Physics 2111
Unit 13

Today's Concepts:

a) Impulse

b) Average Force during Collisions

c) Conceptual Review

Your comments:

I was slightly confused when they talked about relative kinetic energy and what that meant.

Can you explain the concept of kinetic energy discussed in this lecture: KE sys,lab = KE relative + KE cm?

the ball example in the prelecture- equation

The kinetic energy of the system relative to the lab using the center of mass reference frame as part of the kinetic energy.

I would like to go over the 2-box collision problem again

energy of a system of particles.

It makes sense, except for the bouncing ball question.

I'm confused on the reference frames for the KE of system.

I'm a bit confused on the math since less steps were shown

How the reference frames work in this section seemed a little confusing to me.

go over the last question on the checkpoint

Reference Frames

impulse examples confused me the most, but in general it was confusing

Question

You hop down twice from the top of a table which is 1m off the floor. The first time you hop down, you keep your knees very stiff. The second time you hope down, you flex your knees to allow your body to come to stop gradually. In which jump was the total impulse delivered to your body the greatest?

A. when you flexed your knees
B. when you kept your knees stiff
C. the impulse is the same in both cases

Question

You hop down twice from the top of a table which is 1m off the floor. The first time you hop down, you keep your knees very stiff. The second time you hope down, you flex your knees to allow your body to come to stop gradually. In which jump was the average force delivered to your body the greatest?

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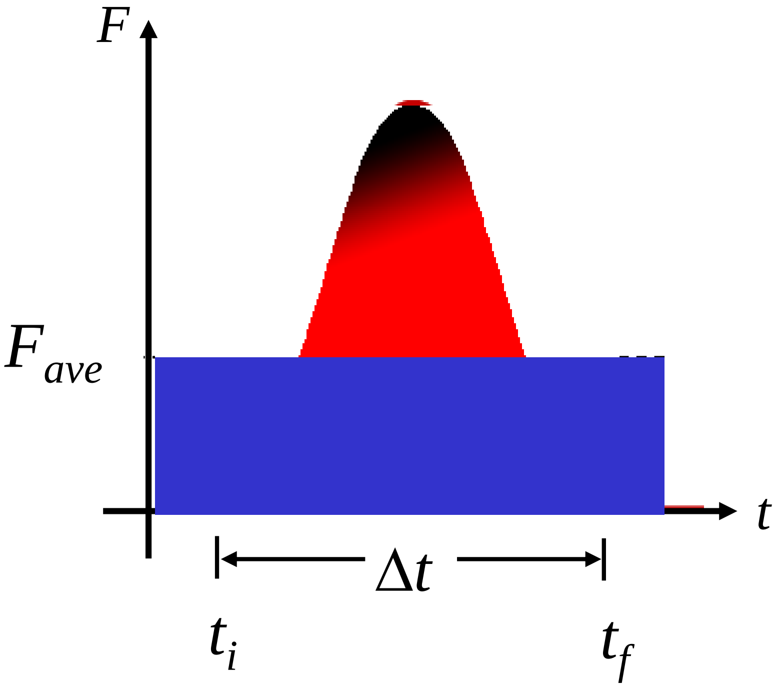
Forces during Collisions

