LINEAR MOMENTUM

$* [Dimensions] \xrightarrow{\text{SI units}} [L]\rightarrow m,\ [M]\rightarrow kg,\ [T]\rightarrow s$

Mathematical representation

$$\text{Linear momentum } \frac{[M][L]}{[T]} \equiv \vec{p} = m\,\vec{v}$$

$$\text{Impulse } \frac{[M][L]}{[T]} \equiv \vec{J} = \underbrace{\sum \vec{F}_{external}\ \Delta t = \Delta \vec{p}_{system}}_{\textbf{Impulse-Momentum Theorem}}$$

"The average net external force acting on a system for some amount of time Δt, causes the momentum of the system to change."

Conservation of momentum

$$\underbrace{\underbrace{\sum \vec{F}_{ext}\,\Delta t = \Delta \vec{p}_{sys}}_{\vec{0}} }_{\vec{0} = \Delta \vec{p}_{sys}}$$

$$\sum \vec{p}_i = \sum \vec{p}_f$$

"If the average net external force on a system is zero, then the change in momentum is zero. Thus, the initial momentum of the system is equal to the final momentum of the system. If internal forces are present within the system, the momentum of the system remains unchanged, thus it is a 'conserved quantity' ".

Approximations

If $\sum \vec{F}_{ext} \approx \vec{0}$	If $\Delta t \approx 0$	If $\Delta t \approx 0$ and $\sum \vec{F}_{ext} \approx \vec{0}$
$\sum \vec{F}_{ext}\,\Delta t = \Delta \vec{p}_{sys}$	$\sum \vec{F}_{ext}\,\Delta t = \Delta \vec{p}_{sys}$	$\sum \vec{F}_{ext}\,\Delta t = \Delta \vec{p}_{sys}$
$\vec{0} \approx \Delta \vec{p}_{sys}$	$\vec{0} \approx \Delta \vec{p}_{sys}$	$\vec{0} \approx \Delta \vec{p}_{sys}$
$\sum \vec{p}_i \approx \sum \vec{p}_f$	$\sum \vec{p}_i \approx \sum \vec{p}_f$	$\sum \vec{p}_i \approx \sum \vec{p}_f$

Caution

- Velocity is dependent on the coordinate system. Thus momentum is also dependent on the coordinate systems.
  - Make sure that the velocities used in conservation of momentum are all with respect to the same reference frame.

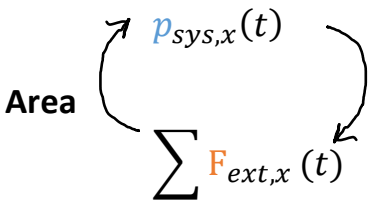
$$\underbrace{\vec{v}_{A/B}}_{\text{Velocity of A with respect to B}} = \vec{v}_{A/C} + \vec{v}_{C/B}$$

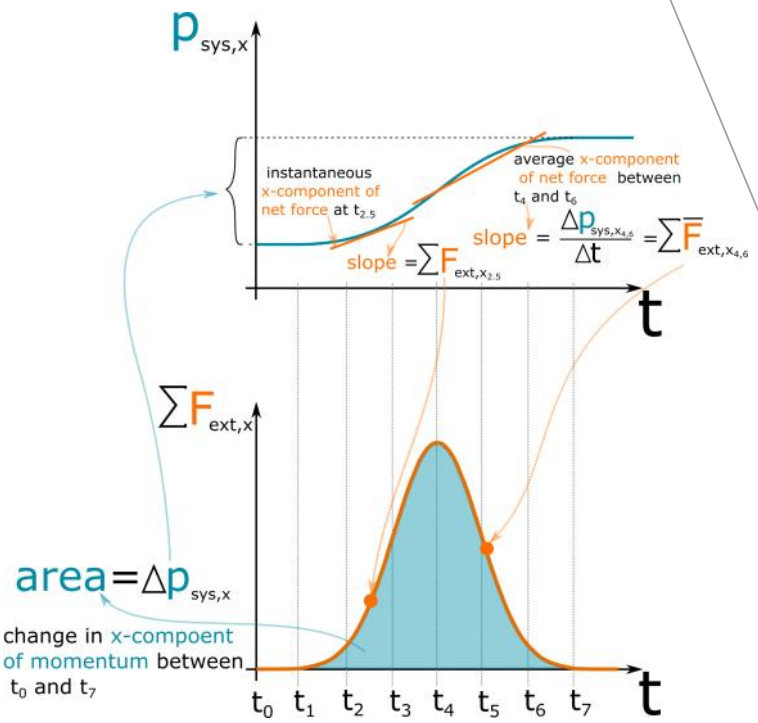
$$\vec{v}_{A/B} = -\vec{v}_{B/A}$$

Newton's 2nd law of motion update

$$\sum \vec{F}_{ext} = m_{sys}\,\vec{a}_{cm} \longrightarrow \sum \vec{F}_{ext} = \frac{\Delta \vec{p}_{sys}}{\Delta t}$$

Graphical representation





Physical representation