The next three questions pertain to the situation described below.

A ball of mass m = 0.4 kg is thrown horizontally with speed v_0 = 7 m/s against a vertical wall. The ball rebounds (horizontally) with the same speed, after being in contact with the wall for 0.0035 s. Then, the ball is caught by a person, whose hand moves back a distance d = 0.4 m before the hand and the ball come to rest. (You may neglect the effects of gravity for this set of questions.)

1) What is the magnitude of the average force exerted by the ball on the wall during the collision?

a. $F_{\text{wall}} = 0$ N
b. $F_{\text{wall}} = 19.6$ N
c. $F_{\text{wall}} = 1600$ N
d. $F_{\text{wall}} = 800$ N
e. $F_{\text{wall}} = 9.8$ N

2) What is the magnitude of the impulse received by the person when catching the ball?

a. $I_{\text{person}} = 5.6$ kg m/s
b. $I_{\text{person}} = 2.8$ kg m/s
c. $I_{\text{person}} = 0$ kg m/s

3) If we assume the hand exerts a constant force in stopping the ball, what is the magnitude of that force?

a. $F_{\text{hand}} = 14$ N
b. $F_{\text{hand}} = 24$ N
c. $F_{\text{hand}} = 7$ N

The next three questions pertain to the situation described below.

A female ice skater of mass $m_1 = 45$ kg is skating straight East with speed $v_1 = 6$ m/s. A male skater of mass $m_2 = 67.5$ kg is skating straight North with speed $v_2 = 4.2$ m/s. Both skaters fall, collide, and slide together across the frictionless ice.

4) What is their speed as they slide across the ice together?

a. $v_{\text{final}} = 7.32$ m/s
b. $v_{\text{final}} = 5$ m/s
c. $v_{\text{final}} = 4.92$ m/s
d. $v_{\text{final}} = 5.1$ m/s
e. $v_{\text{final}} = 3.48$ m/s

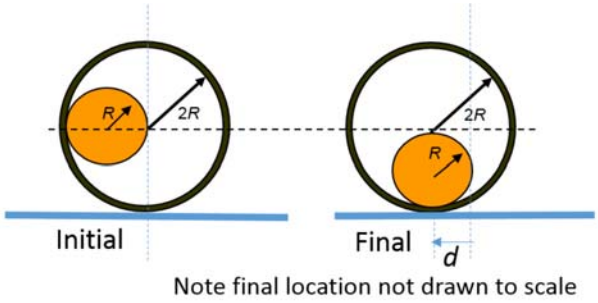
5) After the collision, the skaters slide at an angle θ, with respect to the East direction, equal to

a. $\theta = 56°$
b. $\theta = 35°$
c. $\theta = 46°$

6) Compare E_i, the total mechanical energy of the skaters before the collision, with E_f, the total mechanical energy of the skaters after the collision.

a. $E_i < E_f$
b. $E_i > E_f$
c. $E_i = E_f$

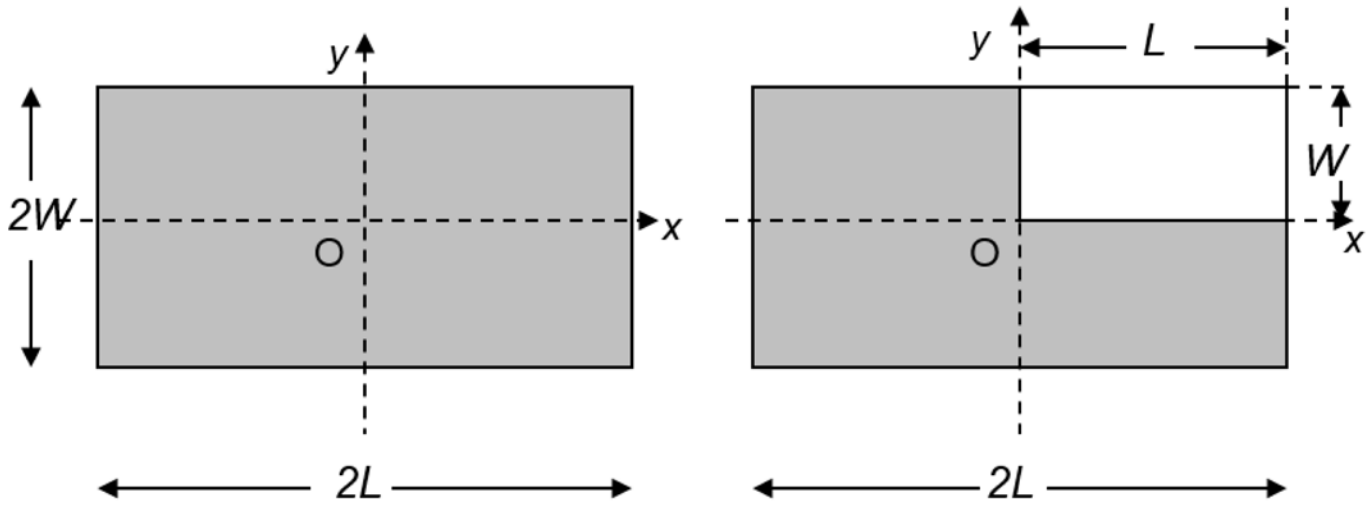
7) A solid, cylinder of mass m and radius R is placed inside a larger, hollow cylinder with **twice the mass** and twice the radius. The system is initially at rest on a horizontal, frictionless surface as shown in the left figure. The solid cylinder is then released and rolls inside the hollow cylinder until it finally comes to rest at the bottom, as shown in the right figure.