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

$$\vec{J} \equiv \int \vec{F}\,dt = \Delta\vec{P}$$

Impulse = change in momentum



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

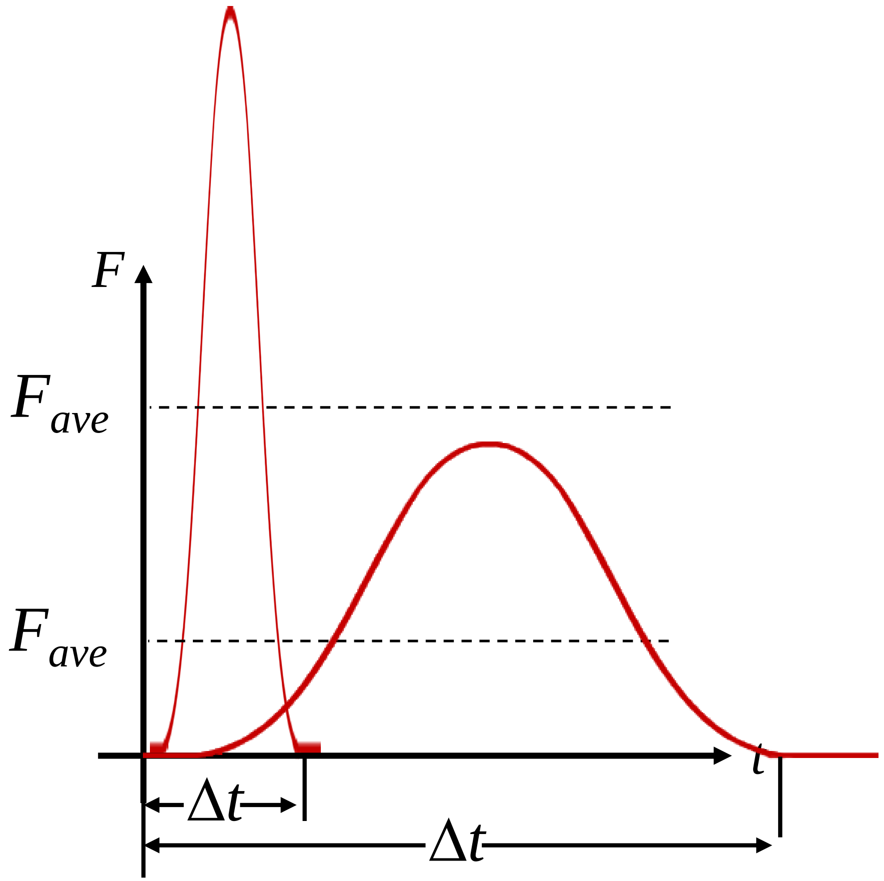
Example 13.1 Hopping down

A physics professors hops down from the top of a table which is 1m off the floor. Because he's old and not too smart, he keeps his knees very stiff when he comes in contact with the floor. If his mass is 82kg and the his body comes to rest in 0.01 seconds, what is the average force on his body from the floor during this "collision"?

He hops down a second time, but having learned a painful lesson, he now flexes his knees and he comes to rest in 0.5sec. What is the average force from the floor in this case?

Forces during Collisions

$$\vec{F}_{tot} = m\vec{a}$$



Prelecture Question

In Case A a block of mass 2M is pushed for one second by a force F. In Case B a block of half the mass is pushed for one second with the same force F. In both cases the track is frictionless and the blocks are initially at rest.

Compare the final momentum of the two blocks.

A) $|\vec{p}_A| = |\vec{p}_B|$

B) $|\vec{p}_A| > |\vec{p}_B|$

C) $|\vec{p}_A| < |\vec{p}_B|$

Prelecture Question

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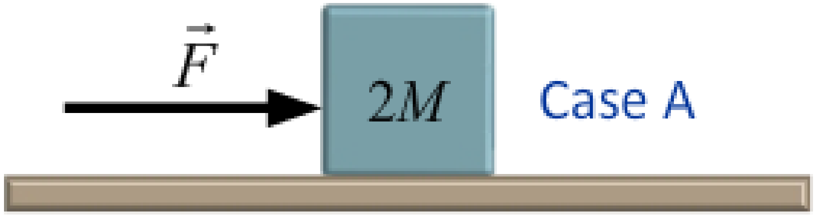
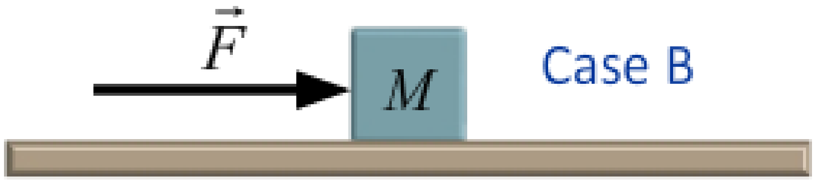




Compare the final kinetic energy of the two blocks.

