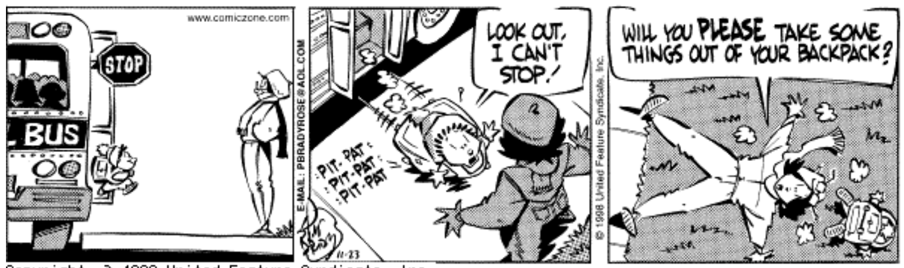
October 19, 2011 Physics 131 Prof. E. F. Redish

- **Theme Music:** **Aimee Mann**
  Momentum
- **Cartoon:** **Pat Brady**
  Rose is Rose



10/19/12 Physics 131 **1**

Momentum: Definition

- We define <u>momentum</u>:

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

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

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

which we can rewrite as

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

10/19/12 Physics 131 **3**

The Impulse-Momentum Theorem

- Newton 2 $\vec{a} = \vec{F}^{net} / m$
- Put in definition of *a* $\dfrac{d\vec{v}}{dt} = \dfrac{\vec{F}^{net}}{m}$
- Multiply up by Δt $m\Delta\vec{v} = \vec{F}^{net}\Delta t$
- Define Impulse $\vec{\mathscr{J}}^{net} = \vec{F}^{net}\Delta t$
- Combine to get Impulse-Momentum Theorem $\Delta\vec{p} = \vec{\mathscr{J}}^{net}$

10/19/12 Physics 131 4

Momentum Conservation: 1

- If two objects, A and B, interact with each other and with other ("external") objects, By the IMT

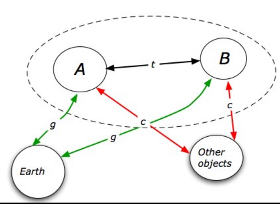
$$m_A \Delta\vec{v}_A = (\vec{F}_A^{ext} + \vec{F}_{B\to A})\Delta t$$

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

- Adding:

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

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



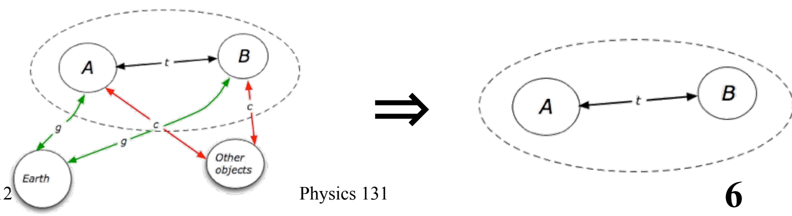
10/19/12 Physics 131

Momentum Conservation: 2

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

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

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



10/19/12 Physics 131 **6**

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?

10/19/12 Physics 131 **7**