Lecture 11, Oct 4, 2021

Inertial Reference Frames

- An *inertial reference frame* is a reference frame moving at a constant speed; two observers moving relative to one another at a constant speed are both in inertial reference frames
  - However, both observers could be accelerating relative to some third frame (e.g. the Earth); as long as they're accelerating the same amount and so have a constant relative speed
    - e.g. two astronauts orbiting the earth
- Example of noninertial reference frame: accelerating car
  - Noninertial reference frames lead to fictitious forces from the perspective of the observer in the reference frame, e.g. centrifugal force

Galilean Coordinate Transformations

- The core of Galilean relativity is that all observers agree on the time of events: $t_{Be} = t_{Ae} = t_e$
- The position of events are different: $\vec{r}_{Be} = \vec{r}_{Ae} - \vec{v}_{AB}t_e$
- Note: First letter is observer, e.g. $\vec{r}_{AB}$ is the position of B relative to A
- Suppose A and B are in inertial reference frames and c is an accelerating object
  - $\Delta\vec{r}_{Ac} = \Delta\vec{r}_{AB} + \Delta\vec{r}_{Bc}$
  - $\Delta\vec{r}_{Ac} = \Delta\vec{r}_{AB} + \Delta\vec{r}_{Bc} \implies \vec{v}_{Ac} = \vec{v}_{AB} + \vec{v}_{Bc} \implies \Delta\vec{v}_{Ac} = \Delta\vec{v}_{Bc}$ assuming $\vec{v}_{AB}$ is constant
  - Therefore $\vec{a}_{Ac} = \vec{a}_{Bc}$, assuming $\vec{v}_{AB}$ is constant
- If we're careful about the subscripts then we can use "cancellation": $\vec{r}_{Ae} = \vec{r}_{A\cancel{B}} + \vec{r}_{\cancel{B}e}$
- Position vectors are each other's opposites: $\vec{r}_{AB} = -\vec{r}_{BA}$, which also applies to velocities, accelerations, etc

Principles of Relativity

- Since changes in velocity are the same regardless of inertial reference frame, momentum and kinetic energy are conserved
  - Note only *changes* in kinetic energy are the same, but the entire kinetic energy may be different
  - Differences in kinetic energy are the same even for inelastic collisions
- In general, *all laws of physics are frame independent*
- As a direct result, physics measurements cannot distinguish one inertial reference frame from another