4-22-10

$$\vec{\tau} \equiv \frac{d\vec{L}}{dt}$$ Chico

analogy:

ch8: $\vec{F} = \frac{d\vec{p}}{dt} = \frac{d(m\vec{v})}{dt}$

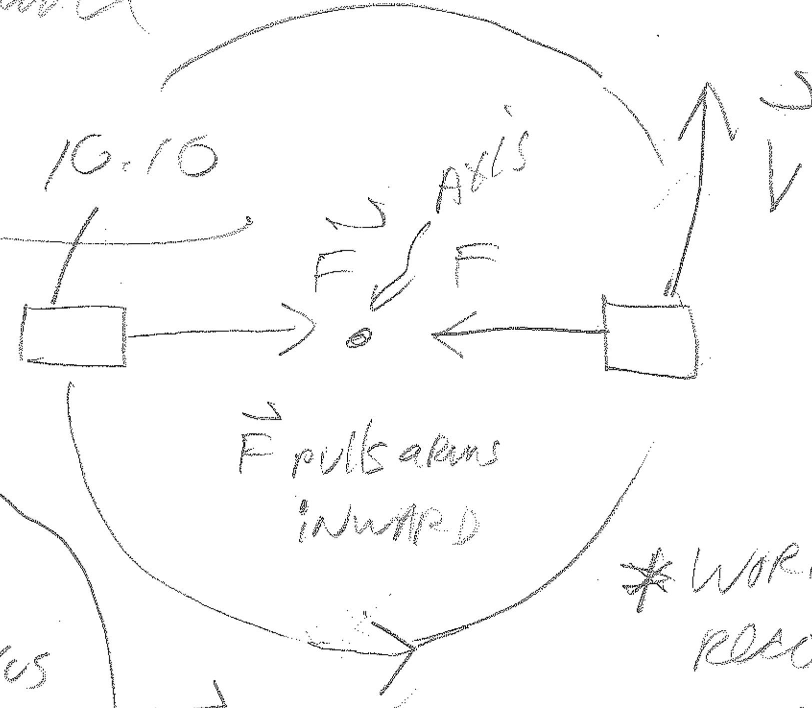
$= m\frac{d\vec{v}}{dt}$

$= m\vec{a}$

Lecture

EX 10.10

p329



$\vec{F}$ points to AXIS; thus TORQUE = 0.

$\vec{L}$ is conserved

$I_i \omega_i = I_f \omega_f$

$I_f < I_i$

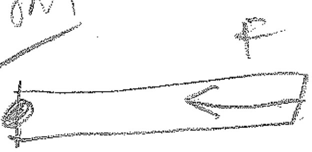
THUS

$\omega_f > \omega_i$ *

* WORLD RECORD: 304 $\frac{REV}{MIN}$

$\frac{1\ MIN}{60\ S} \cdot 304 \frac{REV}{MIN} \sim 5 \frac{REV}{S}$

won't rotate.



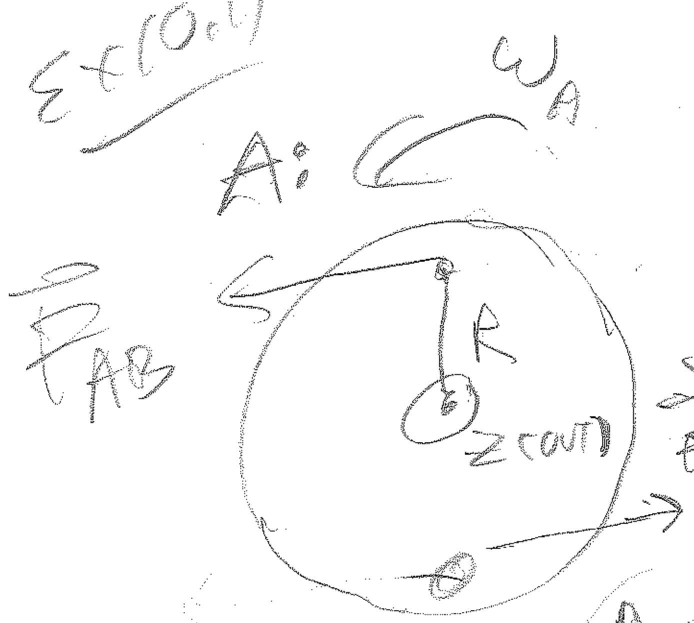
AXIS ROD

EX 10.11

Equal and opposite torques conserve the angular momentum.

Ex (cont)

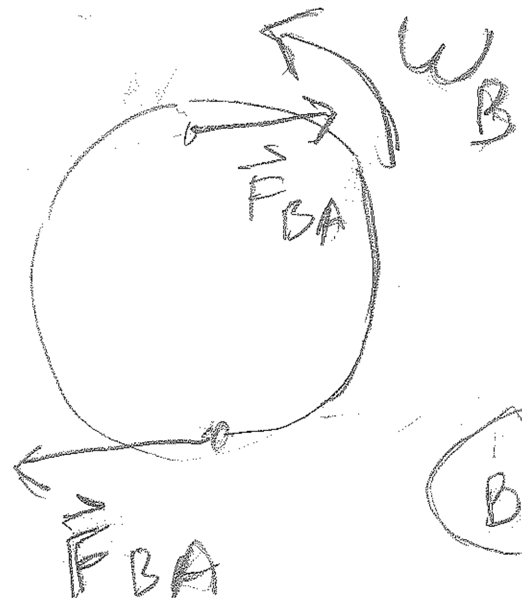
A:



$R \cdot F_{AB} = \text{Torque} = \tau_{AB_z} > 0$

A speeds up.