A) $KE_A = KE_B$

B) $KE_A > KE_B$

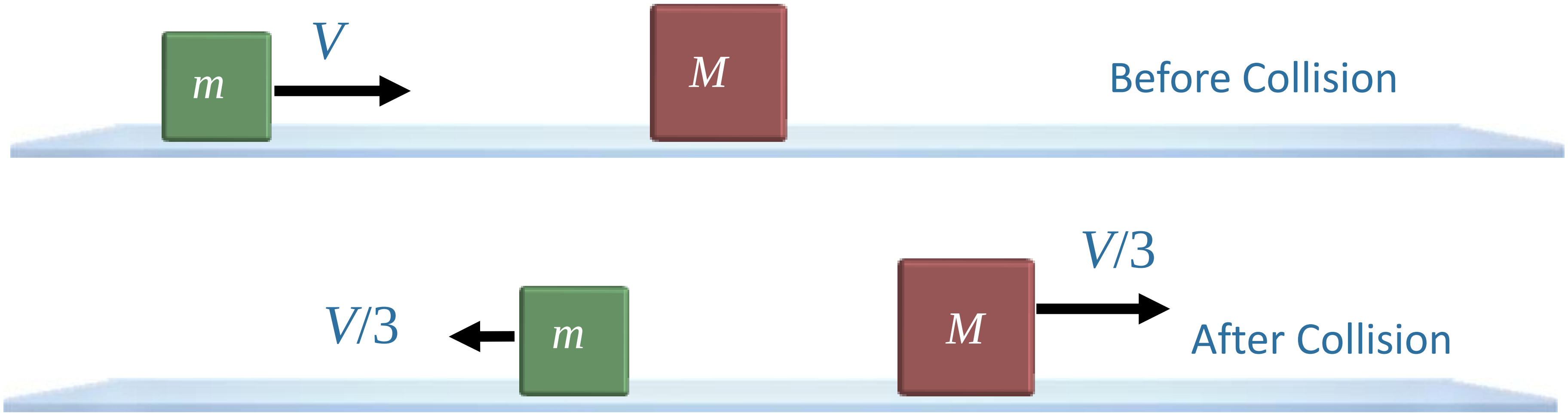
C) $KE_A < KE_B$

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 perfectly elastic?

A) Yes

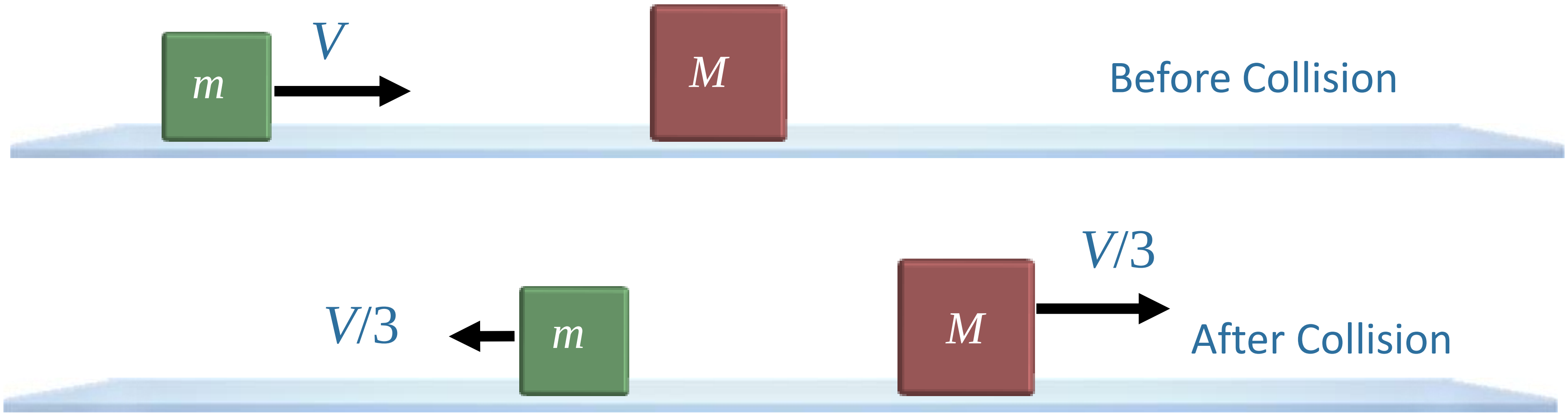
B) No



What we thought…..

Is the collision completely elastic?

A) Yes   B) No   C) Need more information



A) both blocks ended with the same velocities

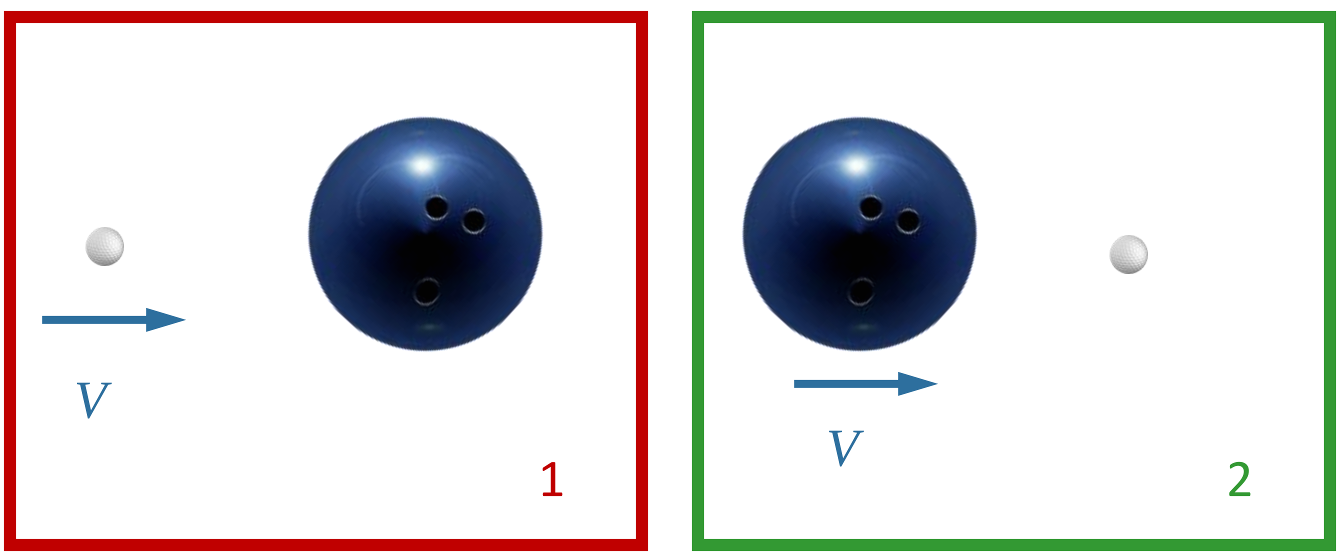
B) The rate of approach is not the same as they leave each other

