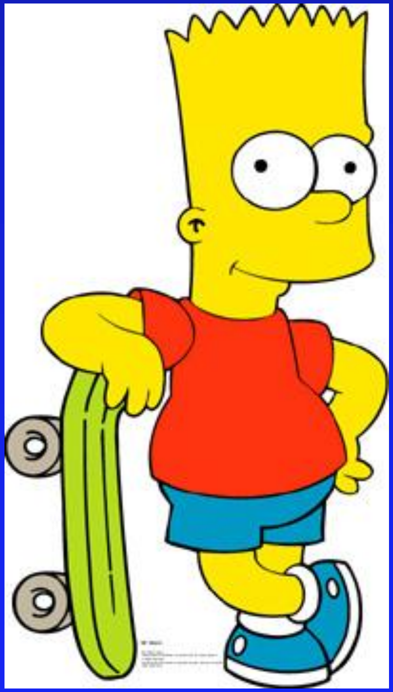
Exam II

Physics 101: Lecture 12
Collisions and Explosions

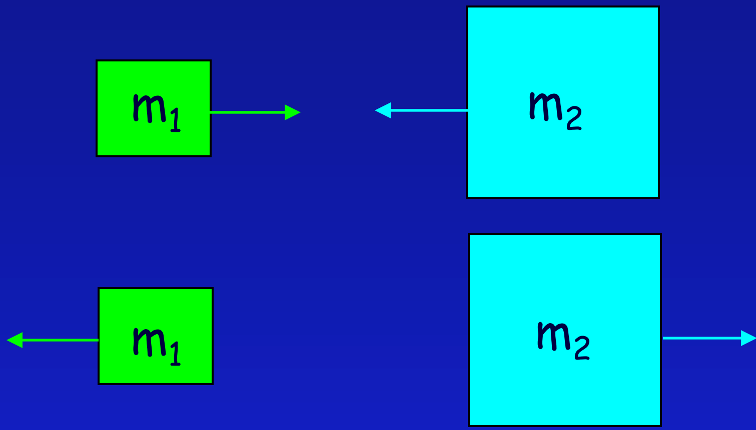
- Today's lecture covers Textbook Sections 7.5 - 7.8



Overview of Semester

- Newton's Laws
  - ➔ $\Sigma F = m a$
- Work-Energy
  - ➔ $\Sigma F = m a$ multiply both sides by d
  - ➔ $\Sigma W = \Delta KE$ Energy is "conserved"
  - ➔ Useful when know Work done by forces
- Impulse-Momentum
  - ➔ $\Sigma F = m a$ multiply both sides by Δt
  - ➔ $\Sigma I = \Delta p$ Momentum is "conserved"
  - ➔ Useful when EXTERNAL forces are known
  - ➔ Works in each direction independently

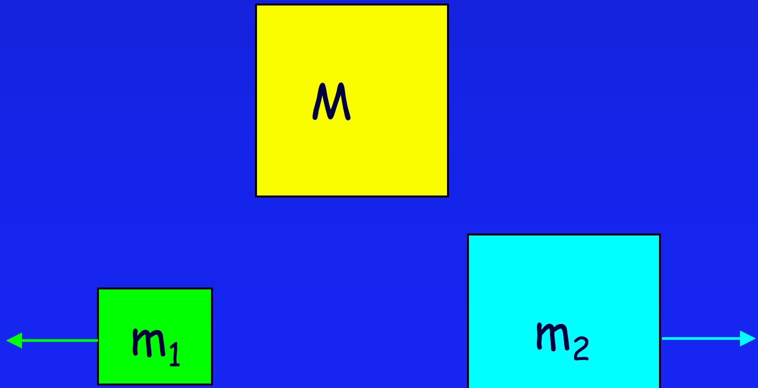
Collisions



"before"

"after"

Explosions



"before"

"after"

Procedure

- Draw "before", "after"
- Define system so that $F_{ext} = 0$
- Set up axes
- Compute P_{total} "before"
- Compute P_{total} "after"
- Set them equal to each other

ACT

A railroad car is coasting along a horizontal track with speed V when it runs into and connects with a second identical railroad car, initially at rest. Assuming there is no friction between the cars and the rails, what is the speed of the two coupled cars after the collision?

