Halliday/Resnick/Walker
Fundamentals of Physics 8th edition

Classroom Response System Questions

Chapter 9 Center of Mass and Linear Momentum

Interactive Lecture Questions
9.2.1. Consider the Earth and Mars in their orbit around the Sun. Where is the center of mass located for this three body system?

a) It is closer to the Earth, than it is to either the Sun or Mars.

b) It is at the center of a triangle that has the Sun at one apex, the Earth at another apex, and Mars at the third apex.

c) It is half of the distance between the Sun and Mars.

d) It is closer to the Sun, than it is to either the Earth or Mars.

e) It is closer to Mars, than it is to either the Earth or the Sun.
9.2.1. Consider the Earth and Mars in their orbit around the Sun. Where is the center of mass located for this three body system?

a) It is closer to the Earth, than it is to either the Sun or Mars.

b) It is at the center of a triangle that has the Sun at one apex, the Earth at another apex, and Mars at the third apex.

c) It is half of the distance between the Sun and Mars.

d) It is closer to the Sun, than it is to either the Earth or Mars.

e) It is closer to Mars, than it is to either the Earth or the Sun.
9.2.2. Two girl scouts are sitting in a large canoe on a still lake while at summer camp. The canoe happens to be oriented with the front of the canoe pointing due north. One of the girls is at the front of the canoe and the other is at the back of the canoe. The girl at the front walks to sit next to her friend at the back and sits down. What effect does this event have on the canoe?

a) The canoe will still be at rest, but it will be south of its original position.

b) The canoe will still be at rest, but it will be north of its original position.

c) The canoe will be moving toward the south.

d) The canoe will be moving toward the north.

e) The canoe will still be at rest at its original position.
9.2.2. Two girl scouts are sitting in a large canoe on a still lake while at summer camp. The canoe happens to be oriented with the front of the canoe pointing due north. One of the girls is at the front of the canoe and the other is at the back of the canoe. The girl at the front walks to sit next to her friend at the back and sits down. What effect does this event have on the canoe?

a) The canoe will still be at rest, but it will be south of its original position.

b) The canoe will still be at rest, but it will be north of its original position.

c) The canoe will be moving toward the south.

d) The canoe will be moving toward the north.

e) The canoe will still be at rest at its original position.
9.2.3. A high school physics teacher also happens to be the junior hockey team coach. During a break at practice, the coach asks two players to go to the center of the ice with a 10.0-m pole. A 40-kg player is at one end of the pole and a 60-kg player is at the other end. The players then start pulling themselves together by pulling the rod and sliding on the ice as they move along the rod. When the two players meet, what distance will the 60-kg player have moved?

a) zero m

b) 4.0 m

c) 5.0 m

d) 6.0 m

e) 10.0 m
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a) zero m

b) 4.0 m

c) 5.0 m

d) 6.0 m

e) 10.0 m
9.2.4. Two carts are placed on a horizontal air track. The mass of the first cart is \( m \) and the mass of the second cart is \( 1.5m \). The first cart is accelerated to a speed \( v \) just before it collides with the second cart at rest. What is the speed of the center of mass of the system containing the two carts after the collision?

a) \( v \)

b) \( 4v/5 \)

c) \( 2v/5 \)

d) \( v/2 \)

e) This cannot be determined without knowing if the collision is elastic or inelastic.
9.2.4. Two carts are placed on a horizontal air track. The mass of the first cart is \( m \) and the mass of the second cart is 1.5\( m \). The first cart is accelerated to a speed \( v \) just before it collides with the second cart at rest. What is the speed of the center of mass of the system containing the two carts after the collision?

a) \( v \)

b) \( 4v/5 \)

c) \( 2v/5 \)

d) \( v/2 \)

e) This cannot be determined without knowing if the collision is elastic or inelastic.
9.2.5. A very thin, uniform semi-circular disc of radius $R$ is symmetrical about the $y$ axis, as shown in the drawing. Using integration, determine the $y$ coordinate of the center of mass (the $x$ coordinate is zero).

