Physics for Scientists and Engineers, 4e **(Giancoli)**

Chapter 9 Linear Momentum

9.1 Conceptual Questions

1) State Newton's second law of motion in terms of momentum.
Answer: The rate of change of momentum of an object is equal to the net force applied to it.
Diff: 1 Page Ref: Sec. 9-1

2) State the Law of Conservation of Linear Momentum.
Answer: When the net external force on a system of objects is zero, the total momentum of the system remains constant.
OR
The total momentum of an isolated system of objects remains constant.
Diff: 1 Page Ref: Sec. 9-2

3) Is it realistic to apply the conservation of momentum to real world collisions where external forces act?
Answer: Yes, in a collision the force each object exerts on the other acts only over a brief time interval and is very strong relative to the other forces. If the momenta immediately before and after the collision is measured, momentum will be very nearly conserved.
Diff: 2 Page Ref: Sec. 9-2

4) A novice marksman fires a rifle while holding the butt of the rifle a couple of centimeters away from his shoulder. Explain what happens in terms of the physical principles involved.
Answer: The initial momentum of the bullet/gun system was zero kg·m/s, so after firing the rifle the forward momentum of the bullet is equal and opposite to the backward momentum of the rifle alone. The rifle kicks back and hits the marksman on the shoulder with sufficient speed to cause a bruise. An expert marksman would hold the rifle tight against the shoulder. The recoil then involves both the mass of the rifle and the mass of the upper part of the body of the marksman.
Diff: 1 Page Ref: Sec. 9-3

5) Define an inelastic collision in terms of conservation of momentum and energy.
Answer: In an inelastic collision, the momentum of the system is conserved, but its kinetic energy is not.
Diff: 1 Page Ref: Sec. 9-4

6) Define an elastic collision in terms of conservation of momentum and energy.
Answer: In an elastic collision, the momentum and kinetic energy are conserved.
Diff: 1 Page Ref: Sec. 9-4

7) Explain the process through which kinetic energy is conserved in an elastic collision.
Answer: If the two objects are very hard and no heat or other form of energy is produced in the collision, then the kinetic energy of the two objects is the same after the collision as before. For the brief moment during which the two objects are in contact, some (or all(of the energy is stored momentarily in the form of elastic potential energy. But if we compare the total kinetic energy just before the collision with the total kinetic energy just after the collision, and they are found to be the same, then we say that the total kinetic energy is conserved.
Diff: 2 Page Ref: Sec. 9-4

8) When a ball undergoes a one-dimensional elastic collision with a wall, the velocity of the ball is reversed, while the wall remains stationary. Explain why this does not violate conservation of momentum.

Answer: One can regard this as the collision of the ball with a very massive object. As the mass of the object is increased, its speed after the collision becomes smaller and smaller. In the limiting case of an infinite mass, that mass does not move and the ball's velocity is reversed. The momentum is still conserved, but since the mass of the wall is essentially infinite, its velocity is infinitesimal.

Diff: 1 Page Ref: Sec. 9-5

9) Explain the process through which kinetic energy is lost in an inelastic collision.

Answer: Some of the initial kinetic energy is transformed into other types of energy, such as thermal or potential energy, so the total kinetic energy after the collision is less than the total kinetic energy before the collision.

Diff: 2 Page Ref: Sec. 9-6

10) Is it possible for kinetic energy to increase during an inelastic collision? Explain.

Answer: Yes, during an inelastic collision potential energy (such as chemical or nuclear) can be released. In which case the total kinetic energy after the interaction can be greater than the initial kinetic energy.

Diff: 2 Page Ref: Sec. 9-6

11) When a ball undergoes a two-dimensional elastic collision with a smooth wall, the angle that the incident path makes with the perpendicular to the wall is equal to the angle that the outgoing path makes with the perpendicular to the wall. Explain why this is so.

Answer: Because the wall is smooth, it does not exert a tangential force on the ball, and the tangential component of momentum of the ball is unchanged. In the normal direction, there is a force on the ball, and it changes its momentum. In order to conserve energy, however, the magnitude of the normal component of the ball's velocity must remain unchanged. This means that that component of the velocity changes sign, and thus the two angles are equal.

Diff: 1 Page Ref: Sec. 9-7

12) In the two-dimensional elastic collision of a particle with a stationary particle that has the same mass, the trajectories of the two particles after the collision are at right angles to each other. Explain why this should be so.

Answer: Since the masses are equal, conservation of momentum can be stated in the form $v_1 + v_2 = \mathbf{v}$, which states that the three vectors form the sides of a triangle, and conservation of energy becomes $v_1^2 + v_2^2 = v^2$, which says that the sum of the squares of the two sides is equal to the square of the third. That makes it a right-angled triangle, with the two sides corresponding to the final velocities at right angles to each other.

