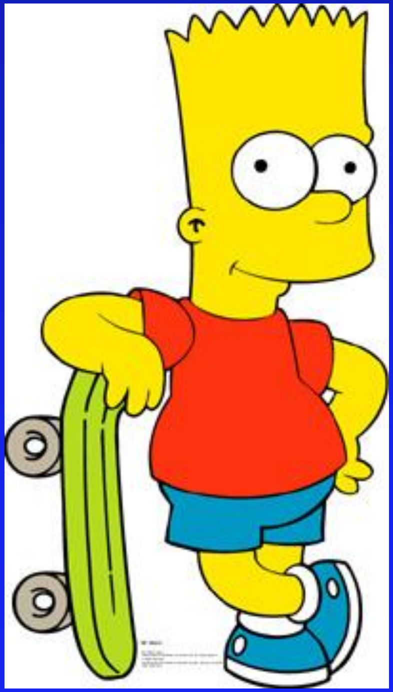
Exam II

Physics 101: Lecture 12
Collisions and Explosions

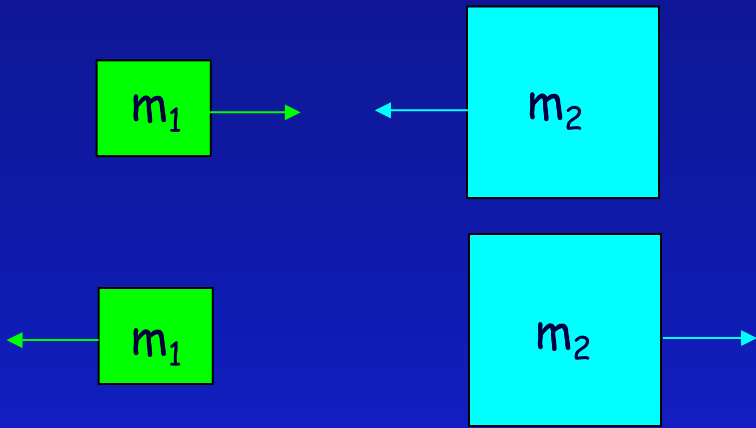
- Today's lecture covers Textbook Sections 7.5 - 7.8



Overview of Semester

- Newton's Laws
  - ➔ $F_{Net} = m\,a = \Delta p/\Delta t$
- Work-Energy
  - ➔ $F_{Net} = m\,a$ multiply both sides by d
  - ➔ $W_{Net} = \Delta K$ Energy is "conserved"
  - ➔ Useful when know Work done by forces
- Momentum Conservation
  - ➔ $F_{Net}\Delta t = \Delta p$
  - ➔ $F_{Net} = 0 \Rightarrow \Delta p = 0$ Momentum is "conserved"
  - ➔ Useful when EXTERNAL forces are known
  - ➔ Works in each direction independently

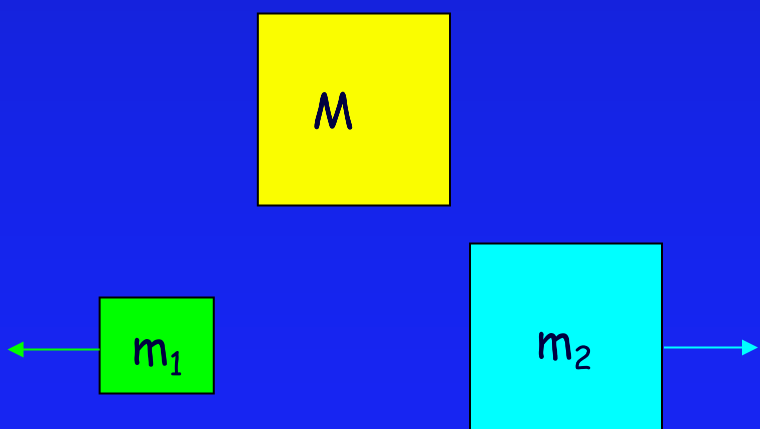
Collisions



"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

$$P_{initial} = P_{final}$$

$$M\,V = M\,V_f + M\,V_f$$

$$V = 2V_f$$

$$V_f = V/2$$

Demo with gliders

ACT

What physical quantities are conserved in the above collision?

