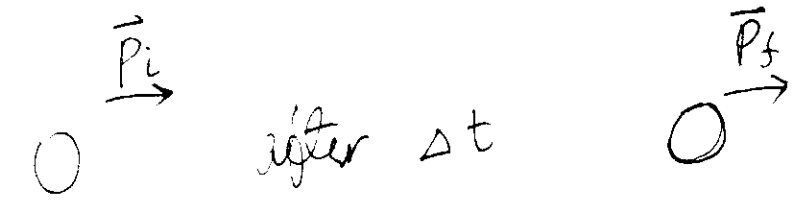


initial momentum = $\vec{P}_i$

final momentum = $\vec{P}_f$

change in momentum $\Delta \vec{P} = \vec{P}_f - \vec{P}_i$

Definition $\vec{P}_i = m\vec{V}_i$

$\vec{P}_f = m\vec{V}_f$

$$\Delta \vec{p} = m(\vec{V}_f - \vec{V}_i) = m\Delta\vec{V}$$

Divide by Δt $\quad \frac{\Delta \vec{p}}{\Delta t} = m\frac{\Delta \vec{V}}{\Delta t}$

For constant force $\vec{F} = m\vec{a} = m\frac{\Delta \vec{V}}{\Delta t}$

$$= \frac{\Delta \vec{p}}{\Delta t}$$

Conservation of momentum

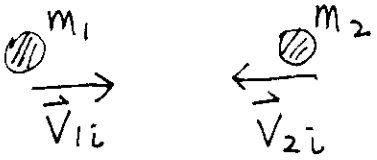
$$\Delta \vec{p} = \vec{F}_{av} \Delta t$$

If $\vec{F}_{av} = 0 \Rightarrow \Delta \vec{p} = 0 \Rightarrow \vec{p}_i = \vec{p}_f$

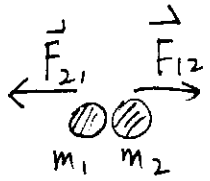
(same as Newton's 2nd law)

2 masses colliding

Initial

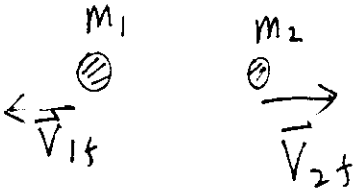


collision



Newton's 3rd law $\vec{F}_{12} = -\vec{F}_{21}$

Final



$$\Delta \vec{p}_1 = m_1 \vec{v}_{1f} - m_1 \vec{v}_{1i} = \vec{F}_{21} \Delta t \quad (1)$$

(Newton's 3rd law)

$$\Delta \vec{p}_2 = m_2 \vec{v}_{2f} - m_2 \vec{v}_{2i} = \vec{F}_{12} \Delta t = -\vec{F}_{21} \Delta t \quad (2)$$

(1) + (2)

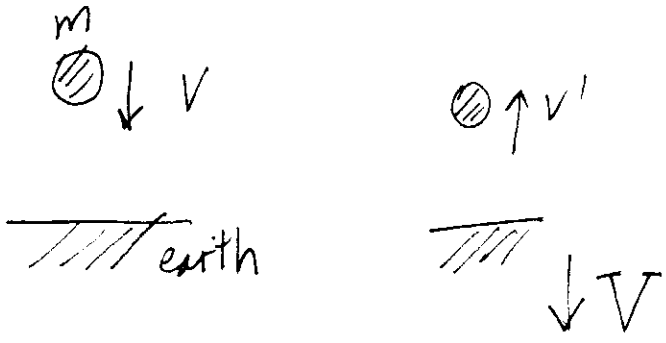
$$\Delta \vec{p}_1 + \Delta \vec{p}_2 = m_1 \vec{v}_{1f} - m_1 \vec{v}_i + m_2 \vec{v}_{2f} - m_2 \vec{v}_{2i} = 0$$

↑ change in momentum of system m_1 & $m_2 = 0$

total momentum is conserved.

$$m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$$

Ball bounce



Momentum conservation

$$m(-v) + M(0) = m(v') + M(-V)$$

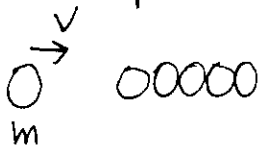
m: mass of ball, M: mass of earth

$$MV = m(v'+v)$$

$$V = \frac{m}{M}(v'+v)$$

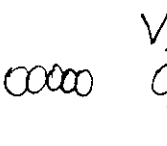
$\simeq 0$ because $m \ll M$

Momentum Balls experiment



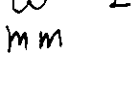
$p_i = mv$

$KE_i = \frac{1}{2}mv^2$

case 1 

$p_f = mv$

$KE_f = \frac{1}{2}mv^2$

case 2 

$p_f = 2m(\frac{v}{2})$

$KE_f = \frac{1}{2}m(\frac{v}{2})^2 + \frac{1}{2}m(\frac{v}{2})^2$

$= \frac{1}{4}mv^2$

$\neq KE_i$

Inelastic collisions

$$P_i = mV + m(-V) = 0$$

$$P_f = 0$$

inelastic $KE_f = 0$

$$P_i = mV + 2m(-V) = -mV$$

stick $P_f = 3m(V_f)$

$$P_i = P_i$$

$$-mV = 3mV_f$$

$$V_f = -\frac{V}{3}$$

$$KE_f = \frac{1}{2}(3m)\left(-\frac{V}{3}\right)^2$$

$$\neq 0$$