**These are NOT notes.** They are a visual aid(20%) for a verbal explanation(80%).

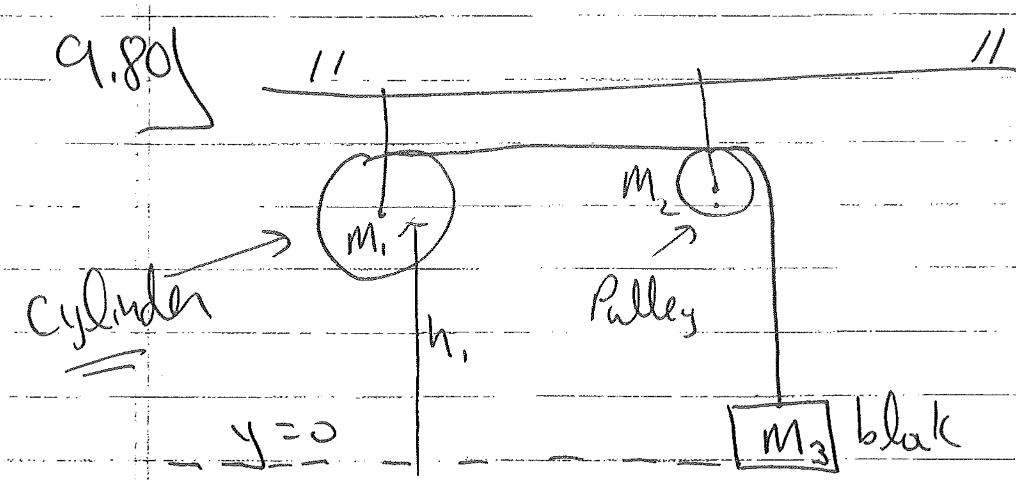
# HW Comments

9.7) $\theta(t) = a + bt + ct^3$ NOT constant $\alpha$

$\omega(t) = \frac{d\theta}{dt}$

$\alpha(t) = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$

9.80)




"@ rest"

$\boxed{A}$

System: Cylinder, Pulley, block, Earth

$TE_{\boxed{A}} = KE_{\boxed{A}} + PE_{g\boxed{A}} = m_1 g h_1 + m_2 g h_2 + m_3 g(0)$

[rotational, translational] For every mass

0 "from rest"

Configuration $\boxed{B}$ ⇒ $M_3$ has fallen 2 meters

$TE_{\boxed{B}} = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} m_3 v_3^2 + m_1 g h_1 + M_2 g h_2 + m_3 g(-2)$

## Conservation of Energy

$$TE_{\boxed{A}} = TE_{\boxed{B}}$$

$$\cancel{m_1} g h_1 + \cancel{m_2} g h_2 = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} m_3 v_3^2 + \cancel{m_1} g h_1 + \cancel{m_2} g h_2 - 2 m_3 g$$

9.53 will be set to extra credit

YES! $\omega_1 = \omega_2 = \omega_3 = \omega$

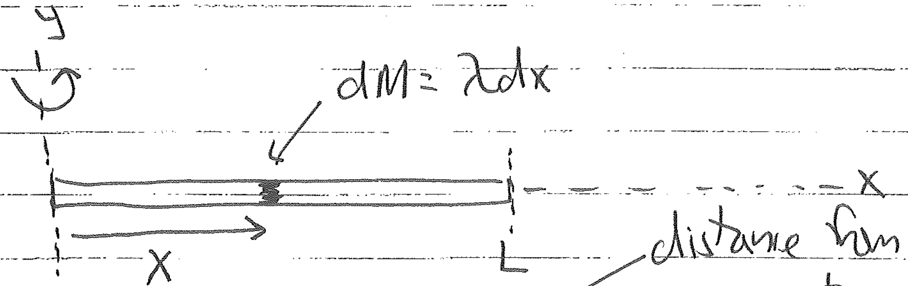
$$\therefore \quad KE = \frac{1}{2}m_1 r_1^2 \omega^2 + \frac{1}{2}m_2 r_2^2 \omega^2 + \frac{1}{2}m_3 r_3^2 \omega^2$$

$$= \frac{1}{2}\underbrace{(m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2)}_{I}\omega^2$$

1

A rod of mass $M$ and length $L$ is spun about an axis $\perp$ to one end. Find $I$.

