Phys 2110 - 4 10/21/11

Note Title 10/21/2011

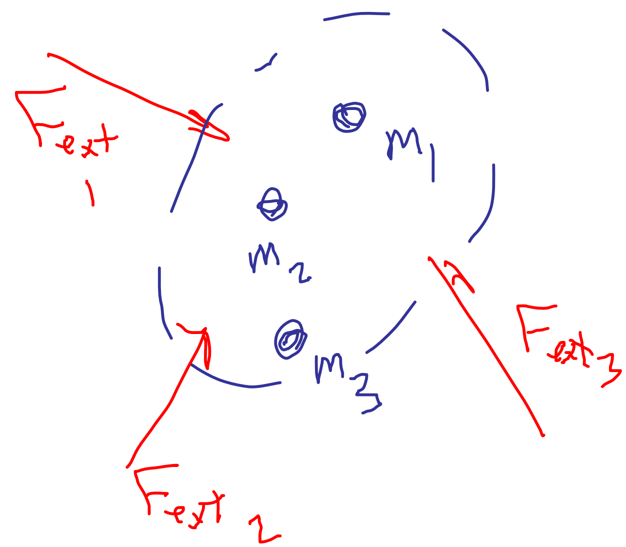
Chap 9 Systems of Particles

$$M = \sum_i m_i$$

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

$$\vec{v}_{cm} = \frac{1}{M} \sum_i m_i \vec{v}_i$$

$$\vec{a}_{cm} = \frac{1}{M} \sum_i m_i \vec{a}_i$$



$$\boxed{\vec{F}_{\substack{ext\\total}} = M\vec{a}_{cm}} = M\frac{1}{M}\sum m_i\vec{a}_i$$

$$= \sum m_i \vec{a}_i$$

$$= \sum m_i \, d\vec{v}_i/dt$$

$$= \frac{d}{dt}\sum_i m_i\vec{v}_i$$

ch 4

$$\vec{F}_{net} = m\vec{a}$$

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

m is constant

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

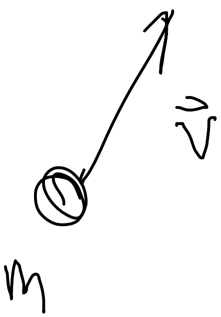
$$m\vec{v} = \vec{p}$$

$$\vec{F}_{net} = \frac{d}{dt}\vec{P}$$

$\vec{p}$ = momentum

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

momentum.



Vector p_x, p_y

Units $\boxed{kg\,\frac{m}{s}}$ No name!

$p_i = m\vec{v}_i$

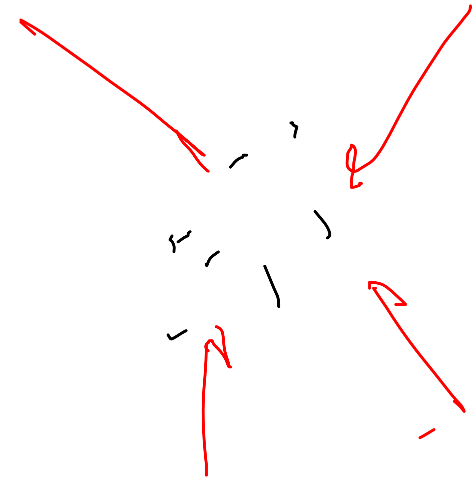
Total momentum $= \sum_i m_i \vec{v}_i$

$= \vec{P}_i$

$$\vec{F}_{ext} = \frac{d}{dt}\left(\sum_i m_i \vec{v}_i\right) = \frac{d}{dt}\left(\sum_i \vec{P}_i\right)$$