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

$$E = K + U = \tfrac{1}{2}\, m\, v^2 + 0$$

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

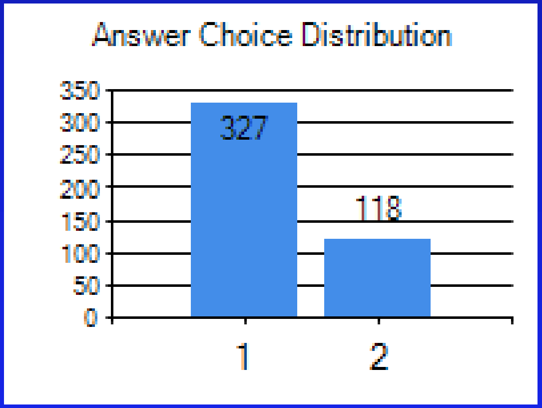
- Elastic Collisions: collisions that conserve **Kinetic** energy
- Inelastic Collisions: collisions that do not conserve **Kinetic** energy
  - * Completely Inelastic Collisons: objects stick together

Checkpoint questions 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."

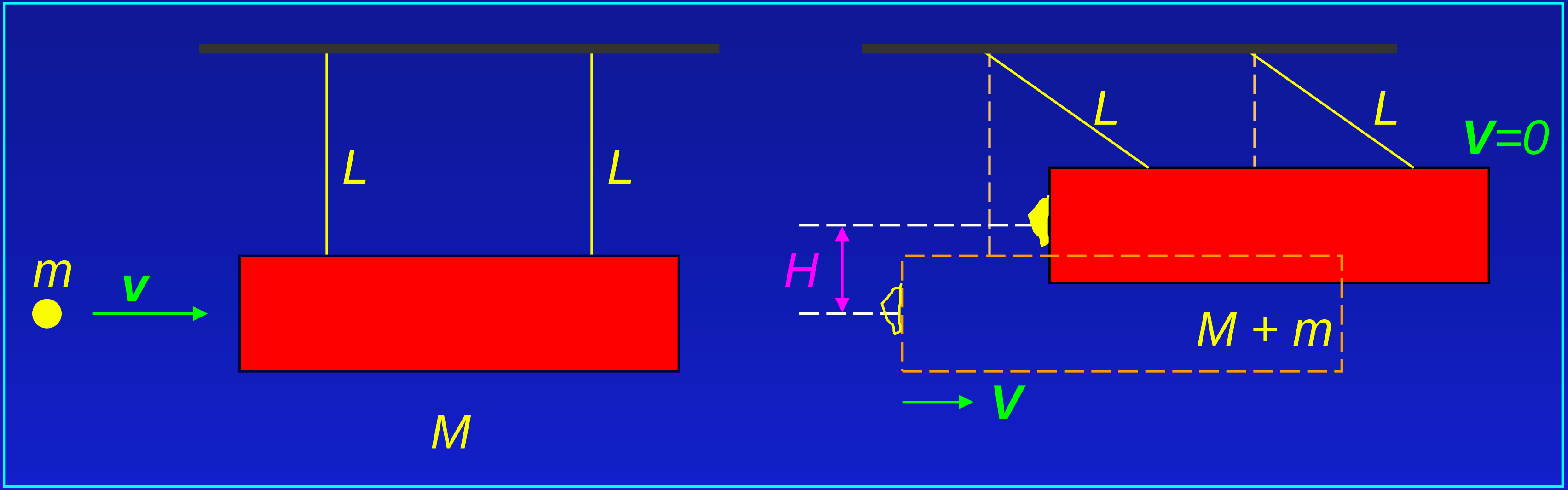
Typical wrong reasons:

"Two ice skaters pushing off each other."

