Exam II

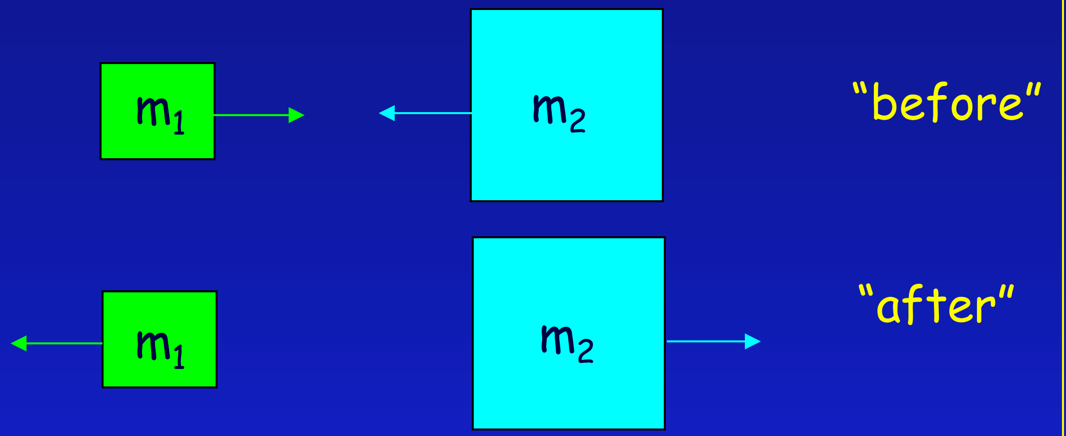
Physics 101: Lecture 12
Collisions and Explosions

- Today's lecture covers Textbook Sections 7.5 - 7.8

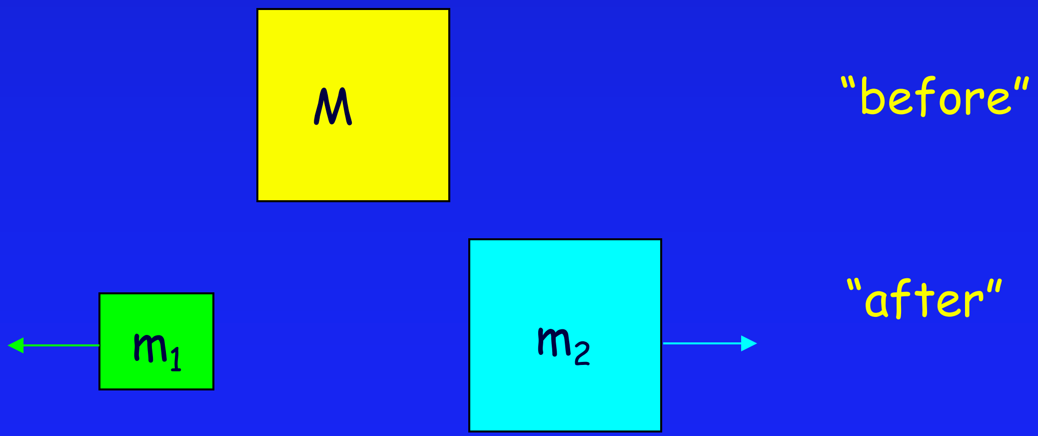
Overview of Semester

- 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



Explosions



Procedure

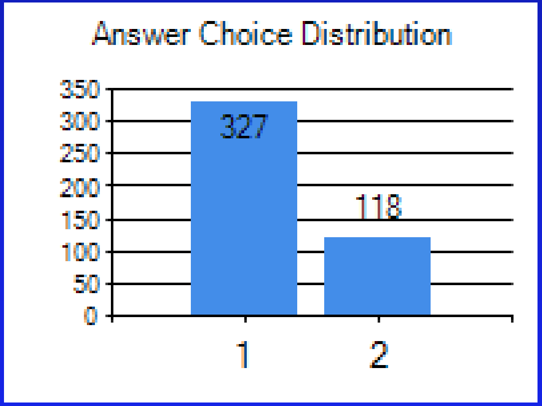
- Draw "before", "after"
- Define system so that $F_{ext} = 0$
- Set up axes
- Compute P_{total} "before"
- Compute P_{total} "after"
- Set them equal to each other

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."