A. V

B. V/2

C. V/4

D. 0

$\Sigma P_{initial} = \Sigma P_{final}$

$M V = M V_f + M V_f$

$V = 2V_f$

$V_f = V/2$

Demo with gliders

ACT

What physical quantities are conserved in the above collision?

A. Only momentum is conserved ← CORRECT
B. Only total mechanical energy is conserved
C. Both are conserved
D. Neither are conserved

Mechanical Energy = Kinetic Energy + Potential E = $\frac{1}{2} m v^2 + 0$

$K_{initial} = \frac{1}{2} m v^2$ $K_{final} = \frac{1}{2} m (v/2)^2 + \frac{1}{2} m (v/2)^2 = \frac{1}{4} m v^2$

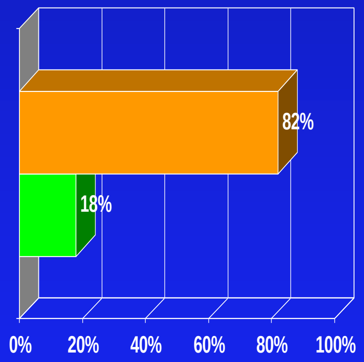
- Elastic Collisions: collisions that conserve **mechanical** energy
- Inelastic Collisions: collisions that do not conserve **mechanical** energy
  - * Completely Inelastic Collisons: objects stick together

Preflight 1 & 2

Is it possible for a system of two objects to have zero total momentum and zero total kinetic energy after colliding, if both objects were moving before the collision?

1. YES ← CORRECT

2. NO

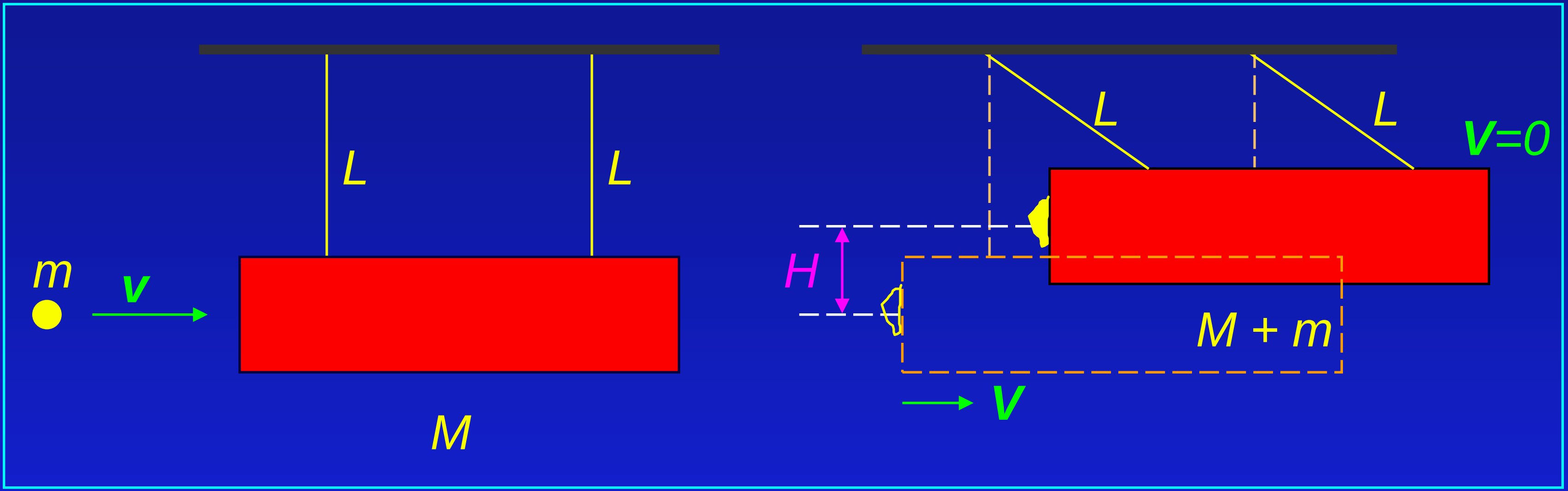


"Two cars crashing in a perfect inelastic collision."