What is the distance d that the **hollow** cylinder (right image) moves relative to its original position?

a. $R/3$ to the left.
b. $2R/3$ to the left.
c. $R/6$ to the left.

8)

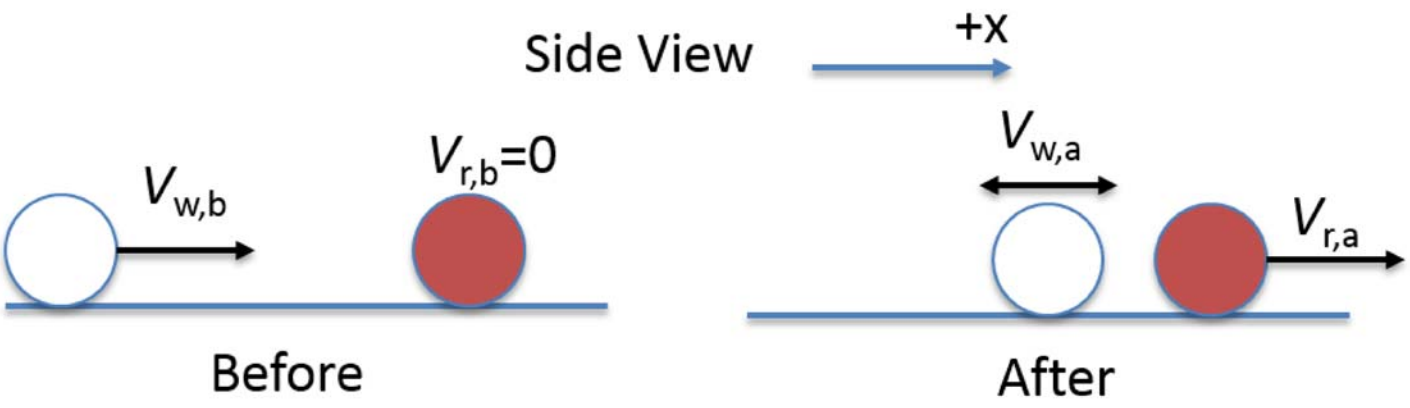


Consider a thin, uniform, solid, rectangular sheet of mass M, length $2L$ in the x-direction, and width $2W$ in the y-direction. It is placed symmetrically with respect to an (x, y)-coordinate system as shown in the left figure. Now, the upper right quadrant of this sheet is cut off, as shown in the right figure.

What is the x position of the center of mass of the sheet with the missing quadrant? (Note that O represents the origin x=0).

a. $X_{CM} = -L/6$
b. $X_{CM} = -L/3$
c. $X_{CM} = -L/2$

The next four questions pertain to the situation described below.



On a billiard table, a white ball strikes a red ball that was at rest before collision. After the collision, both balls are observed to move along the same line. The speed of the white ball before the collision is $V_{w,b}$ = 2 m/s and after the collision is $V_{w,a}$ = 0.3. The speed of the red ball after collision is $V_{r,a}$= 1.7 m/s. The white and red balls have the same mass. (For this set of questions, assume the billiard balls are sliding on a frictionless surface).

