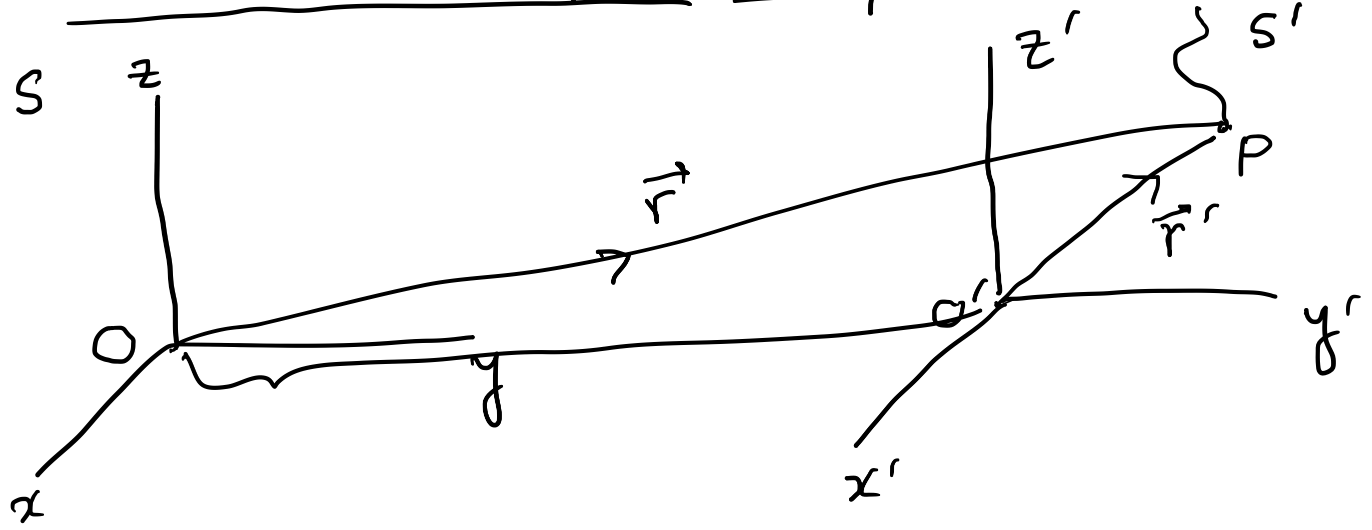
Physics I

Lecture 2

Newton's Laws hold in "inertial frames".

Galilean transformations / Galilean invariance



S' moves with uniform vel u along y

at t = 0, O & O' coincided

$$\vec{r} = \vec{r}' + \vec{u}\,t \qquad \{ t' = t \} \rightarrow \text{implicit assumption}$$

$$\frac{d\vec{r}}{dt} = \frac{d\vec{r}'}{dt} + \vec{u} \longrightarrow \boxed{\vec{v} = \vec{v}' + \vec{u}}$$

$$\left.\begin{aligned}\vec{r} &= \vec{r}\,' + \vec{u}t \\ \vec{v} &= \vec{v}\,' + \vec{u}\end{aligned}\right\} \longrightarrow \vec{r}, \vec{v} \text{ are not absolute but relative.}$$

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

$$\boxed{\vec{a} = \vec{a}\,'} \longrightarrow \text{acceleration is absolute}$$

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

m is scalar and is frame independent.

