Conservation of linear momentum

$$\frac{d}{dt}(\vec{P}_{sys}) = \sum \vec{F} + \sum_{in} \dot{m}\vec{V} - \sum_{out} \dot{m}\vec{V}$$

1) A closer look a $\vec{P}_{sys}$

a. System is a **particle**

$$\vec{P}_{sys} = m_{sys}\vec{V}_{sys}$$

b. System has **uniform velocity**

$$\vec{P}_{sys} = m_{sys}\vec{V}_{sys}$$

c. System is a **general closed system**

$$\vec{P}_{sys} = \int_{\forall_{sys}} \vec{V}\rho d\forall$$

Let $\vec{V}_G = \frac{d\vec{r}_G}{dt}$

where $\vec{r}_G = \frac{1}{m_{sys}} \int_{\forall_{sys}} \vec{r}\rho d\forall$

Then $\vec{P}_{sys} = m_{sys}\vec{V}_G$

Velocity at **center of mass**

2) A closer look at ***F*** (Rate of LM transport at non-flow boundaries)

a. Body forces (“Forces at a distance ”)

- Drawn at:“Center of mass/charge/etc.”
- E.g., gravity, electrostatic…
- Act on **whole body**, but we pretend they act at a point

No contact is needed, but the forces still cross system boundary!

b. Contact forces (Come from interaction *between* bodies in contact.)

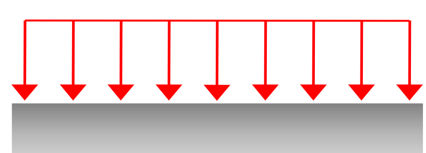
Drawn at: boundaries where things **touch** each other

c. Contact **stresses**

i. Shear

$= F_{tan}/Area$

ii. Normal



$= F_{normal}/Area$

E.g., pressure!

3) A closer look at $\dot{m}\vec{V}$ (Rate of LM transport at flow boundaries)

If $\dot{m}_{in} \Rightarrow \sum \dot{m}_{in}\vec{V}$

If $\dot{m}_{out} \Rightarrow \sum \dot{m}_{out}\vec{V}$

These are *vectors*. Thus they have signs in the component equations and can make entire term *positive* or *negative*.