B:



$R \cdot F_{BA} = \tau_{BA_z} < 0$

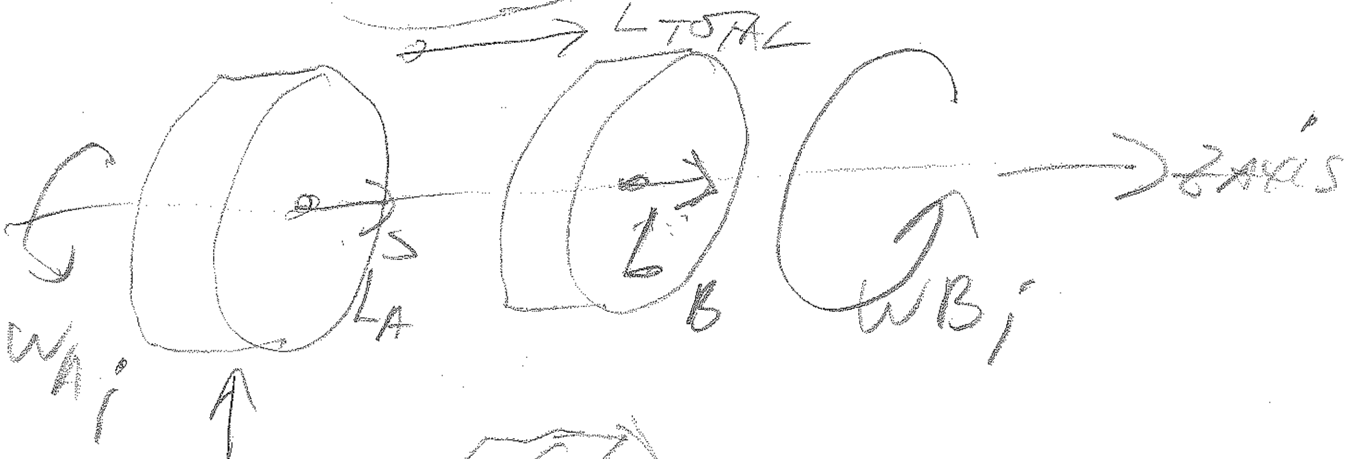
B slows down

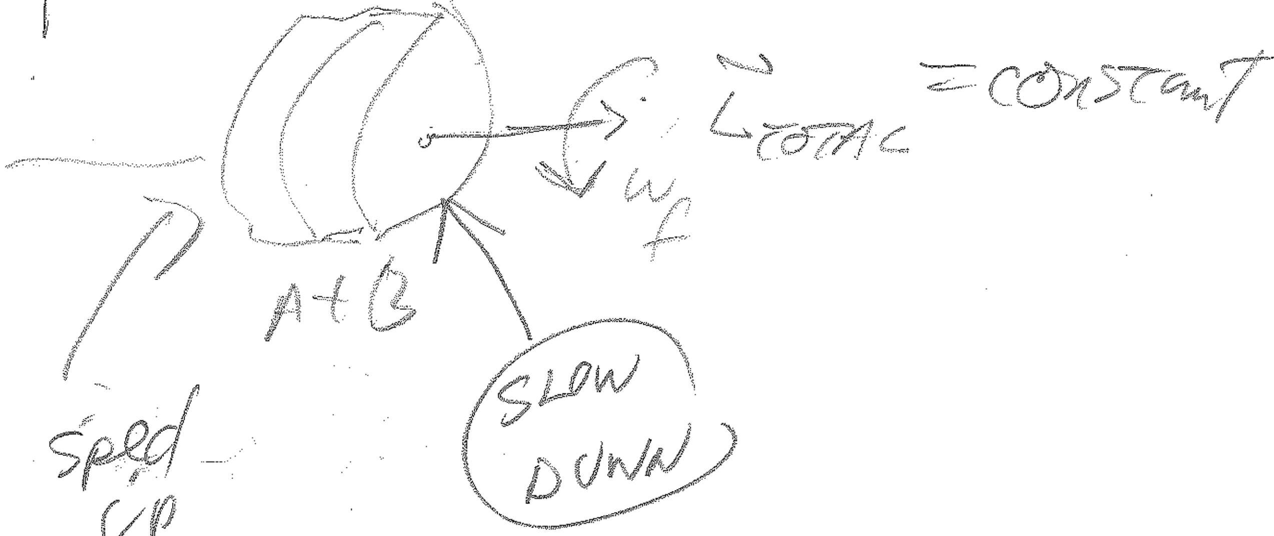
B

$\tau_{AB_z} + \tau_{BA_z} = 0$

Thus $\vec{L}$ is conserved!

$$I_A \omega_{A_i} + I_B \omega_{B_i} = (I_A + I_B)\,\omega_f$$





$$\omega_{A_i} < \omega_f < \omega_{B_i}$$

SHOW THIS: weighted AVERAGE

$$\omega_{A_i} < \omega_f = \frac{I_A \omega_{A_i} + I_B \omega_{B_i}}{(I_A + I_B)} < \omega_{B_i}$$

