http://www.sfu.ca/phys/120/1131/Lectures

Classical Mechanics
Lecture 13

Today's Concepts:

a) More on Elastic Collisions

b) Average Force during Collisions

A. I prefer having the next midterm on March 8 as scheduled

B. I prefer moving the midterm one week later to March 13

DST returns on March 10.

A. I MUST have the midterm on March 8 and if you move it I'll write the Dean and the President and have you fired.
B. I MUST have the midterm on March 15 and if you DON'T move it I'll write the Dean and the President and have you fired.
C. I don't care all that much.

Your comments:

good

I'd like to go over the energy of a system of particles and kinetic energy.

I understand the impulse. However the KE of system seems really weird >>> Help

what happens if u die before getting to a checkpoint?

The prelec was pretty easy but try doing it with real drama happening around you: THen it is not so easy

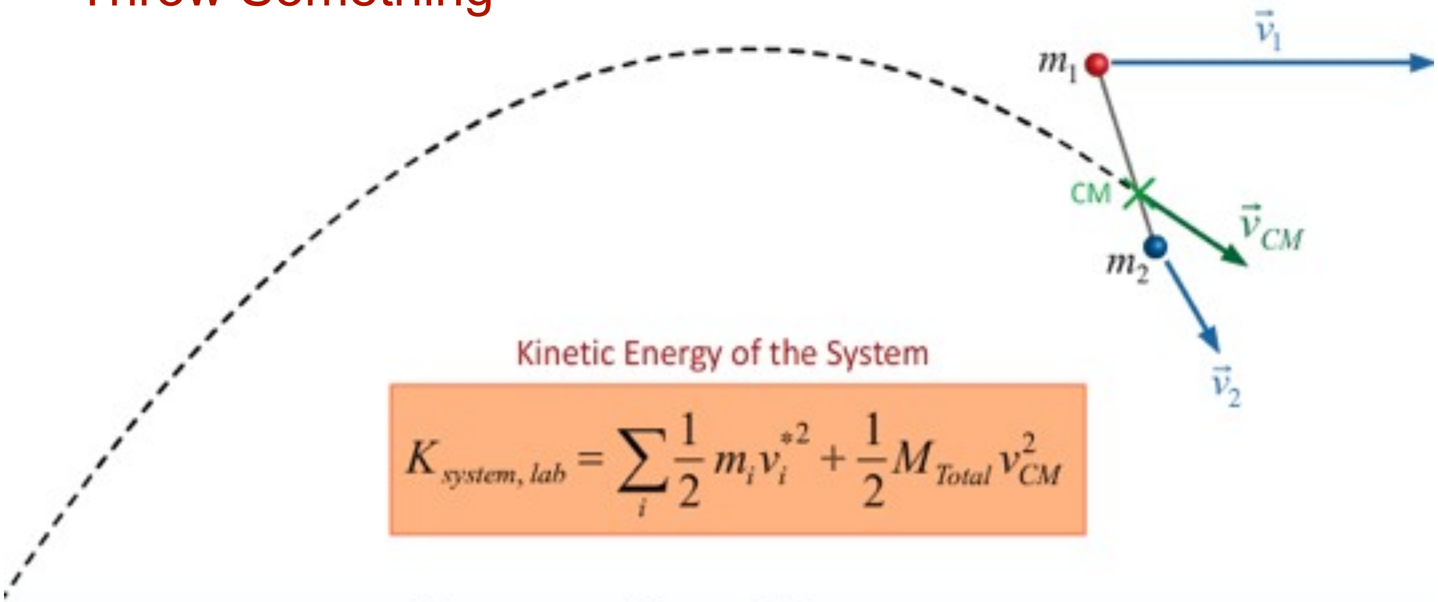
If a ball is dropped from a height h and hits a towel and then I stretch the towel to give the ball an extra boost, is it still considered an elastic collision?

the lectures are becoming more difficult to understand

a few examples would really help show the concept of how the momentum is conserved, especially in the case of the rubber floor and the cement floor, as that is a little bit fuzzy.

In the last slides of the prelecture, it talked about KE in terms of different reference frames and in one of the reference frames the $KE = 0$ why?

Throw Something



Kinetic Energy of the System

$$K_{system,\,lab} = \sum_i \frac{1}{2} m_i v_i^{*2} + \frac{1}{2} M_{Total} v_{CM}^2$$

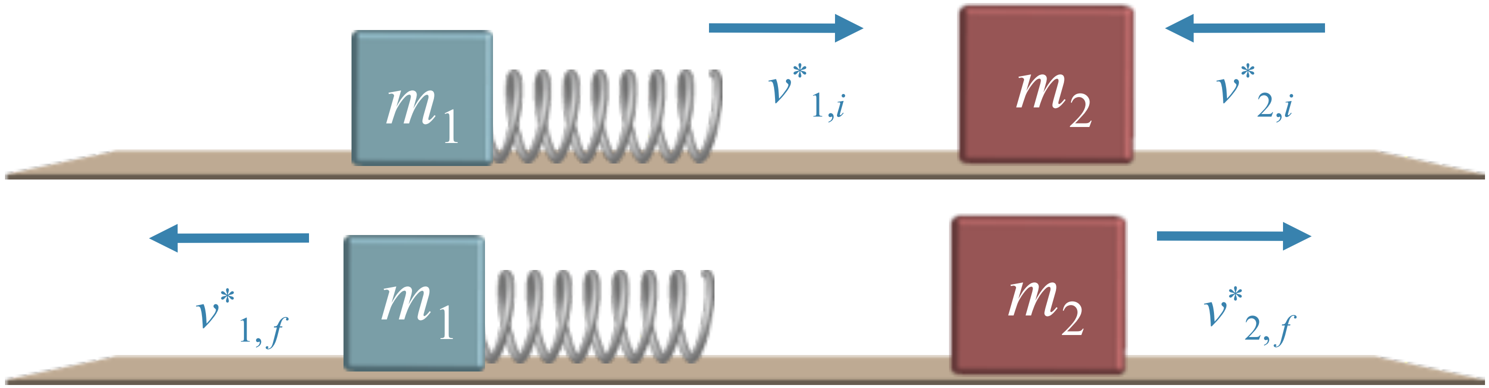
$$K_{system,\,lab} = K_{REL} + K_{CM}$$

Where K_{REL} is the kinetic energy of the objects relative to the Center of Mass

