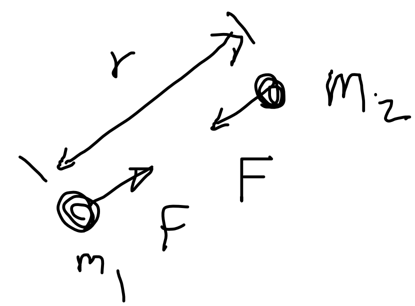
Phys 2110-4 10/19/11

Note Title 10/19/2011

Ch 7 Energy, Cons of Energy

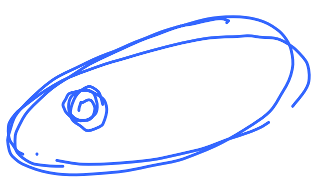
K, U

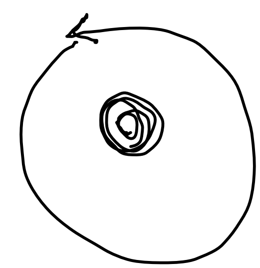
Ch 8 Gravity (Newton's Law



$$F = G\frac{m_1 m_2}{r^2}$$

$$G = 6.67 \times 10^{-11}\ \frac{N \cdot m^2}{kg^2}$$

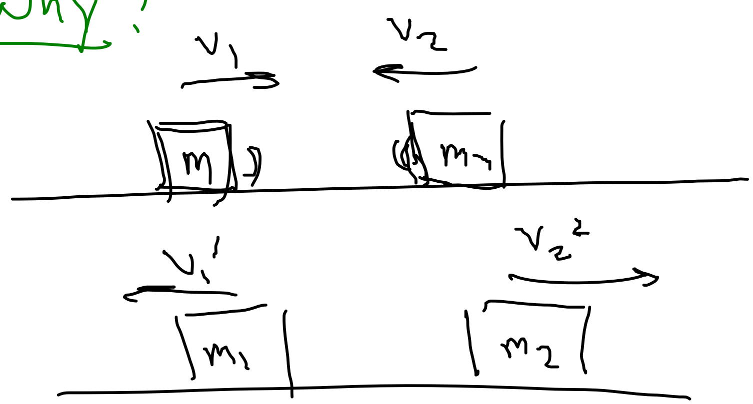




Ch 9 Systems of Particles (Momentum)

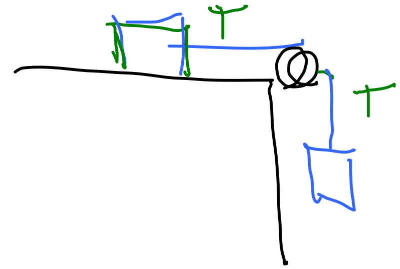
Systems of particles

why?



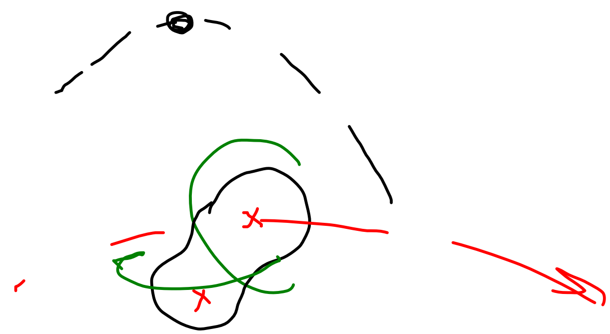
Collision

Can tell final velocities

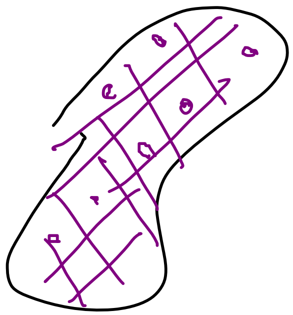


Real objects

Objects are "extended"



