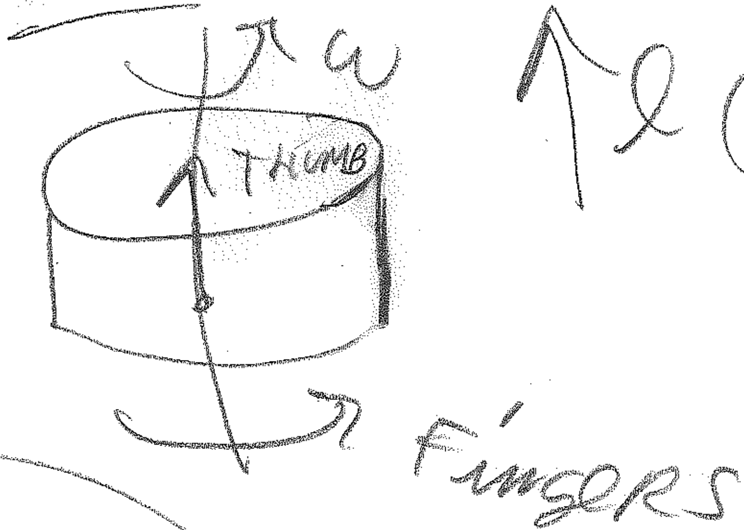
4-17-13 CH10 angular momentum

<u>In-class</u> <u>Demo</u>:



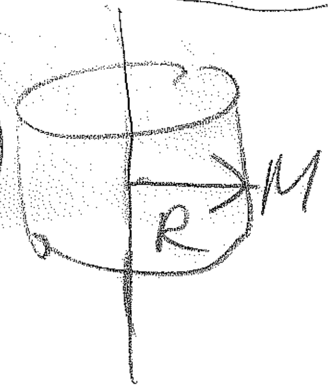
$\uparrow \vec{l}$ UP

$$|\vec{l}| = I\omega$$

Table 9.2

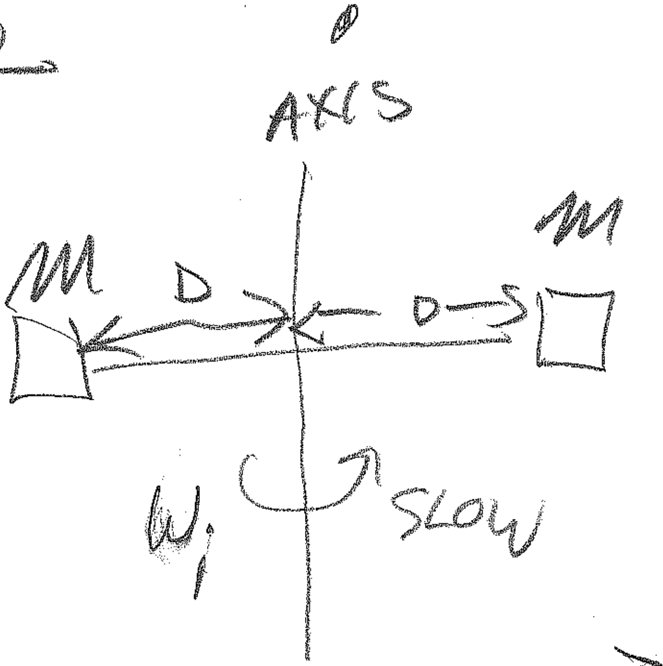
Disk

$I = \frac{1}{2}MR^2$



CH10 angular momentum

VIDEO DEMO

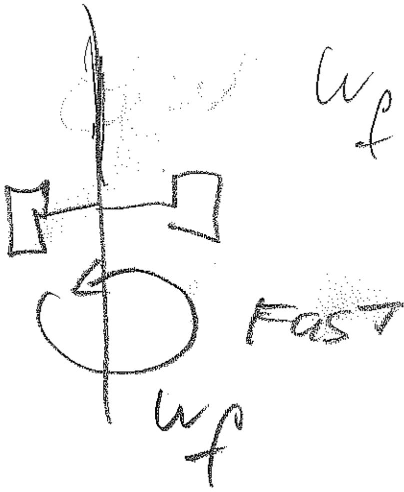


$I_i > I_f$

$\omega_i < \omega_f$

$\omega_f = \frac{I_i}{I_f} \omega_f$

$I_i \omega_i = I_f \omega_f$

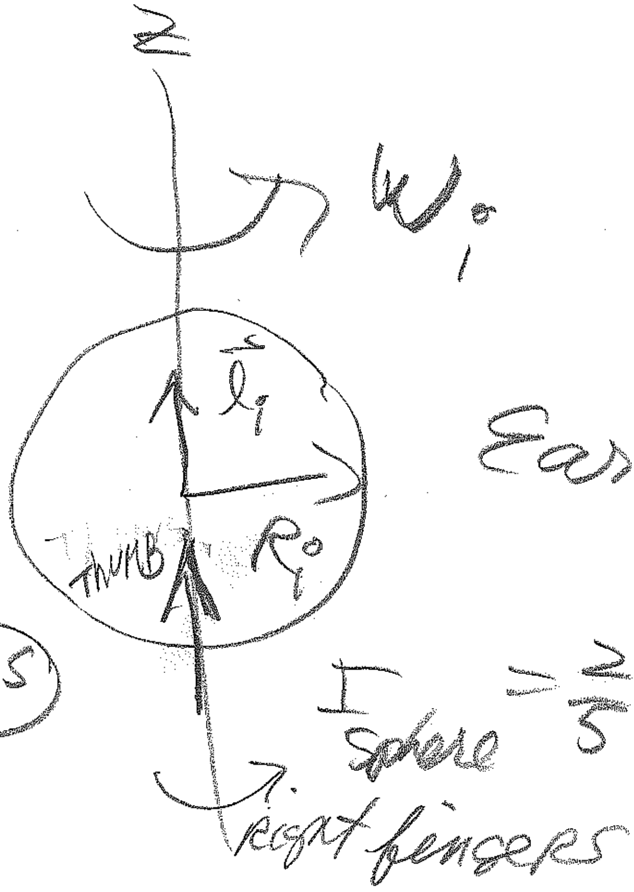


$$I = mD^2 + mD^2 = 2mD^2$$

(table 9.2

+ notes: $I = mr^2$

single particle

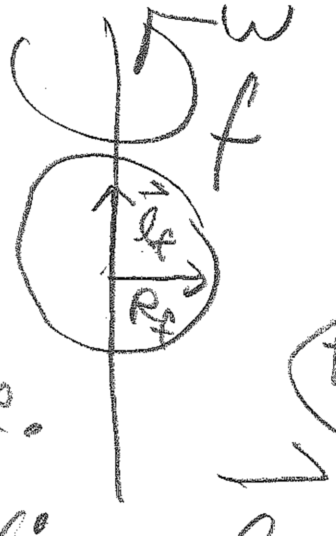


OLD
Earth
LARGE, MOLTEN
material + gas

Earth

$$I_{sphere} = \frac{2}{5}MR^2$$

$$\vec{l}_i = \vec{l}_f$$



new
Earth
smaller, colder.