Question

Consider the two perfectly 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.

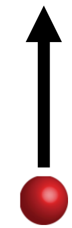
In which case does the golf ball have the greater speed after the collision?

A) 1 B) 2 C) same

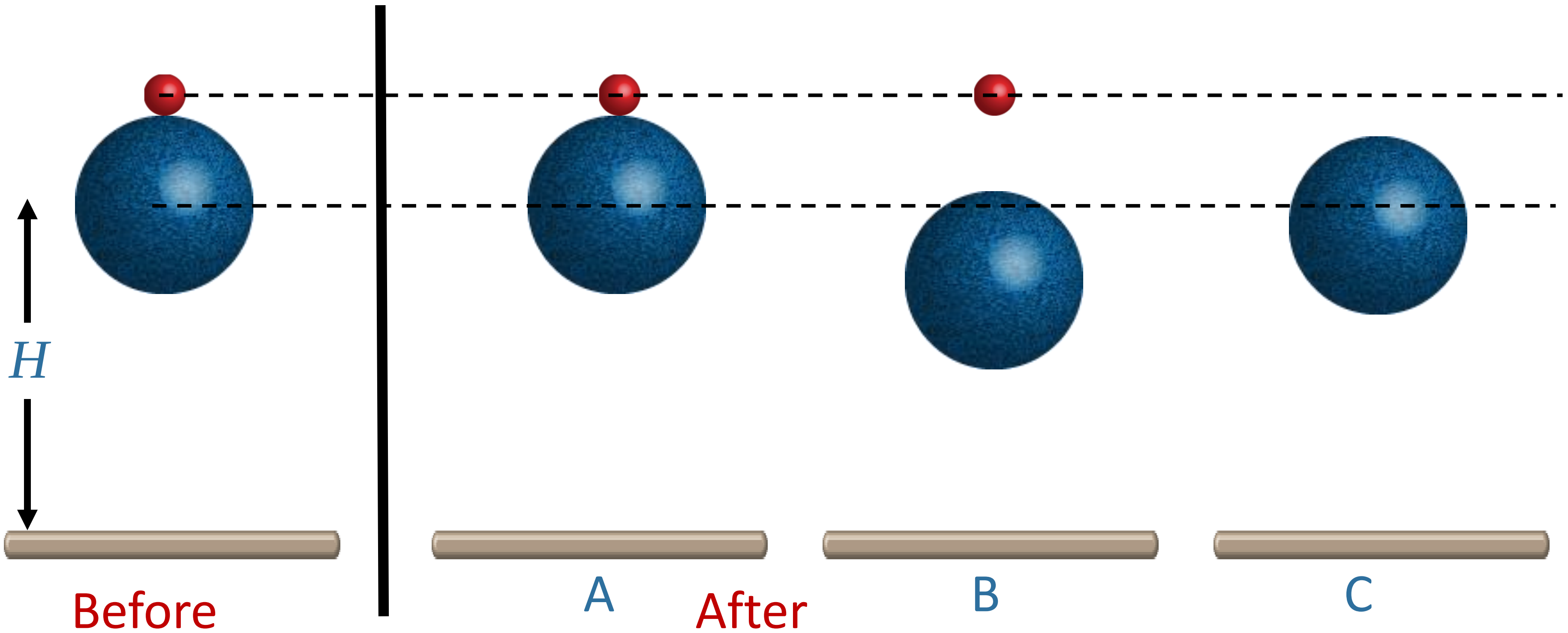


Question

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.