RULE: { FAST ONE always SLOWS DOWN
SLOW ONE " SPEEDS UP

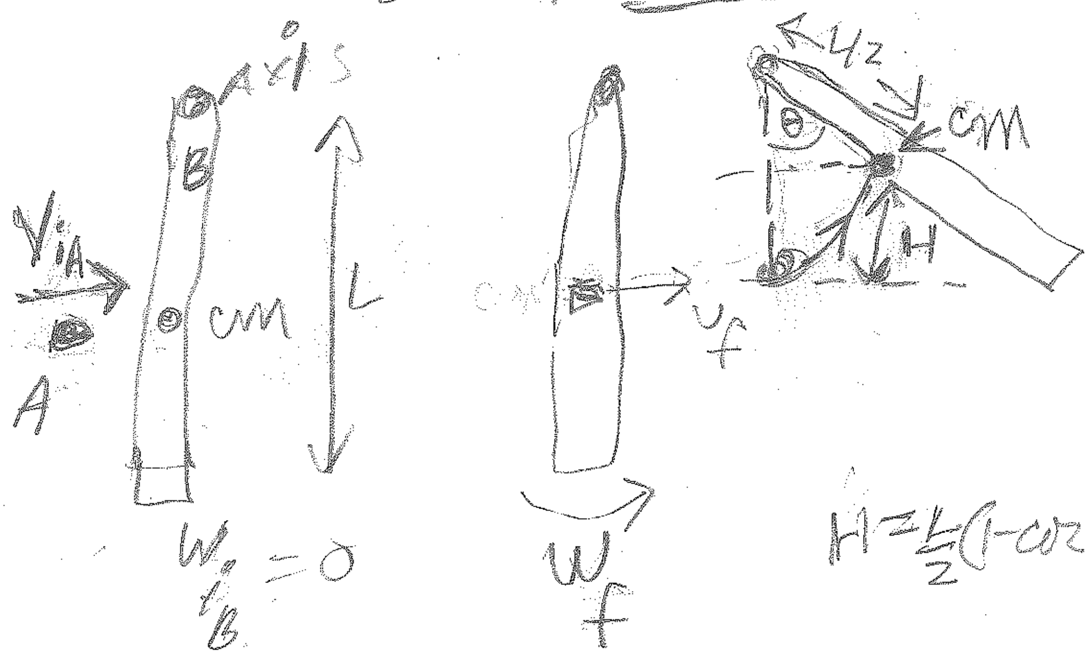
Ex 10.12 Important!

$\vec{l}$ conserved + Energy conserved:

L = DOOR width

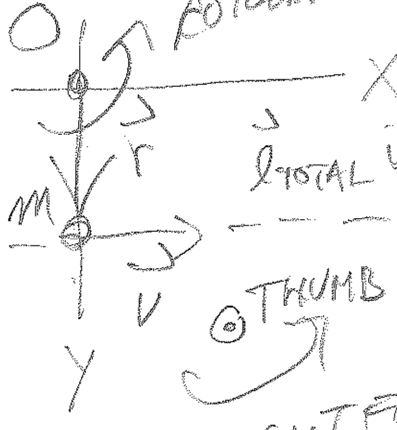
Question

what is direction of $\vec{l}_{TOTAL}$?



$H = \frac{L}{2}(1-\cos\theta)$

1. 2. 3.

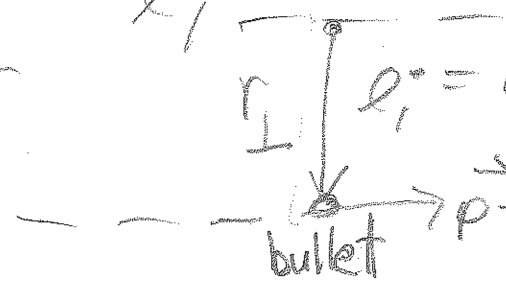


$\vec{l}_{TOTAL}$ is ⊙ OUT.

⊙ THUMB

RIGHT FINGERS

l_i



$l_i = r_\perp p = \frac{L}{2} m v$

$= (0.5)(0.01)(400)$ (m, kg, m/s)

$= 2.0 \frac{kg\, m^2}{s}$

Ex 10.12

$\ell_{1_z} = \ell_{2_z}$

$\downarrow \quad \nearrow 0$

$\ell_{A_i} + \ell_{B_i} = \ell_{A_f} + \ell_{B_f}$

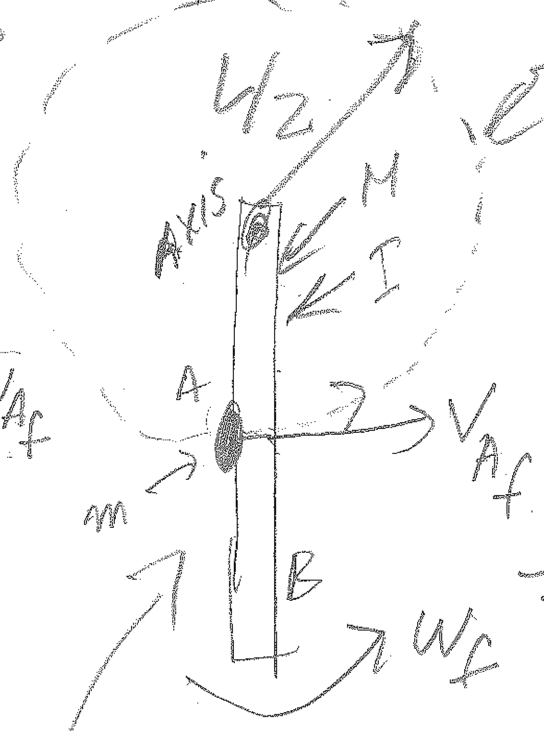
← bullet in DOOR

← DOOR

$2.0\,\frac{kg\,m^2}{s} = \boxed{\frac{L}{2} m v_{A_f}} + \boxed{I\,\omega_f}$

$\omega_f = ?$

circle



= common rotational velocity of bullet + door.

SvM stuck door

$2.0\,\frac{kg\,m^2}{s}$

$= (0.50)(0.01) \cdot V_{A_f} + \frac{ML^2}{3} \cdot \omega_{A_f}$

$V = I\omega$

$V \propto \omega$

$V_{A_f} = \frac{L}{2} \cdot \omega_f$

$2 = 0.005\,V_{A_f} + \frac{(15)(1)^2}{3} \frac{V_{A_f}}{(0.5)} \rightarrow V_{A_f} = \frac{2}{0.005 + 10}$

