Theme Music: Aimee Mann
Momentum

Cartoon: Pat Brady
Rose is Rose
The Impulse-Momentum Theorem

\[ \Delta (m_A \vec{v}_A) = \vec{F}_A^{net} \Delta t \]
Makeup Exam 1

■ Thursday, 10/22
  – Either 4-5 or 5-6.
  – You may come at either time.
  – If you show up and look at a copy of the exam, you are considered to have taken the test.

■ Physics, room 0405
LivePhoto Physics Series

Juggling

Performed by Wes Peden
www.airplayjugglers.com

Ball Mass = 105 g
29.97 Frames/Second

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Foothold ideas: Momentum

■ We define the momentum of an object, $A$:

\[ \vec{p}_A = m_A \vec{v}_A \]

■ This is a way of defining “the amount of motion” an object has.

■ Our “delta” form of N2 becomes

\[ \langle \vec{F}_A^{\text{net}} \rangle = m_A \frac{\Delta \vec{v}_A}{\Delta t} = m_A \langle \vec{a}_A \rangle \]

which we can rewrite as

\[ \langle \vec{F}_A^{\text{net}} \rangle = \frac{\Delta (m_A \vec{v}_A)}{\Delta t} = \frac{\Delta \vec{p}_A}{\Delta t} \]
Foothold idea:
The Impulse-Momentum Theorem

■ Newton 2
\[ \vec{a}_A = \frac{\vec{F}_{A \text{net}}}{m_A} \]

■ Put in definition of \( a \)
\[ \frac{d\vec{v}_A}{dt} = \frac{\vec{F}_{A \text{net}}}{m_A} \]

■ Multiply up by \( \Delta t \)
\[ m_A \Delta \vec{v}_A = \langle \vec{F}_{A \text{net}} \rangle \Delta t \]

■ Define Impulse
\[ \mathcal{J}^\text{net}_A = \langle \vec{F}_{A \text{net}} \rangle \Delta t \]

■ Combine to get Impulse-Momentum Theorem for any object \( A \)
\[ \Delta \vec{p}_A = \mathcal{J}^\text{net}_A \]
Rethinking the juggler

As the juggler throws the ball up, the ball rises, and then falls, how is momentum added to or taken away from the ball?

$$\Delta \left( m_B \vec{v}_B \right) = \left\langle \vec{F}^{\text{net}}_B \right\rangle \Delta t$$
Example: Recoil

■ When an object at rest emits a part of itself, in order to conserve momentum, it must go back in the opposite direction.

■ What forces are responsible for this motion?

(object goes backwards)