"If two African laden swallows were flying towards each other with an equal magnitude of momentum, and they collided completely inelastically, becoming a monster two-headed African laden swallow, then the total kinetic energy after the collision is zero, and the sum of the momentums is also zero."

Demo with gliders

Ballistic Pendulum



A projectile of mass *m* moving horizontally with speed *v* strikes a stationary mass *M* suspended by strings of length *L*. Subsequently, *m + M* rise to a height of *H*.

Given *H*, M and m what is the initial speed *v* of the projectile?

Collision Conserves Momentum

$0 + m\,v = (M+m)\,V$

After, Conserve Energy

$\frac{1}{2}(M+m)\,V^2 + 0 = 0 + (M+m)\,g\,H$

$V = \mathrm{sqrt}(2\,g\,H)$

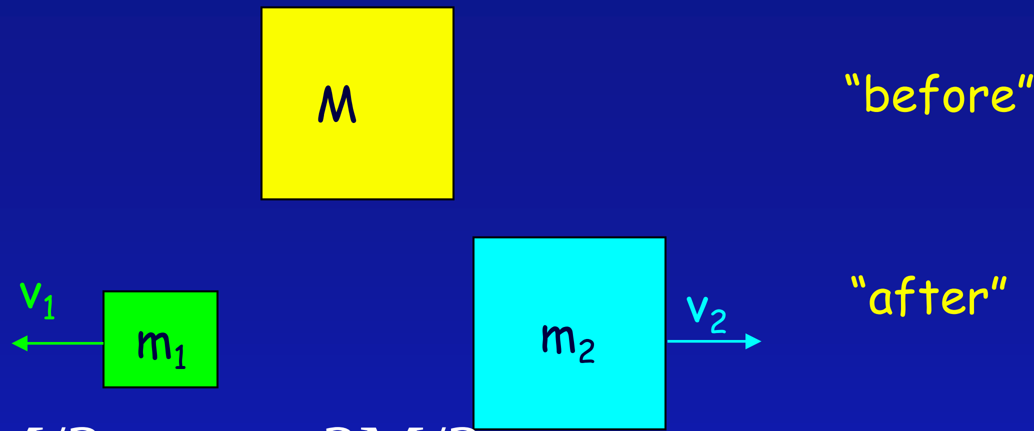
Combine: $$v = \frac{M+m}{m}\sqrt{2gH}$$

