Lecture 21
(Conservation of Momentum)

Physics 160-01 Fall 2012

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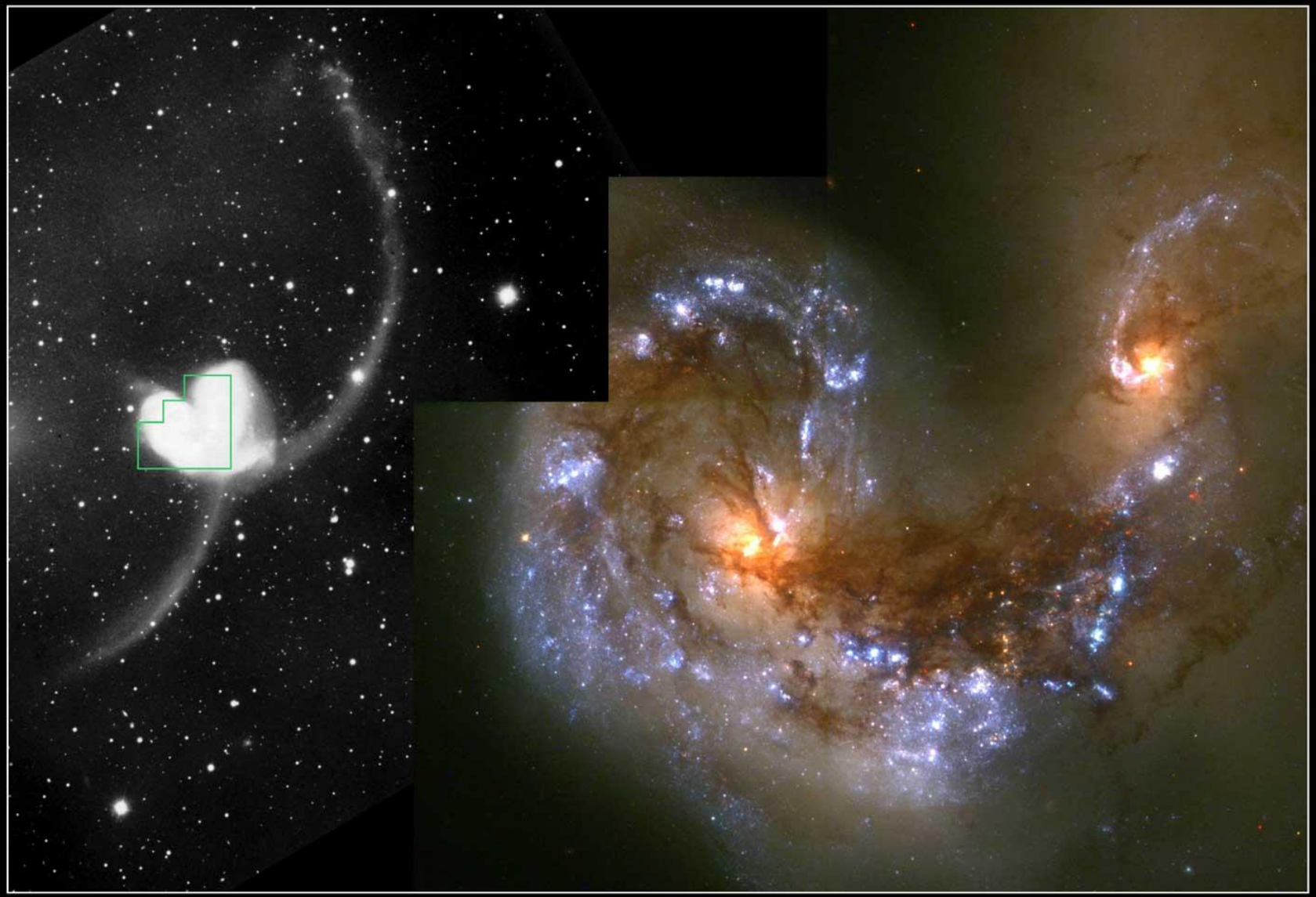
Collisions

- Collisions are interactions between bodies.
- Generally, there is a large force acting over a short period of time:
  - Pool balls, or bat and ball.
  - Bullet strikes a wooden target.
  - Meteor strikes the earth.
  - Cosmic ray hits an atom in the atmosphere.
- Sometimes collisions take a longer period of time:
  - Space probe “sling-shots” around a planet or sun.
  - Galaxies collide.