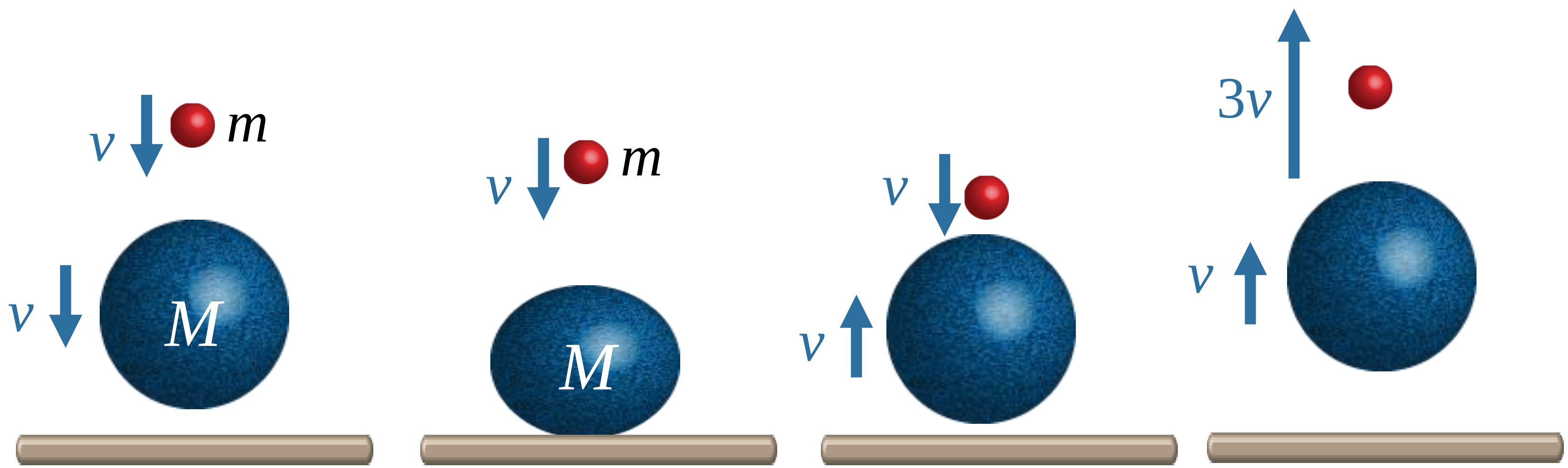


What height do the balls bounce back to?



Explanation

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

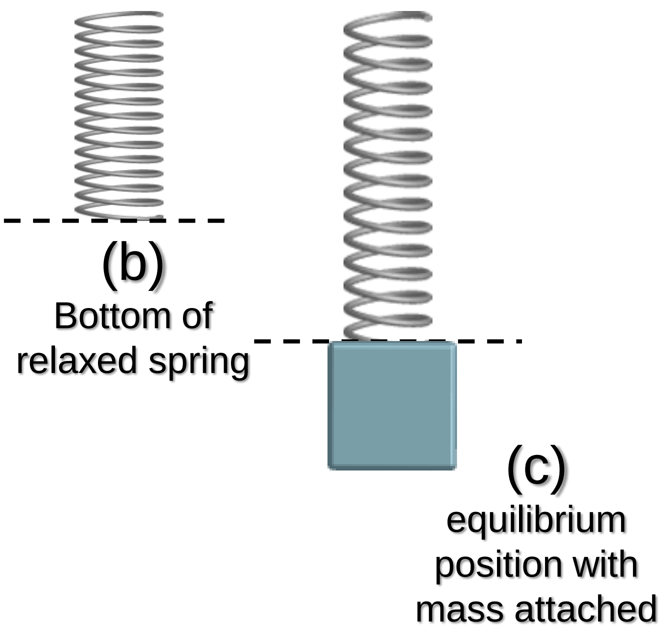


Rate of approach $= 2V$

Rate of separation $= 2V$

Question

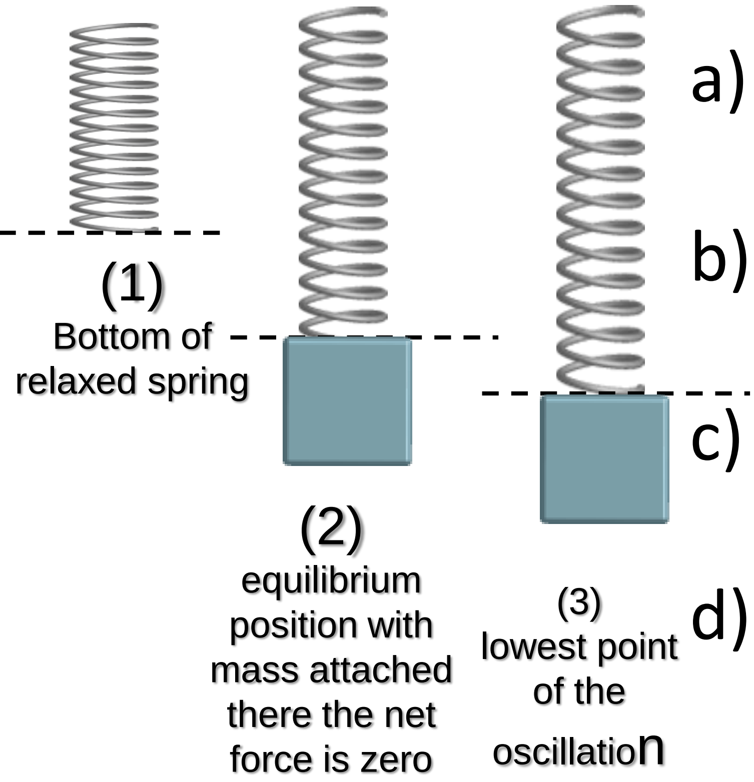
A box is gently hung from a vertical spring and it sags down from position (b) to position (c). What is it that defines position (c)? It is when