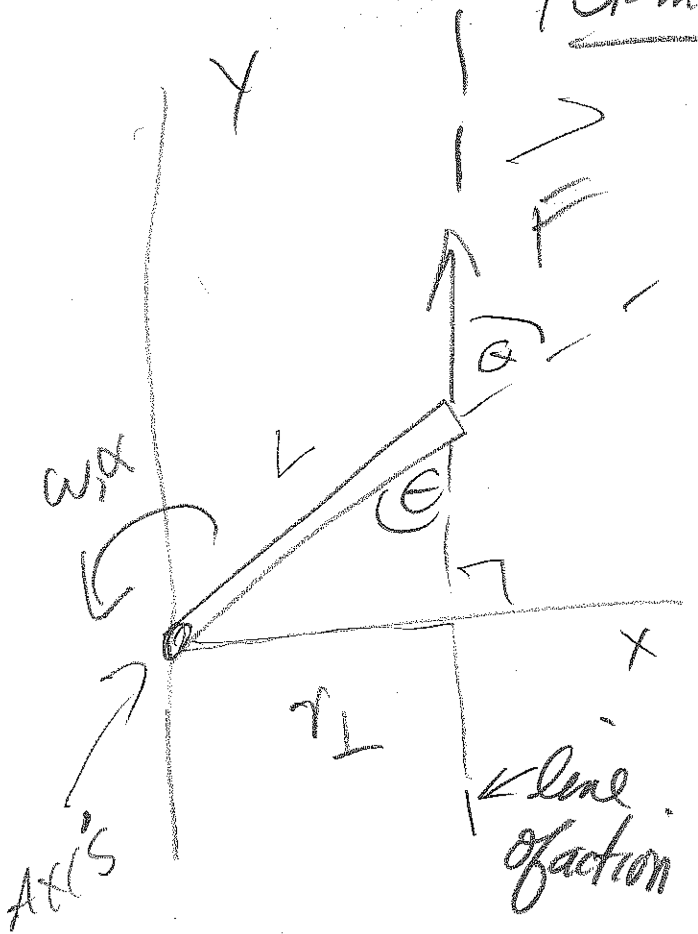
$$\omega_f > \omega_i$$

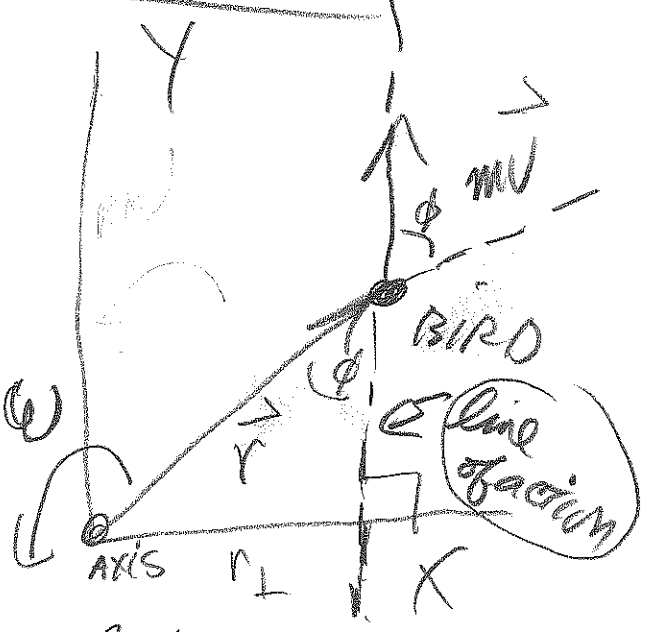
$$\boxed{R_f < R_i}$$

Conservation of l

$$\overset{l_{iz}}{\overbrace{\underset{\overset{\uparrow}{\text{LARGER}}}{I_i}\,\omega_i}} = \overset{l_{fz}}{\overbrace{\underset{\overset{\uparrow}{\text{smaller}}}{I_f}\,\omega_f}}$$

Formal notes





$|\tau_z| = r_\perp \cdot F$

$r_\perp = l \sin\theta$

Important

$|l_z| = r_\perp \cdot mv$

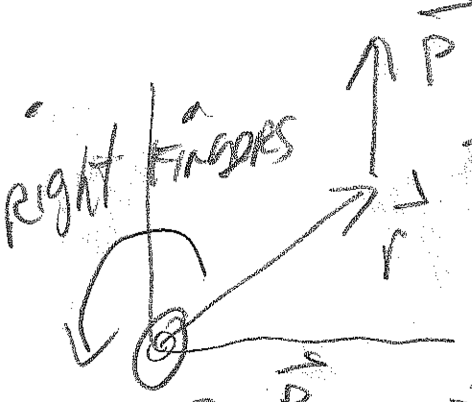
$(mv = |\vec{P}|$ CH8$)$

$|l_z| = r \sin\phi\, mv$

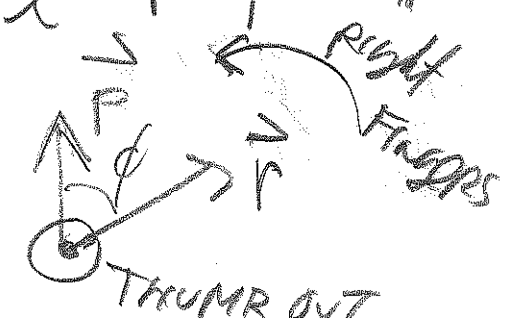
$= r\, mv \sin\phi$

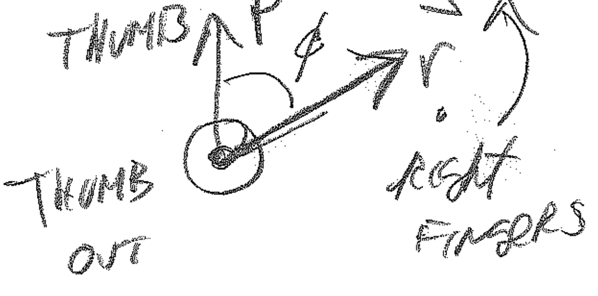
$= |\vec{r} \times \vec{p}| = rp\sin\phi$

