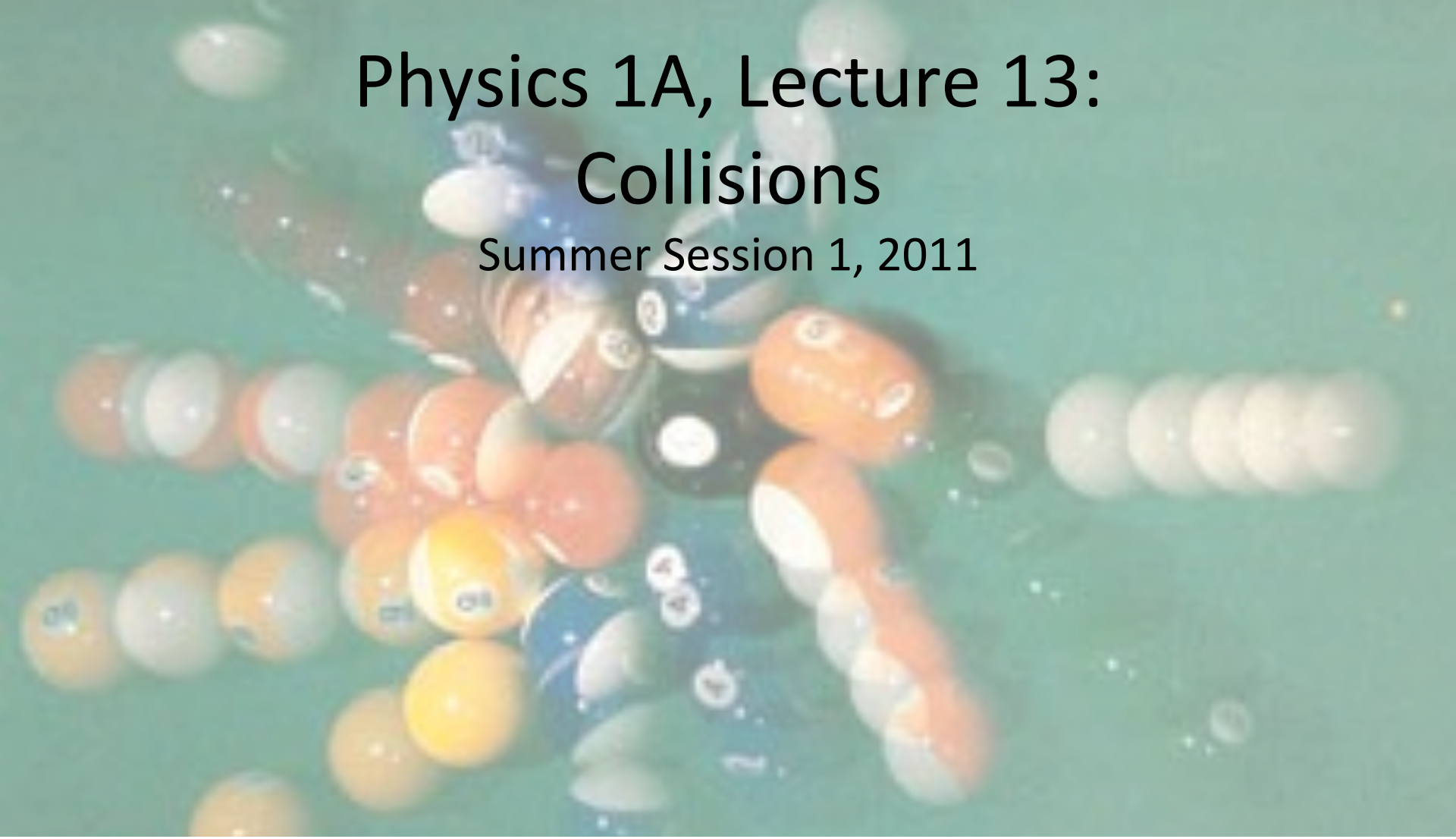


Physics 1A, Lecture 13: Collisions

Summer Session 1, 2011

The quiz will commence at 9:33 AM.