demo

See I.E. 1 in homework

Explosions

A=1, B=2, C=same



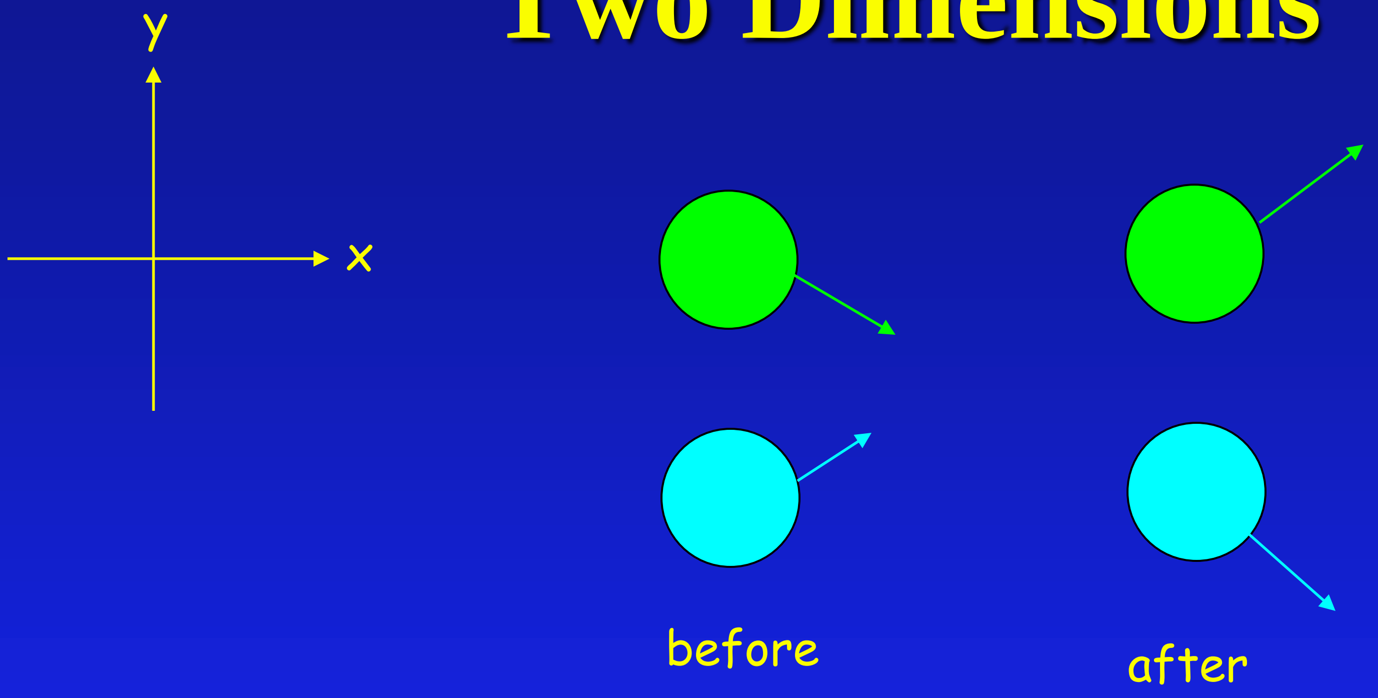
- Example: $m_1 = M/3 \quad m_2 = 2M/3$
- Which block has larger |momentum|?
  - * Each has same |momentum|

$0 = p_1 + p_2$

$p_1 = -p_2$

- Which block has larger speed?
  - * mv same for each $\Rightarrow$ smaller mass has larger velocity
- Which block has larger kinetic energy?
  - * $KE = mv^2/2 = m^2v^2/2m = p^2/2m$
  - * $\Rightarrow$ smaller mass has larger KE
- Is mechanical (kinetic) energy conserved?
  - * NO!!