a) $\frac{R}{2}$

b) $\frac{3R}{5}$

c) $\frac{2R}{3}$

d) $\frac{2R}{\pi}$

e) $\frac{4R}{3\pi}$
9.2.5. A very thin, uniform semi-circular disc of radius $R$ is symmetrical about the $y$ axis, as shown in the drawing. Using integration, determine the $y$ coordinate of the center of mass (the $x$ coordinate is zero).

a) $\frac{R}{2}$
b) $\frac{3R}{5}$
c) $\frac{2R}{3}$
d) $\frac{2R}{\pi}$
e) $\frac{4R}{3\pi}$
9.2.6. A rod of very small diameter with a mass \( m \) and length \( L \) is placed along the \( x \) axis with one end at the origin. An identical rod is placed along the \( y \) axis with one end at the origin, so that the two rods form an L-shape. What are the coordinates of the center of mass for these two rods?

a) \((L/2, L/2)\)

b) \((L/4, L/2)\)

c) \((L/2, L/4)\)

d) \((L/4, L/4)\)

e) \((L/8, L/8)\)
9.2.6. A rod of very small diameter with a mass \( m \) and length \( L \) is placed along the \( x \) axis with one end at the origin. An identical rod is placed along the \( y \) axis with one end at the origin, so that the two rods form an L-shape. What are the coordinates of the center of mass for these two rods?

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b) \((L/4, L/2)\)

c) \((L/2, L/4)\)

d) \((L/4, L/4)\)

e) \((L/8, L/8)\)
9.3.1. Consider a system of two particles: ball A with a mass $m$ is moving to the right a speed $2v$ and ball B with a mass $3m$ is moving to the left at a speed $v$. In the time interval before the two balls collide, what is the magnitude and the direction of the velocity of the center of mass of this system?

a) $\frac{v}{4}$, to the left

b) $\frac{2v}{3}$, to the left

c) $\frac{3v}{2}$, to the left

d) $\frac{2v}{3}$, to the right

e) The center of mass of the system is at a fixed location, so the velocity is zero m/s.
9.3.1. Consider a system of two particles: ball A with a mass \( m \) is moving to the right a speed \( 2v \) and ball B with a mass \( 3m \) is moving to the left at a speed \( v \). In the time interval before the two balls collide, what is the magnitude and the direction of the velocity of the center of mass of this system?

a) \( \frac{v}{4} \), to the left

b) \( \frac{2v}{3} \), to the left

c) \( \frac{3v}{2} \), to the left

d) \( \frac{2v}{3} \), to the right

e) The center of mass of the system is at a fixed location, so the velocity is zero m/s.
9.4.1. A sports car of mass $m$ has the same kinetic energy as an SUV with a mass $3m$ as each is driven along the same road. Which vehicle, if either, has the largest momentum and what is the difference in their momenta, if any? Express your result as a percentage.

a) Since their kinetic energies are the same, their momenta are the same. The difference is zero percent.

b) The car has about 33% greater momentum than the SUV.

c) The car has about 42% greater momentum than the SUV.

d) The SUV has about 66% greater momentum than the car.

e) The SUV has about 73% greater momentum than the car.
9.4.1. A sports car of mass $m$ has the same kinetic energy as an SUV with a mass $3m$ as each is driven along the same road. Which vehicle, if either, has the largest momentum and what is the difference in their momenta, if any? Express your result as a percentage.

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b) The car has about 33% greater momentum than the SUV.

c) The car has about 42% greater momentum than the SUV.

d) The SUV has about 66% greater momentum than the car.

e) The SUV has about 73% greater momentum than the car.
9.4.2. Three events are observed at a baseball game:

I. A baseball is thrown by a pitcher. It starts from rest and is traveling at +38 m/s as it flies toward the catcher.

II. A baseball is traveling at +38 m/s when it enters the catcher’s glove and stops.

III. A baseball is traveling at +38 m/s when it hits a wall and bounces away from the wall at \(-38\) m/s.

The change in the momentum of the baseball has the largest magnitude in which case(s)?

a) I only

b) II only

c) III only

d) I and II only

e) II and III only
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III. A baseball is traveling at +38 m/s when it hits a wall and bounces away from the wall at −38 m/s.

