PHYS 2010 LECTURE 24

Another important quantity that's conserved in an isolated system is (linear) <u>momentum</u>.

Momentum is particularly useful in analyzing collisions:

$\vec{p} = m\vec{v}$ Momentum is a <u>vector</u>, always has same direction (but not magnitude) as $\vec{v}$.

Units : kg·m/s

Total momentum of a system of objects:

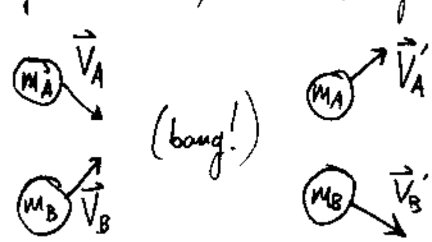
$$\vec{P}_{tot} = \sum_i \vec{p}_i = \sum_i m_i \vec{v}_i = m_1\vec{v}_1 + m_2\vec{v}_2 + \cdots$$

Can <u>never</u> create/destroy momentum, only transfer it from one object to another. Can derive conservation of momentum from Newton's Laws.

$$\sum_i \vec{P}_{i\,(before)} = \sum_i \vec{p}_i\,(after) \quad \text{a collision}$$

Text uses "1" and "2" for "before", "after."

Take two objects A, B: they collide:



$\vec{v}_A, \vec{v}_B$ before

$\vec{v}_A', \vec{v}_B'$ after.

$$\vec{P}_{tot} = m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}_A' + m_B\vec{v}_B'.$$

Types of collisions:

Elastic collision: Total KE is conserved

$(KE_A + KE_B = KE'_A + KE'_B)$

→ Never completely true for macroscopic objects.

Inelastic collision: Some KE is lost to heat, sound, deformation, ...

Totally inelastic: objects stick together: This is the maximum possible energy loss.

Start in 1D (Note "v" can be + or −, it's <u>not</u> speed).

$$\left.\begin{aligned} \text{Say } V_A &= +2\tfrac{m}{s} \\ V_B &= -3\tfrac{m}{s} \end{aligned}\right\} \text{equal mass } m$$

Collision totally inelastic: stick together.

$$\left.\begin{aligned} \text{Before: } & p_{tot} = m V_A + m V_B \\ \text{After } & p_{tot} = 2mV' \end{aligned}\right\} \text{must be equal!}$$

$$m V_A + m V_B = 2mV'$$

$$\cancel{m}(+2) + \cancel{m}(-3) = 2\cancel{m}(V')$$

$$V' = -0.5 \, m/s.$$

Totally elastic: Say B is init. at rest, A has velocity V_A.

$$\cancel{m}V_A + \cancel{m}V_B = \cancel{m}V'_A + \cancel{m}V'_B \qquad \text{m's cancel only if equal!}$$

$$\frac{1}{2}\cancel{m}V_A^2 = \frac{1}{2}\cancel{m}V_A'^2 + \frac{1}{2}\cancel{m}V_B'^2$$