A) $\frac{1}{2} kx^2 = mgh$
B) $kx = mgh$
C) $kx = mg$
D) $\frac{1}{2} kx^2 = mg$
E) Both (A) and (C)

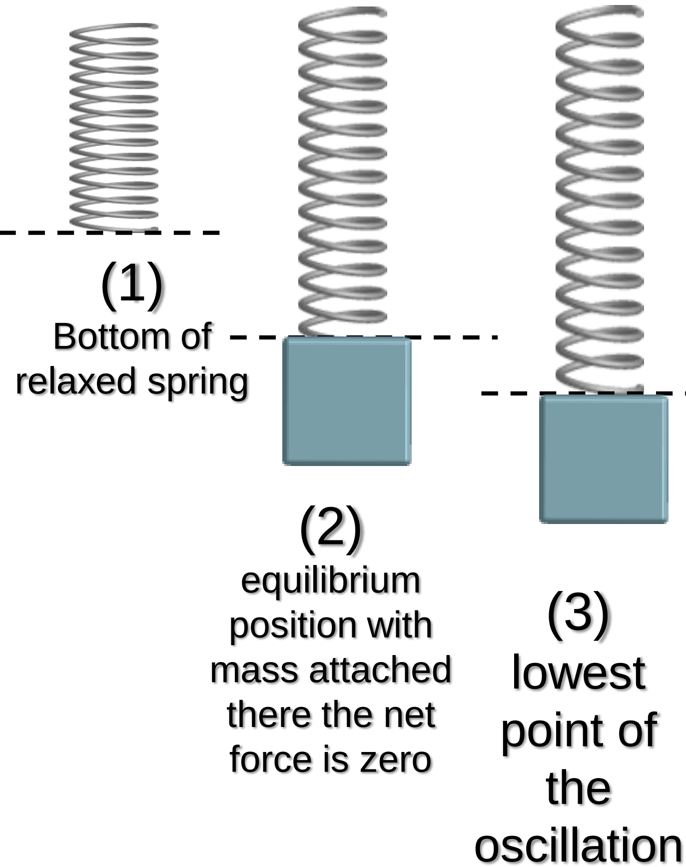
Question

Which of the following would be a correct method to calculate the PE of the box and spring?



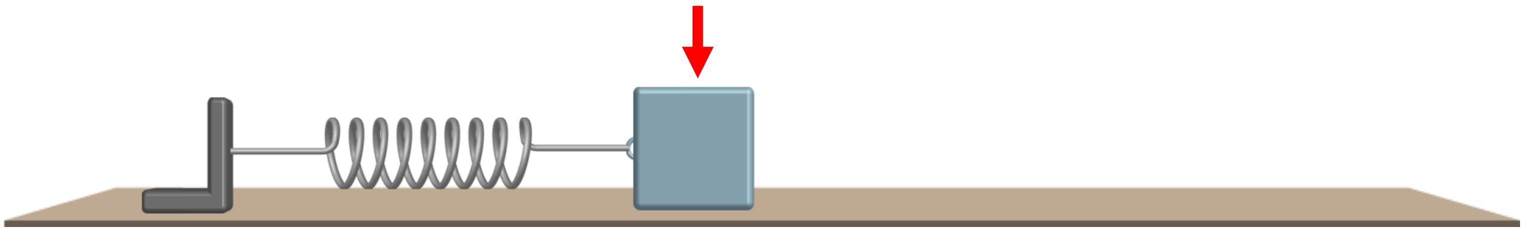
a) Use (1) for PE=0 and include two different PE terms
b) Use (2) for PE=0 and include two different PE terms
c) Use (3) for PE= 0 and include only one PE term
d) Use (3) for PE=0 and include only one PE term

Which of the following would be a correct method to calculate the PE of the box and spring?



a) Use (1) for PE=0 and include two different PE terms
b) Use (2) for PE=0 and include two different PE terms
c) Use (1) for PE= 0 and include only one PE term
d) Use (2) for PE=0 and include only one PE term
e) Both answers (a) and (d)

Big point of confusion in the past!!!!