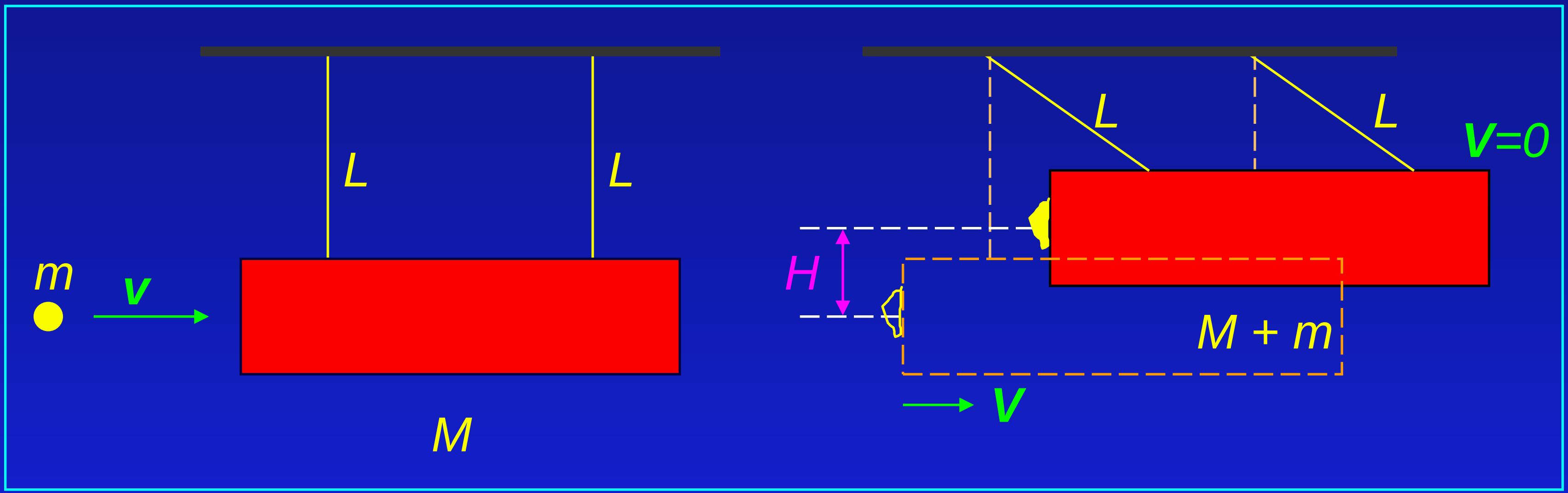
Typical wrong reasons:

"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

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

$V = \mathrm{sqrt}(2gH)$

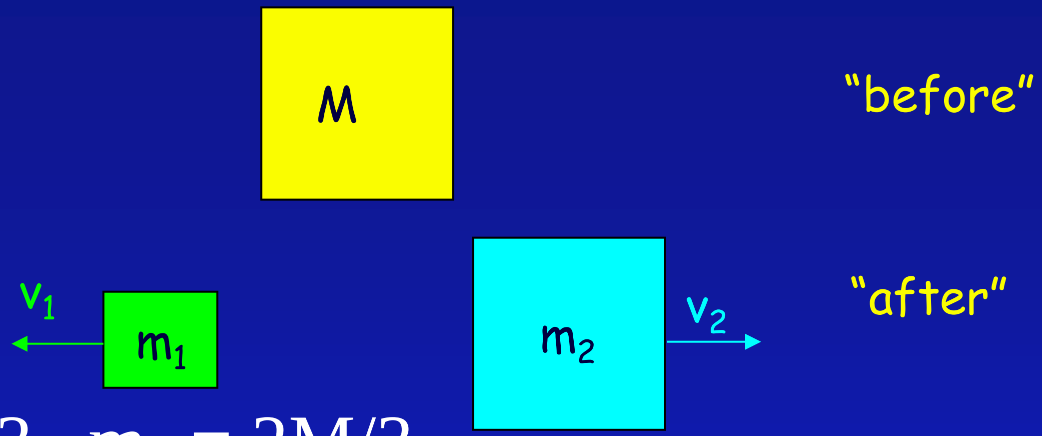
Combine: $v = \frac{M+m}{m}\sqrt{2gH}$

demo

See I.E. 1 in homework

Explosions

A=1, B=2, C=same

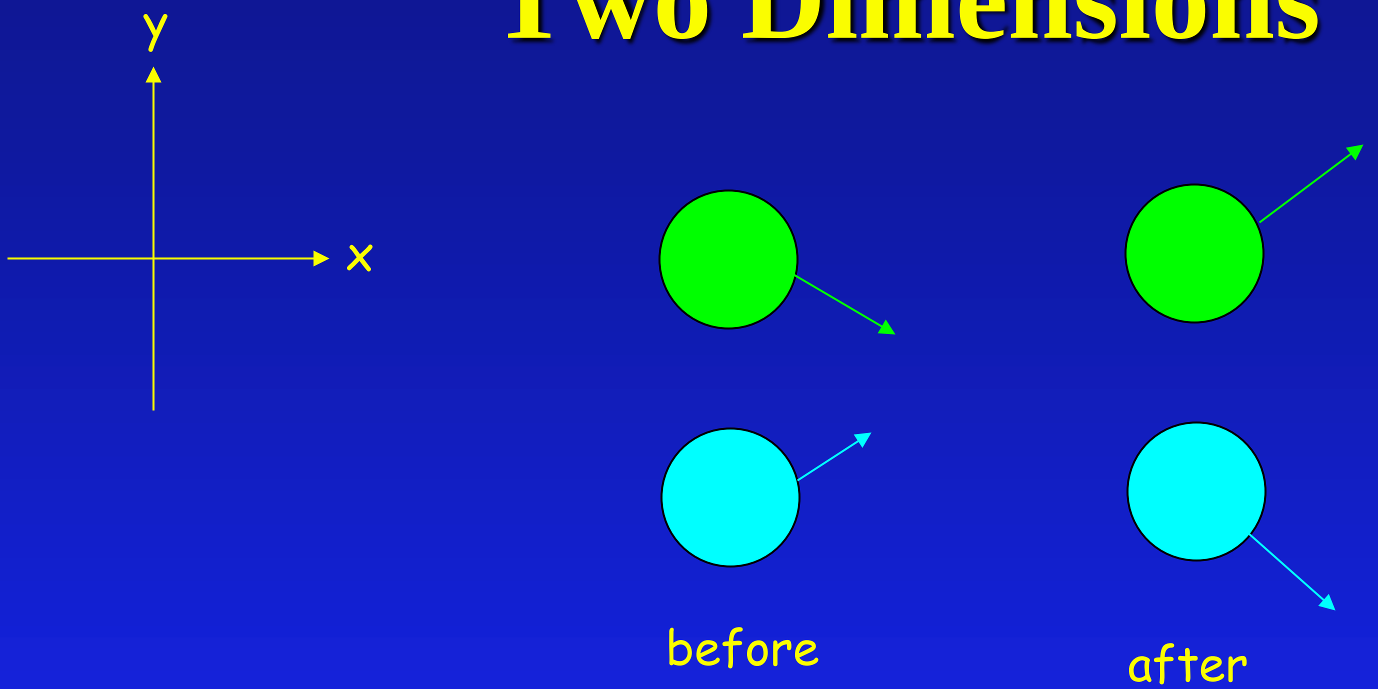


- Example: $m_1 = M/3$ $m_2 = 2M/3$
- Which block has larger |momentum|?
  - * Each has same |momentum|

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

- 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

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

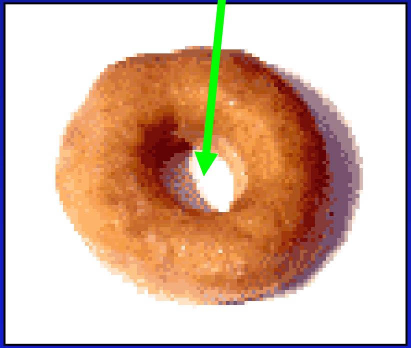
  $P_{total,y,before} = P_{total,y,after}$

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

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

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)

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