The change in the momentum of the baseball has the largest magnitude in which case(s)?

a) I only
b) II only
c) III only
d) I and II only
e) II and III only
9.4.3. An astronaut drops a golf ball that is initially at rest from a cliff on the surface of the moon. The ball falls freely under the influence of gravity. Which one of the following statements is true concerning the ball as it falls? Neglect any frictional effects.

a) The ball will gain an equal amount of kinetic energy during each second.

b) The ball will gain an equal amount of momentum during each second.

c) The ball will gain an equal amount of momentum during each meter through which it falls.

d) The ball will gain twice the amount of speed for each meter through which it falls.

e) The amount of momentum the ball gains will be directly proportional to the amount of potential energy that it loses.
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e) The amount of momentum the ball gains will be directly proportional to the amount of potential energy that it loses.
9.4.4. A stone of mass \( m \) is dropped and falls freely under the influence of gravity. Ignoring any effects of air resistance, which one of the following expressions gives the momentum of the stone as a function of time \( t \)? The local acceleration due to gravity is \( g \).

a) \( \frac{1}{2} mgt^2 \)

b) \( gt \)

c) \( \frac{1}{2} gt^2 \)

d) \( mgt \)

e) \( g \frac{dm}{dt} \)
9.4.4. A stone of mass $m$ is dropped and falls freely under the influence of gravity. Ignoring any effects of air resistance, which one of the following expressions gives the momentum of the stone as a function of time $t$? The local acceleration due to gravity is $g$.

a) $\frac{1}{2}mgt^2$

b) $gt$

c) $\frac{1}{2}gt^2$

d) $mgt$

e) $g \frac{dm}{dt}$
9.5.1. Consider the following objects:

(1) an electron ($m = 9.1 \times 10^{-31} \text{ kg}$, $v = 5.0 \times 10^7 \text{ m/s}$)
(2) the Hubble Space Telescope ($m = 1.1 \times 10^4 \text{ kg}$, $v = 7.6 \times 10^3 \text{ m/s}$)
(3) a snail ($m = 0.02 \text{ kg}$, $v = 0.0003 \text{ m/s}$)
(4) the largest super oil tanker ($m = 1.5 \times 10^8 \text{ kg}$, $v = 2.0 \text{ m/s}$)
(5) a falling rain drop ($m = 0.0002 \text{ kg}$, $v = 9.5 \text{ m/s}$)

Which one of these objects requires the greatest change in momentum to stop moving?

a) 1

b) 2

c) 3

d) 4

e) 5
9.5.1. Consider the following objects:

1. an electron \( m = 9.1 \times 10^{-31} \) kg, \( v = 5.0 \times 10^7 \) m/s
2. the Hubble Space Telescope \( m = 1.1 \times 10^4 \) kg, \( v = 7.6 \times 10^3 \) m/s
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5. a falling rain drop \( m = 0.0002 \) kg, \( v = 9.5 \) m/s

Which one of these objects requires the greatest change in momentum to stop moving?

a) 1
b) 2
c) 3
d) 4
e) 5
9.6.1. A football of mass $m$, initially at rest, is kicked so that leaves the foot at a speed $v$. If $t$ represents the duration of the collision between the ball and the foot, which one of the following expressions determines the magnitude of the average force exerted on the ball?

a) $mvt$

b) $(1/2)mv^2$

c) $(1/2)mv^2/t$

d) $mv/t$

e) $(1/2)mvt^2$
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c) $(1/2)mv^2/t$

d) $mv/t$

e) $(1/2)mvt^2$
9.6.2. During the filming of a movie, a stunt person jumps from the roof of a tall building, but no injury occurs because the person lands on a large, air-filled bag. Which one of the following best describes why no injury occurs?

a) The bag increases the amount of time the force acts on the person and reduces the change in momentum.

b) The bag increases the amount of time during which the momentum is changing and reduces the average force on the person.

c) The bag decreases the amount of time during which the momentum is changing and reduces the average force on the person.

d) The bag provides the necessary force to stop the person.