more mathematical

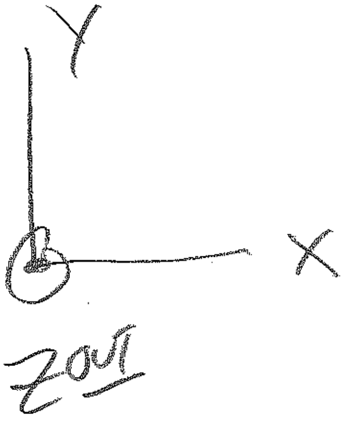


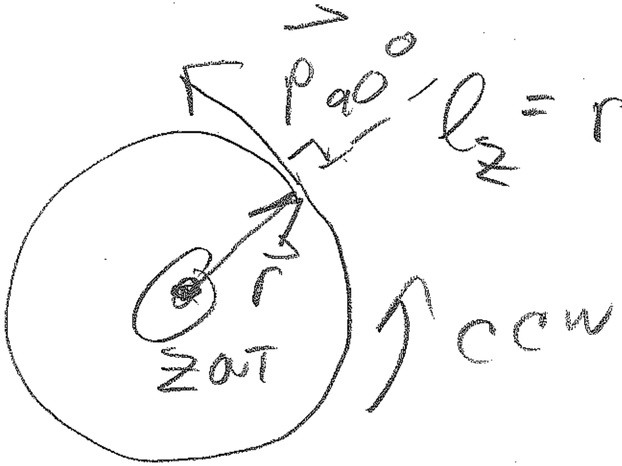
$\vec{l} = \vec{r} \times \vec{p}$





circular motion
single particle





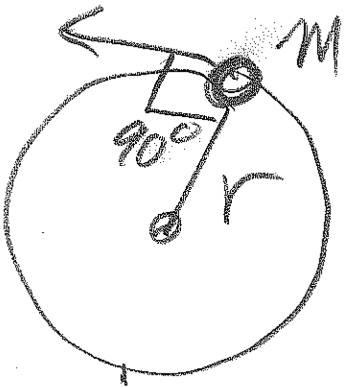
$l_z = rp\sin 90^\circ$

$l_z > 0$

$\vec{l}$ points out, along +z axis

$$l_z = rp$$
$$= rmv$$
$$= rmr\omega$$
$$= mr^2 \cdot \omega$$
$$= I\omega$$

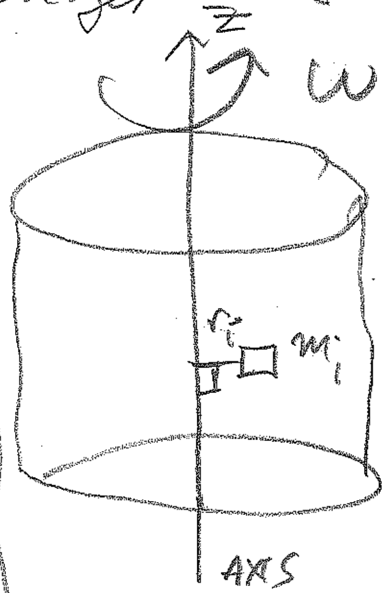
CN9
$v = r\omega$

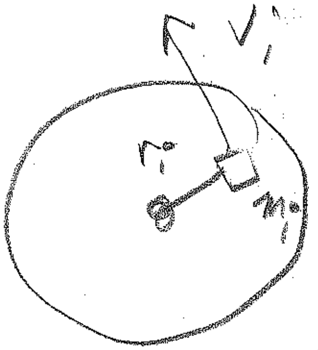


circular motion

4-19-13

In general: solid body





$l_{TOTAL_z} = \sum l_{i_z}$

$l_{i_z} = m_i r_i^2 \omega$

$l_{TOTAL_z} = \sum m_i r_i^2 \omega$

$= \omega \sum m_i r_i^2$

$l = \omega \cdot I$

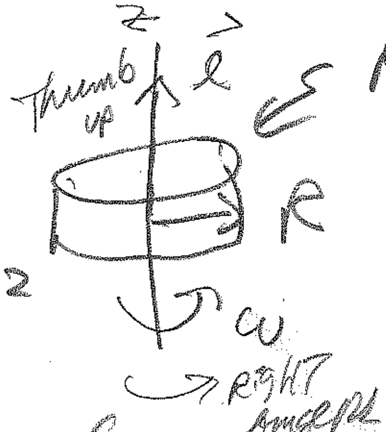
$l_{z_{TOT}} = I\omega$

$= \sum m_i r_i^2 = \frac{1}{2}MR^2$ (DISK)

calculus

DISK:

$I = \frac{1}{2}MR^2$



$\vec{l} = \frac{1}{2}MR^2 \cdot \omega$

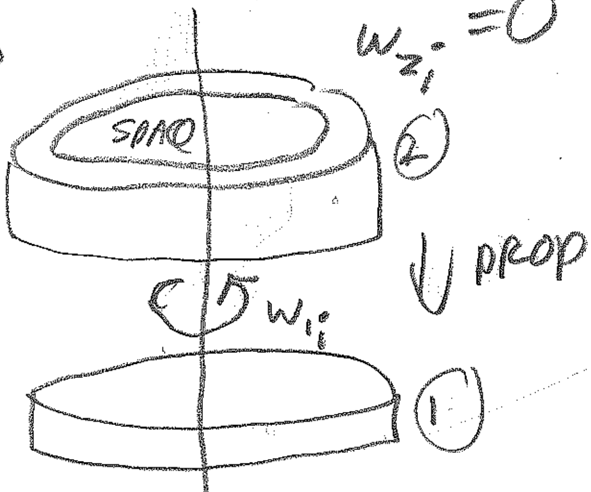
table 9.2

conservation of angular momentum: CLASSIC!