$$\frac{2}{0.005 + 10} = \frac{2}{10.005}$$

$$= 0.2 \ m/s$$

$$\omega_p = \frac{v_{A/P}}{L/2} = \frac{0.2 \ m/s}{0.5 m}$$

$$= 0.4 \ \frac{RAD}{S}$$

Ch 11

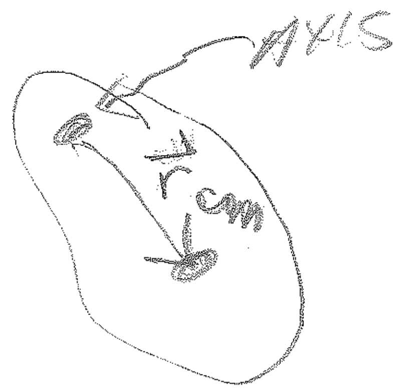
$$\sum \vec{F} = 0$$

$$\sum_{\text{axis}*} \vec{\tau} = 0$$

* any Axis

CM = CG = center of gravity

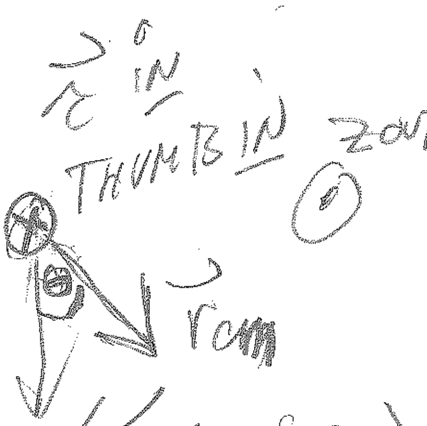
center of mass

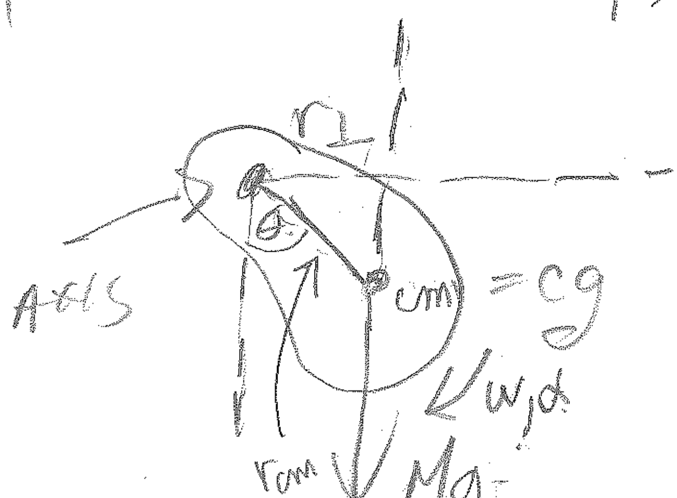


$$\vec{r}_{cm} = \frac{\sum m_i \vec{r}_i}{\sum m_i}$$ (Ch 8)

OLD definition

$$|\vec{\tau}| = |\vec{r}_{cm} \times M\vec{g}| \; ; \; M = \sum_i m_i$$





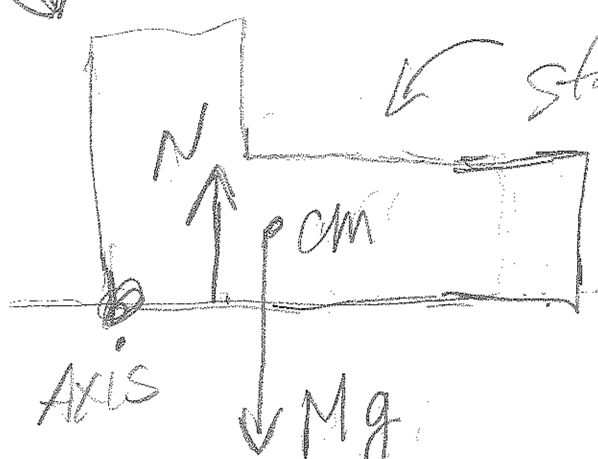
$$|\vec{\tau}| = r_\perp \cdot Mg = r_{cm} \cdot \sin\theta \, Mg = |\tau_z|$$

$$\tau_z < 0$$

center of gravity and stability (p347)

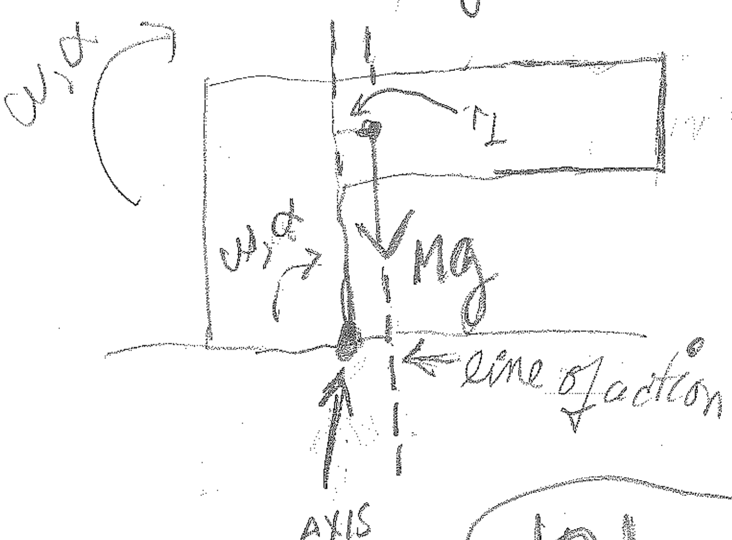
L-SHAPED BRICK

p347 mechanical engineering project (stability)



