(b)  $I_{y1} = \frac{1}{12} m_1 (a^2 + b^2)$

$$= \frac{1}{12} (10.550 \text{ kg}) [(0.24 \text{ m})^2 + (0.14 \text{ m})^2] = 67.87 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_{y2} = I_{y3} = \frac{1}{2} m_2 r_2^2 - m_2 d_{2a}^2 + m_2 d_{2b}^2$$

$$= (2.417 \text{ kg}) \left\{ \frac{1}{2} (0.07 \text{ m})^2 - \left[ \frac{4}{3\pi} (0.07 \text{ m}) \right]^2 + \left[ (0.12 \text{ m}) + \frac{4}{3\pi} (0.07 \text{ m}) \right]^2 \right\}$$

$$= 57.96 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$I_{y4} = I_{y5} = \frac{1}{2} m_4 r_4^2 + m_4 d_4^2$$

$$= (1.9098 \text{ kg}) \left[ \frac{1}{2} (0.044 \text{ m})^2 + (0.12 \text{ m})^2 \right] = 29.34 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

$$\begin{aligned}
I_y &= I_{y1} + I_{y2} + I_{y3} + I_{y4} - I_{y5} \\
&= [(67.87) + 2 (57.96) + 0] \times 10^{-3} \text{ kg}\cdot\text{m}^2 \\
&= 183.79 \times 10^{-3} \text{ kg}\cdot\text{m}^2 \quad \Rightarrow \quad I_y = 183.8 \times 10^{-3} \text{ kg} \cdot \text{m}^2
\end{aligned}$$

(c)  $m = m_1 + m_2 + m_3 + m_4 - m_5$

$$\begin{aligned}
&= (10.550 \text{ kg}) + 2 (2.417 \text{ kg}) + 0 = 15.384 \text{ kg} \\
k_x^2 &= \frac{I_x}{m} = \frac{28.259 \times 10^{-3} \text{ kg} \cdot \text{m}^2}{15.384 \text{ kg}} = 1.8369 \times 10^{-3} \text{ m}^2 \\
&\quad \Rightarrow \quad k_x = 0.0429 \text{ m} = 42.9 \text{ mm} \\
k_y^2 &= \frac{I_y}{m} = \frac{183.79 \times 10^{-3} \text{ kg} \cdot \text{m}^2}{15.384 \text{ kg}} = 11.947 \times 10^{-3} \text{ m}^2 \\
&\quad \Rightarrow \quad k_y = 0.1093 \text{ m} = 109.3 \text{ mm}
\end{aligned}$$