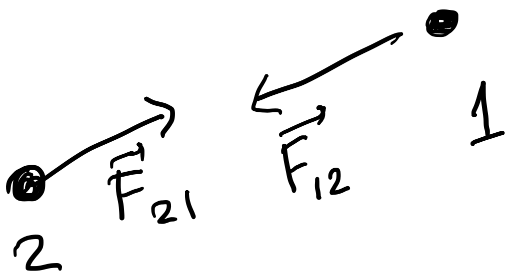
$\downarrow$ holds in all frames

$\longrightarrow$ Invariant under Galilean transformation

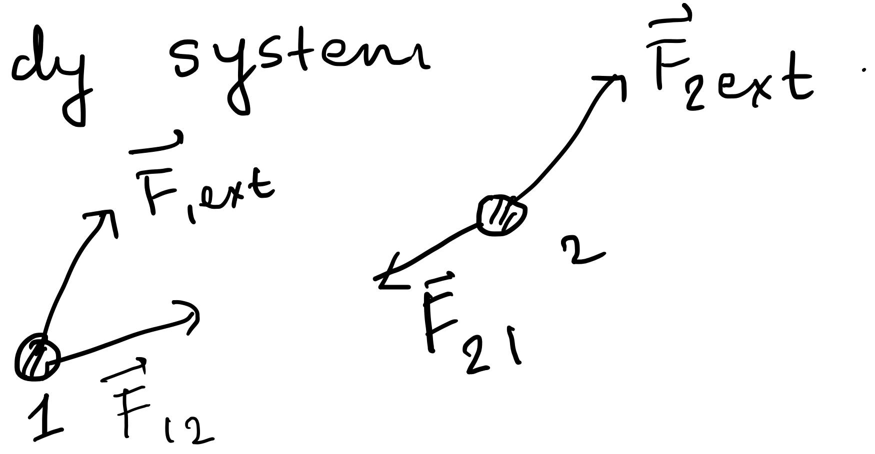
Newton's 3rd Law

If object 1 exerts force $\vec{F}_{21}$ on object 2 then object 2 always exerts a reaction force $\vec{F}_{12}$ on 1 such that

$$\boxed{\vec{F}_{21} = -\vec{F}_{21}}$$



2 body system



$$\dot{\vec{p}}_1 = \vec{F}_1 = \vec{F}_1^{ext} + \vec{F}_{12}$$

$$\dot{\vec{p}}_2 = \vec{F}_2 = \vec{F}_2^{ext} + \vec{F}_{21}$$

$$\vec{p} = \vec{p}_1 + \vec{p}_2$$

$$\dot{\vec{p}} = \dot{\vec{p}}_1 + \dot{\vec{p}}_2 = \left(\vec{F}_1^{ext} + \vec{F}_2^{ext} + \underbrace{\vec{F}_{12} + \vec{F}_{21}}_{=0}\right)$$

$$\boxed{\dot{\vec{p}} = \vec{F}^{ext}}$$

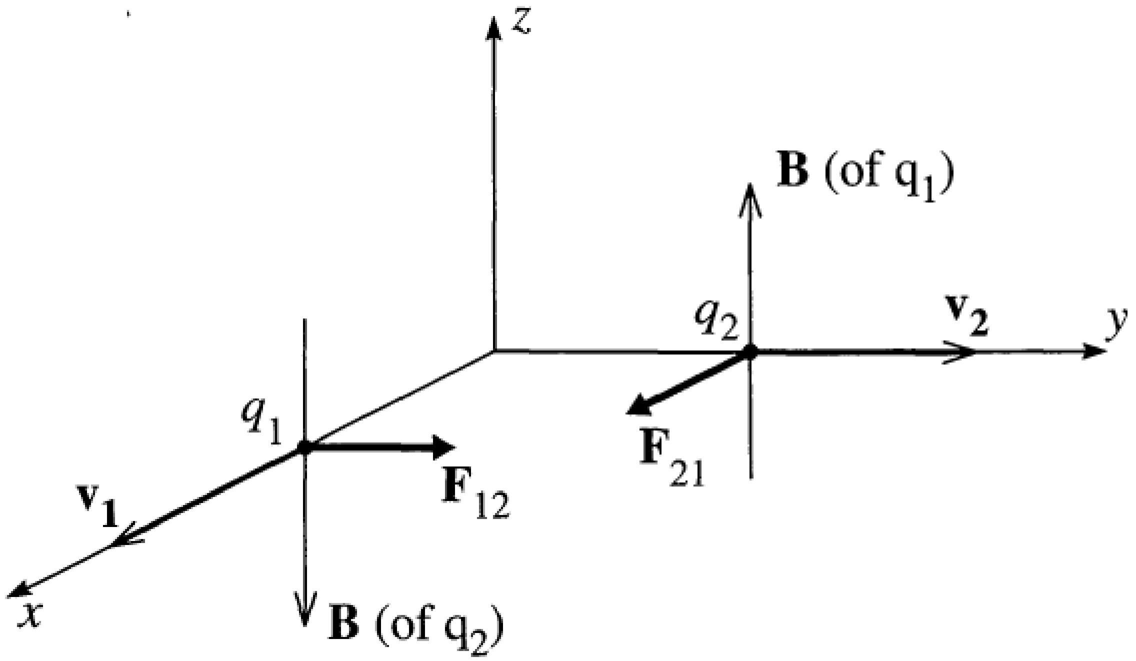
If $\vec{F}^{ext} = 0$

$$\dot{\vec{p}} = 0$$

$$\Rightarrow \boxed{\vec{p} = \text{const}} \longrightarrow \text{conservation of momentum}$$

$\vec{F}_{12} \neq \vec{F}_{21}$!

third law violated.



Is 3rd Law always true?

Relativity → time is not universal / observer dependent

$$\vec{F}_{12}(t) = -\vec{F}_{21}(t)$$ → cannot hold true for all observers

measured at same time

simultaneity is NOT ABSOLUTE