

# MOMENTUM

Definition:

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

it's a vector!!

→ units are  $\text{kg}\cdot\text{m/s}$   
(no shortcut)

Momentum is important for a couple reasons: it's conserved and the more general form of Newton's Second Law

1) N2L:

$\Sigma \vec{F} = m\vec{a}$  is actually a special case. Should be written as

$$\Sigma \vec{F} = \frac{d\vec{p}}{dt}$$

← really only need if doing rockets or special relativity

So  $\Sigma F = \frac{d(m\vec{v})}{dt} \rightarrow$  if  $m$  is constant  
then  $\Sigma \vec{F} = m \frac{d\vec{v}}{dt}$

$$\Sigma \vec{F} = m\vec{a}$$

2) Impulse:

Let's just call "F" the net force for a moment:

$$\therefore \vec{F} = \frac{d\vec{p}}{dt} \Rightarrow d\vec{p} = \vec{F} dt$$
$$\int d\vec{p} = \int \vec{F} dt$$

$$\Delta \vec{p} = \int \vec{F} dt$$

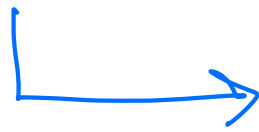
→  Area = J

So Area =  $\Delta p$

The integral is called IMPULSE and the impulse on an object is equal to the change in momentum of the object

Hey! Kind of like  $\int F \cdot dx = \Delta K$

momentum of the object.



$$\vec{J} = \int \vec{F} dt = \Delta \vec{p}$$

units of Impulse are N·s or kg·m/s

The simple algebra version of This is

$$J = \bar{F} t$$

where  $\bar{F}$  is the average force over the time interval  $t$

3) N3L :

$$F_{AB} = - F_{BA}$$

2 objects interact

$$\text{so } F_{AB} dt = - F_{BA} dt$$

$$\text{so } \int F_{AB} dt = - \int F_{BA} dt$$

the impulses are equal and opposite

$$\text{so } \Delta \vec{p}_B = - \Delta \vec{p}_A$$

Means momentum is conserved! If B gains momentum, then A loses the same amount and vice versa!

Let's rearrange that statement to make it easier to do problems:

$$\Delta \vec{p}_B = -\Delta \vec{p}_A$$

$$\textcircled{1} \quad \Delta \vec{p}_A + \Delta \vec{p}_B = 0$$

i.e. the total change in momentum from the two objects pushing each other is 0.

or

$$\textcircled{2} \quad \vec{p}_{B_f} - \vec{p}_{B_i} = -(\vec{p}_{A_f} - \vec{p}_{A_i})$$

$$\vec{p}_{B_f} + \vec{p}_{A_f} = \vec{p}_{A_i} + \vec{p}_{B_i}$$

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

i.e. the total initial momentum is the same as the total final momentum.

This is the way I usually approach conservation of momentum.