IMPORTANT POINT – Works every time!!!

a) define PE = 0 at the relaxed position of the spring
b) include all conservative forces doing work on the object in the PE (1 or 2)

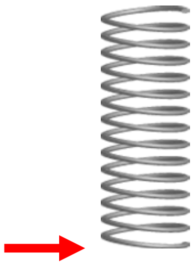
Both vertical or horizontal springs

Big point of confusion in the past!!!!

Want the one that always works?

a) define PE = 0 at the relaxed position of the spring

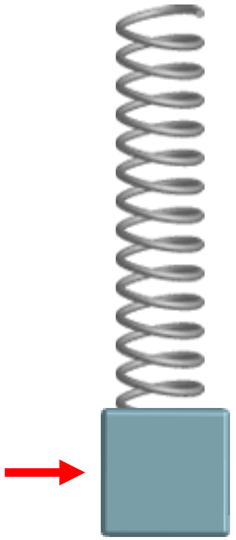
b) include both conservative forces doing work on the object in the PE (gravity and spring)



Save yourself time for special cases?

a) define PE = 0 at the **equilibrium position** of the box/spring

b) include only gravity in the PE of the object



Question

A 0.5 kg piece of clay has an initial velocity of +3.0 m/sec. It hits the back of the physics room wall and sticks there. What is the external impulse delivered to the piece of clay during this time?

A. 0 kg m/sec
B. –1.5 kg m/sec
C. +1.5 kg m/sec
D. –3.0 kg m/sec
E. +3.0 kg m/sec

Question

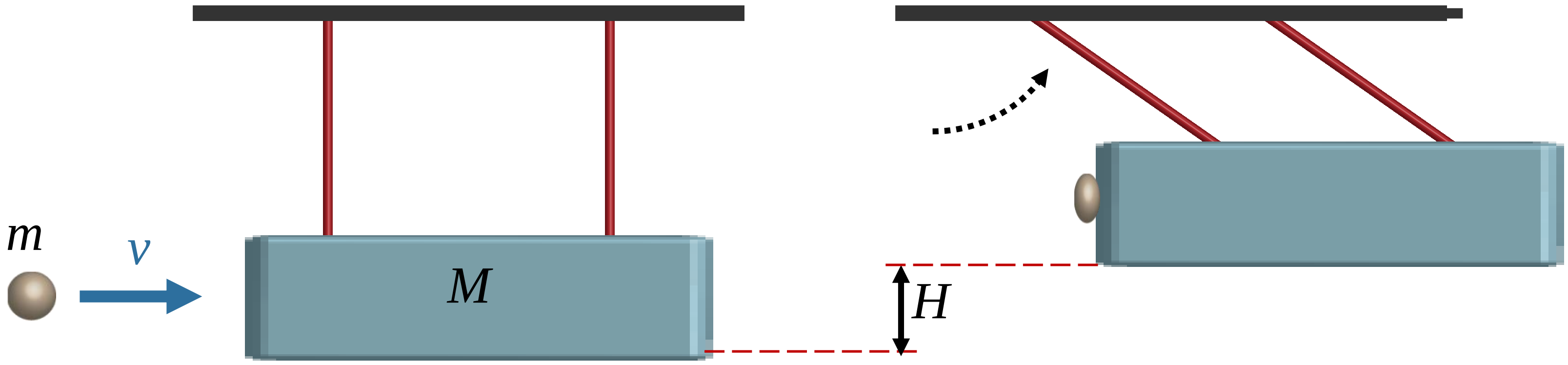
A 0.5 kg rubber ball has an initial velocity of +3.0 m/sec. It hits the back of the physics room wall and bounces off with the magnitude of its velocity unchanged. What is the external impulse delivered to the rubber ball during this time?

A. 0 kg m/sec
B. –1.5 kg m/sec
C. +1.5 kg m/sec
D. –3.0 kg m/sec
E. +3.0 kg m/sec

Example 13.2 (Soccer Ball AGAIN!)

A 0.5kg soccer ball is kicked at an initial velocity of 20m/sec at 30^o above the horizontal. It lands some distance away at the same height from which it was kicked. Using the impulse momentum theorem, determine how long the soccer ball is in the air.

Example 11.4 (Ballistic Pendulum)



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

During the collision, what qualities about the mass/block system are conserved?