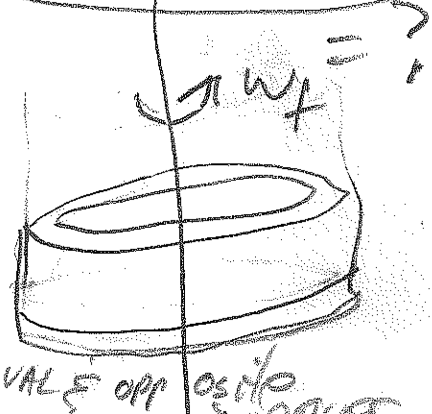
RING →

$I \approx MR^2$ →

$I = \frac{1}{2}MR^2$ →

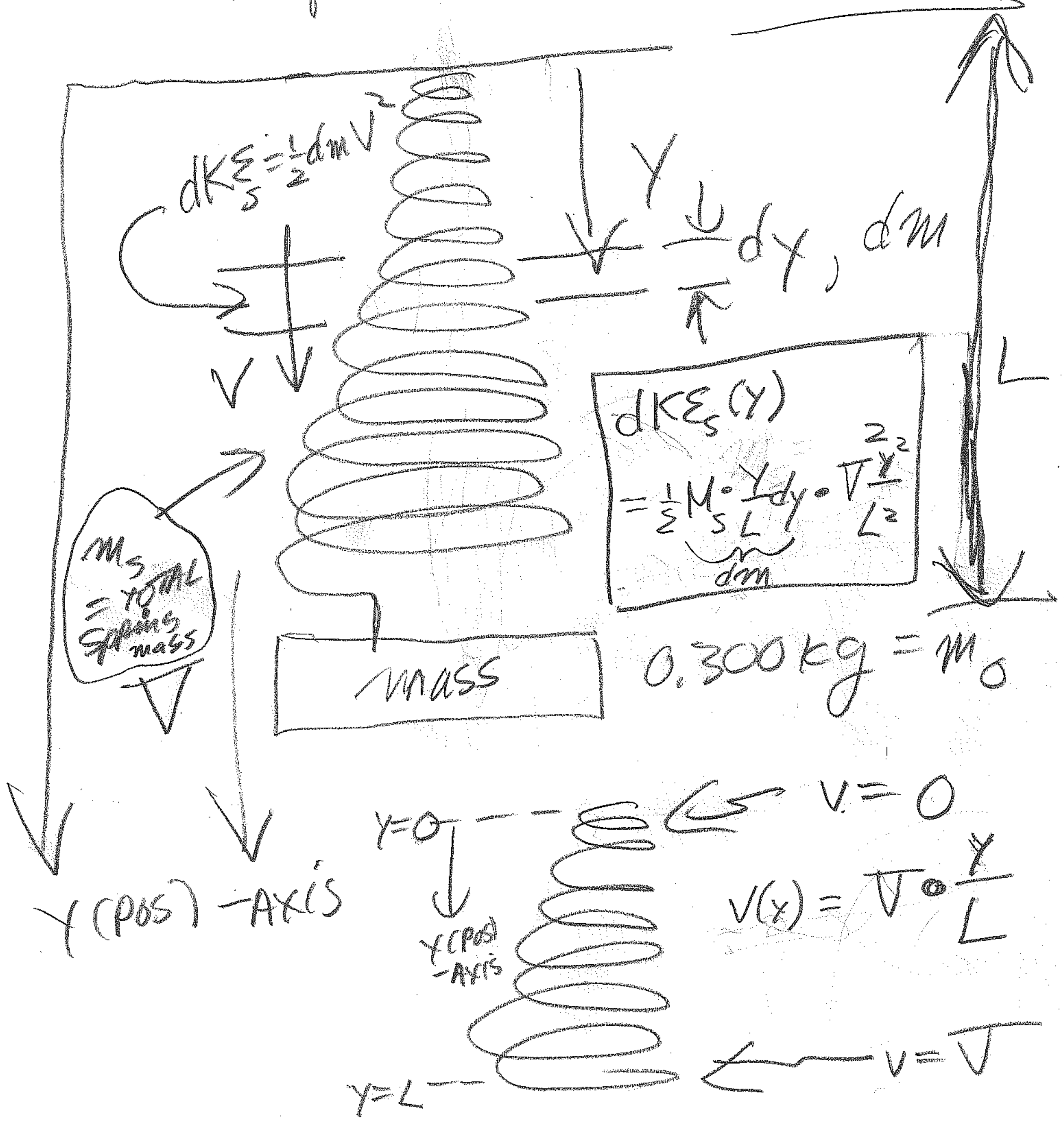


② speeds up
① slows down



Lab SHM

$m_{eff} = ?$


$dKE_s = \frac{1}{2} dm V^2$
Y
dy, dm
V
m_s = total spring mass
$dKE_s(Y) = \frac{1}{2} \underbrace{M_s \cdot \frac{Y}{L} dy}_{dm} \cdot \bar{V}^2 \frac{Y^2}{L^2}$
L
mass
$0.300\,kg = m_0$
Y (pos) - Axis
$Y=0$
$V=0$
Y (pos) - Axis
$V(Y) = \bar{V} \cdot \frac{Y}{L}$
$Y=L$
$V=\bar{V}$

Q-1

$$dKE_s = \boxed{\frac{1}{2} M_s \cdot \frac{V^2}{L^3} \cdot y^2 dy}$$

$$KE_s = \int_0^L dKE_s = \frac{1}{2} \cdot m_{eff} \cdot V^2$$

Math!

m_{eff} = ? in terms of M_s.

SHOW $m_{eff} = \frac{M_s}{3}$

GRADE computation

3 TERMS

$$\left(\frac{\text{SUM of SCORES}}{150}\right)(15) + \left(\frac{\text{QUIZSUM}}{\text{QUIZTOTAL}}\right)(15) + \left(\frac{\text{Testsum}}{388}\right)(33) = X$$

Lab

$\frac{X}{85} \times 100\%$ = YOUR GRADE

percentage read on GRADEBOOK ⇒

(decimal form)

⇒ 92% = 0.92

SHM lab

Name	Partner	Sect 00	Clean Start?	Early Bird?	Weights in order?	Instructor Initial
Date experiment performed	Partner	Station				

Mass on a spring

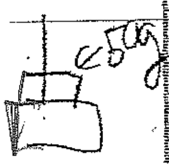
*(Q-1) Finish the derivation for $m_{S\,Eff}$:

100g = 50g + 50g
← hanger

$m_{S\,Eff}$ = ____________

(Q-3)

M (kg)	F_S (N)	x' (m)
0.1		
0.2	1.96	
0.3	2.94	
0.4	3.92	
0.5	4.90	



→ 50g HANGER

(Q-4) Computing m: m_s = ~161 g

$m_{S\,Eff}$ = 161/3 g

m_a = 300 g

m = ____________ g

300g + 161g/3g

convert to kg

For the hand-timer, $\delta_{Inst}T = (\delta_{Inst}t)/n = 0.003$ s/n.