stable

$$\vec{\tau}_N + \vec{\tau}_g = 0$$

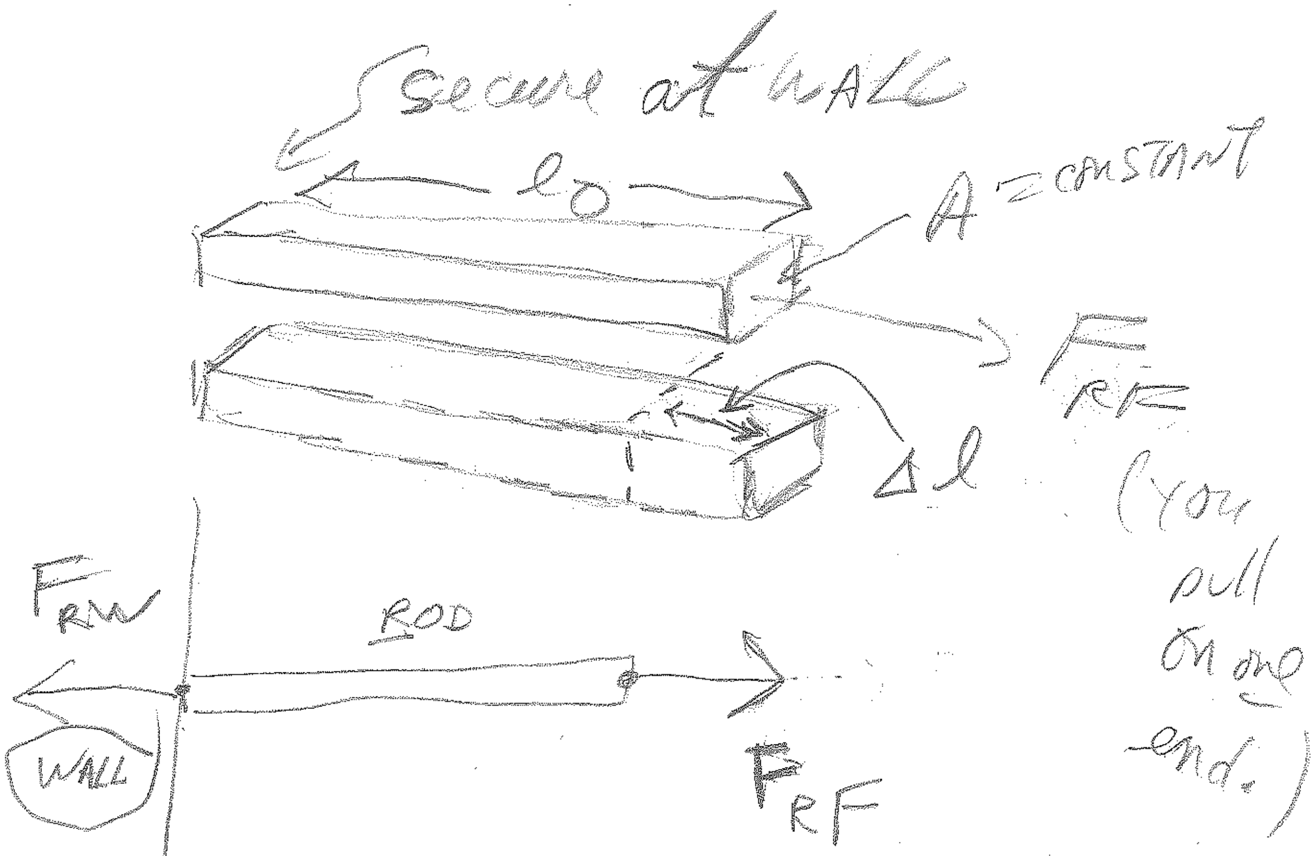


unstable: since line of action is to right of AXIS

$$|\vec{\tau}_z| = r_\perp \cdot Mg \text{ about AXIS.}$$

sec. 16.4

stress, strain:



$\vec{F}_{RW} = -\vec{F}_{RF}$

since $\vec{a} = 0$

Hooken

$k = \frac{F}{\Delta x} \iff Y = \frac{F_{RF}/A}{\Delta l / l_0} = \frac{F l_0}{A \Delta l}$

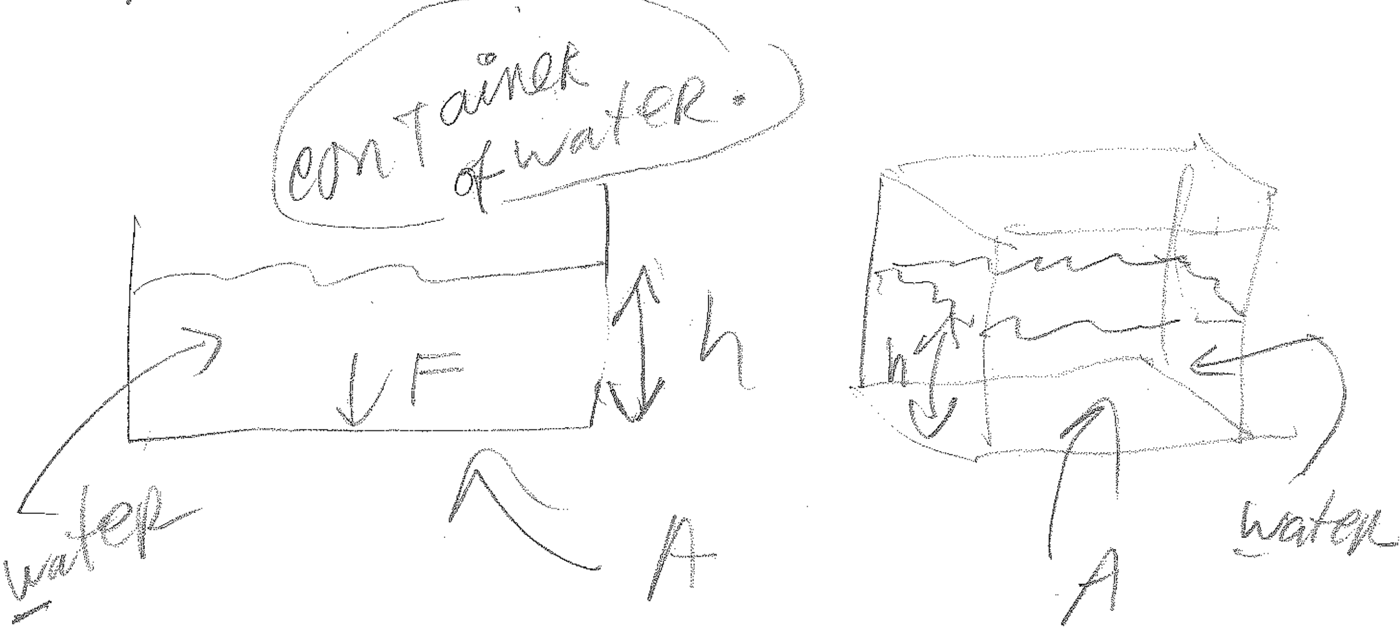
HOOKES LAW NOTE: $F_{RF} = \frac{Y \cdot A}{l_0} \Delta l = \boxed{k} \cdot l$

like a spring!

