LECTURE #12 – SUMMARY

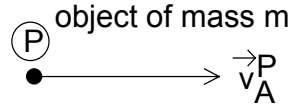
Section III.2 Inertial vs. Noninertial Reference Frames

Newton's Laws of Motion do not hold

(1) when $v \approx c$, i.e., motion near the speed of light

(2) in non-inertial reference frames, i.e., in accelerating frames of reference

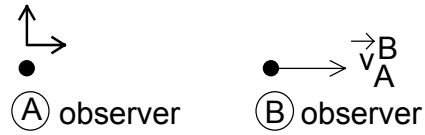
References frames which move at constant velocity = inertial frames of reference.



Let's say that A is an inertial frame of reference.

$\vec{v}^{\,P}_B = \vec{v}^{\,P}_A + \vec{v}^{\,A}_B$ and $\vec{a}^{\,P}_B = \vec{a}^{\,P}_A + \vec{a}^{\,A}_B$

First Case: $\vec{v}^{\,A}_B$ is constant



$\Rightarrow$ then B is also an inertial frame of reference

$\vec{v}^{\,P}_B = \vec{v}^{\,P}_A + \vec{v}^{\,A}_B$ so A and B measure different velocities

$\vec{a}^{\,P}_B = \vec{a}^{\,P}_A$ so A and B measure the same acceleration

$\therefore\ m\vec{a}^{\,P}_B = m\vec{a}^{\,P}_A$ and $\vec{F}_A = \vec{F}_B$

So observers in different inertial reference frames agree on the net force on P.

Special case: $\vec{a}^{\,P}_A = 0 \ \Rightarrow$ then $\vec{a}^{\,P}_B = 0$. Both observers say no net force acts on P.

This means that

- velocities can be different in different inertial frames of reference, but
- accelerations and forces CANNOT differ in different inertial reference frames

$\therefore$"rest" is relative: can only measure relative velocities of inertial reference frames

Second Case: $\vec{v}^{\,A}_B$ is NOT constant $\Rightarrow$ then B is a non-inertial reference frame

$\vec{v}^{\,P}_B = \vec{v}^{\,P}_A + \vec{v}^{\,A}_B$ so A and B still measure different velocities

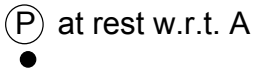
$\vec{a}^{\,P}_B = \vec{a}^{\,P}_A + \vec{a}^{\,A}_B$ so A and B now measure different accelerations

$\therefore m\vec{a}^{\,P}_B = m\vec{a}^{\,P}_A + m\vec{a}^{\,A}_B$ and $\vec{F}_B = \vec{F}_A + \vec{F}_f$

Observer B sees a different force applied to P than the force that observer A sees.

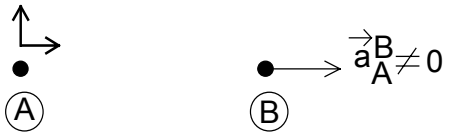
Observer B is mistaking his/her own acceleration for that of the object.

error $= \vec{F}_f = m\vec{a}^{\,A}_B$ = fictitious force



$\vec{a}^{\,P}_B = \vec{a}^{\,P}_A + \vec{a}^{\,A}_B = 0 + \vec{a}^{\,A}_B$

$\vec{F}_B = m\vec{a}^{\,P}_B \qquad \therefore \vec{F}_B = m\vec{a}^{\,A}_B = -m\vec{a}^{\,B}_A$



Two interpretations:

(1) a force of unknown origin is accelerating P w.r.t. B

(2) observer B is accelerating and object P only APPEARS to be accelerating

Therefore, we conclude that Newton's Laws of motion do not hold in non-inertial frames of reference. Do NOT apply "$\vec{F} = m\vec{a}$" in accelerating frames of reference !