Diff: 2 Page Ref: Sec. 9-7

13) Explain the significance of the center of gravity.

Answer: The center of gravity of an object is that point at which the force of gravity can be considered to act. The force of gravity actually acts on all the different parts or particles of an object, but for purposes of determining the translational motion of an object as a whole, it is safe to assume that the entire weight of the object acts at the center of gravity.

Diff: 1 Page Ref: Sec. 9-8

14) In space there is nothing for the rocket to "push against" so how does it accelerate?

Answer: In terms of forces, the rocket pushes the exhaust gases back and they in turn (action-reaction) push the rocket forward. In terms of momentum, in order to conserve momentum since the exhaust gases acquire negative momentum (moving backwards) the rocket acquires positive momentum (increasing velocity forward).

Diff: 2 Page Ref: Sec. 9-10

15) The net force acting on an object is equal to the rate of change of its momentum.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-1

16) The change in the momentum vector is in the direction of the net force.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-1

17) If no net external force acts on a system, the total momentum of the system is a conserved quantity.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-2

18) The impulse delivered to an object is equal to the change in the object's velocity.
Answer: FALSE
Diff: 1 Page Ref: Sec. 9-3

19) Collisions in which kinetic energy is conserved are said to be ineleatic collisions.
Answer: FALSE
Diff: 1 Page Ref: Sec. 9-4

20) Collisions in which total energy is conserved are said to be elastic collisions.
Answer: FALSE
Diff: 1 Page Ref: Sec. 9-4

21) In a one-dimensional elastic collision of two identical masses, the masses always exchange velocities.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-5

22) In any elastic head-on collision, the relative speed of the two objects after the collision has the same magnitude (but opposite direction) as before the collision, no matter what the masses are.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-5

23) In an inelastic collision, the total kinetic energy after the interaction can be greater than the initial kinetic energy.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-6

24) If two objects stick together as a result of a collision, the collision is said to be perfectly elastic.
Answer: FALSE
Diff: 1 Page Ref: Sec. 9-6

25) The center of mass of an object has to be located within the object.
Answer: FALSE
Diff: 1 Page Ref: Sec. 9-8

26) The center of mass of a continuous, uniform object is located at the geometric center of the object.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-8

27) The center of mass of a system of particles (or objects) with total mass M moves like a single particle of mass M acted upon by the same net external force.
Answer: TRUE
Diff: 1 Page Ref: Sec. 9-9

28) The linear momentum of an extended object is the product of the object's mass and the velocity of its center of mass.

Answer: TRUE

Diff: 1 Page Ref: Sec. 9-9

29) Identical forces act for the same length of time on two different masses. The change in momentum of the smaller mass is

A) smaller than the change in momentum of the larger mass, but not zero.
B) larger than the change in momentum of the larger mass.
C) equal to the change in momentum of the larger mass.
D) zero.
E) There is not enough information to answer the question.

Answer: C

Diff: 1 Page Ref: Sec. 9-1

30) The area under the curve on a Force versus time (F vs. t) graph represents

A) impulse.
B) momentum.
C) work.
D) kinetic energy.
E) potential energy.

Answer: A

Diff: 1 Page Ref: Sec. 9-3

31) A small car meshes with a large truck in a head-on collision. Which of the following statements concerning the magnitude of the average collision force is correct?

A) The truck experiences the greater average force.
B) The small car experiences the greater average force.
C) The small car and the truck experience the same average force.
D) It is impossible to tell since the masses are not given.
E) It is impossible to tell since the velocities are not given.

Answer: C

Diff: 1 Page Ref: Sec. 9-3

32) In a collision between two unequal masses, how does the impulse imparted to the smaller mass by the larger mass compare with the impulse imparted to the larger mass by the smaller one?

A) It is larger.
B) It is smaller.
C) They are equal.
D) The answer depends on the ratio of the masses.
E) The answer depends on how fast they are moving.

Answer: C

Diff: 1 Page Ref: Sec. 9-3

33) A Ping-Pong ball moving east at a speed of 4 m/s, collides with a stationary bowling ball. The Ping-Pong ball bounces back to the west, and the bowling ball moves very slowly to the east. Which object experiences the greater magnitude impulse during the collision?

A) Neither; both experienced the same magnitude impulse.
B) the Ping-Pong ball
C) the bowling ball
D) It's impossible to tell since the actual mass values are not given.
E) It's impossible to tell since the velocities after the collision are unknown.

Answer: A

Diff: 2 Page Ref: Sec. 9-3

34) An elastic collision of two objects is characterized by the following.