Key Questions: (Discuss with neighbors before quiz)

1) What is the difference between elastic and inelastic collisions?
2) What type of collisions conserve momentum?
3) What type of collisions conserve energy?

Reading Quiz 11-1

Elastic collisions are when two things _____.
Inelastic collisions are when two things _____.

A) bounce apart; come to a stop

B) bounce apart; stick together

C) stick together; bounce apart

D) used to be attached; stick together

E) stick together; used to be attached

Reading Quiz 11-2

- What type of collisions conserve momentum?

A) Elastic only.

B) Inelastic only.

C) Momentum is always conserved.

D) Momentum is conserved as long as there is motion both before and after a collision.

E) Momentum is conserved as long as there are no external forces.

Reading Quiz 11-3

- What type of collisions conserve energy?

A) Elastic only.

B) Inelastic only.

C) Energy is always conserved.

D) Energy is conserved as long as there is motion both before and after a collision.

E) Energy is conserved as long as there are no external forces.

Announcements

- Clicker/Reading Quiz and Quiz grades online
- Homework 5 due Wednesday at **4pm**
- Extra homework (even numbered answers) are posted
- Fill out student survey
- Tomorrow deadline to drop with W
- Office hours today at noon

Final Exam this Friday

- 30 multiple choice questions, 3 hours
  - 15 will be from this week's material
  - 15 will be from the previous 4 weeks.

- Review old homework, reading quizzes, clickers, and quizzes.

- No make-up finals

Anonymous Poll

- Have you listened to the podcast of this class?

A) I didn't know that you have been podcasting.
B) I knew about it but I didn't check it out.
C) I tried it once just to see what it was like.
D) I tried it out a couple of times.
E) I've been using it a lot.

Anonymous Poll

- Did you run out of time on last week's quiz?

A) Not really. I was done when I turned it in.
B) Kind of. I was done, but I probably could have caught some mistakes if I had more time.
C) Yes. I didn't finish working on the problems.
D) Yes. I didn't even try some of the problems.

Momentum

- Linear momentum:

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

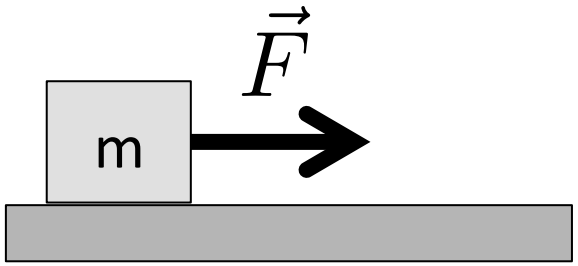
- Impulse, the change in momentum

$$\vec{I} = \Delta\vec{p} = \vec{F}\Delta t$$

- F is in the direction of the displacement

- Example:

You push on a 1 kg box that is at rest with a force of 1 N for 5 s. What is v_F?



Comparing Impulse to Work

Impulse:

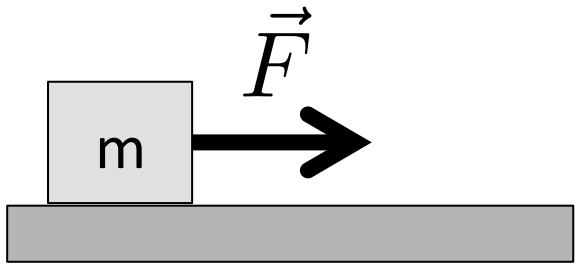
$$\vec{I} = \vec{F}\Delta t$$

- Tells us the change in momentum
- Impulse is a vector

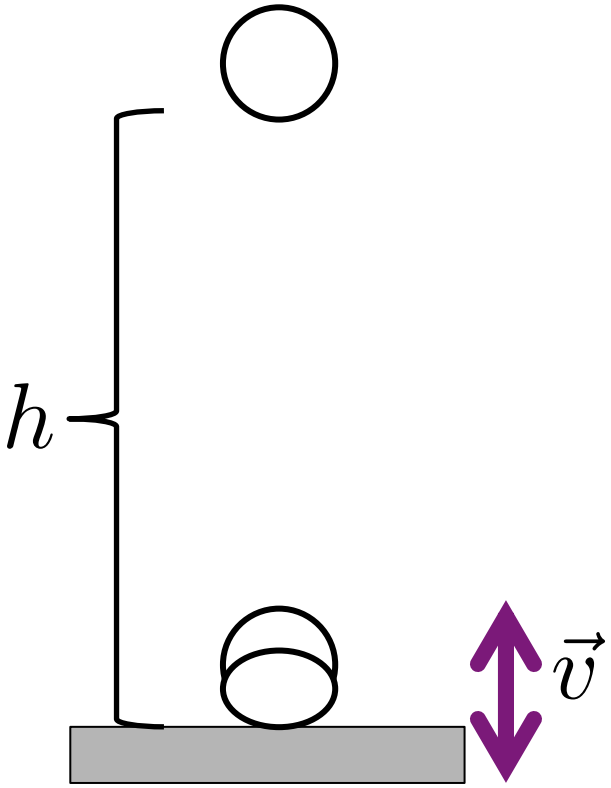
Work:

$$W = \vec{F} \cdot \Delta\vec{x}$$

- Tells us the change in energy
- Work is a scalar



Bouncing ball



No energy lost to the floor during the bounce

The average force exerted by the ball on the floor:

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$$

$$\vec{F} = \frac{d\vec{p}}{dt} = \frac{d(m\vec{v})}{dt}$$

$$= m \cdot \frac{d\vec{v}}{dt} + \vec{v} \cdot \frac{dm}{dt}$$

$$= m\vec{a}$$

Clicker Question 11-1

A 1 kg ball is thrown horizontally towards a wall with a speed of 10 m/s. The initial velocity is chosen to be the positive x-direction for this question. The ball horizontally rebounds back from the wall with a speed of 10 m/s in the negative x-direction. What is the change in momentum, Δp, of the ball?

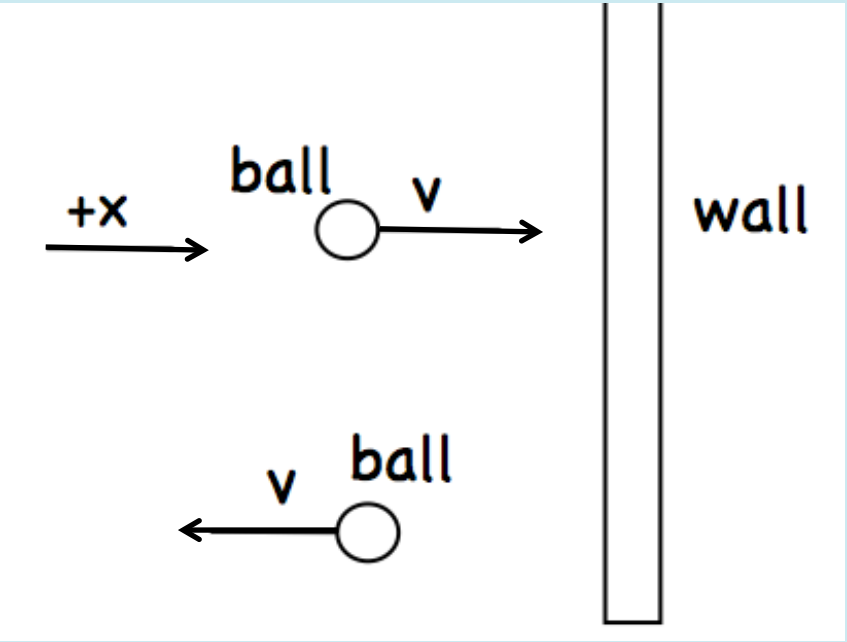
A) 0 kg m/s î.

B) 10 kg m/s î.

C) –10 kg m/s î.

D) 20 kg m/s î.

E) –20 kg m/s î.