"If the two objects are moving in opposite directions but have the same mass and velocity, they should have a velocity of 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

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

After, Conserve Energy

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

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

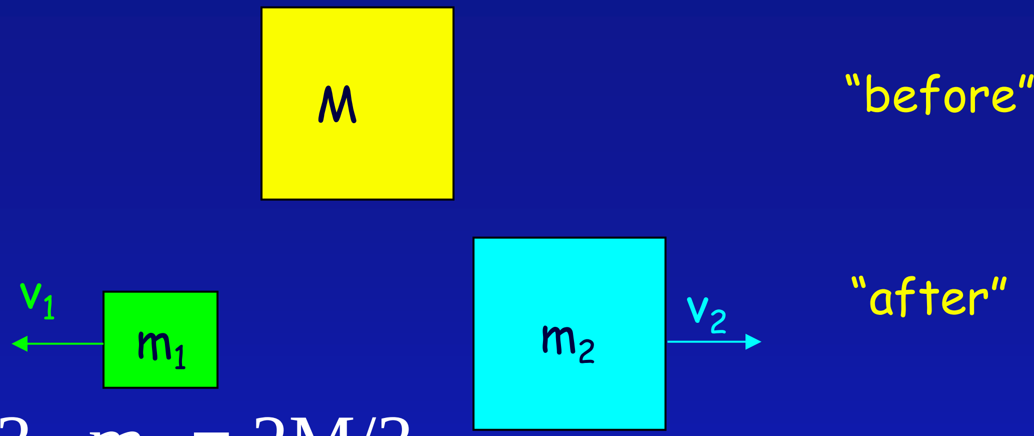
Combine: $$v = \frac{M+m}{m}\sqrt{2gH}$$

demo

See I.E. 1 in homework

Explosions

A=1, B=2, C=same

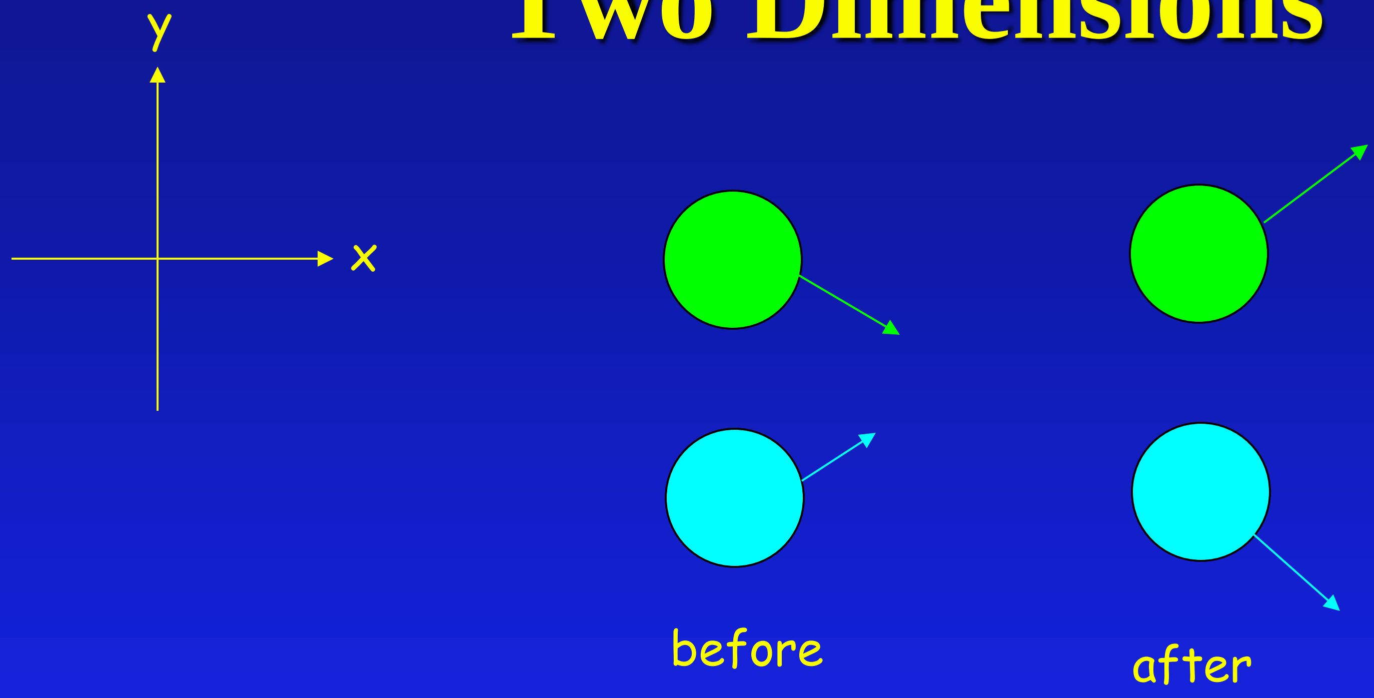


- Example: $m_1 = M/3 \quad m_2 = 2M/3$
- Which block has larger |momentum|?
  - * Each has same |momentum|