e) The bag reduces the impulse to the person.
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e) The bag reduces the impulse to the person.
9.6.3. A beginning 28-kg roller skater is standing in front of a wall. By pushing against the wall, she is propelled backward with a velocity of $-1.2 \text{ m/s}$. While pushing, her hands are in contact with the wall for $0.80 \text{ s}$. Ignoring frictional effects, find the magnitude and direction of the impulse acting on the skater.

a) $-34 \text{ N} \cdot \text{s}$

b) $+34 \text{ N} \cdot \text{s}$

c) $-42 \text{ N} \cdot \text{s}$

d) $+42 \text{ N} \cdot \text{s}$

e) $-53 \text{ N} \cdot \text{s}$
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c) $-42 \text{ N} \cdot \text{s}$

d) $+42 \text{ N} \cdot \text{s}$

e) $-53 \text{ N} \cdot \text{s}$
9.6.4. A force that varies with time is applied to an object. The force increases linearly from zero newtons to twenty-four newtons during the first two seconds. Then, the force remains constant for four seconds. During the last two seconds, the force linearly decreases to zero newtons. What is the total impulse exerted on the object?

a) This cannot be determined because neither the initial momentum nor the final momentum is known.

b) This cannot be determined because the mass of the object is not given.

c) The total impulse is 96 N \cdot s.

d) The total impulse is 128 N \cdot s.

e) The total impulse is 144 N \cdot s.
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d) The total impulse is 128 N \cdot s.

e) The total impulse is 144 N \cdot s.
9.6.5. A small asteroid collides with a planet. Which one of the following statements concerning what happens during the collision is correct?

a) The asteroid exerts a smaller force on the planet than the planet exerts on the asteroid.

b) The planet exerts a force on the asteroid, but the asteroid does not exert a force on the planet.

c) The asteroid exerts the same amount of force on the planet as the planet exerts on the asteroid.

d) The asteroid exerts a force on the planet, but the planet does not exert a force on the asteroid.

e) The planet exerts a smaller force on the asteroid than the asteroid exerts on the planet.
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d) The asteroid exerts a force on the planet, but the planet does not exert a force on the asteroid.

e) The planet exerts a smaller force on the asteroid than the asteroid exerts on the planet.
9.7.1. A 9-kg object is at rest. Suddenly, it explodes and breaks into two pieces. The mass of one piece is 6 kg and the other is a 3-kg piece. Which one of the following statements concerning these two pieces is correct?

a) The speed of the 6-kg piece will be one eighth that of the 3-kg piece.

b) The speed of the 3-kg piece will be one fourth that of the 6-kg piece.

c) The speed of the 6-kg piece will be one forth that of the 3-kg piece.

d) The speed of the 3-kg piece will be one half that of the 6-kg piece.

e) The speed of the 6-kg piece will be one half that of the 3-kg piece.
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d) The speed of the 3-kg piece will be one half that of the 6-kg piece.

e) The speed of the 6-kg piece will be one half that of the 3-kg piece.
9.7.2. A sled of mass $m$ is coasting at a constant velocity on the ice covered surface of a lake. Three birds, with a combined mass $0.5m$, gently land at the same time on the sled. The sled and birds continue sliding along the original direction of motion. How does the kinetic energy of the sled and birds compare with the initial kinetic energy of the sled before the birds landed?

a) The final kinetic energy is one half of the initial kinetic energy.

b) The final kinetic energy is one third of the initial kinetic energy.

c) The final kinetic energy is one quarter of the initial kinetic energy.

d) The final kinetic energy is one ninth of the initial kinetic energy.

e) The final kinetic energy is equal to the initial kinetic energy.
9.7.2. A sled of mass \( m \) is coasting at a constant velocity on the ice covered surface of a lake. Three birds, with a combined mass 0.5\( m \), gently land at the same time on the sled. The sled and birds continue sliding along the original direction of motion. How does the kinetic energy of the sled and birds compare with the initial kinetic energy of the sled before the birds landed?

