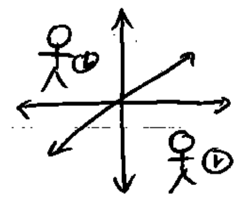
Read 37.1 - 37.3 for Monday

Everyday experience → things behave the same in vehicle at constant velocity (not true if accelerating)

SILLY DEMO



Make this more precise:

define FRAME OF REFERENCE = system of coordinates + clocks + observers at rest in this system

- these observers can assign coordinates + times (x, y, z, t) to EVENTS + describe motion of objects (TRAJECTORIES) via $\vec{X}(t) = (x(t), y(t), z(t))$

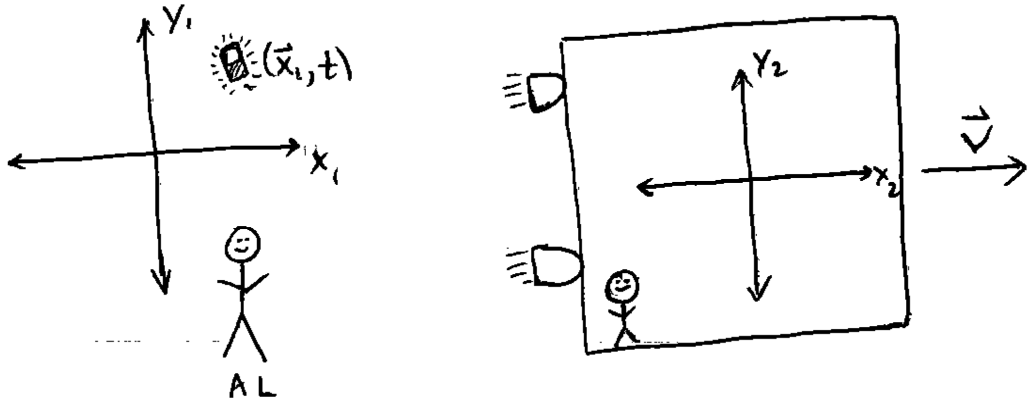
INERTIAL FRAME: frame of reference for which $\vec{X}(t) = \vec{u}\,t + \vec{X}_0$ (const. velocity) in absence of forces i.e. Newton's 1st Law holds.

- any 2 inertial frames move at constant relative velocity (otherwise object @ rest in one would be accelerating in other)

(GALILEAN) PRINCIPLE OF RELATIVITY: The laws of mechanics are the same in all inertial frames

Will show this for $\vec{F} = m\vec{a}$:

consider 2 frames at constant relative velocity



Assume $t_1 = t_2$
$\vec{x}_1 = \vec{x}_2$ at $t=0$
(choice

At time t: if Al sees event at $\vec{x}_1$
Betty sees event at $\vec{x}_2 = \vec{x}_1 - \vec{v}t$

check: $\vec{x}_1 = 0$ should be in $-$ve $\vec{v}$ direction for $t>0$

For object with trajectory $\vec{X}_1(t)$ in Al's frame:

$$\vec{X}_2(t) = \vec{X}_1(t) - \vec{v}t$$

time derivative

$$\dot{\vec{X}}_2(t) = \dot{\vec{X}}_1(t) - \vec{v}$$

(no forces $\Rightarrow \dot{\vec{X}}_1 = \vec{u}$
$\Rightarrow \dot{\vec{X}}_2 = \vec{u} - \vec{v}$ $\therefore$ 1st Law holds for both)

$$\ddot{\vec{X}}_2(t) = \ddot{\vec{X}}_1(t) \Rightarrow \text{Al + Betty agree on accelerations}$$

Also: $\vec{F}_2 = \vec{F}_1$ since basic forces depend on relative positions, relative velocities

e.g. Coulomb $\sim k \frac{q_1 q_2 \hat{r}}{|\vec{x}_1 - \vec{x}_2|^2}$ spring $k(\vec{x}_1 - \vec{x}_2)$

So: $\vec{F}_1 = m\vec{a}_1 \Longrightarrow \vec{F}_2 = m\vec{a}_2$

Different inertial observers → Observe different velocity, momentum, energy for a given object

BUT : each will find same laws of mechanics.