Extended objects



Object = bunch of point masses

System of particles

$\Longrightarrow$ Center of mass

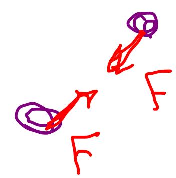
Momentum $\vec{p} = m\vec{v}$

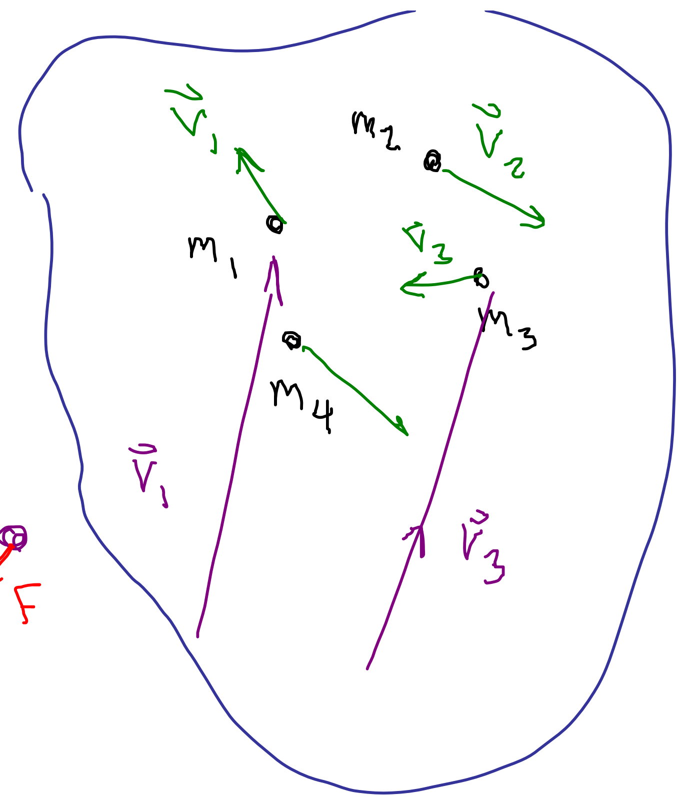
Derivations

System of particles

Newton's Law $\quad \vec{F} = m\vec{a}$

$$\vec{F}_{AB} = -\vec{F}_{BA}$$





$$\vec{F}_{i\,\text{Total}} = m_i \vec{a}_i$$

$$= m_i \frac{d^2\vec{r}_i}{dt^2} = \frac{d^2(m_i\vec{r}_i)}{dt^2}$$

$$M = \text{total mass} = \sum_i m_i$$

Add up all forces on all particles

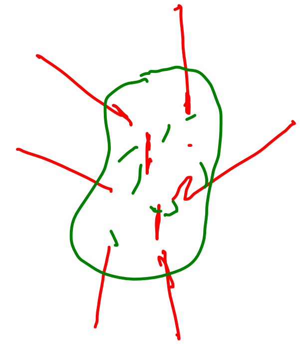
$$M \sum_i \frac{1}{M} \frac{d^2 m_i \vec{r}_i}{dt^2} = \sum_i F_{\text{Total}_i}$$

$$= M \frac{d^2}{dt^2} \left(\sum_i \frac{m_i \vec{r}_i}{M} \right)$$

$$= M \frac{d^2}{dt^2} (\vec{R})$$

$$\vec{F}_{\text{Total}} = M \underbrace{\frac{d^2}{dt^2} \vec{R}}_{\vec{a}_{cm}}$$

What is $\vec{R}$?



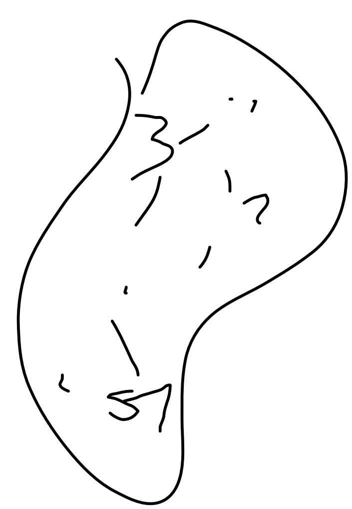
$\sum F_i$

$= M$

Looks like N's 2^n Law

$$R = \sum_i \frac{m_i \vec{r}_i}{M}$$

$$= \frac{1}{M} \sum_i m_i \vec{r}_i$$



Weighted average

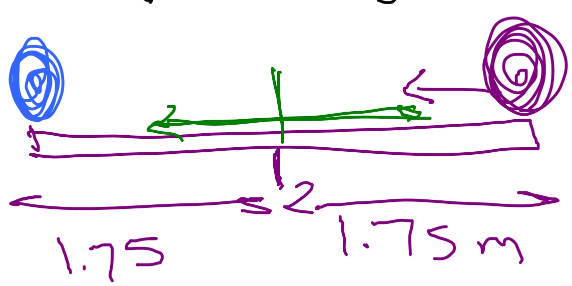
Average location. Give more "weight" to point with larger mass

Center of mass

X_{cm}, Y_{cm} . —

$$X_{cm} = \sum \frac{m_i x_i}{M} = \frac{1}{M}(m_1 x_1 + m_2 x_2 + \cdots)$$

9.12 28 kg child sits on one end of 3.5 m-long seesaw. Where should her 65-kg father sit so that center of mass will be at center of seesaw?