4-22-13

Bulk stress, STRAIN

Water pressure



$F = M_w g$ = Force on container bottom

$p = \frac{M_w g}{A}$ = Force/area

mass = volume × density $\longleftrightarrow$ note $M_w = A \cdot h \, \rho_w$

ρ_w = density $\left(\frac{kg}{m^3}\right)$

$M_w = A h \cdot \rho_w$

$$\boxed{p = \rho_w g h}$$

$= 1000 \frac{kg}{m^3}$.

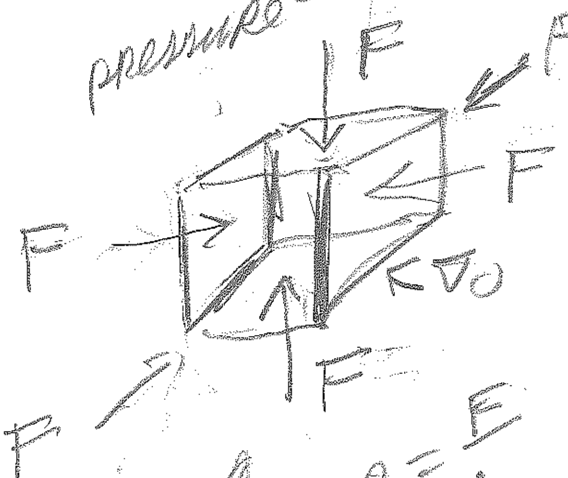
water pressure $\propto h$.

Bulk Modulus:

$$B = \frac{-\Delta P}{\Delta V / V_0}$$

Important for speed of sound in air $= \sqrt{\frac{B}{\rho_{AIR}}}$ (Ch. 16)

pressure $= P_0$

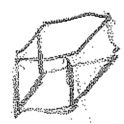


P = force/area

6 F's, 6 Faces

pressure $P = P_0 + \Delta P$

$\Delta V = V - V_0 < 0$



V

$P_0 = \frac{F}{A_0}$

$$B = \frac{-\Delta P}{\Delta V / V_0} > 0$$

like $k = \frac{F}{|\Delta x|}$

$A_0 = L_0^2$

volume of air.

$\Delta P > 0$

$\delta V < 0$

note: $\Delta P = -\frac{B}{V_0} \cdot \Delta V$

like spring (analogy $F = -kx$)

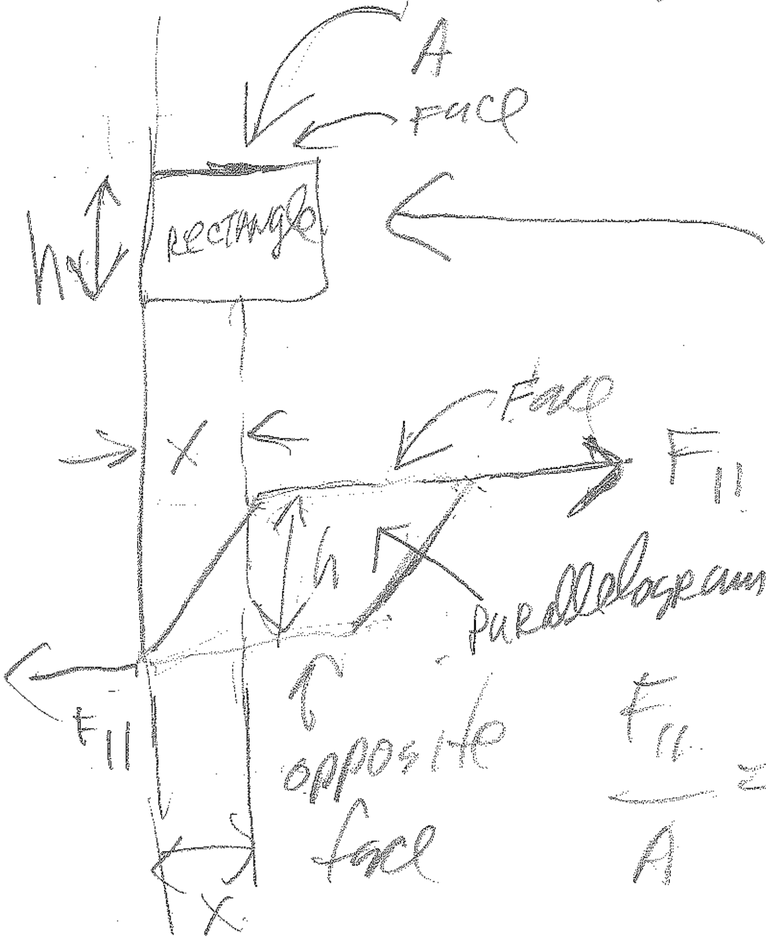
net pressure increase.

note:
F = force on a section of air of volume V_0. F comes from other parts of air.