Collisions or Explosions in Two Dimensions

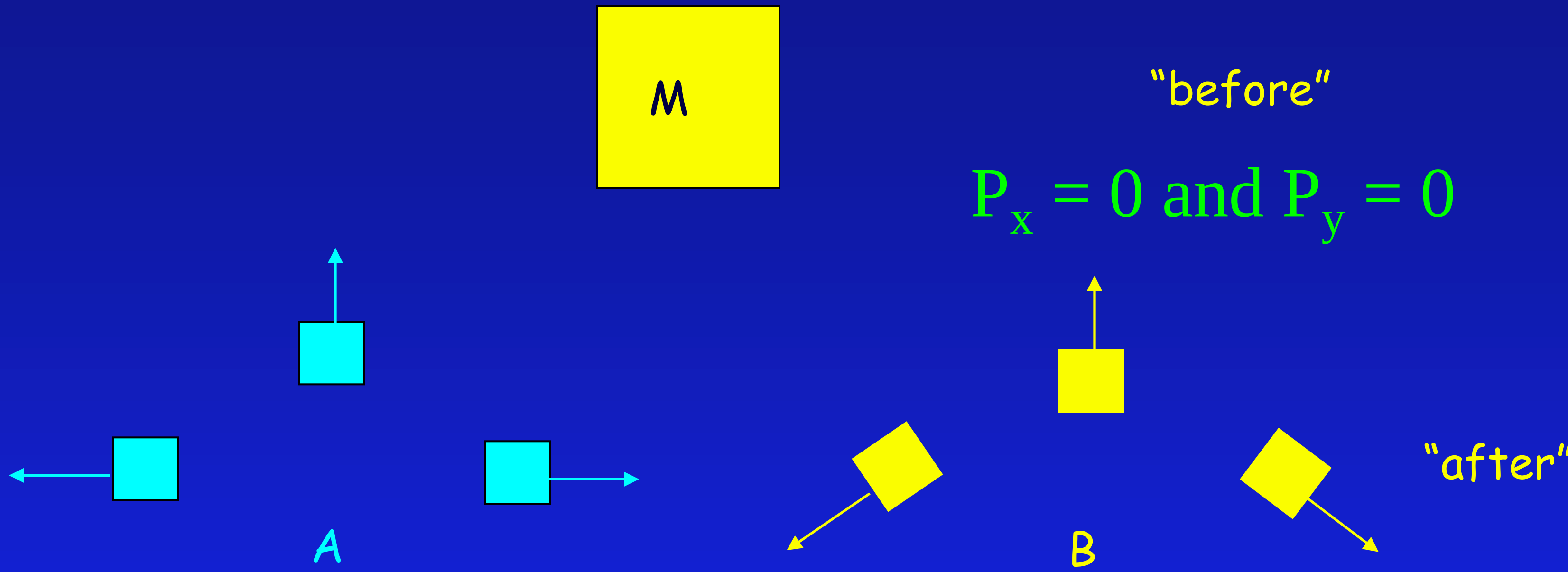


- $P_{total,x}$ and $P_{total,y}$ independently conserved

  $P_{total,x,before} = P_{total,x,after}$

  $P_{total,y,before} = P_{total,y,after}$

Explosions ACT



$P_x = 0$ and $P_y = 0$

$\Sigma P_x = 0$, but $\Sigma P_y > 0$

$\Sigma P_x = 0$, and $\Sigma P_y = 0$

Which of these is possible? (Ignore friction and gravity)

A

B

C =both

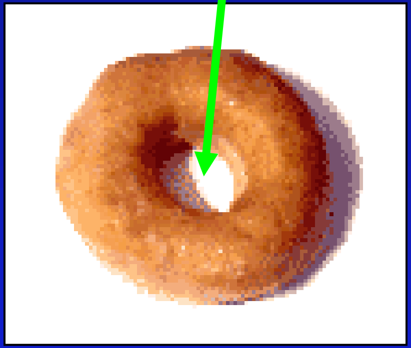
D = Neither

Center of Mass

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{\sum m_i}$$

Center of Mass = Balance point

Center of Mass!



- Shown is a yummy doughnut. Where would you expect the center of mass of this breakfast of champions to be located?

in my stomach

The fact that that doughnut is "yummy" is debatable if you ask me. I prefer mine with chocolate frosting and some sort of filling. The center of mass then is much easier to figure out. It's clearly the center of the jelly or custard filling area.

doughnuts don't have a center of mass because they are removed and sold as doughnut hole

Center of Mass

$P_{tot} = M_{tot}V_{cm}$ $F_{ext}\Delta t = \Delta P_{tot} = M_{tot}\Delta V_{cm}$

So if $F_{ext} = 0$ then V_{cm} is constant

Also: $F_{ext} = M_{tot}a_{cm}$

Center of Mass of a system behaves in a SIMPLE way

- moves like a point particle!
- velocity of CM is unaffected by collision if $F_{ext} = 0$

(pork chop demo)

Summary

- Collisions and Explosions
  - •Draw "before", "after"
  - •Define system so that $F_{ext} = 0$
  - •Set up axes
  - •Compute P_{total} "before"
  - •Compute P_{total} "after"
  - •Set them equal to each other

- Center of Mass (Balance Point)

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{\sum m_i}$$