(Q-5) n	Time t for n cycles (s)	$T_{Ex} = \frac{t}{n}$ (s)
10	13.0651	1.30651
10		1.31292
10		1.28101
10		1.33111
10		1.30121
$T_{Ex\,Best}$		AVERAGE
= R/N		Ⓐ
$\delta_{Inst}T_{Ex}$		0.00001 Ⓑ
δT_{Ex}		BIGGER of Ⓐ or B

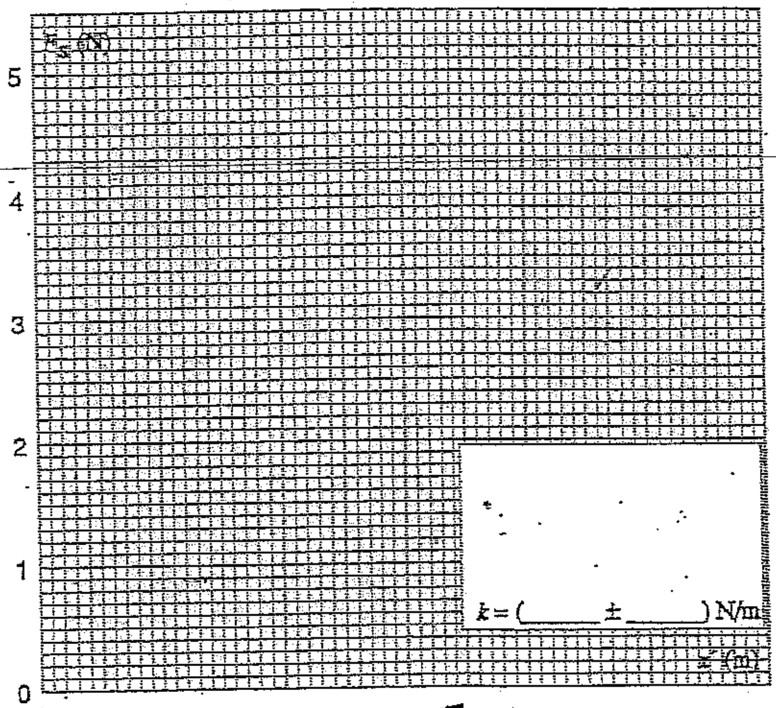
MAX − MIN / 5

← 0.0001 / 10

*(Q-2) Derive an expression for δT_{Th}:

use partial derivatives
math 3 — optional

δT_{Th} = ____________



k = (______ ± ______) N/m

Compute T_{Th}: $2\pi\sqrt{\frac{m}{K}}$

T_{Th} = (______ ± ______) s

(Q-6) Discrepancy: $|T_{Th\,Best} - T_{Ex\,Best}|$ = ____________ s

$2(\delta T_{Th} + \delta T_{Ex})$ = ____________ s

Does experiment support theory at the five percent level? Yes ☐ No ☐

$\frac{1.33111 - 1.28101}{5}$

Does the experiment support the theory at the five percent level? Yes ☐ No ☐

Does the experiment support the theory at the five percent level? Yes ☐ No ☐

SWM - Lab

Name ______	Partner ______	Sect 00 ___	Clean Stat?	Early Bird?	Weights in order?	Instructor Initial
Date experiment performed ______	Partner ______	Station ___				

Mass on a spring

*(Q-1) Finish the derivation for $m_{s\,\text{Eff}}$:

100g = 50g + 50g
← HANGER

$m_{s\,\text{Eff}}$ = ______

(Q-3)

M (kg)	F_s (N)	x' (m)
0.1		
0.2	1.96	
0.3	2.94	
0.4	3.92	
0.5	4.90	

← 50g

→ 50g
HANGER

(Q-4) Computing m: m_s = ~161 g

$m_{s\,\text{Eff}}$ = 161/3 g

m_a = 300 g

m = ______ g

300g + $\frac{161g}{3}$

CONVERT TO kg

For the hand-timer, $\delta_{\text{Inst}}T = (\delta_{\text{Inst}}t)/n = 0.003$ s/n.

(Q-5) n	Time t for n cycles (s)	$T_{\text{Ex}} = \frac{t}{n}$ (s)
10	13.0651	1.30651
10		1.31292
10		1.28101
10		1.33111
10		1.30124

$T_{\text{Ex Best}}$ AVERAGE

$\pm$ RN (A)

$\delta_{\text{Inst}}T_{\text{Ex}}$ 0.00001 (B)

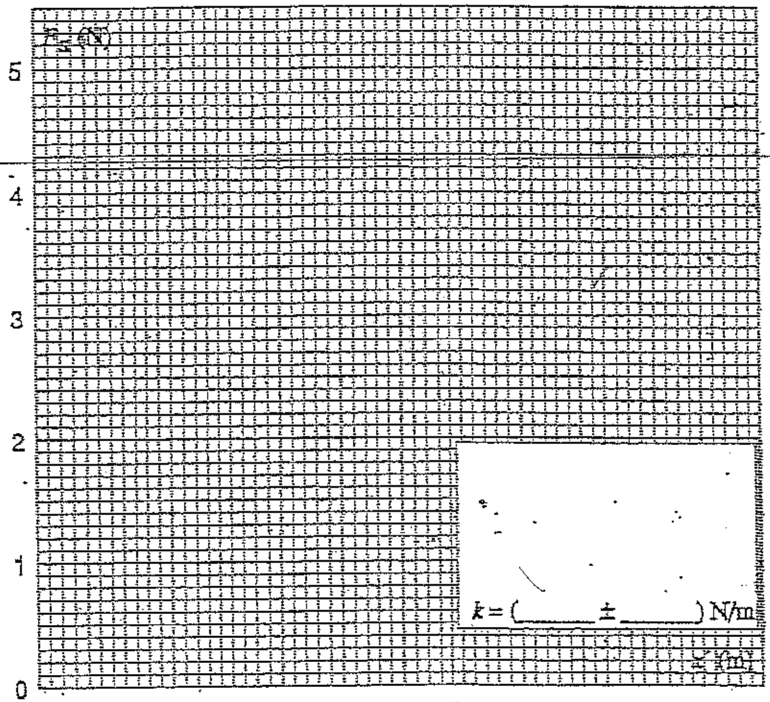
δT_{Ex} BIGGER OF (A) OR B

$\frac{\text{MAX} - \text{MIN}}{5}$

$\frac{1.33111 - 1.28101}{5}$

*(Q-2) Derive an expression for δT_{Th}:

δT_{Th} = ______



k = (______ ± ______) N/m

Compute T_{Th}: $2\pi\sqrt{\frac{m}{K}} = T_{\text{Th BEST}}$

T_{Th} = (______ ± ______) s

(Q-6) Discrepancy: $|T_{\text{Th Best}} - T_{\text{Ex Best}}|$ = ______ s

$2(\delta T_{\text{Th}} + \delta T_{\text{Ex}})$ = ______ s

Does experiment support theory at the five percent level? Yes ☐ No ☐

Does the experiment support the theory at the five percent level? Yes ☐ No ☐

Does the experiment support the theory at the five percent level? Yes ☐ No ☐

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4-19-13

Objective---in this experiment, you will analyze elastic collisions in one dimension, then confirm the principle of conservation of linear momentum.

Procedure:

You will use a track, two gliders of (un) equal mass and two Photogate timers.

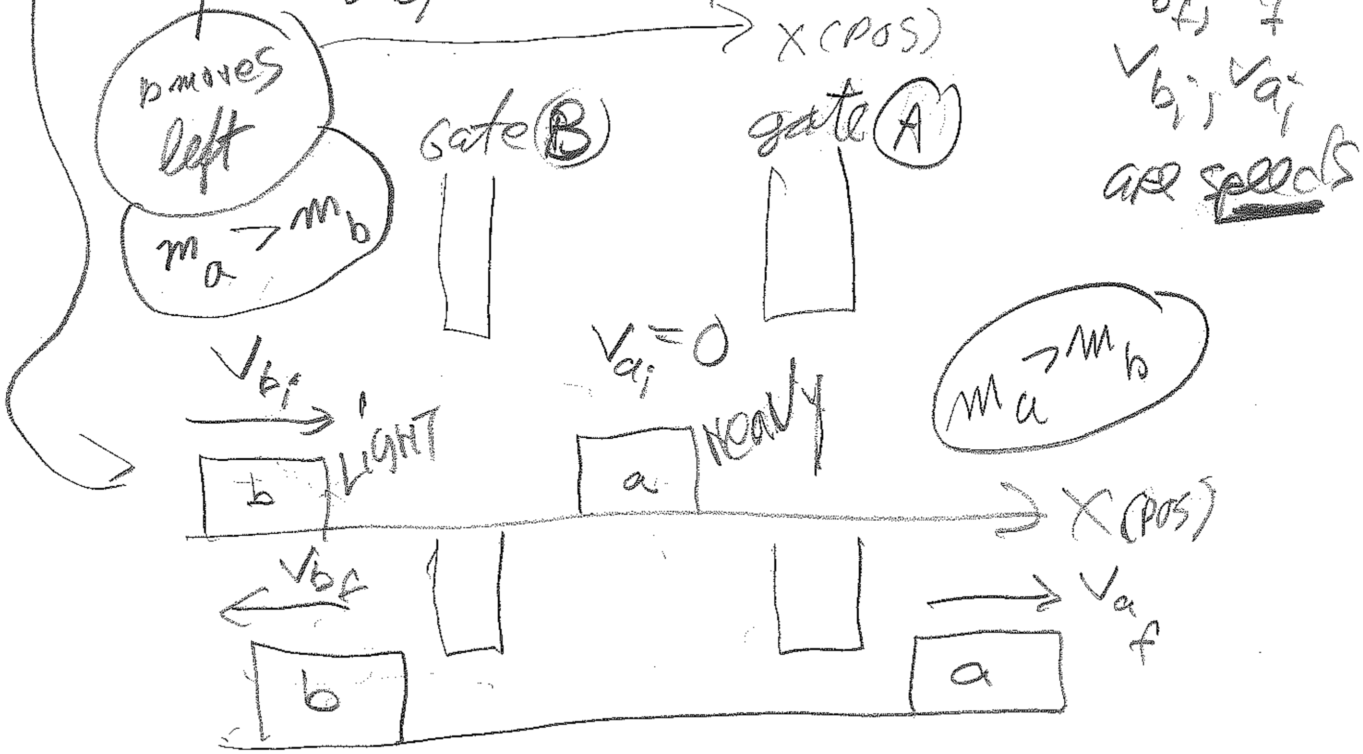
1. Level the air track. Weigh two gliders of the ~~same~~ different mass. (m_a *not* = m_b.)
2. Place two Photogate timers, separated by a certain distance from each other.
3. Set both timers to GATE mode and push reset. Turn on the air supply (IF SUPPLIED, NORMALLY WE USE WHEELED CARTS ON TRACK) to the track. Place both gliders, m_a and m_b, on track-one inside, the other outside, the timers.
4. Give ONE glider (OUTIDE TIMER) a push so IT HITS THE OTHER GLIDER (INSIDE TIMER) WHICH IS AT *REST.*
5. As soon as glider has passed through its Photogate, quickly record the time. After the gliders have collided they will again pass through the gates. Record this second set of data (the total times FROM before TO after the collisions!). **Remember to subtract the first time from the total to obtain the second time *as needed.***
6. Repeat as indicated by the data sheets. For each of the 5 trials you are to find the percent difference between the initial and the final momentum to test whether momentum is indeed conserved. The following notation will help you through the data sheet:

$p_i = m_b v_{bi} - \cancel{m_a v_{ai}}^{\,0}$ = *initial momentum* $= m_b v_{bi}$

$p_f = -m_b v_{bf} + m_a v_{af}$ = *final momentum*

$m_b v_{bi} = -m_b v_{bf} + m_a v_{af}$)

note: V_{bf}, V_{af}
V_{bi}, V_{ai}
are speeds



Chabot College

Data Sheet---Elastic Collisions

m_a = ____________ pole diameter (vernier) = ______________

m_b = ____________

Trial 1

Δt_{ai} = NA

v_{ai} = 0
Show calculation.

Δt_{bi} = number i

v_{bi} =
Show calculation.

$$\frac{\text{diameter (pole)}}{\Delta t_{bi}}$$

Δt_{af} =
Show calculation.

v_{af} =
Show calculation.