Sheer stress, strain:

fig. 11.17

side view



Before $F_{\parallel}$ is applied

$\frac{F_{\parallel}}{A}$ = sheer stress

sheer strain $= \frac{x}{h}$

Hooke's Law $F_{\parallel} = \frac{S \cdot A}{h} \cdot x \longleftrightarrow |F_x| = |kx|$ (spring)

S = sheer modulus

STATICS: $\sum \vec{F} = 0$ and $\sum \vec{\tau} = 0$
NO MOTION *

Classical BIO-physics

Example: EX 11.4 pg 357

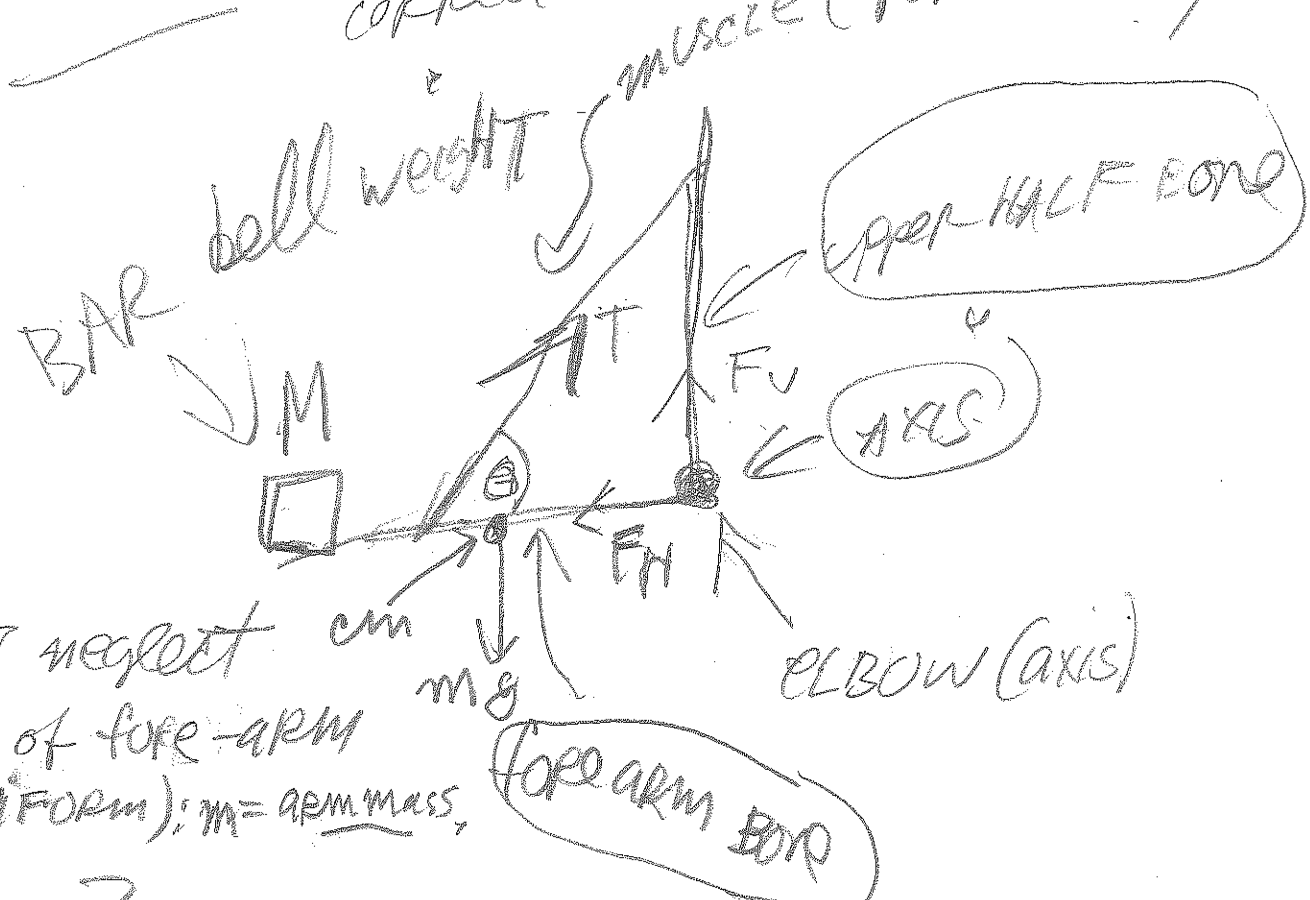
* comment

$\vec{v}$ = constant, ω = constant is $\sum \vec{F} = 0$, $\sum \vec{\tau} = 0$ and motion.

p 350 EX 11.3 classic ladder!

EX 11.4 pg 351

CORRECT DESIGN, WRONG scale



DO NOT neglect mass of fore-arm (UNIFORM); m = arm mass,

T = ?

F_V = force of elbow on forearm

F_H = " " " " "

$$\sum_{\text{AXIS}} \tau = 0 = \circlearrowleft - \circlearrowright = |\tau_{OUT}| - |\tau_{IN}|$$

Ex 11.4

$$\sum \tau = \circlearrowleft - \circlearrowright = 0$$

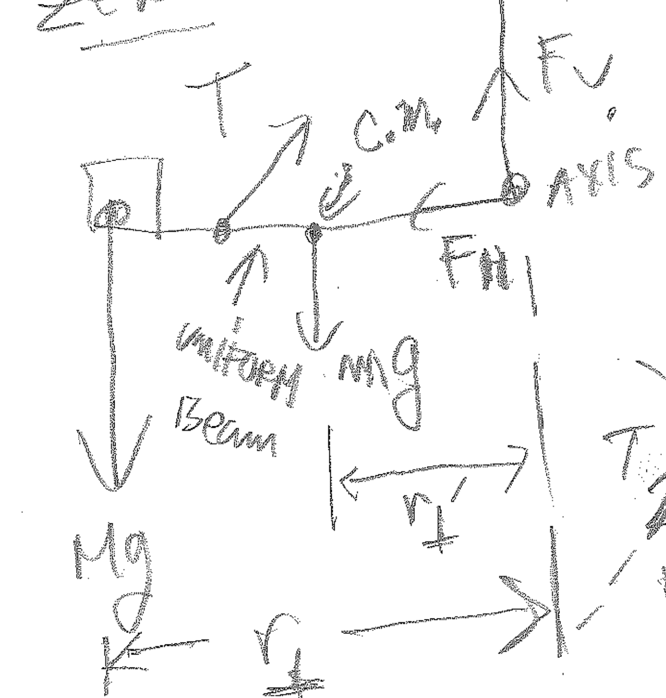
$$0 = \circlearrowleft - \circlearrowright$$