K_{CM} is the kinetic energy of the Center of Mass in the lab frame

More on Elastic Collisions

In *CM* frame, the speed of an object before an elastic collision is the same as the speed of the object after.



$$\left|v^*_{1,i} - v^*_{2,i}\right| = \left|-v^*_{1,f} + v^*_{2,f}\right| = \left|-(v^*_{1,f} - v^*_{2,f})\right| = \left|v^*_{1,f} - v^*_{2,f}\right|$$

So the magnitude of the difference of the two velocities is the same before and after the collision.

But the difference of two vectors is the same in any reference frame.

Just Remember This

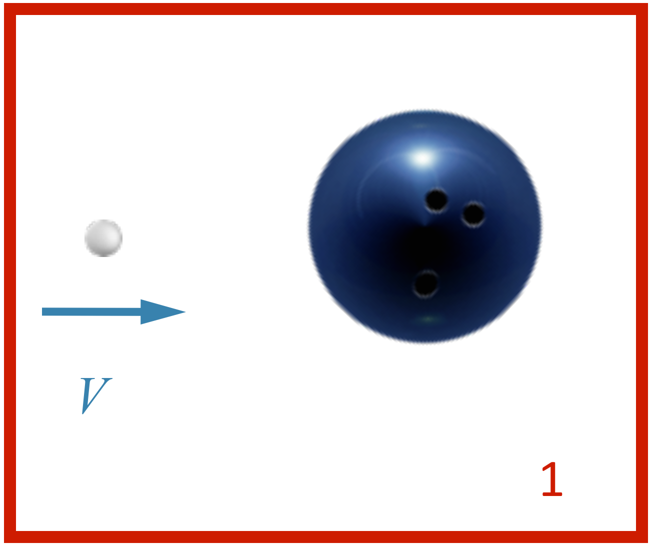
Rate of approach before an elastic collision is the same as the rate of separation afterward, in any reference frame!

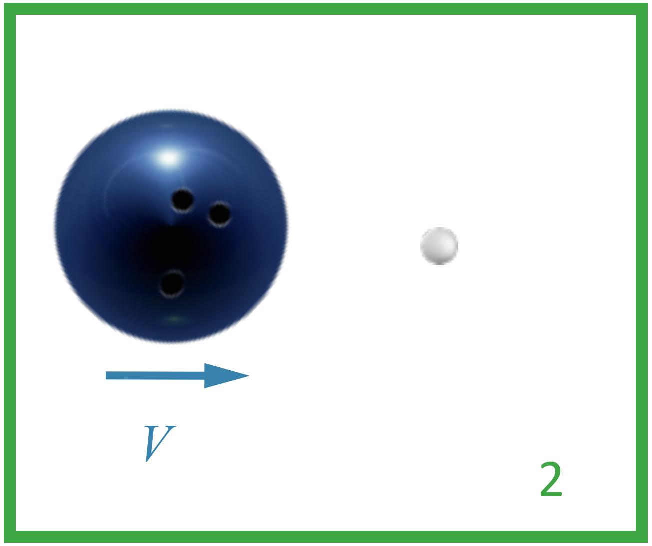
Clicker Question

Consider the two elastic collisions shown below. In 1, a golf ball moving with speed V hits a stationary bowling ball head on. In 2, a bowling ball moving with the same speed V hits a stationary golf ball.

In which case does the golf ball have the greater speed after the collision?