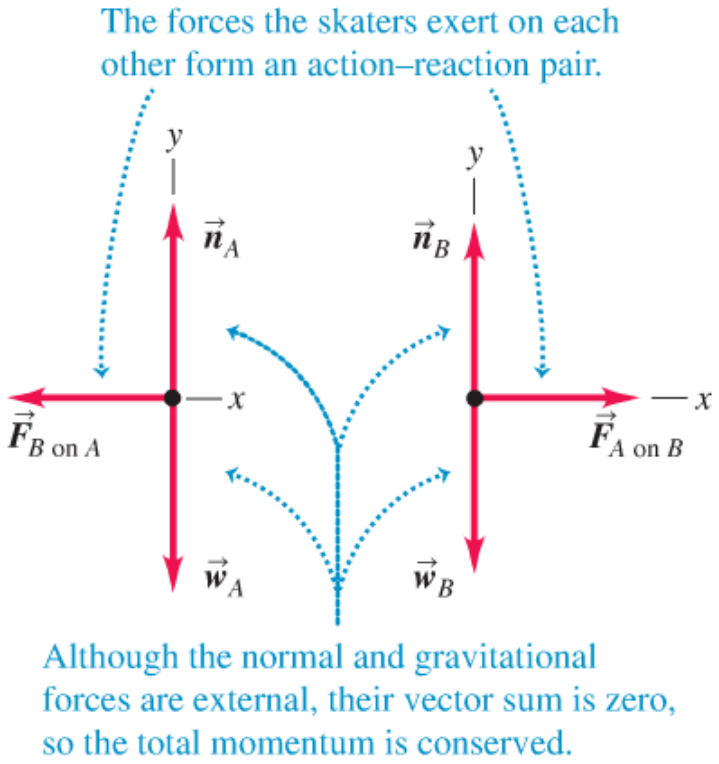
Colliding Galaxies NGC 4038 and NGC 4039

Hubble Space Telescope • Wide Field Planetary Camera 2

PRC97-34a • ST ScI OPO • October 21, 1997 • B. Whitmore (ST ScI) and NASA

Collisions

- In many circumstances, collisions of a "system" of bodies (can be more than two) has no NET forces acting on them from outside of the system.

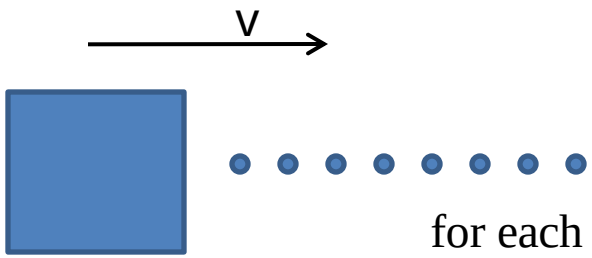


Collisions

- In that case, since $\vec{J} \equiv \int_{t_1}^{t_2} \vec{F}_{Net} dt = \vec{p}_2 - \vec{p}_1$
- Then $p_2 = p_1$, or better stated, the momentum *of the system* remains constant.
- It does NOT mean that the kinetic energy of the system is constant…

Drag Force

- Series of collisions:



for n particles hitting in time Δt,

$\Delta\vec{p} = -nm\vec{v}$

so,

$\vec{J} = -nm\vec{v}$

so,

$$\vec{F}_{Avg} = \frac{-nm\vec{v}}{\Delta t} = -\frac{n}{\Delta t}m\vec{v}$$

but,

$$\frac{nm}{\Delta t} = \rho A|\vec{v}|$$

so,

$$\vec{F}_{Avg} = -\rho A v^2$$

for each particle,

$\vec{p}_i = 0$

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

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

Collisions

- Two general categories of collisions:
- Elastic –
  - Both momentum and kinetic energy are conserved.
- Inelastic –
  - Only momentum is conserved.
- In general a collision is somewhere between these (not all kinetic energy is “lost” in inelastic collisions).

CPS 20-1

- Given one ball with initial velocity in the Newton's cradle, how many balls will have a non-zero final velocity on the other side?
- A) 1
- B) 2
- C) 3
- D) 4
- E) It depends

Problem 8.84

8.84. A 5.00-g bullet is shot *through* a 1.00-kg wood block suspended on a string 2.00 m long. The center of mass of the block rises a distance of 0.45 cm. Find the speed of the bullet as it emerges from the block if its initial speed is 450 m/s.

- For most students, the problem here is "Where is momentum conserved and where is energy conserved?"