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c) The final kinetic energy is one quarter of the initial kinetic energy.

d) The final kinetic energy is one ninth of the initial kinetic energy.

e) The final kinetic energy is equal to the initial kinetic energy.
9.7.3. Darrin, \( m = 45 \) kg, runs and jumps off a stationary, 168-kg floating platform on a lake. Darrin’s velocity as he leaps is +2.7 m/s. Ignoring any frictional effects, what is the recoil velocity of the platform?

a) \(-2.7 \) m/s

b) +0.72 m/s

c) \(-1.4 \) m/s

d) \(-0.72 \) m/s

e) +2.7 m/s
9.7.3. Darrin, \( m = 45 \text{ kg} \), runs and jumps off a stationary, 168-kg floating platform on a lake. Darrin’s velocity as he leaps is +2.7 m/s. Ignoring any frictional effects, what is the recoil velocity of the platform?

a) \(-2.7 \text{ m/s}\)

b) \(+0.72 \text{ m/s}\)

c) \(-1.4 \text{ m/s}\)

d) \(-0.72 \text{ m/s}\)  \(\boxed{\text{Correct}}\)

e) \(+2.7 \text{ m/s}\)
9.7.4. Consider the recoil of a rifle when it is fired. Recoil is an example of which of the following concepts?

a) Newton’s Third Law of Motion

b) Impulse

c) Conservation of Momentum

d) all of the above

e) none of the above
9.7.4. Consider the recoil of a rifle when it is fired. Recoil is an example of which of the following concepts?

a) Newton’s Third Law of Motion
b) Impulse
c) Conservation of Momentum
d) all of the above
e) none of the above
9.8.1. A water balloon is dropped from a third story balcony. The balloon bursts when it hits the ground. It is a completely inelastic collision with the earth. How much kinetic energy is transferred to the earth as a result of the collision?

a) $mv^2/2$

b) $mv^2$

c) $mv$

d) $2mv^2$

e) zero joules
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a) $mv^2/2$

b) $mv^2$

c) $mv$

d) $2mv^2$

e) zero joules
9.8.2. A ball is thrown downward and its speed is $v$ just before it strikes the ground. After the collision with the earth, it heads upward with a speed $v$. Which one of the following statements concerning this situation is true?

a) Only the momentum of the earth is changed by the collision.

b) The momentum of the earth is not changed by the collision.

c) Only the momentum of the ball is changed by the collision.

d) The momentum of the ball is not changed by the collision.

e) The collision causes both the momentum and the kinetic energy of the ball to change.
9.8.2. A ball is thrown downward and its speed is \( v \) just before it strikes the ground. After the collision with the earth, it heads upward with a speed \( v \). Which one of the following statements concerning this situation is true?

a) Only the momentum of the earth is changed by the collision.

b) The momentum of the earth is not changed by the collision.

c) Only the momentum of the ball is changed by the collision.

d) The momentum of the ball is not changed by the collision.

e) The collision causes both the momentum and the kinetic energy of the ball to change.
9.8.3. A cart that can slide freely on a frictionless track has a vertical rigid sail as shown in the drawing is at rest on the track. In case A, a ball of clay is launched horizontally as shown and strikes the sail, but does not stick. The ball falls straight downward after the collision. In case B, a rubber ball, with the same mass and initial speed as the clay ball, strikes the sail and bounces backward. Which one of the following statements concerning this situation is true?

a) The final velocity of the cart is the same in both cases and its magnitude is greater than zero m/s.

b) The final velocity of the cart is the larger in case A than it is in case B.

c) The final velocity of the cart is the smaller in case A than it is in case B.

d) The final velocity of the cart is zero m/s in both cases.

e) This question cannot be answered without knowing the masses of the balls and the cart and the initial speed of the balls.
9.8.3. A cart that can slide freely on a frictionless track has a vertical rigid sail as shown in the drawing is at rest on the track. In case A, a ball of clay is launched horizontally as shown and strikes the sail, but does not stick. The ball falls straight downward after the collision. In case B, a rubber ball, with the same mass and initial speed as the clay ball, strikes the sail and bounces backward. Which one of the following statements concerning this situation is true?