Think about it…

- Besides keeping you attached to the car, how do airbags and seat belts help during a car accident?

$$\vec{I} = \Delta\vec{p}$$
$$= \vec{F}\Delta t$$

Isolated systems

- The total momentum is conserved for *both*:

<u>Elastic collisions</u>

- Energy conserved!

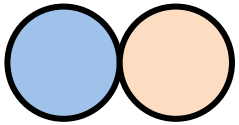
Bounce apart:

<u>Inelastic collisions</u>

- Energy *not* conserved!

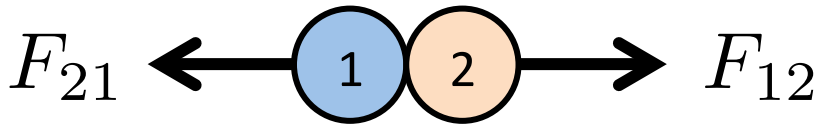
Collide together and stick:

Throwing stuff / explosions:



Momentum conservation (no external forces)

- Newton's Third Law:



- Δt is the same for both masses
- Impulse is the same for both masses:

$$\vec{I}_1 = \vec{F}_{21}\Delta t = -\vec{F}_{12}\Delta t = -\vec{I}_2$$

- Change in momentum is the same for each:

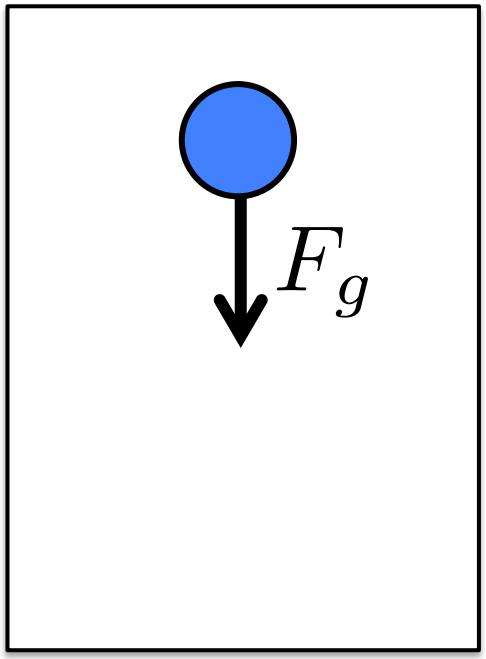
$$\Delta\vec{p}_1 = -\Delta\vec{p}_2$$

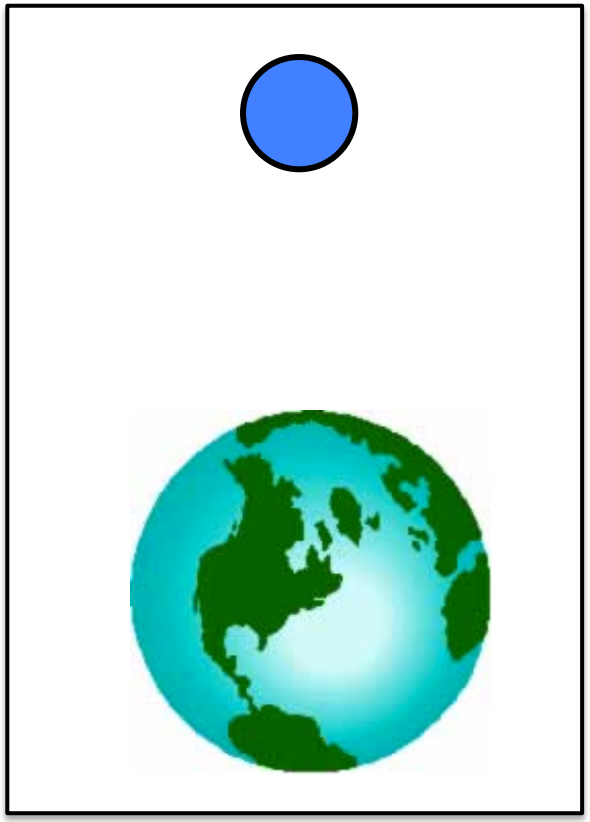
$$\vec{p}_{(1f)} - \vec{p}_{(1i)} = -\left(\vec{p}_{(2f)} - \vec{p}_{(2i)}\right)$$

$$\vec{p}_{tot,i} = \vec{p}_{(1i)} + \vec{p}_{(2i)} = \vec{p}_{(1f)} + \vec{p}_{(2f)} = \vec{p}_{tot,f}$$

Think about it…

A mass in free fall gains more and more speed as it falls towards earth. Is momentum conserved?