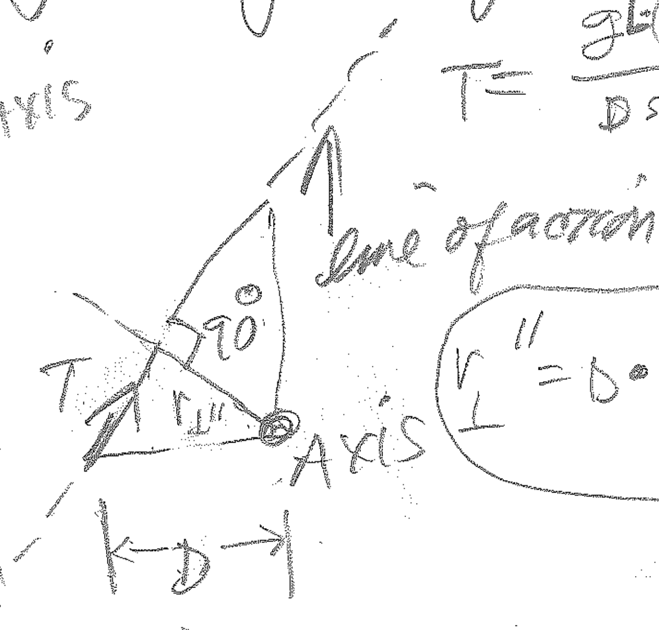
F_V, F_H exert zero torque.

$$r_\perp Mg + r_\perp' mg - r_\perp'' \cdot T = 0$$

$$L \cdot Mg + \frac{L}{2} mg - D\sin\theta \cdot T = 0$$

$$T = \frac{gL\left(M + \frac{m}{2}\right)}{D\sin\theta}$$

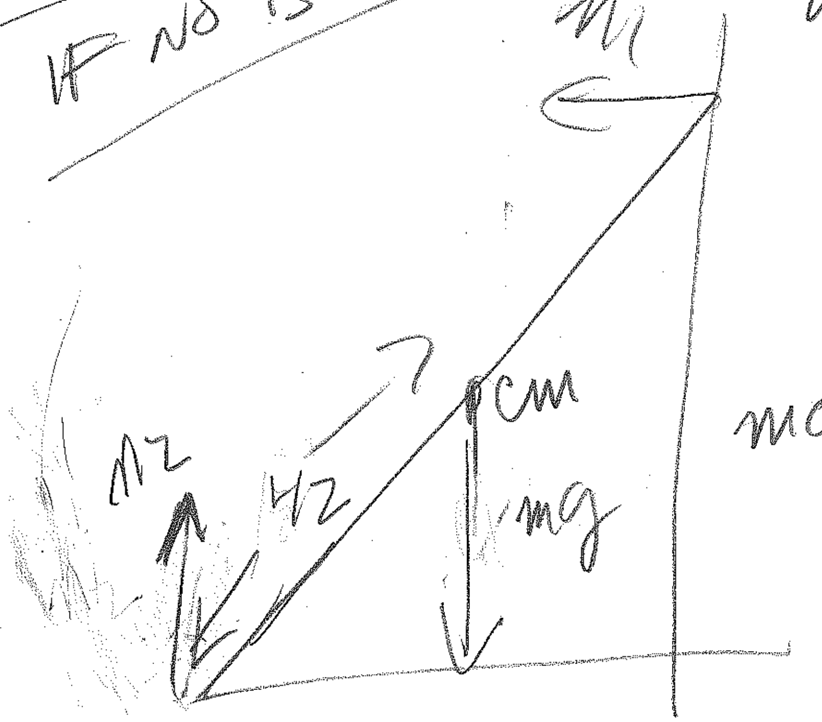




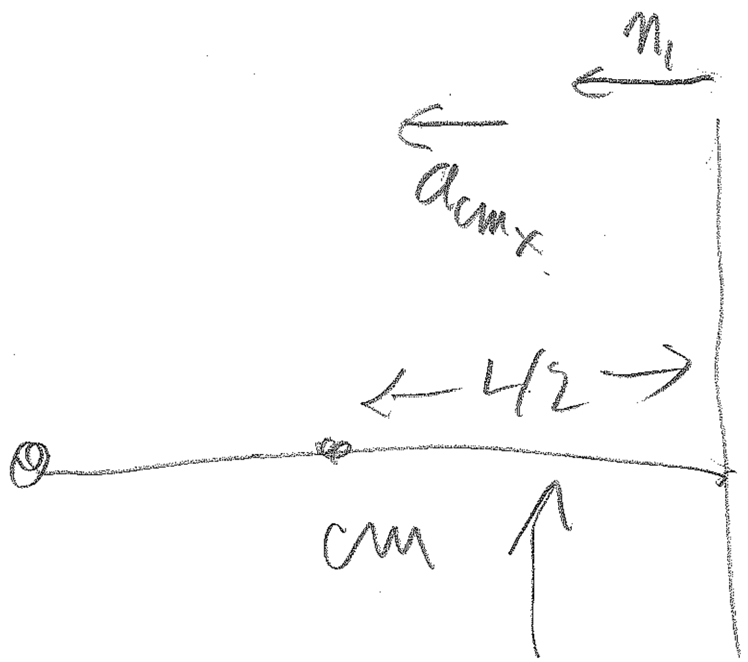
$$r_\perp'' = D \cdot \sin\theta$$

Ex 11.3

IF NO f_s at GROUND: ladder will accelerate



$$ma_{cm_y} = mg - n_2$$



$$n_1 = ma_{cm_x}$$

after ladders falls TO HORIZONTAL position.