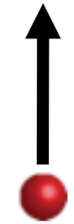
A) 1 B) 2 C) same



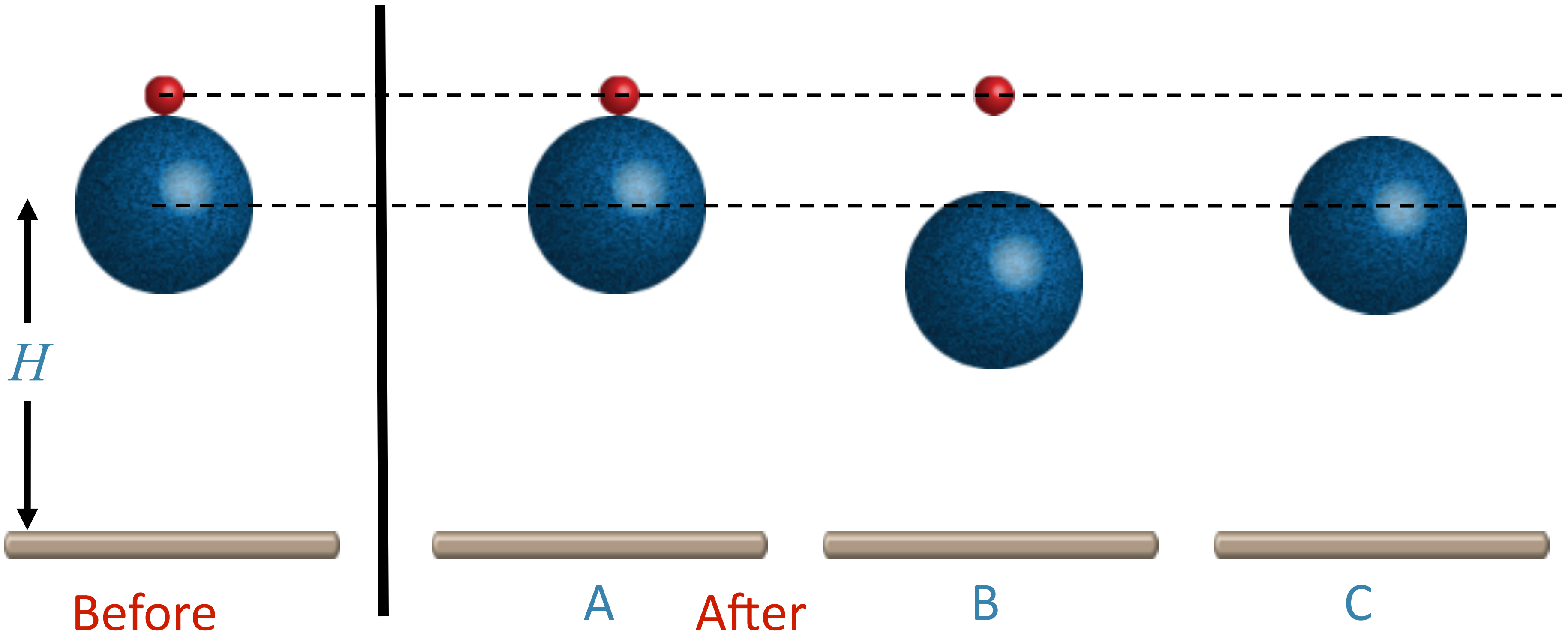


Clicker Question

A small ball is placed above a much bigger ball, and both are dropped together from a height H above the floor. Assume all collisions are elastic.

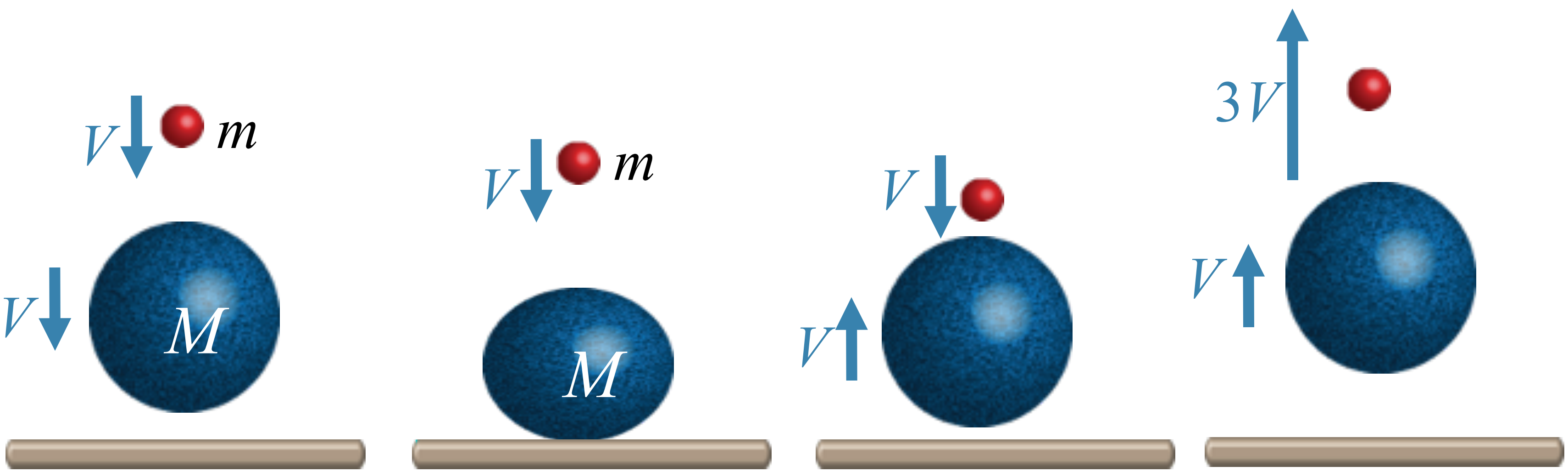


What height do the balls bounce back to?



Explanation

For an elastic collision, the rate of approach before is the same as the rate of separation afterward:



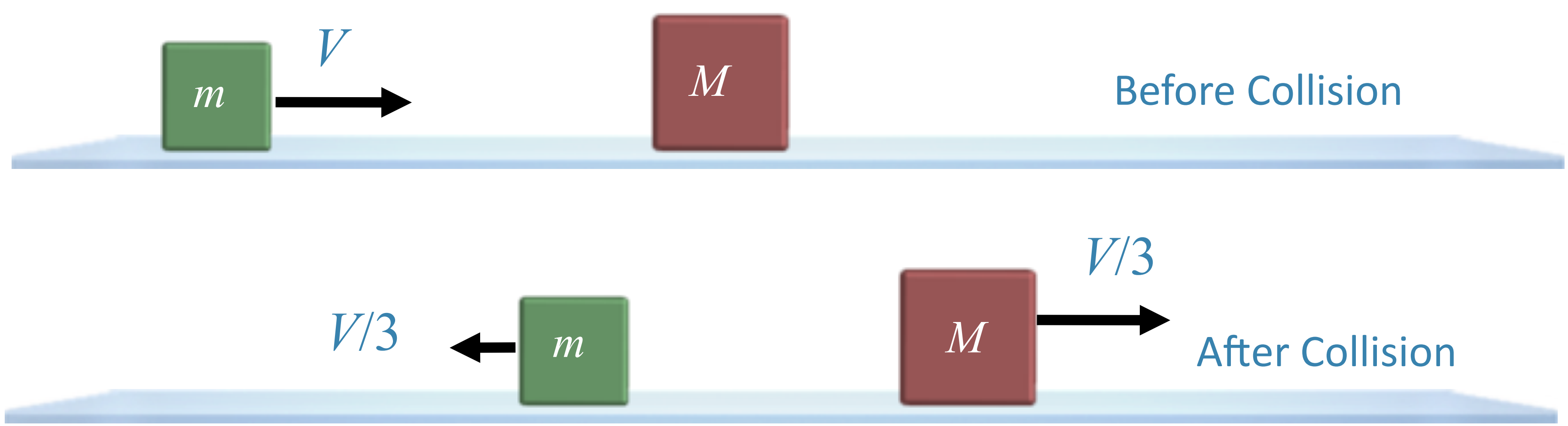
Rate of approach $= 2V$

Rate of separation $= 2V$

CheckPoint

A block slides to the right with speed V on a frictionless floor and collides with a bigger block which is initially at rest. After the collision the speed of both blocks is $V/3$ in opposite directions. Is the collision elastic?

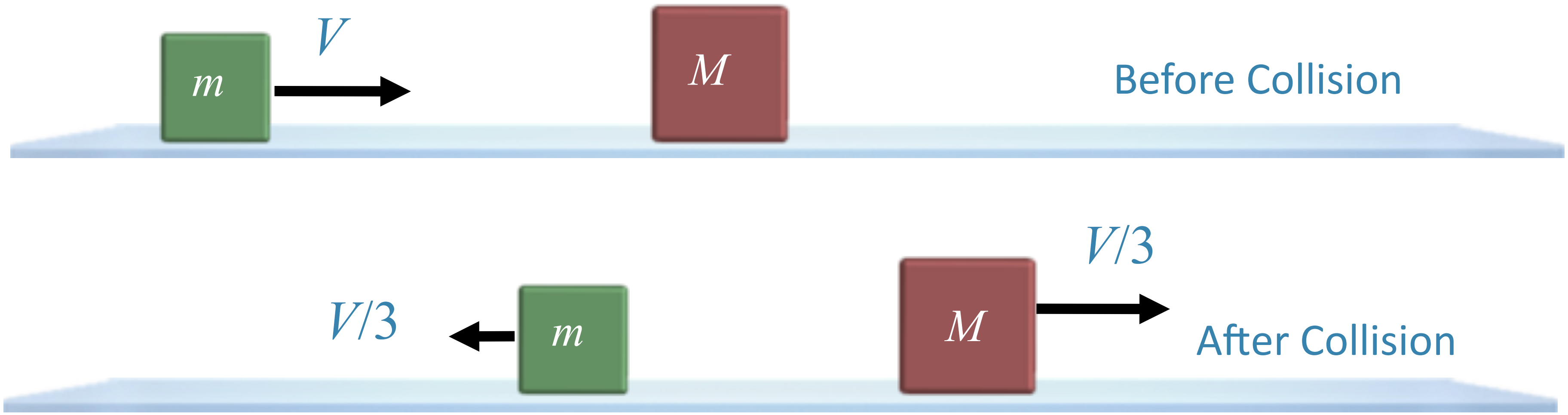
A) Yes B) No C) Need more information



CheckPoint Response

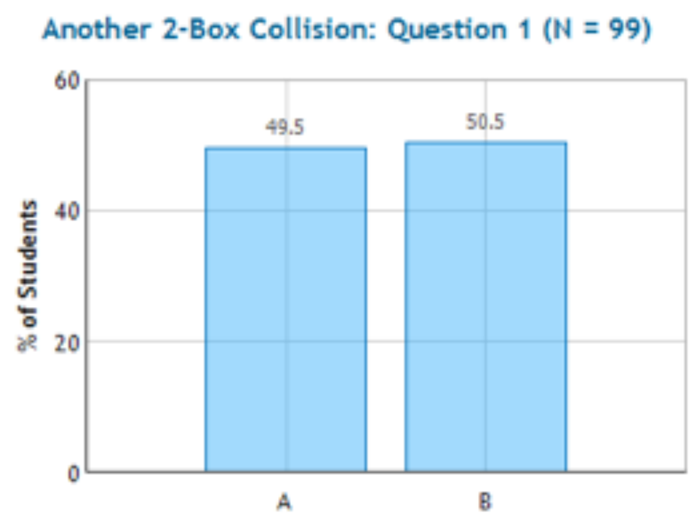
Is the collision elastic?

A) Yes   **B) No**



A) Yes, the blocks do not stick together.

B) No because the relative speed before the collision is V and after it's $2V/3$ and since those two do not equal each other the collision is not elastic.

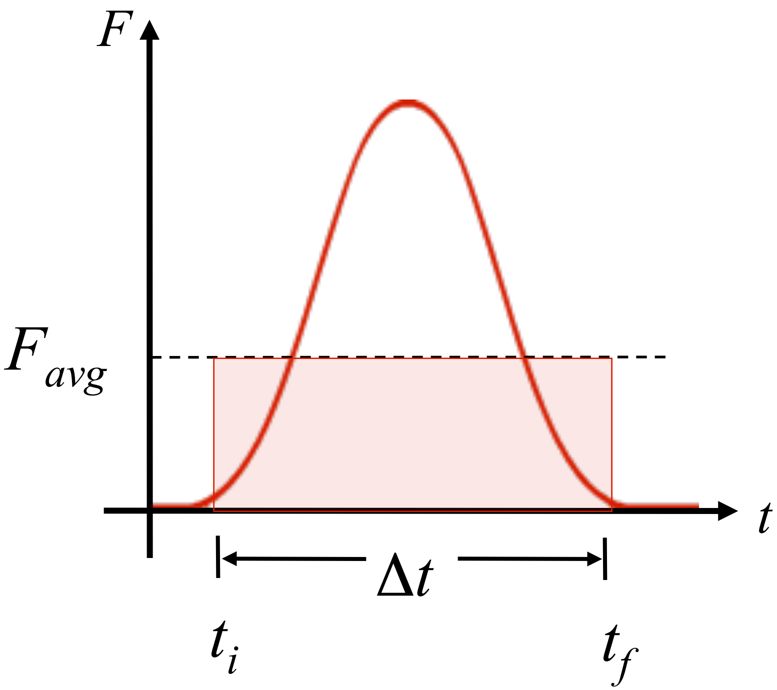


More on collisions

Forces during Collisions

$$\vec{F}_{tot} = m\vec{a} \qquad \vec{F}_{tot} = \frac{d\vec{P}}{dt} \qquad \vec{F}_{tot}\,dt = d\vec{P}$$

