

October 19, 2011

Physics 131

Prof. E. F. Redish

■ Theme Music: Aimee Mann

Momentum

■ Cartoon: Pat Brady

Rose is Rose



Momentum: Definition



- We define momentum:

$$\vec{p} = m\vec{v}$$

- This is a way of defining “the amount of motion” an object has.
- Our “delta” form of N2 becomes

which we can rewrite as

$$\vec{F}^{net} = m \frac{\Delta \vec{v}}{\Delta t} = m \vec{a}$$

$$\vec{F}^{net} = \frac{\Delta(m\vec{v})}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t}$$

The Impulse-Momentum Theorem



- Newton 2

$$\vec{a} = \vec{F}^{net} / m$$

- Put in definition of a

$$\frac{d\vec{v}}{dt} = \frac{\vec{F}^{net}}{m}$$

- Multiply up by Δt

$$m\Delta\vec{v} = \vec{F}^{net} \Delta t$$

- Define Impulse

$$\vec{\mathcal{J}}^{net} = \vec{F}^{net} \Delta t$$

- Combine to get
Impulse-Momentum
Theorem

$$\Delta\vec{p} = \vec{\mathcal{J}}^{net}$$

Momentum Conservation: 1



- If two objects, A and B, interact with each other and with other (“external”) objects,

By the IMT

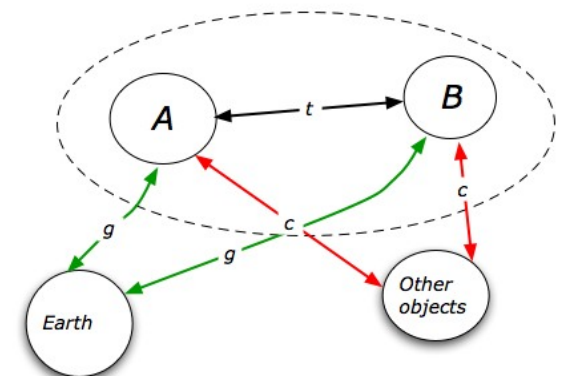
$$m_A \Delta \vec{v}_A = (\vec{F}_A^{ext} + \vec{F}_{B \rightarrow A}) \Delta t$$

$$m_B \Delta \vec{v}_B = (\vec{F}_B^{ext} + \vec{F}_{A \rightarrow B}) \Delta t$$

- Adding:

$$m_A \Delta \vec{v}_A + m_B \Delta \vec{v}_B = \left[\vec{F}_A^{ext} + \vec{F}_B^{ext} + (\vec{F}_{A \rightarrow B} + \vec{F}_{B \rightarrow A}) \right] \Delta t$$

$$\Delta(m_A \vec{v}_A + m_B \vec{v}_B) = \vec{F}_{AB}^{ext} \Delta t$$



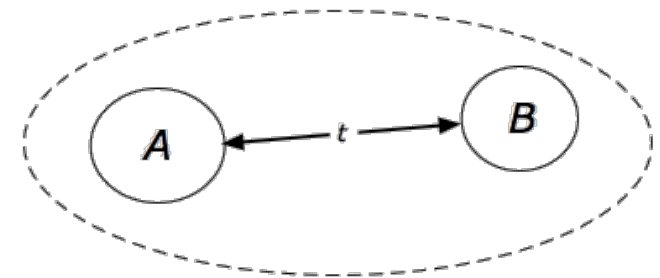
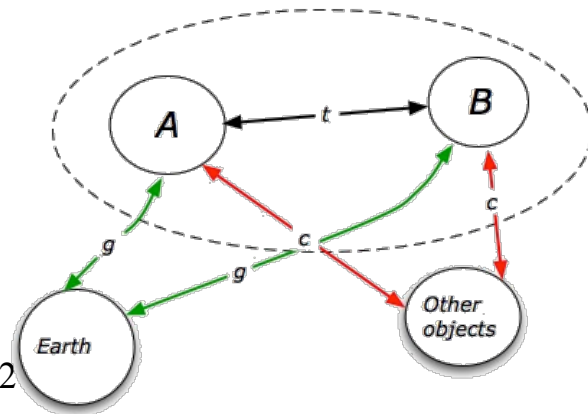
Momentum Conservation: 2



- So: If two objects interact with each other in such a way that the external forces on the pair cancel, then momentum is conserved.

$$\Delta(m_A \vec{v}_A + m_B \vec{v}_B) = 0$$

$$m_A \vec{v}_A^i + m_B \vec{v}_B^i = m_A \vec{v}_A^f + m_B \vec{v}_B^f$$



Reading question

- What does it mean when you say the total momentum of the system doesn't change but the individual momenta might? Is this looking at forces versus looking at mass times velocity? Can you give an example?
- In some cases the mass of an object can change after a collision. Does the linear momentum equation include this possibility? I am confused because the readings said that the mass can be included in the derivative in the force equation because it is constant. However, can it still be brought into the derivative if it is not constant?