$$\boxed{\vec{F}_{\substack{ext\\tot}} = \frac{d}{dt}(\vec{P})}$$

$$\vec{F}_{tot} = \frac{d}{dt}\vec{P}$$

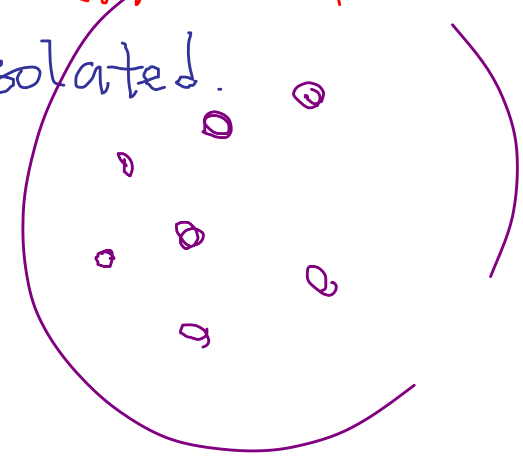


No external forces

Important special case

$$\vec{F}_{\substack{ext\\(total)}} = \vec{0}$$

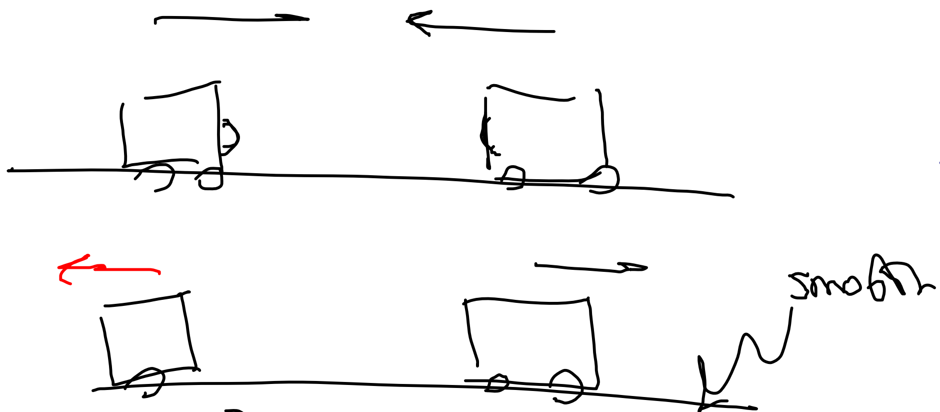
Isolated.



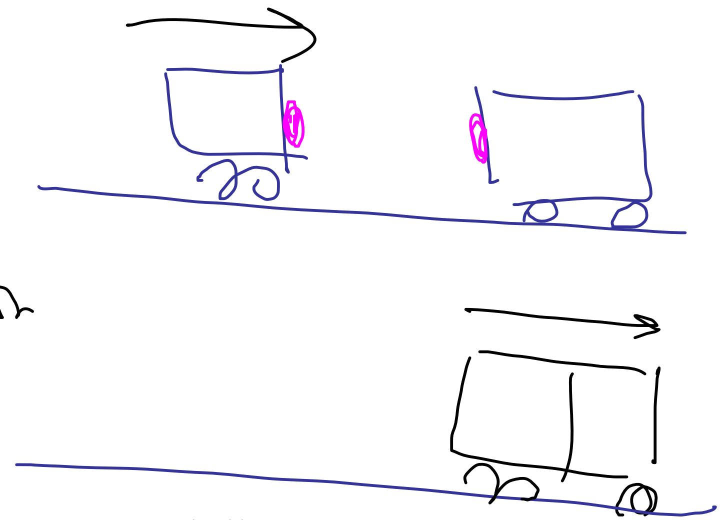
$$\frac{d}{dt}\vec{P} = 0$$

$$\vec{P} = \text{constant}$$

Can study the motions of particles in isolated systems!



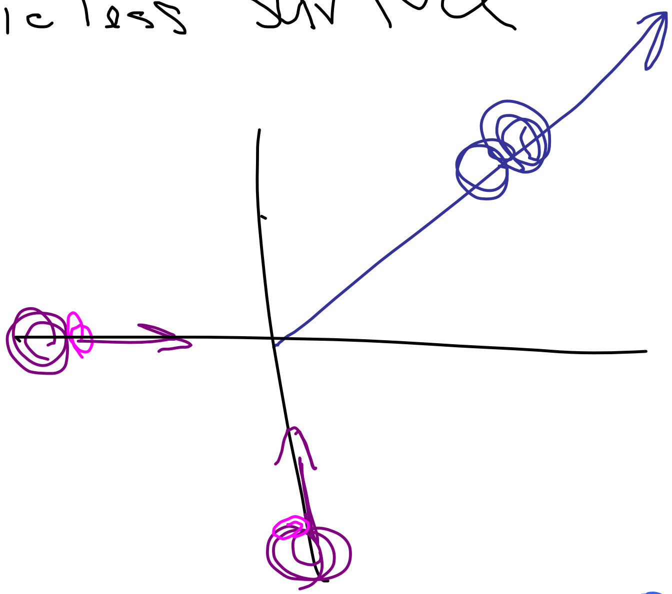
$\vec{P}$ is conserved



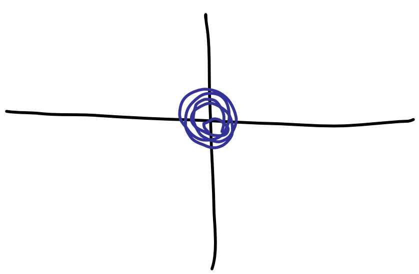
still isolated

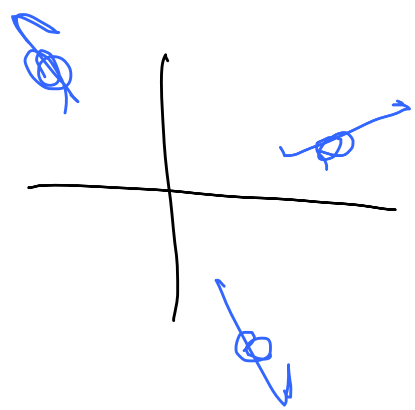
$\vec{P}$ is constant $\Rightarrow$ Conservation of momentum