$$\underbrace{\int_{t_1}^{t_2} \vec{F}_{tot}\,dt}_{\vec{F}_{avg}\Delta t} = \underbrace{\vec{P}(t_2) - \vec{P}(t_1)}_{\Delta\vec{P}}$$



$$\boxed{\Delta\vec{P} = \vec{F}_{avg}\Delta t}$$

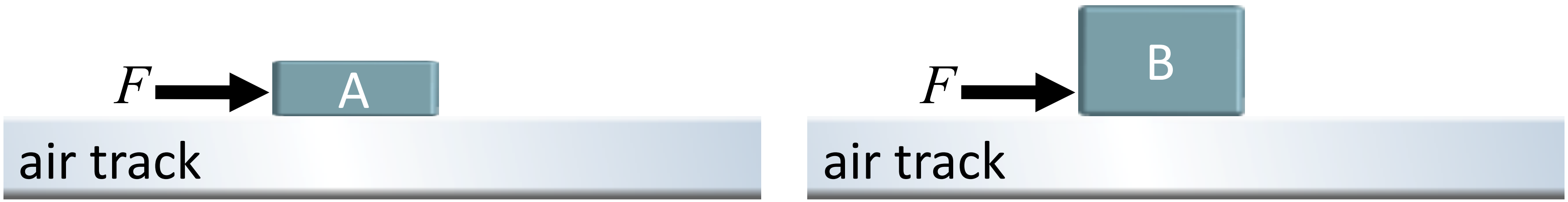
$$\int_{t_1}^{t_2} \vec{F}_{tot}\,dt \equiv \vec{F}_{avg}\Delta t$$

Impulse

Clicker Question

$$\Delta\vec{P} = \vec{F}_{avg}\Delta t$$

Two identical blocks, B having twice the mass of A, are initially at rest on frictionless air tracks. You now apply the same constant force to both blocks for exactly one second.



The change in momentum of block B is:

A) Twice the change in momentum of block A

B) The same as the change in momentum of block A

C) Half the change in momentum of block A

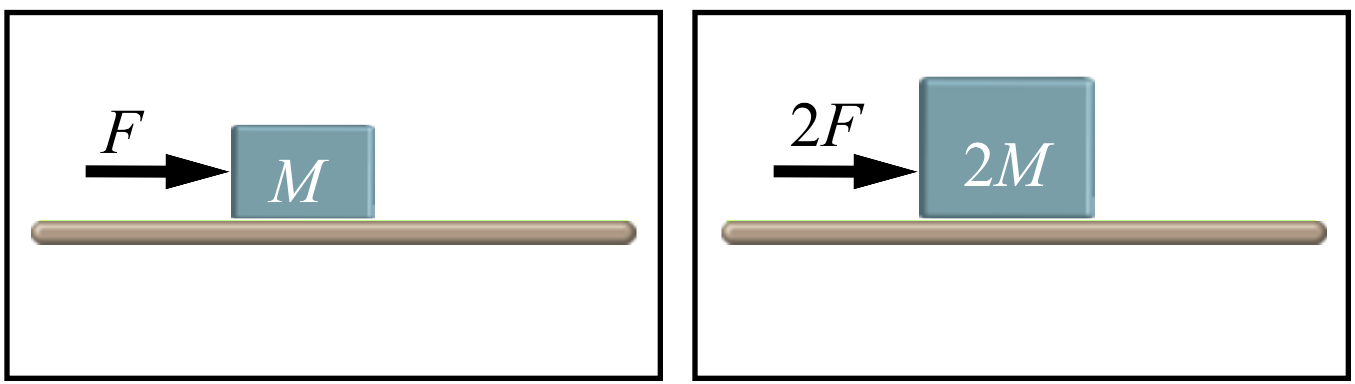
Clicker Question

$$\Delta\vec{P} = \vec{F}_{avg}\Delta t$$

Two boxes, one having twice the mass of the other, are initially at rest on a horizontal frictionless surface. A force F acts on the lighter box and a force $2F$ acts on the heavier box. Both forces act for exactly one second.

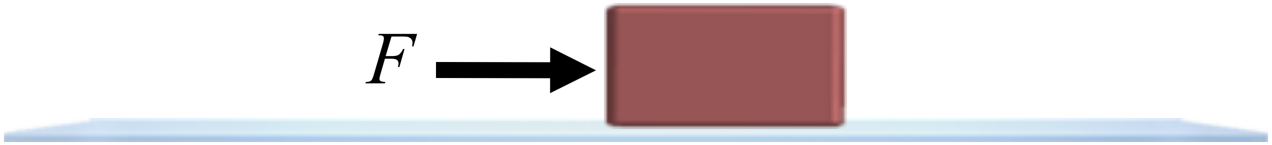
Which box ends up with the biggest momentum?

A) Bigger box B) Smaller box C) same



CheckPoint

A constant force acts for a time Δt on a block that is initially at rest on a frictionless surface, resulting in a final velocity V. Suppose the experiment is repeated on a block with twice the mass using a force that's half as big. For how long would the force have to act to result in the same final velocity?