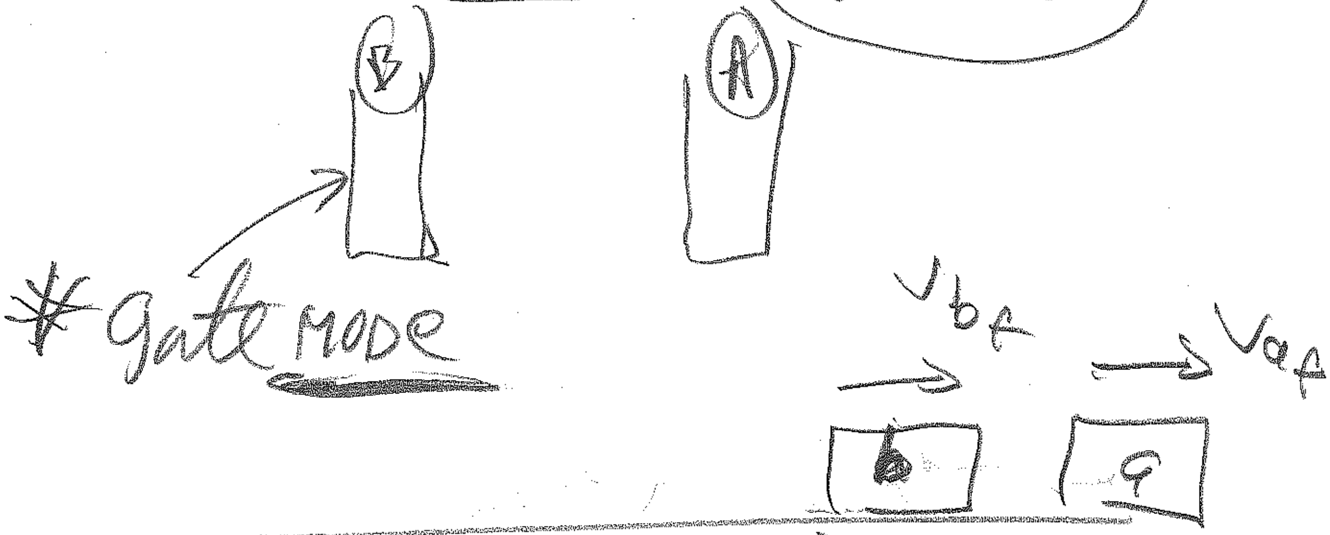
Δt_{bf} = $t_f - \Delta t_{bi}$
Show calculation.

v_{bf} =
Show calculation.

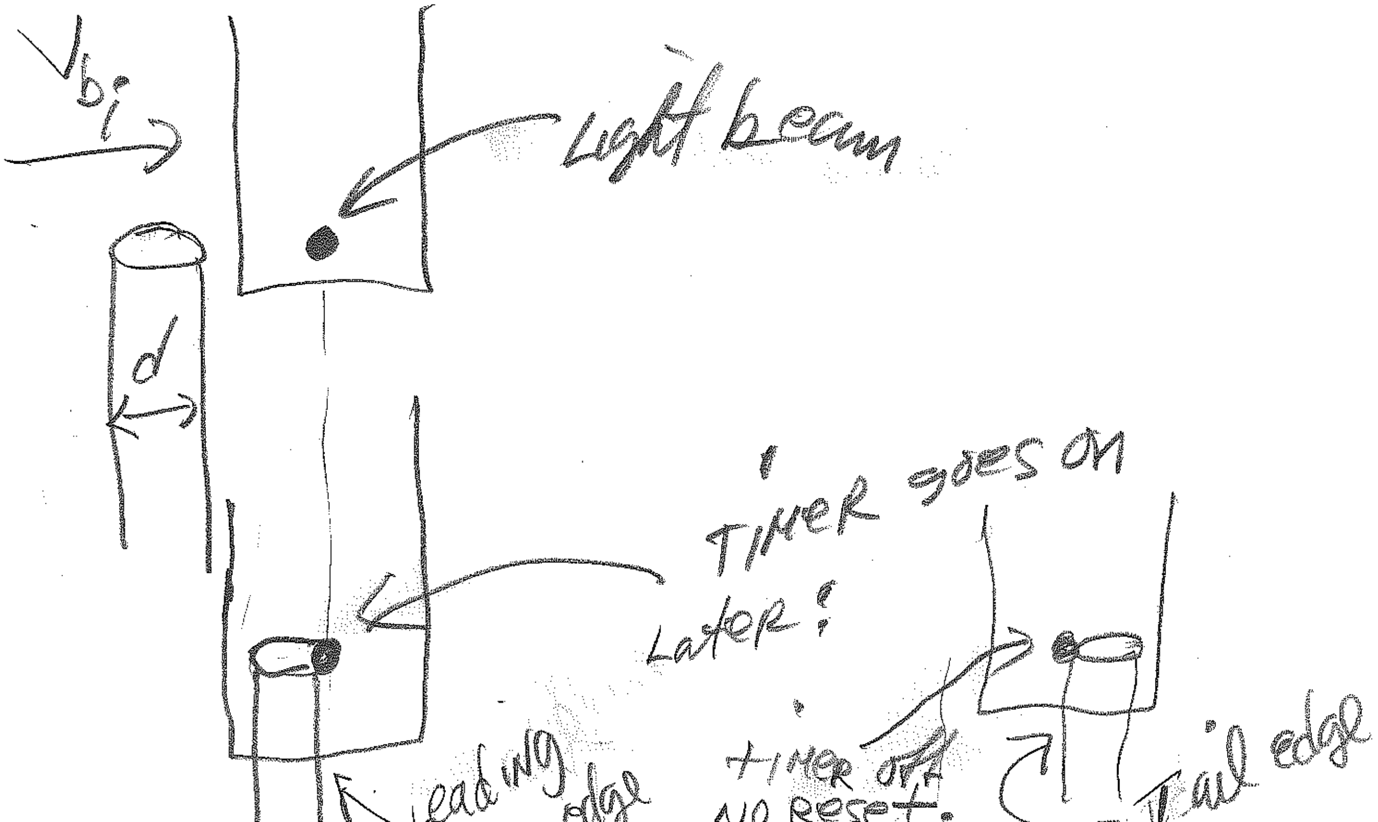
p_i =
Show calculation.