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d) The final velocity of the cart is zero m/s in both cases.

e) This question cannot be answered without knowing the masses of the balls and the cart and the initial speed of the balls.
9.9.1. Object A is traveling due north while object B is traveling due south along the same line. The two objects have a head-on collision. Which one of the following statements best describes the velocities of the objects after the collision?

a) The final velocity of B will be the same as the initial velocity of A and *vice versa*.

b) The final velocities of both A and B will be less than the velocities before collision

c) The final velocities of A and B will be the same as they had before the collision.

d) The final velocities of A and B could be equal to zero m/s.

e) The final velocities of A and B will be equal to zero m/s.
9.9.1. Object A is traveling due north while object B is traveling due south along the same line. The two objects have a head-on collision. Which one of the following statements best describes the velocities of the objects after the collision?

a) The final velocity of B will be the same as the initial velocity of A and *vice versa*.

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c) The final velocities of A and B will be the same as they had before the collision.

d) The final velocities of A and B could be equal to zero m/s.

e) The final velocities of A and B will be equal to zero m/s.
9.9.2. A rubber ball of mass $m$ is dropped from rest from a window from a height $h$ above the ground. Just before the ball hits the ground, it is traveling at a speed $v$. Just after it bounces, the ball is moving upward at a speed $0.75v$. Which one of the following expressions gives the change in momentum of the ball as a result of the collision? Ignore any effects due to air resistance.

a) $\Delta p = \frac{m}{4} \sqrt{2gh}$

b) $\Delta p = \frac{7m}{4} \sqrt{2gh}$

c) $\Delta p = \frac{7mgh}{4}$

d) $\Delta p = \frac{mg}{4} \sqrt{2h}$

e) $\Delta p = \frac{3mg}{4} \sqrt{2h}$
9.9.2. A rubber ball of mass \( m \) is dropped from rest from a window from a height \( h \) above the ground. Just before the ball hits the ground, it is traveling at a speed \( v \). Just after it bounces, the ball is moving upward at a speed \( 0.75v \). Which one of the following expressions gives the change in momentum of the ball as a result of the collision? Ignore any effects due to air resistance.

\[
\begin{align*}
\text{a)} & \quad \Delta p = \frac{m}{4} \sqrt{2gh} \\
\text{b)} & \quad \Delta p = \frac{7m}{4} \sqrt{2gh} \\
\text{c)} & \quad \Delta p = \frac{7mgh}{4} \\
\text{d)} & \quad \Delta p = \frac{mg}{4} \sqrt{2h} \\
\text{e)} & \quad \Delta p = \frac{3mg}{4} \sqrt{2h}
\end{align*}
\]
9.9.3. In a scary science fiction movie, an asteroid is on a direct collision path with the Earth. The asteroid has mass \( m = 3.98 \times 10^{15} \text{ kg} \) and velocity \( v = -7.00 \times 10^3 \text{ m/s} \). The Earth has mass \( M = 5.98 \times 10^{24} \text{ kg} \) and velocity \( V = +2.99 \times 10^4 \text{ m/s} \). Assuming the collision is perfectly inelastic and that no mass is lost from the Earth/asteroid system, determine the velocity of the Earth after the collision.

a) \( +2.39 \times 10^4 \text{ m/s} \)

b) \( +2.48 \times 10^4 \text{ m/s} \)

c) \( +2.61 \times 10^4 \text{ m/s} \)

d) \( +2.82 \times 10^4 \text{ m/s} \)

e) \( +2.99 \times 10^4 \text{ m/s} \)
9.9.3. In a scary science fiction movie, an asteroid is on a direct collision path with the Earth. The asteroid has mass \( m = 3.98 \times 10^{15} \) kg and velocity \( v = -7.00 \times 10^3 \) m/s. The Earth has mass \( M = 5.98 \times 10^{24} \) kg and velocity \( V = +2.99 \times 10^4 \) m/s. Assuming the collision is perfectly inelastic and that no mass is lost from the Earth/asteroid system, determine the velocity of the Earth after the collision.

a) \(+2.39 \times 10^4\) m/s

b) \(+2.48 \times 10^4\) m/s

c) \(+2.61 \times 10^4\) m/s

d) \(+2.82 \times 10^4\) m/s

e) \(+2.99 \times 10^4\) m/s
9.9.4. Two identical cars were involved in a collision at an icy intersection. Car A was stopped at a traffic light. Car B was moving at a speed $v$ when it suffered a perfectly inelastic collision with the back end of car A. With what speed did the two cars slide into the intersection after the collision?