A) Four times as long.

B) Twice as long.

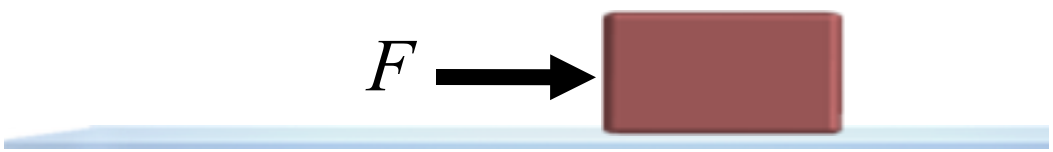
C) The same length.

D) Half as long.

E) A quarter as long.

Lets try it again !

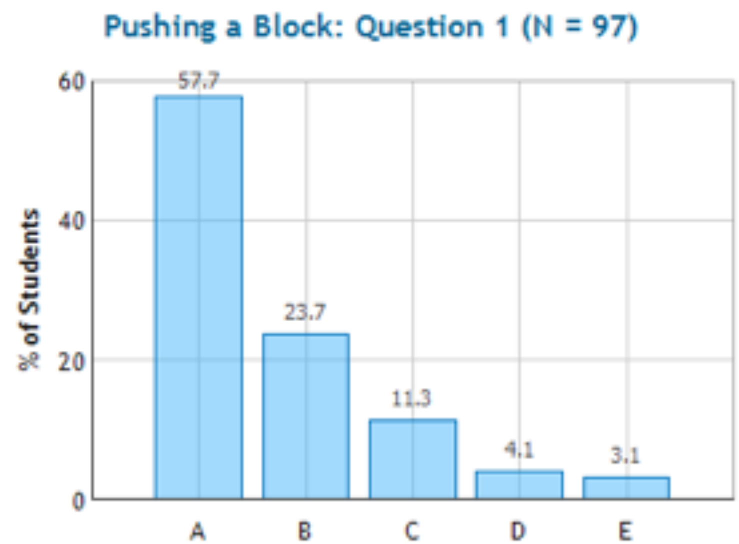
The experiment is repeated on a block with twice the mass using a force that's half as big. For how long would the force have to act to result in the same final velocity?



A) Four times as long.

B) Twice as long.

C) The same length.



A) $F\Delta t = mv$. If the velocity is to remain constant between case 1 and case 2, then halving the force and doubling the mass would require 4 times as much time to balance the equation.

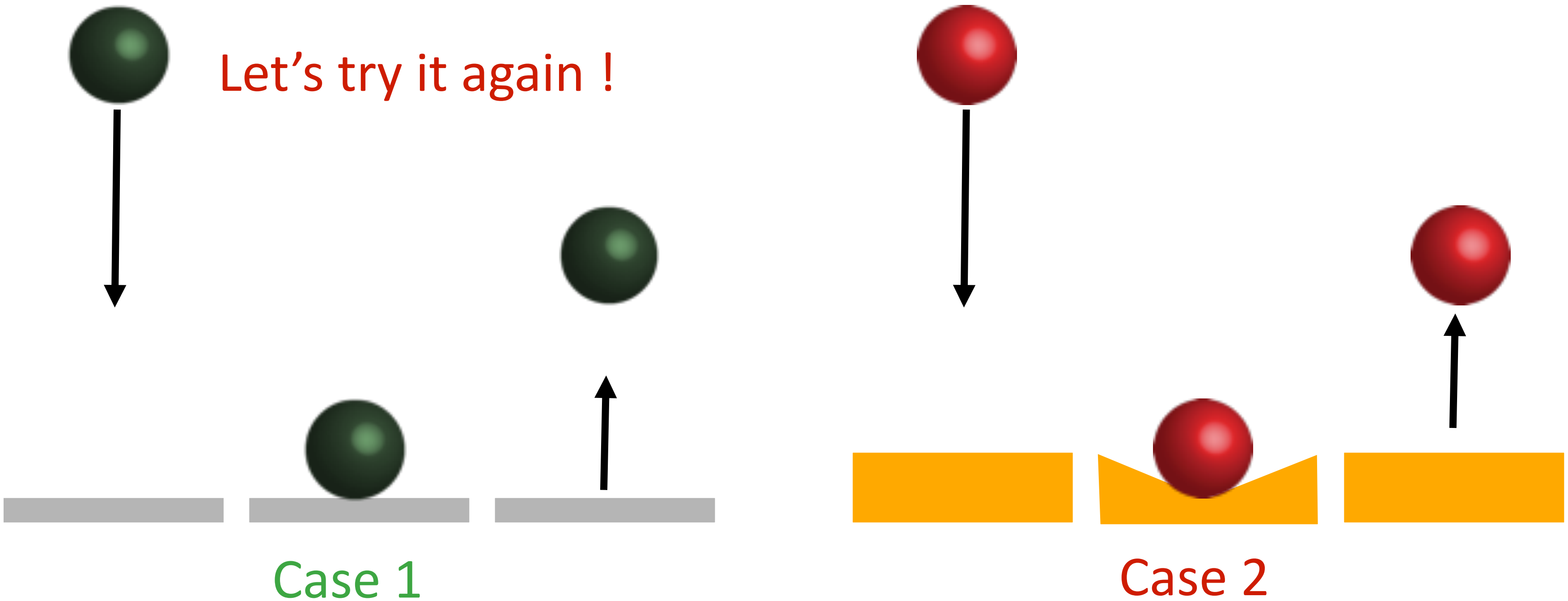
B) the momentum is the same, and the force is halved, so it would take twice the given time to get the same velocity

C) $mv = Ft$, so if you solve for t in each case using the given values then t will be the same.