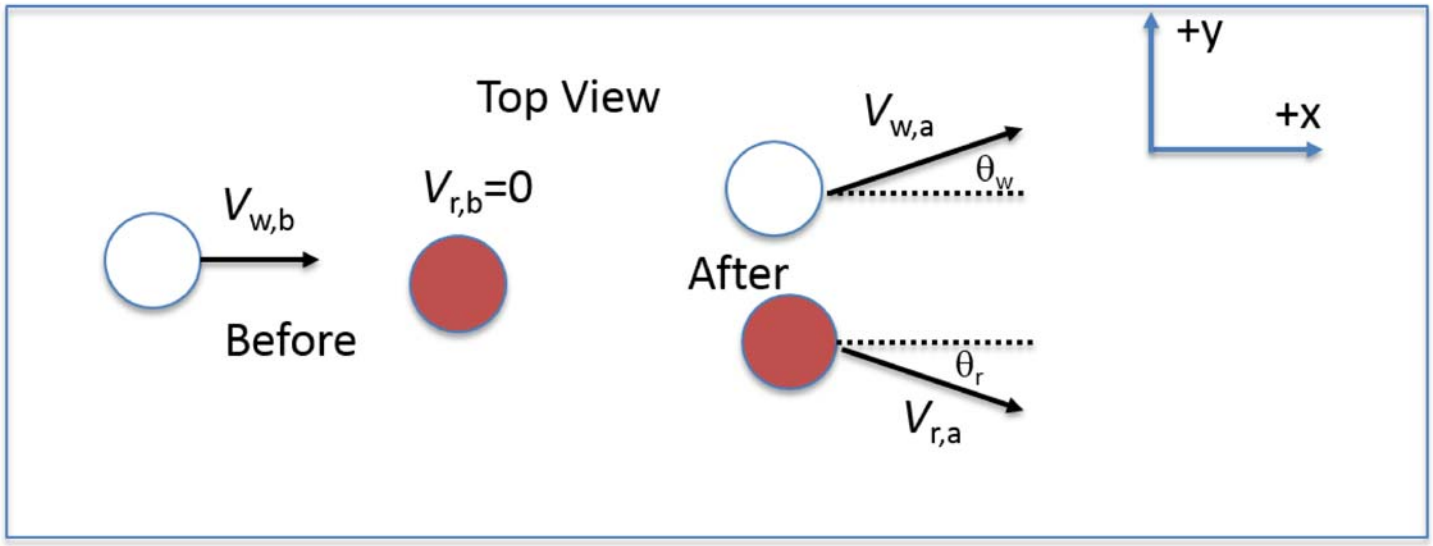
9) The collision was

a. inelastic.
b. completely inelastic.
c. elastic.

10) In what direction is the white ball moving after the collision?

a. -*x*
b. There is not enough information to determine the direction.
c. +*x*

11)



The experiment is repeated. The white ball has an initial velocity $V_{w,b}$ = 2 m/s in the +x direction, but strikes the red ball slightly off center. After the collision the white ball travels in the positive y direction at an angle θ_w = 13° with respect to the positive x direction and the red ball travels in the negative y direction at an angle θ_r = 17° with respect to the positive x direction as shown in the figure. The speeds of the red and white ball after the collision are not known, and can not be assumed to be the same as in the first experiment.

Compare the speed of the two balls after the collision.

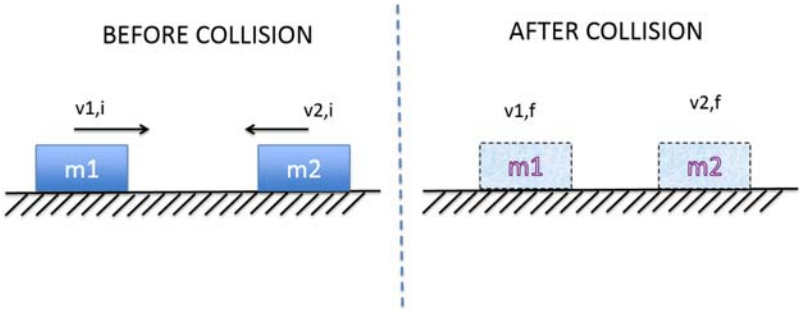
a. $|V_{w,a}| = |V_{r,a}|$
b. $|V_{w,a}| < |V_{r,a}|$
c. $|V_{w,a}| > |V_{r,a}|$

12) What is the speed of the red ball after the collision?

a. $|V_{r,a}|$ = 2.09 m/s
b. $|V_{r,a}|$ = 1.57 m/s
c. $|V_{r,a}|$ = 0.9 m/s
d. $|V_{r,a}|$ = 1.54 m/s
e. $|V_{r,a}|$ = 6.84 m/s

The next four questions pertain to the situation described below.

Two blocks of mass $m_1 = 2$ kg and $m_2 = 5$ kg are moving toward each other along a narrow stationary frictionless track. Block 1 is initially moving to the right with speed $v_1 = 3$ m/s and block 2 is initially moving to the left with speed $v_2 = 2$ m/s relative to the track. After the collision, the masses move along the track.



13) What is the direction of the momentum of the system of two blocks before the collision?

a. to the right.
b. to the left.
c. it is zero.