Momentum Lab

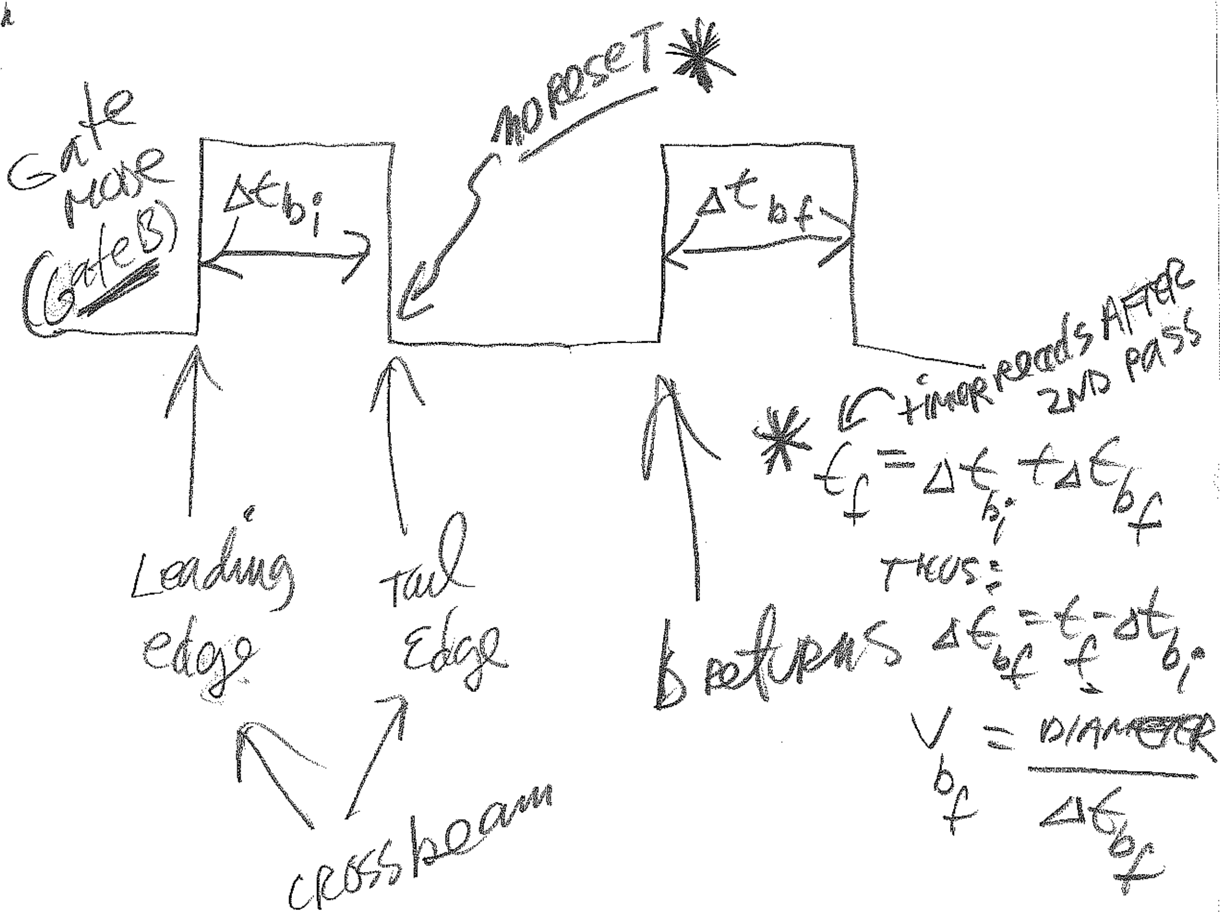
Note: if $m_a < m_b$



Gate-mode detail



$m_b < m_a$

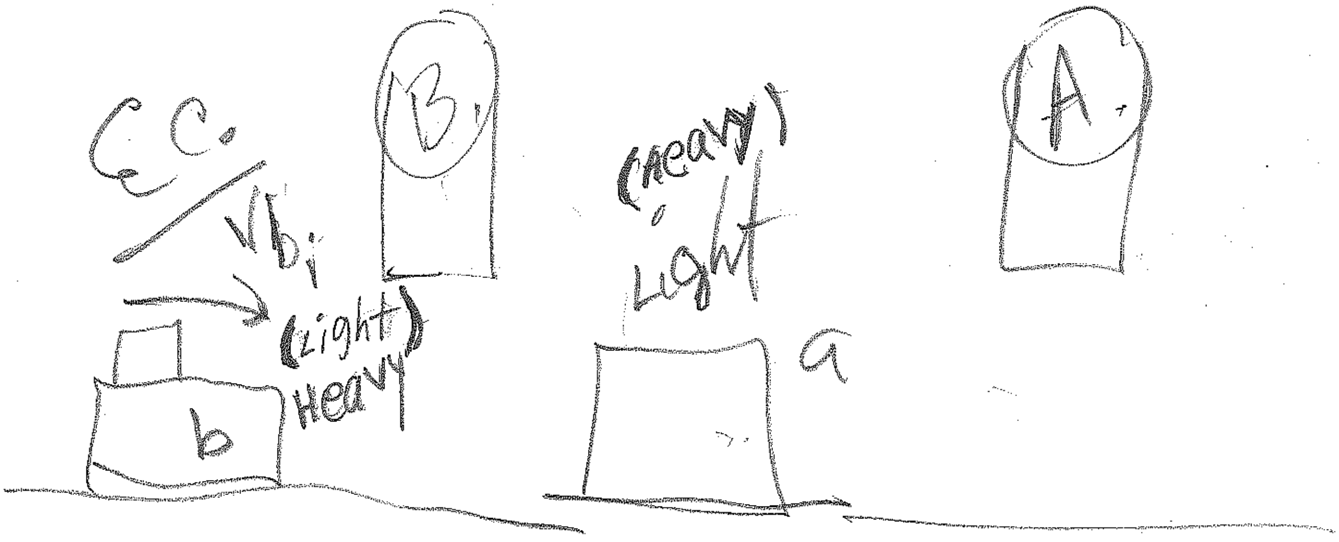


$$* \; t_f = \Delta t_{b_i} + \Delta t_{b_f}$$

THUS:

b returns $\Delta t_{b_f} = t_f - \Delta t_{b_i}$

$$V_{b_f} = \frac{\text{DIAMETER}}{\Delta t_{b_f}}$$



5 More trials with masses swapped.