Fricless surface



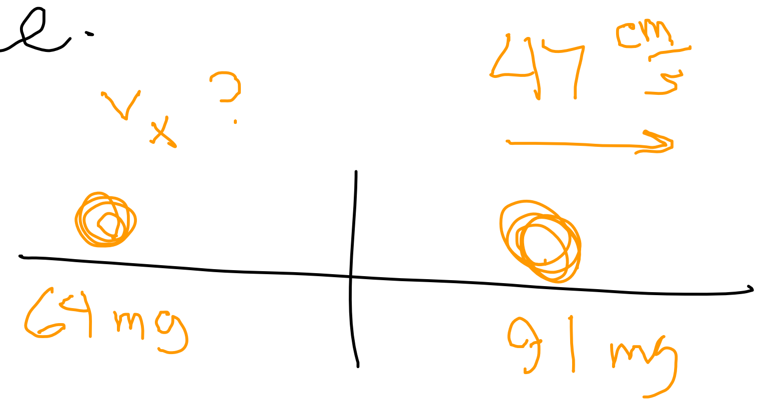
Can also treat a system as isolated for a short time.





$\vec{p}$ is conserved

9.17 A popcorn kernel at rest bursts into two pieces w/ masses 91 mg and 64 mg. More massive piece moves horizontally at 47 $\frac{cm}{s}$. Describe motion of second piece.



$$P = 0 = (64\ \text{kg})V_x + (91\ \text{kg})(47\ \tfrac{\text{cm}}{\text{s}})$$