CheckPoint

Identical balls are dropped from the same initial height and bounce back to half the initial height. In Case 1 the ball bounces off a cement floor and in Case 2 the ball bounces off a piece of stretchy rubber. In which case is the average force acting on the ball during the collision the biggest?

A) Case 1   B) Case 2   C) Same in both cases

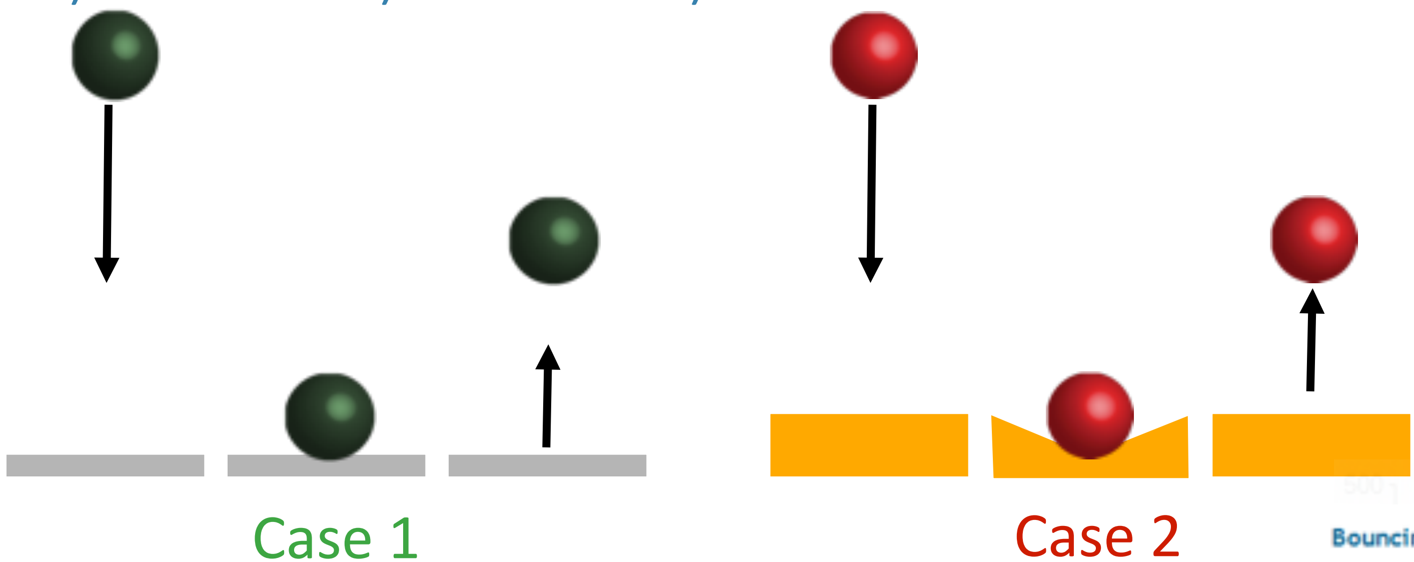


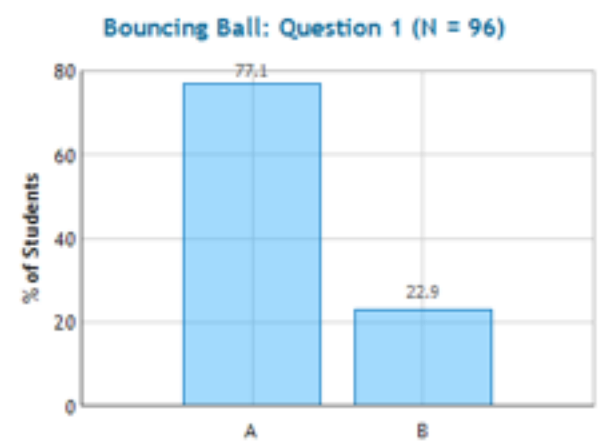
CheckPoint Responses

In which case is the average force acting on the ball during the collision the biggest?

A) Case 1 B) Case 2 C) Same in both cases

$$\vec{F}_{avg} = \frac{\Delta \vec{P}}{\Delta t}$$





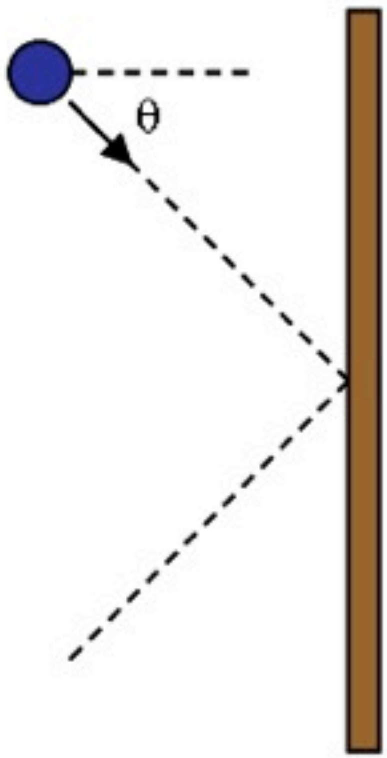
A) Because the same change in momentum happens in a shorter time.

B) its in contact with the ball for longer

C) Because change in momentum is bigger in Case 2.