$0 = p_1 + p_2$
$p_1 = -p_2$

- 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

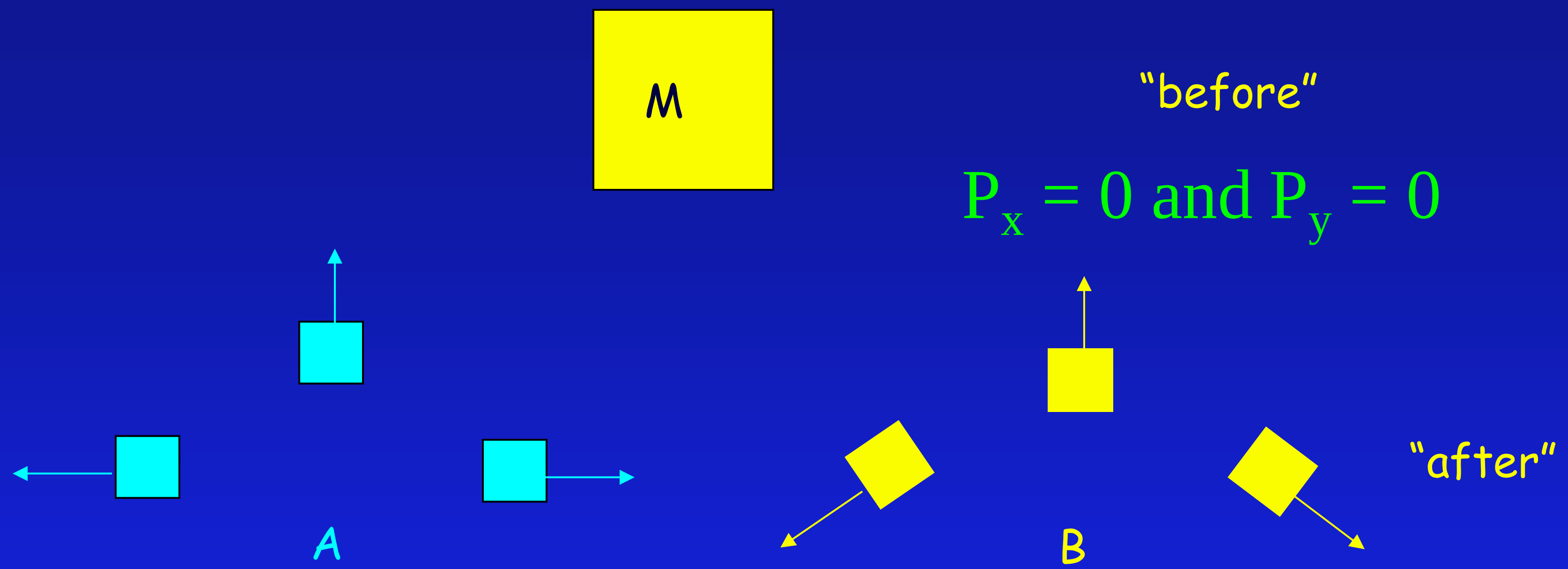


- $P_{total,x}$ and $P_{total,y}$ independently conserved

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

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

Explosions ACT



$P_{Net,\,x} = 0$, but $P_{Net,\,y} > 0$

$P_{Net,\,x} = 0$, and $P_{Net,\,y} = 0$

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

A

B ←

C =both

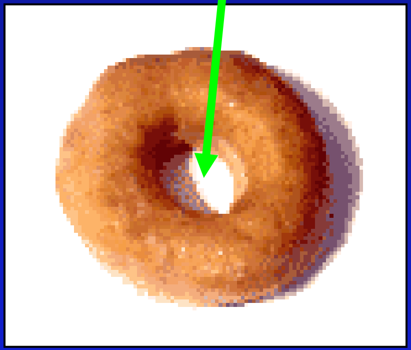
D = Neither

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?

Typical wrong answer:

evenly distributed around the doughnut

in my stomach

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

Center of Mass

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

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)

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