A. Its momentum

B. Its mechanical energy

C. Both its momentum and its mechanical energy

D. Neither its momentum or its mechanical energy

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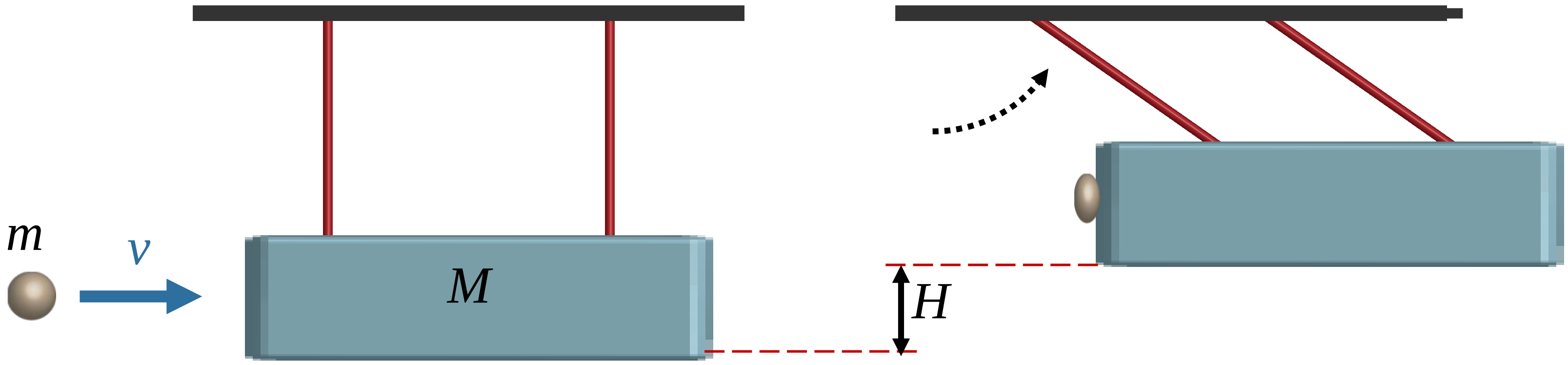

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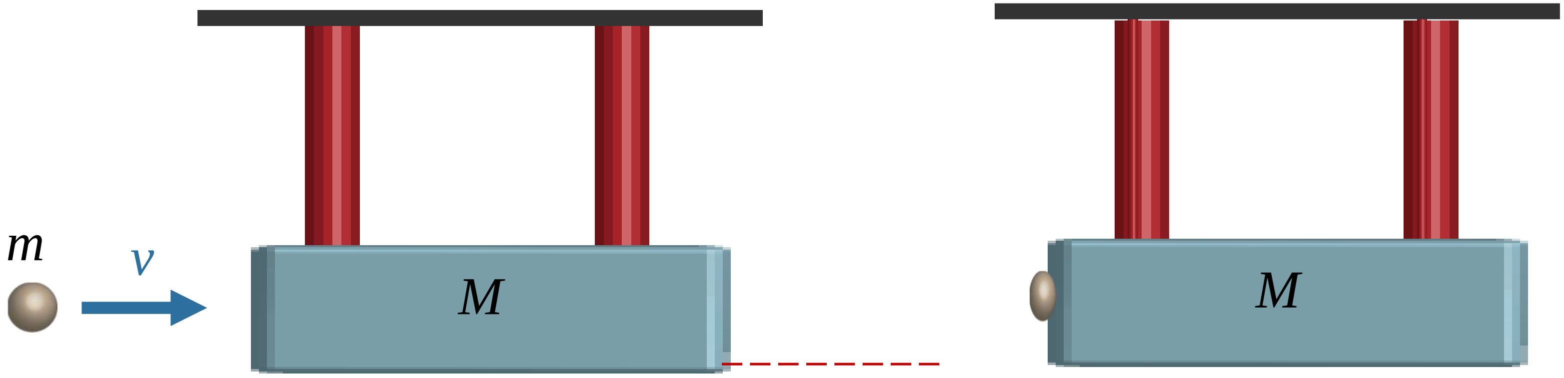

A projectile of mass *m* moving horizontally with speed *v* strikes a stationary block *M* held in place by two stiff rods of length *L*.

<u>During the collision</u>, what qualities about the mass/block system are conserved?

A. Its momentum

B. Its mechanical energy

C. Both its momentum and its mechanical energy

D. Neither its momentum or its mechanical energy

Summary

$$\vec{J} \equiv \int \vec{F} dt = \Delta \vec{P}$$

If you know the external impulse….

then you know the change in momentum

If you know the change in momentum….

then you know the external impulse

If you know the external impulse *and* the total time for the impulse….

then you know the average force

Which Method to Use (some hints)

- Involves time in the question or given information
  - **Newton's Second Law**
- There is a collision or an explosion
  - $\vec{J}_{NET} = \Delta\vec{p}$ ($\vec{p}_o = \vec{p}_f$ if $\vec{J}_{NET} = 0$)
- Force is constant in direction and magnitude
  - **Newton's Second Law**
- Force changes in direction or magnitude
  - $W_{tot} = \Delta KE$
- No non-conservative forces (e.g. no friction)
  - $W_{NC} = \Delta ME$ (or $ME_o = ME_f$)
- Two objects are isolated (e.g Karen in boat)
  - **COM**