14) If after the collision block 1 is moving to the left with a speed 0.5 m/s, what is the speed of block 2?

a. $V_{2,f} = 0.5$ m/s
b. $V_{2,f} = 0.6$ m/s
c. $V_{2,f} = 0.8$ m/s
d. $V_{2,f} = 4.25$ m/s
e. $V_{2,f} = 0.2$ m/s

15) The experiment is repeated but magnets are attached to the blocks, so they stick and slide together on the frictionless surface after the collision. What is the speed of the two blocks after the collision?

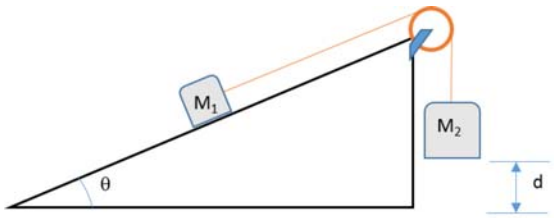
a. $|V_{12,f}| = 8$ m/s
b. $|V_{12,f}| = 2.29$ m/s
c. $|V_{12,f}| = 0.571$ m/s
d. $|V_{12,f}| = 1.2$ m/s
e. $|V_{12,f}| = 3.2$ m/s

16) The experiment is repeated but with a small explosive attached to the blocks, such that after the collision both blocks are moving faster than they were before the collision. Which of the following statements is correct?

a. The kinetic energy of the two block system is larger after the collision.
b. Both the momentum and the kinetic energy of the two block system are larger after the collision.
c. The momentum of the two block system larger after the collision.

The next three questions pertain to the situation described below.

A mass $M_1 = 8$ kg is being pulled up a ramp at a constant speed by rope that passes over a pulley and is then tied to the top of a mass $M_2 = 12$ kg. Initially, the distance between the bottom of the second mass and the ground is $d = 1.5$ m. The ramp's angle of inclination is $\theta = 25°$ and has an unknown coefficient of kinetic friction μ_k.



17) What is the total work done by gravity on the two blocks, as mass M_2 drops a distance $d = 1.5$ m?

a. $W_g = 58.8$ J
b. $W_g = 294$ J
c. $W_g = 127$ J
d. $W_g = 49.7$ J
e. $W_g = 226$ J

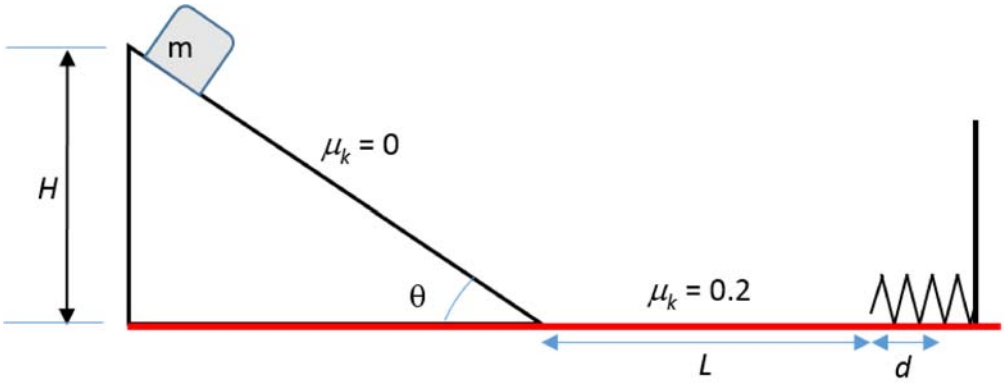
18) What is the total work done by all forces on block 1 as mass M_2 drops a distance $d = 1.5$ m?

a. $W_1 = 0$ J
b. $W_1 = -49.7$ J
c. $W_1 = 49.7$ J
d. $W_1 = -176$ J
e. $W_1 = 176$ J

19) What is the tension in the rope?

a. $T < M_2 g$
b. $T = M_2 g$
c. $T > M_2 g$

The next three questions pertain to the situation described below.



A block with mass m = 4 kg is released from rest at the top of a frictionless inclined plane. The initial height of the block is H. The block slides down the inclined plane and then along a rough horizontal surface for a distance L = 0.4 m at which point it compresses a spring. The spring has a spring constant of k = 45 N/m, and the spring compresses a distance d = 0.15 m from equilibrium. The entire horizontal surface including the part under the spring has coefficient of kinetic friction μ_k = 0.2.

20) What is the height of the ramp?

a. H = 0.0129 m
b. H = 0.0629 m
c. H = 0.11 m
d. H = 0.03 m
e. H = 0.123 m

21) What is the work done by the spring as it stops the block?

a. W_s = -3.14 J
b. W_s = -0.506 J
c. W_s = -4.82 J

22) If a block with 1/2 the mass (2 kg) was released from the top of the ramp, the distance that it compresses the spring would be

a. larger than 0.075 m.
b. equal to 0.075 m.
c. less than 0.075 m.