$$\lambda = \frac{M}{L}$$




distance from rot. axis to dM

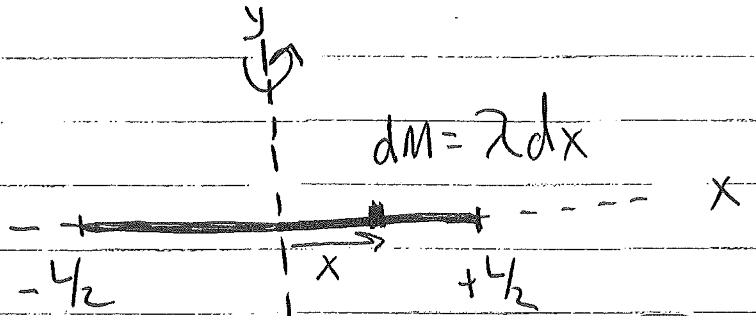
$$I = \int r^2 \, dm$$

$$I = \int_0^L x^2 \lambda \, dx = \lambda \int_0^L x^2 = \lambda \frac{x^3}{3}\Big|_0^L$$

$$I = \frac{\lambda L^3}{3} = \frac{ML^2}{3}$$

Answer.

For the same rod, find $I$ about an axis running through the center (as shown below).




$$I = \int r^2 dm$$

$$I = \int_{-L/2}^{L/2} x^2 \lambda \, dx$$

REALLY ?? $\boxed{\checkmark}$
Sign on $x$ makes no difference

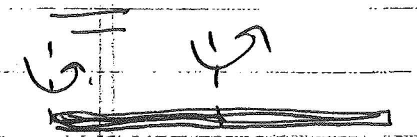
$$I = \lambda \frac{x^3}{3}\Big|_{-L/2}^{L/2} = \frac{\lambda}{3}\left[x^3\right]\Big|_{-L/2}^{L/2} = \frac{\lambda}{3}\left[\frac{L^3}{8} - \left(-\frac{L^3}{8}\right)\right]$$

$$I = \frac{\lambda}{3}\left(\frac{2L^3}{8}\right) = \frac{\lambda L^3}{12} = \frac{ML^2}{12}$$ Answer.

## Parallel Axis Thrm.

$$I_{\underset{\text{Axis}}{\parallel}} = I_{cm} + MD^2$$

distance between axes



$I_\parallel = ?$ $\quad I_{cm} = \frac{ML^2}{12}$

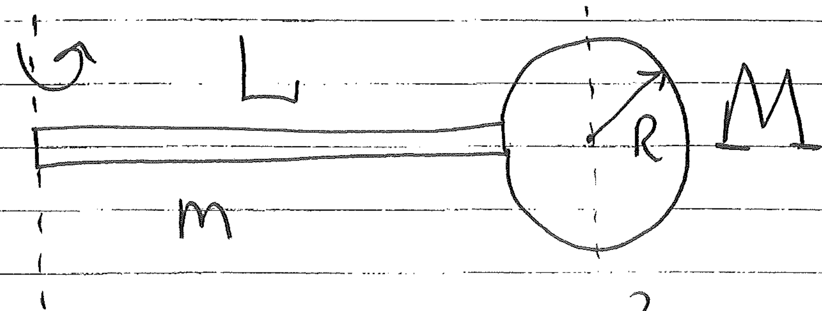
$$I_\parallel = \frac{ML^2}{12} + M\left(\frac{L}{2}\right)^2 = \frac{ML^2}{12} + \frac{ML^2}{4}$$

$$= \frac{4ML^2}{12} = \frac{ML^2}{3}$$

$\boxed{\checkmark}$

TABLE 9.2 along w/ ∥ axes thrm. and Superposition.

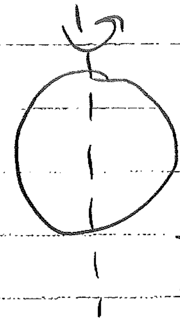
EX.] Find I for a mace (rod w/ a ball on the end) rotated as shown.




$$I = I_{rod} + I_{ball} = \frac{mL^2}{3} + I_{ball}$$

??

TABLE 9.2



sphere (solid)

$$I_{sphere} = \frac{2}{5} M R^2$$

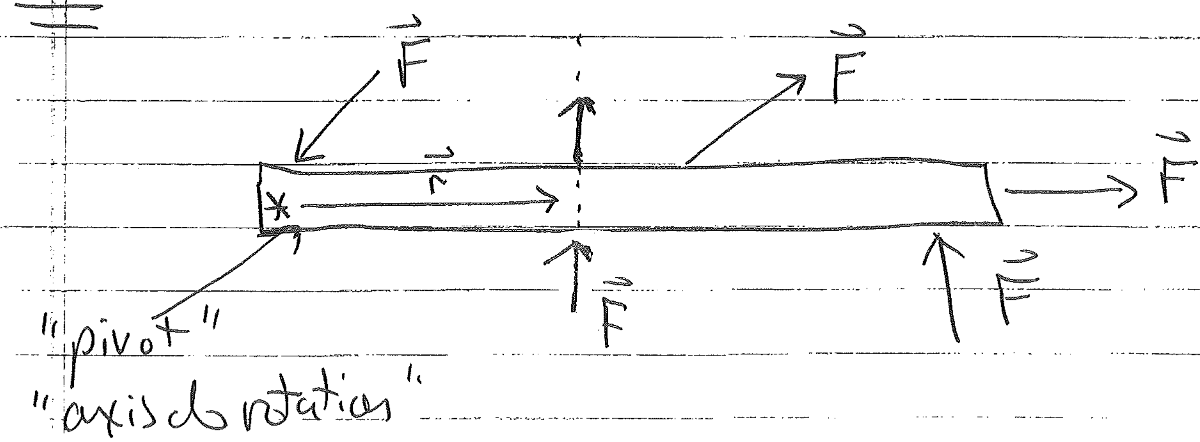
$$I_{ball} = \frac{2}{5} M R^2 + M D^2$$

