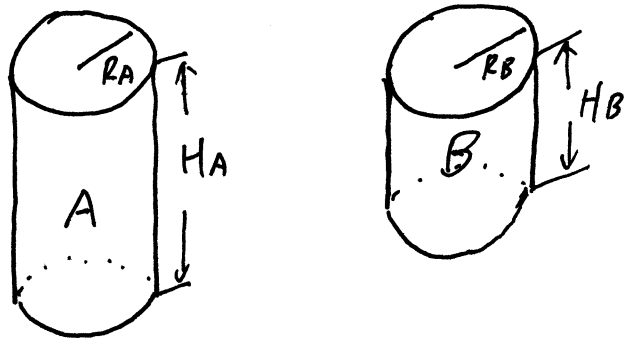
Phys 101.

Lecture 22.

e.g. Two solid cylinders, A and B, are made of the same material.

$R_A = R_B$.

$H_A = 2H_B$.



If the moment of inertia of A is $I_A = I$.

What's the moment of inertia of B. $I_B = ?$

Note: for a solid cylinder: $I = \frac{1}{2} m R^2$.

A). $I_B = I$

B) $I_B = 2I$

✓ C) $I_B = I/2$.

D) $I_B = 4I$

E) $I_B = I/4$.

$m = \rho \pi R^2 H$ (ρ – density).

[redacted].

$\therefore I \propto H$.

since $H_B = H_A/2$.

$I_B = I_A/2$.

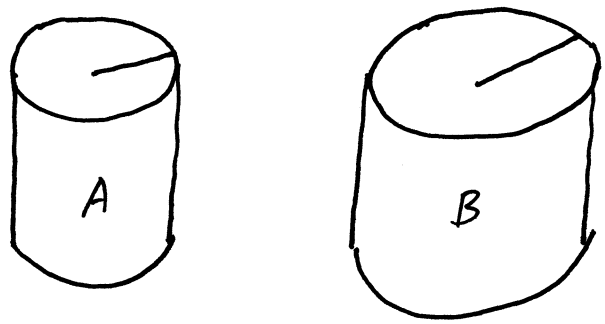
Now. $H_A = H_B$, $R_B = 2R_A$, $I_A = I$, $I_B = ?$

A). $I_B = I_A = I$

B). $I_B = 2I$.

C). $I_B = 4I$.

✓ D) $I_B = 16I$.



Why? $I = \frac{1}{2} m R^2$.

But I is NOT proportional to R^2.!

Because m depends on R too!

$m = \rho \pi R^2 H$ $\quad I \propto R^4$

$\therefore \quad I = \frac{1}{2} \rho \pi R^4 H$

e.g. 2. A solid sphere of mass M and Radius R rolls without slipping along a table at speed v. What is its kinetic energy ? $\left(\frac{7}{10} Mv^2\right)$

$$KE = \frac{1}{2} mv^2 + \frac{1}{2} I\omega^2 \qquad v = R\omega . \qquad I = \frac{2}{5} mR^2$$

$$= \frac{1}{2} mv^2 + \frac{1}{2}\left(\frac{2}{5} mR^2\right) \cdot \frac{v^2}{R^2}$$

$$= \frac{1}{2} mv^2 + \frac{1}{5} mv^2$$

$$= \frac{7}{10} mv^2 . \qquad \text{(independent of } R \text{)}$$

A) $\frac{1}{2} mv^2$

B) Mv^2

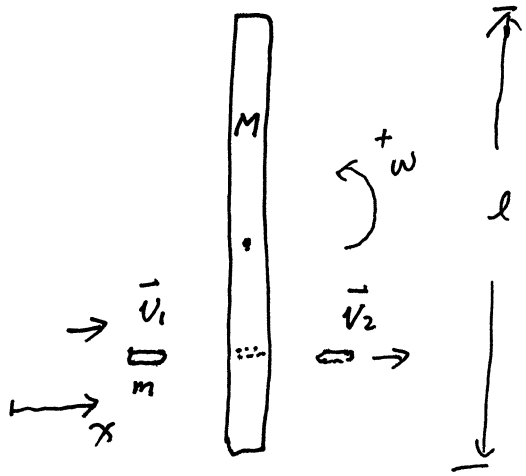
C) $\frac{2}{5} mv^2$

D) $\frac{5}{2} mv^2$

✓ E) $\frac{7}{10} mv^2$.

p.g. 3.

A uniform stick 2.0 m long with a mass of 1.8 kg is pivoted at its centre. A 15-g bullet is shot through the stick midway between the pivot and one end. The bullet approaches at 250 m/s and leaves at 140 m/s. With what angular speed is the stick spinning after the collision?



$I = \frac{1}{12} M\ell^2$

No external Torque → conservation of angular momentum.

$$mv_1 \frac{\ell}{4} = mv_2 \frac{\ell}{4} + I\omega \qquad (L_i = L_f)$$

$$mv_1 \frac{\ell}{4} = mv_2 \frac{\ell}{4} + \frac{1}{12} M\ell^2 \omega.$$

$$\omega = \frac{3m(v_1 - v_2)}{M\ell} = \frac{3 \times 0.015 (250 - 140)}{1.8 \times 2}$$

$$= 1.375 \text{ rad/s}$$

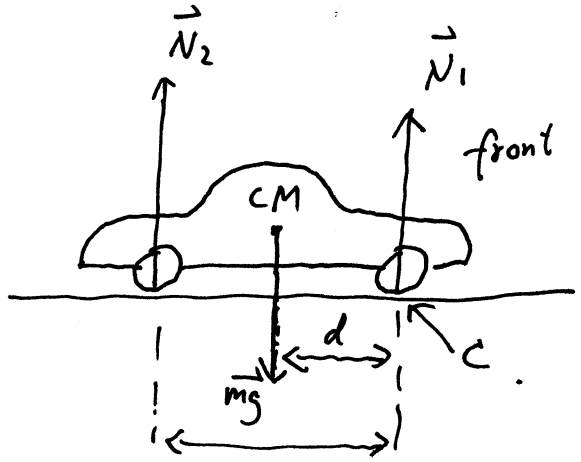
$$= 1.4 \text{ rad/s}$$

e.g. To determine the location of the centre of mass of a car, the car is driven over a scale.

$N_1 = 5800\ N$,

$N_2 = 6500\ N$

Find $d = ?$



$\Sigma \vec{F} = 0$: $N_1 + N_2 - Mg = 0$.

$\Sigma \tau = 0$ (about C): $Mgd - N_2\ell = 0$.

$$\therefore \quad d = \frac{N_2 \ell}{Mg}$$

$$= \frac{N_2 \ell}{N_1 + N_2}$$

$$= \frac{6500 \times 3.2}{5800 + 6500}$$

$$= 1.69\ m.$$