Example problem

A 3,000 kg truck traveling at 5.0 m/s collides head on with a 1,500 kg car traveling at 15 m/s. If they stick together after the collision, what is their mutual velocity?

- Is energy conserved? Is momentum conserved?
- What is the initial momentum?
- What is the final momentum?
- Solve for the unknown.

Elastic collisions

- Conserve momentum:

$$m_1\vec{v}_{(1i)} + m_2\vec{v}_{(2i)} = m_1\vec{v}_{(1f)} + m_2\vec{v}_{(2f)}$$

- Conserve energy:

$$\frac{1}{2}m_1(v_{(1i)})^2 + \frac{1}{2}m_2(v_{(2i)})^2 = \frac{1}{2}m_1(v_{(1f)})^2 + \frac{1}{2}m_2(v_{(2f)})^2$$

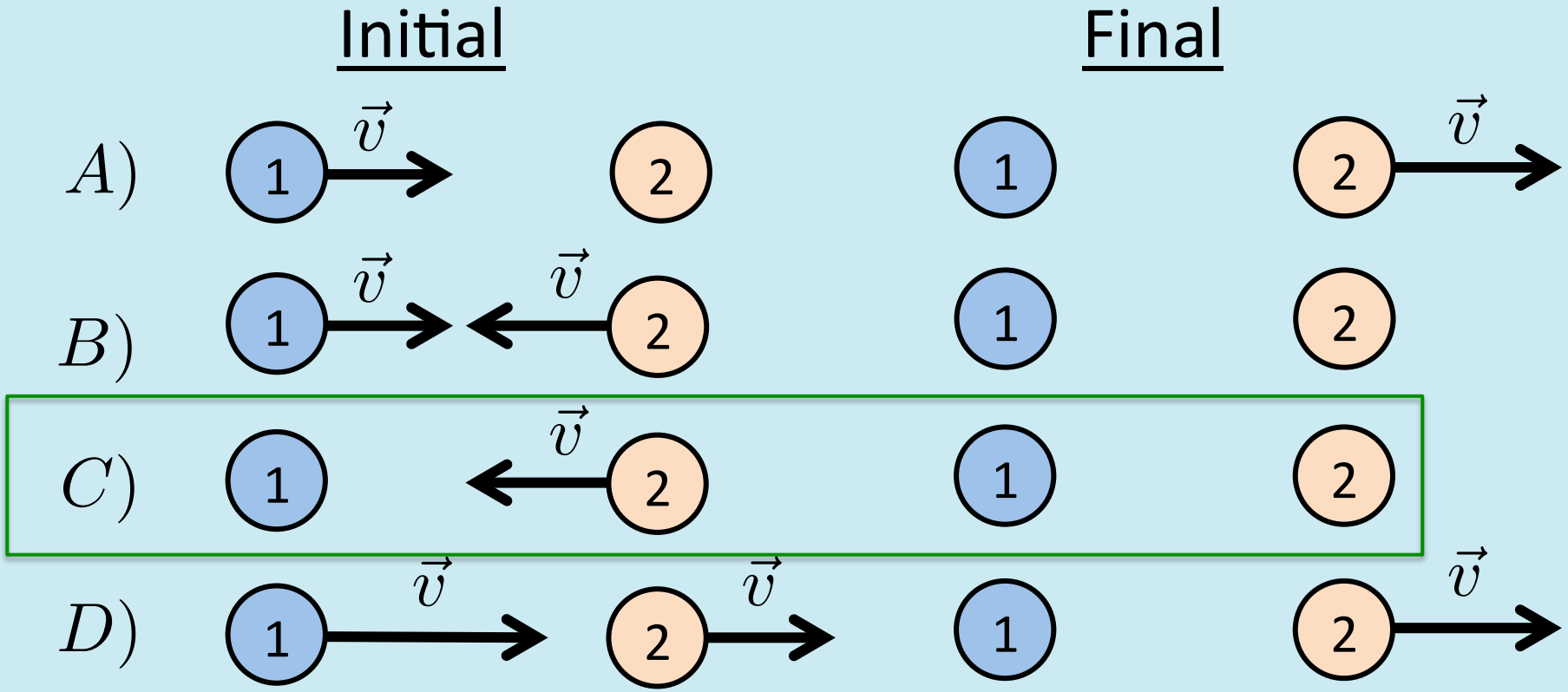
→ After tons of algebra:

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right) v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) v_{2i}$$

Clicker question 11-2

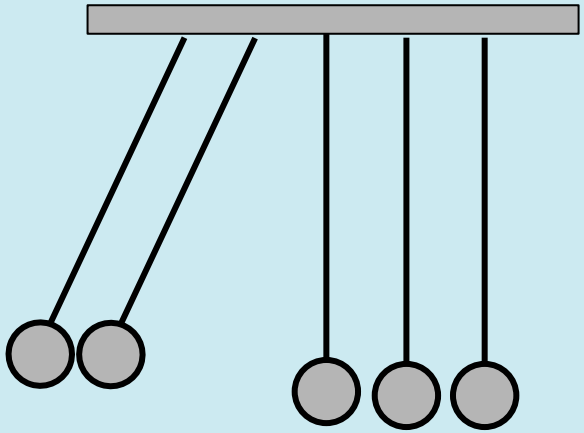
- Which of the following before / after pictures of elastic collisions is not possible?



Clicker question 11-3

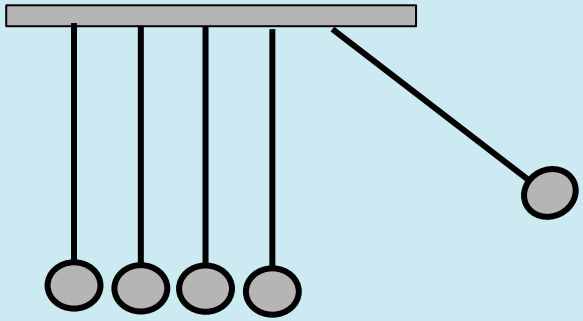
- What happens if we lift two balls in the Newton's cradle? (elastic collision)

Initial

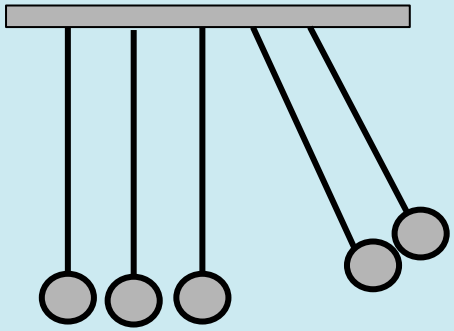


Final

$A)$



$B)$



Example problem

A tennis ball of mass *m* is held just above a basketball of mass 10*m*. With their centers vertically aligned, both are released from rest at the same time to fall a height *h*. Assume that an elastic collision with the ground instantaneously reverses the velocity of the basketball so that it can collide elastically with the tennis ball. To what height does the tennis ball rebound? Ignore the radii of the balls as part of the height.

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right) v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) v_{2i}$$

Clicker question 11-4

- You are at a carnival game where the point is to knock over a wooden plank. You can choose between a rubber ball that will bounce off the plank elastically or a wad of clay that will stick to the plank inelasticity. Assume the ball and the clay are of equal mass and that you can aim and throw both of them with the equal velocity. Which should you choose?

A) The ball.

B) The clay.

C) They are equally good choices.

Homework

- Check Clicker/Reading Quiz and Quiz grades online
- Homework 5 due Wednesday at 4pm
- Extra homework (even numbered answers) are posted
- Fill out student survey
- Tomorrow deadline to drop with W
- Office hours today at noon