$$= \frac{2}{5} M R^2 + M (L+R)^2$$

$$I = \frac{mL^2}{3} + \left( \frac{2}{5} M R^2 + M (L+R)^2 \right)$$

Procession: Section 10.7 pg 323

Torque is an indication of the effectiveness of a force @ producing rotation.




hinge of door, top view.

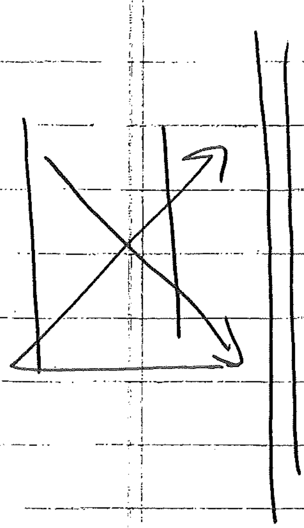
$$\vec{\tau}orque = \vec{r} \times \vec{F}$$

$\vec{F}$ ↑ applied force

$\vec{r}$ ↑ Vector from axis of rotation to the point where force is applied

"Vector Cross Product" (Chapter 1)

$$\vec{C} = \vec{A} \times \vec{B} = \begin{vmatrix} \hat{i}^{+} & \hat{j}^{-} & \hat{k}^{+} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$



$$= +\hat{i}\begin{vmatrix} A_y & A_z \\ B_y & B_z \end{vmatrix}$$

$$-\hat{j}\begin{vmatrix} A_x & A_z \\ A_x & B_z \end{vmatrix}$$

$$+\hat{k}\begin{vmatrix} A_x & A_y \\ B_x & B_y \end{vmatrix}$$

$$\vec{C} = +\hat{i}\,(A_y B_z - B_y A_z)$$

$$-\hat{j}\,(A_x B_z - B_x A_z)$$

$$+\hat{k}\,(A_x B_y - B_x A_y)$$

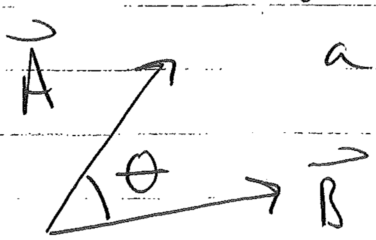
Answer.

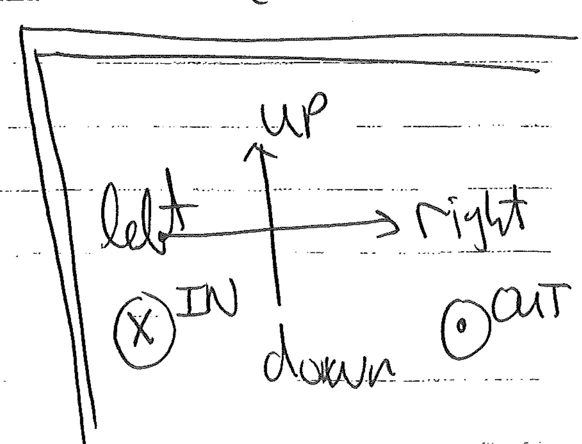
OR

$$|\vec{C}| = |\vec{A} \times \vec{B}| = |\vec{A}||\vec{B}|\sin(\theta)$$

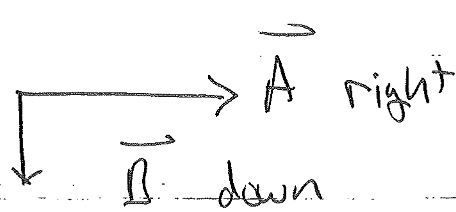
with direction determined by a "right hand rule"

$\vec{C}$ is $\boxed{\text{IN}}$




$\vec{C}$ is $\boxed{\text{IN}}$



OUT

$\vec{B} \odot \longrightarrow \vec{A}$ right

$\vec{B} \otimes \longrightarrow \vec{C}$ right

IN

$\vec{C}$ is <u>Down</u>

$\vec{A}$ is <u>Down</u>