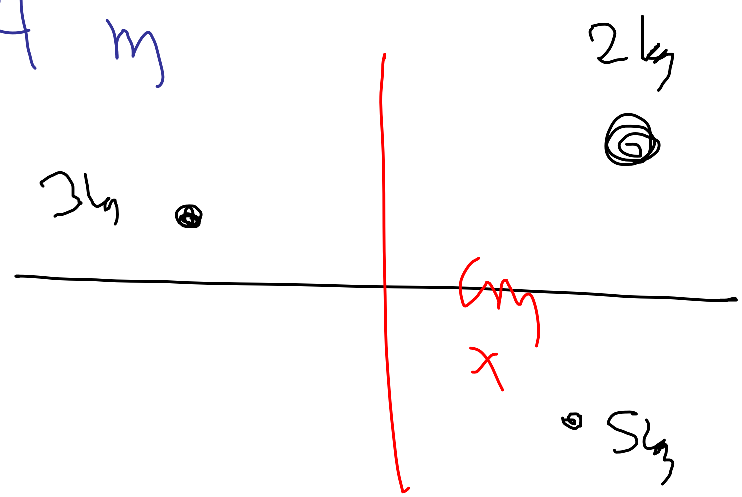
$M = 93$ kg

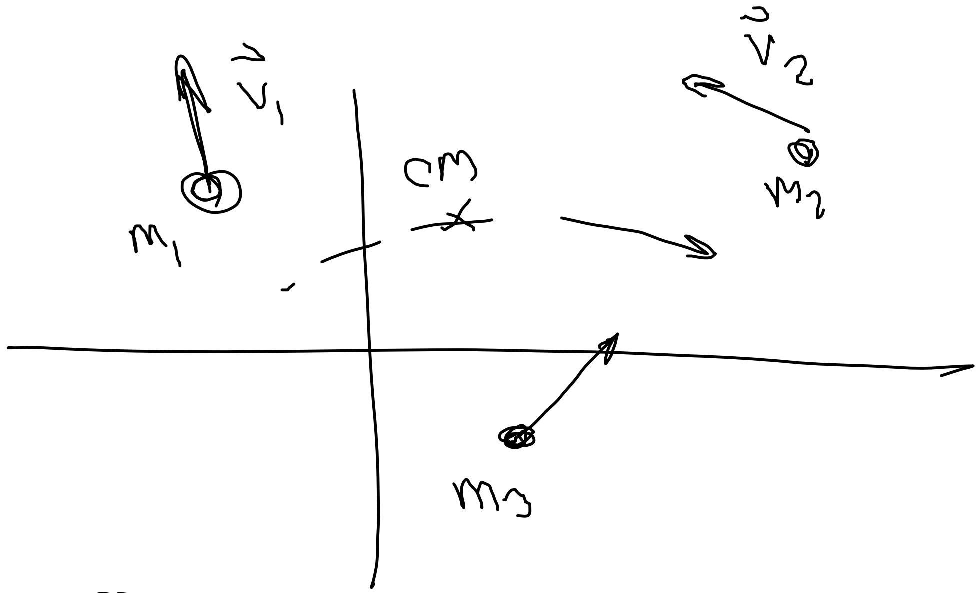
$$x_{cm} = 0 = \frac{1}{M}\sum m x$$

$$= \frac{1}{93}\left(28(-1.75\,m) + 65\,x\right)$$

Do it

$$\Rightarrow x = 0.754\ m$$





V_{cm} is weighted avg of the velocities.

$$\vec{r}_{cm} = \vec{R} = \frac{1}{M} \sum m_i \vec{r}_i$$

$$\frac{d\vec{R}}{dt} = \vec{V}_{cm} = \frac{1}{M} \sum m_i \frac{d\vec{r}_i}{dt} = \frac{1}{M} \sum m_i \vec{v}_i$$

$$\vec{a}_{cm} = \frac{1}{M}\sum m_i \vec{a}_i = \frac{1}{M}\sum_i m_i \frac{d^2\vec{r}_i}{dt^2}$$