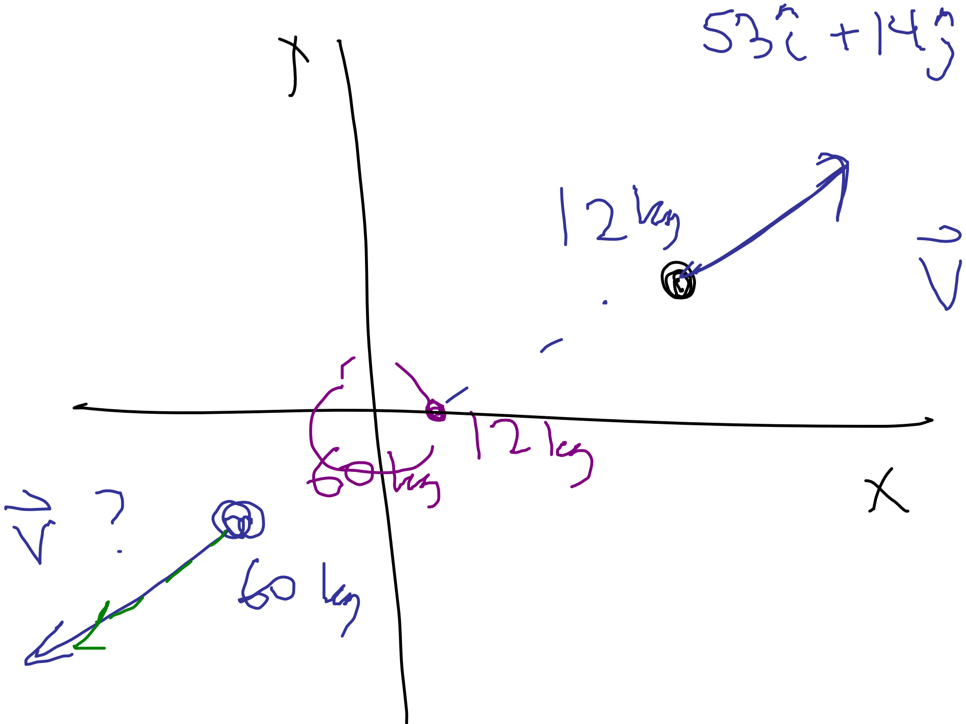
$$= 0$$

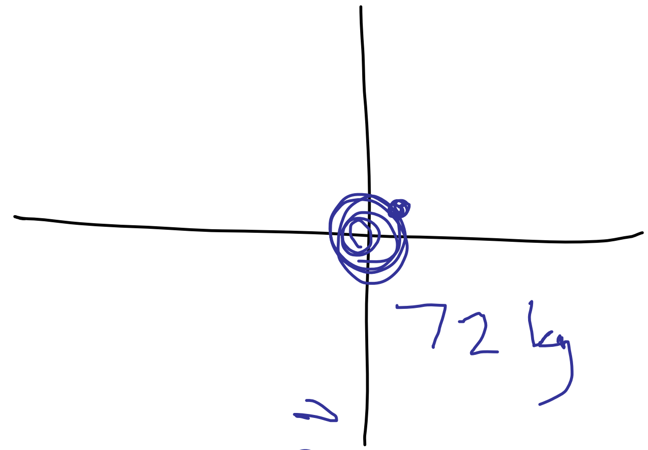
mom cons

Do it $\Longrightarrow$ $V_x = -67\ \frac{\text{cm}}{\text{s}}$

9.18 A 60 kg skater at rest on frictionless ice tosses 12-kg snowball w/ velocity $\vec{v} = (53.0\,\hat{i} + 14.0\,\hat{j})\ \frac{\text{m}}{\text{s}}$

Find skater's subsequent velocity





$\vec{P} = 0$

Find:

$\vec{v}_2 = (-10.6\hat{i} - 2.8\hat{j})\frac{m}{s}$

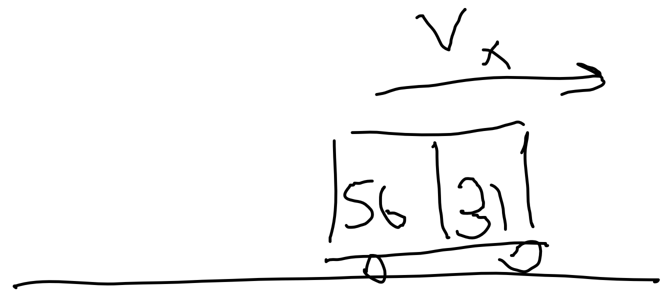
P_x is conserved: $P_x = 0 = (12\,kg)(53\,\frac{m}{s}) + (60\,kg)V_x$

P_y is conserved: $P_y = 0 = (12\,kg)(14) + (60\,kg)V_y$

9.26 In railroad switchyard 56-ton freight car is sent at $7.0 \frac{mi}{hr}$ toward 31-ton car moving in same direction at $2.6 \frac{mi}{hr}$

a) Stick together, speed of cars after they couple

b) What fraction of the initial kinetic energy is lost?



$\vec{P}$ is conserved (P_x)

$$(56\ \cancel{\text{tons}})\left(7.0\ \frac{mi}{h}\right) + (31\ \cancel{\text{tons}})\left(2.6\ \frac{mi}{h}\right) = (87\ \cancel{\text{tons}})\,V_x$$

$$\longrightarrow \quad V_x = 5.4\ \frac{mi}{h}$$

$$KE_1 = \frac{1}{2}(56_{\text{ton}})\left(7.0\,\frac{mi}{h}\right)^2 + \frac{1}{2}(31\text{ ton})\left(2.6\,\frac{mi}{hr}\right)^2$$

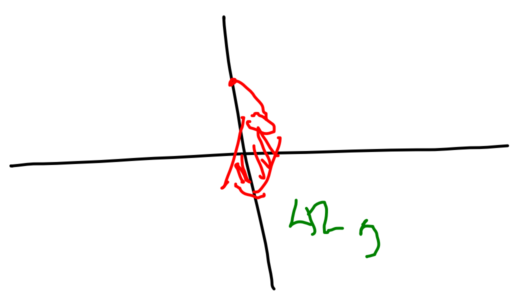
$$KE_f = \frac{1}{2}(87\text{ kg})\left(5.4\,\frac{mi}{h}\right)^2$$

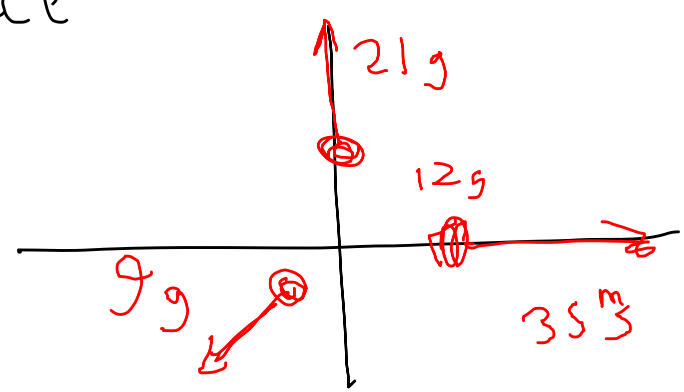
Calc $\dfrac{K_f - K_i}{K_i} = -13\%$

Inelastic

42 − g

9.50 A firecracker at rest at origin. Explodes. First, 12 g moves along x-axis at $35 \frac{m}{s}$. Second w/ mass 21 g moves along y-axis at $29 \frac{m}{s}$. Find velocity of third piece





Cons of momentum

$\longrightarrow$ Comp's of $\vec{v}$ of 3rd piece