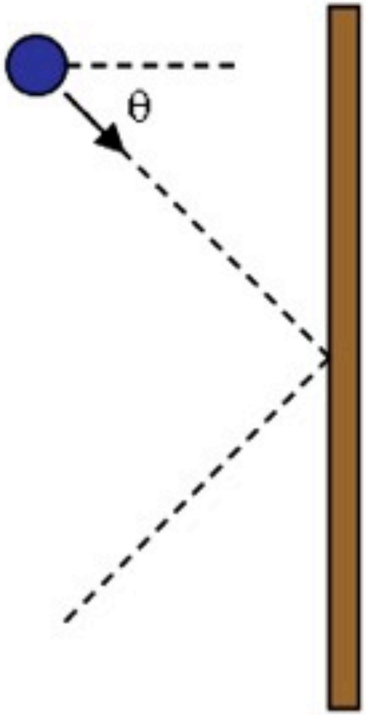
HW Problem with demo

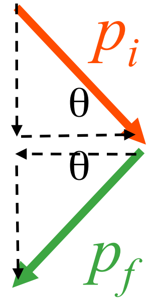
Ball Hits Wall



A racquet ball with mass m = 0.249 kg is moving toward the wall at v = 14.8 m/s and at an angle of θ = 26° with respect to the horizontal. The ball makes a perfectly elastic collision with the solid, frictionless wall and rebounds at the same angle with respect to the horizontal. The ball is in contact with the wall for t = 0.068 s.

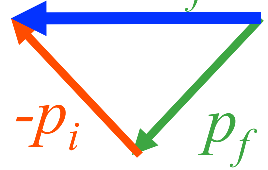
Ball Hits Wall





Another way to look at it

$$\Delta P = p_f - p_i$$



A racquet ball with mass m = 0.249 kg is moving toward the wall at v = 14.8 m/s and at an angle of θ = 26° with respect to the horizontal. The ball makes a perfectly elastic collision with the solid, frictionless wall and rebounds at the same angle with respect to the horizontal. The ball is in contact with the wall for t = 0.068 s.

1) What is the magnitude of the initial momentum of the racquet ball? mv

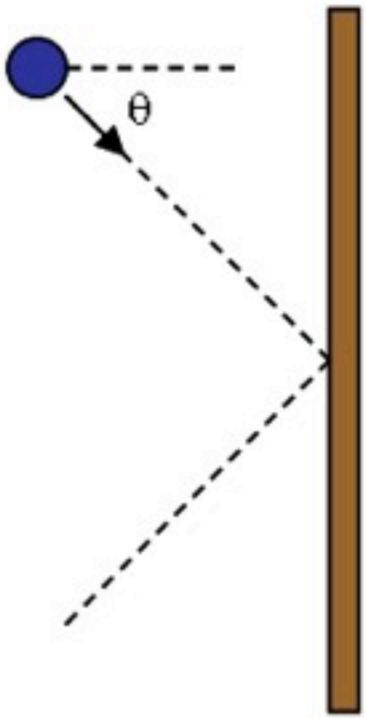
[ ] kg-m/s Submit

2) What is the magnitude of the change in momentum of the racquet ball?

$$|\Delta P_X| = 2mv\cos\theta$$
$$|\Delta P_Y| = 0$$

[ ] kg-m/s Submit

Ball Hits Wall

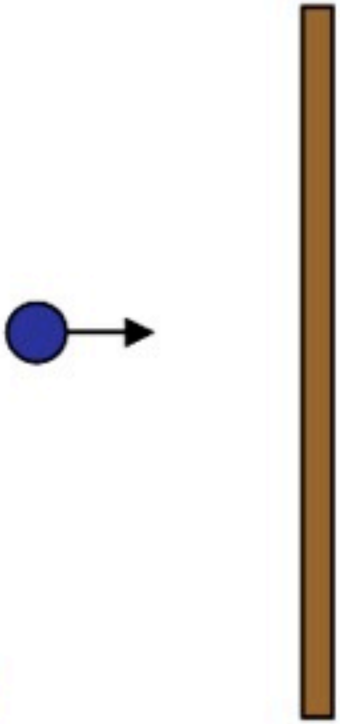


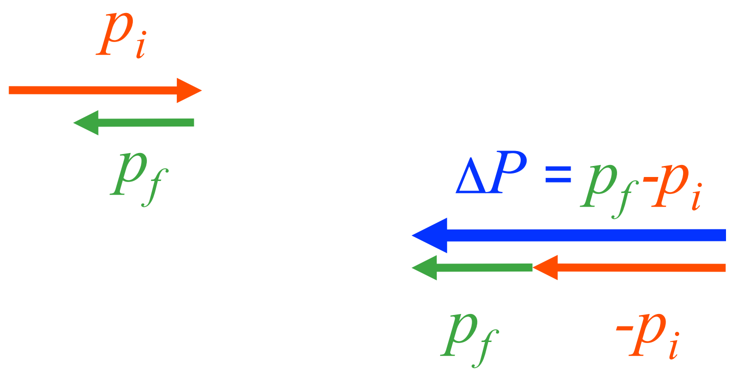
$$|F_{avg}| = |\Delta P| / \Delta t = 2mv\cos\theta / \Delta t$$

A racquet ball with mass m = 0.249 kg is moving toward the wall at v = 14.8 m/s and at an angle of θ = 26° with respect to the horizontal. The ball makes a perfectly elastic collision with the solid, frictionless wall and rebounds at the same angle with respect to the horizontal. The ball is in contact with the wall for t = 0.068 s.

3) What is the magnitude of the average force the wall exerts on the racquet ball?

[ ] N Submit





$$F_{avg} = \Delta P / \Delta t$$

4)

Now the racquet ball is moving straight toward the wall at a velocity of v_i = 14.8 m/s. The ball makes an inelastic collision with the solid wall and leaves the wall in the opposite direction at v_f = -9 m/s. The ball exerts the same average force on the ball as before.

What is the magnitude of the change in momentum of the racquet ball?

kg-m/s Submit

$$|\Delta P| = |p_f - p_i| = m|v_f - v_i|$$

5) What is the time the ball is in contact with the wall?

s Submit

$$\Delta t = \Delta P / F_{avg}$$

6) What is the change in kinetic energy of the racquet ball?

J Submit

$$\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$