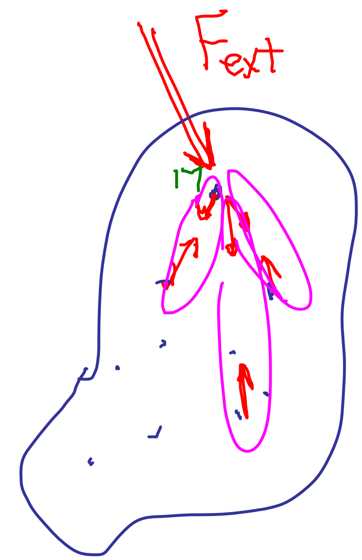
Look back a couple pages:

$$\boxed{\vec{F}_{\substack{\text{Total}\\ \text{\underline{all} masses}}} = M\vec{a}_{cm}}$$

total mass

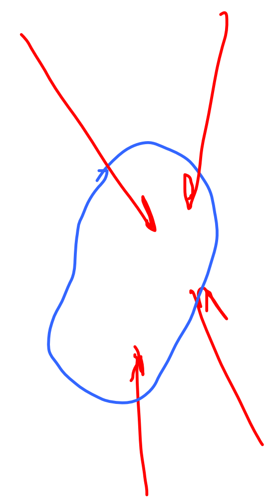
accel of CM

Add up all the forces that the guys inside the system are exerting on each other.



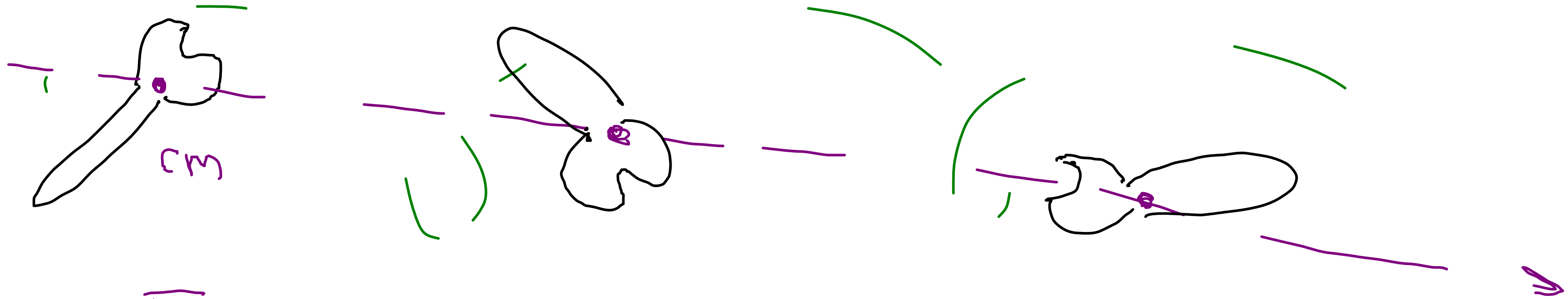
This is ~~zero~~ zero from Newton's 3^{rd} Law

$$\sum_i \vec{F}_{Total,i} = \sum_i \vec{F}_{external,i}$$

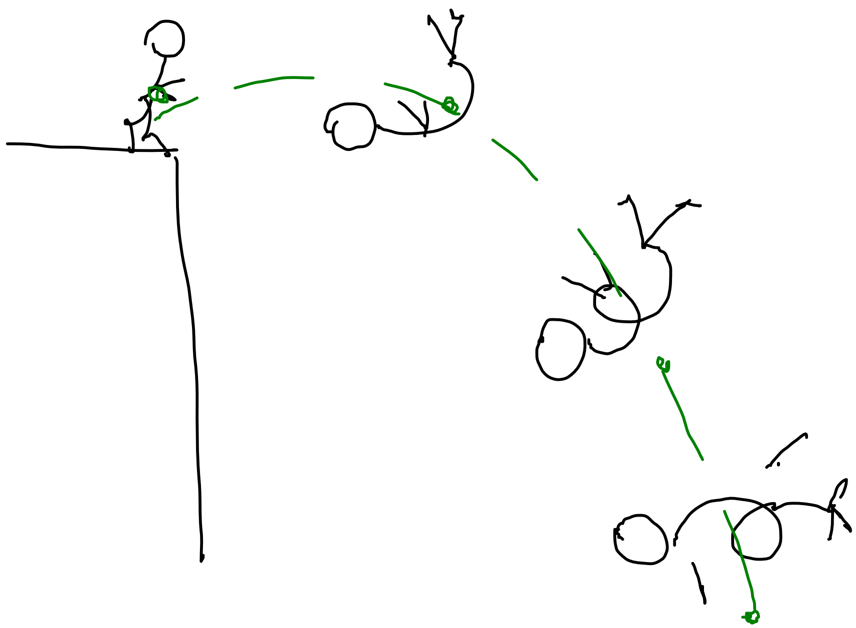


$$\boxed{F_{\text{Total external force}} = M\,\bar{a}_{cm}}$$

accel of CM



$\vec{F}_{ext} = 0 \qquad \vec{a}_{cm} = 0$



$M\vec{g}$