a) $2v$

b) $v$

c) $v/2$

d) $v/4$

e) $v/8$
9.9.4. Two identical cars were involved in a collision at an icy intersection. Car A was stopped at a traffic light. Car B was moving at a speed $v$ when it suffered a perfectly inelastic collision with the back end of car A. With what speed did the two cars slide into the intersection after the collision?

a) $2v$

b) $v$

c) $v/2$

d) $v/4$

e) $v/8$
9.9.5. Two identical 2.0-kg objects are involved in a collision. The objects are on a frictionless track. The initial velocity of object A is +12 m/s and the initial velocity of object B is −6.0 m/s. What is the final velocity of the two objects?

a) Object A moves at −6.0 m/s and B moves at +12 m/s.
b) Object A moves at +9.0 m/s and B moves at +9.0 m/s.
c) Object A moves at −6.0 m/s and B moves at +6.0 m/s.
d) Object A moves at −12 m/s and B moves at +6.0 m/s.
e) This cannot be determined without more information.
9.9.5. Two identical 2.0-kg objects are involved in a collision. The objects are on a frictionless track. The initial velocity of object A is +12 m/s and the initial velocity of object B is −6.0 m/s. What is the final velocity of the two objects?

a) Object A moves at −6.0 m/s and B moves at +12 m/s.

b) Object A moves at +9.0 m/s and B moves at +9.0 m/s.

c) Object A moves at −6.0 m/s and B moves at +6.0 m/s.

d) Object A moves at −12 m/s and B moves at +6.0 m/s.

e) This cannot be determined without more information.
9.11.1. On an air hockey table, two identical pucks have an elastic collision. Puck A is observed to be traveling northeast at \( v \) m/s before the collision and northwest at \( v \) m/s after the collision. Puck B is observed to be traveling northwest at \( v \) m/s before the collision and northeast at \( v \) m/s after the collision. Describe the direction of the impulse exerted on each disk during the collision.

a) The impulse on puck A is directed due west and the impulse on puck B is directed due east.

b) The impulse on puck A is directed due east and the impulse on puck B is directed due west.

c) The impulse on puck A is directed due north and the impulse on puck B is directed due north.

d) The impulse on puck A is directed northwest and the impulse on puck B is directed northeast.

e) The impulse on puck A is directed southwest and the impulse on puck B is directed southeast.
9.11.1. On an air hockey table, two identical pucks have an elastic collision. Puck A is observed to be traveling northeast at $v$ m/s before the collision and northwest at $v$ m/s after the collision. Puck B is observed to be traveling northwest at $v$ m/s before the collision and northeast at $v$ m/s after the collision. Describe the direction of the impulse exerted on each disk during the collision.

a) The impulse on puck A is directed due west and the impulse on puck B is directed due east.

b) The impulse on puck A is directed due east and the impulse on puck B is directed due west.

c) The impulse on puck A is directed due north and the impulse on puck B is directed due north.

d) The impulse on puck A is directed northwest and the impulse on puck B is directed northeast.

e) The impulse on puck A is directed southwest and the impulse on puck B is directed southeast.
9.12.1. Children sometimes play with water rockets, in which an inner compartment is partially filled with water. The air pocket above the water is pressurized using a small pump. When the rocket is released from the pump, it flies upward at an initial velocity of 17 m/s as water exits through a nozzle at the bottom that has a radius of 2.5 mm. If the density of the water is 999 kg/m³, what is the initial thrust of the rocket?

a) 0.33 N

b) 5.7 N

c) 0.88 N

d) 2.4 N

e) 3.7 N
9.12.1. Children sometimes play with water rockets, in which an inner compartment is partially filled with water. The air pocket above the water is pressurized using a small pump. When the rocket is released from the pump, it flies upward at an initial velocity of 17 m/s as water exits through a nozzle at the bottom that has a radius of 2.5 mm. If the density of the water is 999 kg/m$^3$, what is the initial thrust of the rocket?

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