A) Total momentum of the system is conserved.
B) Total energy of the system remains constant.
C) Total kinetic energy of the system remains constant.
D) Only A and B are true.
E) A, B, and C are all true.

Answer: E
Diff: 1 Page Ref: Sec. 9-4

35) An inelastic collision of two objects is characterized by the following.

A) Total momentum of the system is conserved.
B) Total energy of the system remains constant.
C) Total kinetic energy of the system remains constant.
D) Only A and B are true.
E) A, B, and C are all true.

Answer: D
Diff: 1 Page Ref: Sec. 9-4

36) Jacques and George meet in the middle of a lake while paddling in their canoes. They come to a complete stop and talk for a while. When they are ready to leave, Jacques pushes George's canoe with a force $\vec{F}$ to separate the two canoes. What is correct to say about the final momentum and kinetic energy of the system?

A) The final momentum is in the direction of $\vec{F}$ but the final kinetic energy is zero J.
B) The final momentum is in the direction opposite of $\vec{F}$ but the final kinetic energy is zero J.
C) The final momentum is in the direction of $\vec{F}$ and the final kinetic energy is positive.
D) The final momentum is zero kg·m/s and the final kinetic energy is zero J.
E) The final momentum is zero kg·m/s but the final kinetic energy is positive.

Answer: E
Diff: 1 Page Ref: Sec. 9-4

37) A mass of 2 kg traveling at 3 m/s undergoes a one-dimensional elastic collision with a group of four 1-kg masses that are at rest in contact with each other and lined up in the same direction as the velocity of the 2-kg mass. As a result of the collision

A) the 2-kg mass comes to a stop and one of the 1-kg masses takes off at 6 m/s.
B) the 2-kg mass comes to a stop and two of the 1-kg masses take off at 3 m/s.
C) the 2-kg mass comes to a stop and three of the 1-kg masses take off at 2 m/s.
D) the 2-kg mass comes to a stop and all four of the 1-kg masses take off at 2 m/s.
E) the 2-kg mass and the five other masses travel at 1 m/s.

Answer: B
Diff: 1 Page Ref: Sec. 9-5

38) A red ball with a velocity of +3.0 m/s collides head-on with a yellow ball of equal mass moving with a velocity of -2.0 m/s. What is the velocity of the red ball after the collision?

A) zero B) -2.0 m/s C) +3.0 m/s D) +2.5.0 m/s E) +5.0 m/s

Answer: B
Diff: 1 Page Ref: Sec. 9-5

39) In a game of pool, the white cue ball hits the #9 ball and is deflected at a 35° angle to the original line of motion. What is the angle of deflection below the original line of motion for the #9 ball?

A) 15° B) 35° C) 55° D) 75° E) 90°

Answer: C
Diff: 2 Page Ref: Sec. 9-7

40) A plane, flying horizontally, releases a bomb, which explodes before hitting the ground. Neglecting air resistance, the center of mass of the bomb fragments, just after the explosion

A) is zero.
B) moves horizontally.
C) moves vertically.
D) moves along a parabolic path.

Answer: D
Diff: 2 Page Ref: Sec. 9-9

41) Two cars collide head-on on a level friction-free road. The collision was completely inelastic and both cars quickly came to rest during the collision. What is true about the velocity of this system's center of mass?

A) It was always zero.
B) It was never zero.
C) It was not zero, but ended up zero.
D) none of the above

Answer: A
Diff: 2 Page Ref: Sec. 9-9

42) A rocket of mass M carries a mass m of fuel and starts from rest. Which method of burning the fuel would result in the greatest final speed of the rocket after all the fuel is burned if the velocity of the exhaust gas relative to the rocket is fixed at u_{ex}?

A) Burn the exhaust gas at an exponentially increasing rate until it is exhausted.
B) Burn the fuel as slow as possible so the force on the rocket acts for the greatest time resulting in the greatest possible impulse to the rocket.
C) Burn the fuel slowly until the rocket reaches a speed equal to u_{ex} and then burn the remainder as quickly as possible so that the exhaust gas has the minimum kinetic energy.
D) Burn the exhaust gas at an exponentially decreasing rate to make it last forever.
E) Burn all the fuel in as short a time as possible.

Answer: E
Diff: 1 Page Ref: Sec. 9-10

9.2 Quantitative Problems

1) An interacting system of two objects has no external force acting on the system. The first object has a mass 2.00 kg and is moving with a velocity (2.00 m/s) $\hat{i}$ + (1.00 m/s) j at time t = 0.00 s. The second object has a mass 3.00 kg and is moving with a velocity (-1.00 m/s) $\hat{i}$ + (1.00 m/s) j at time t = 0.00 s. The second object is moving with a velocity (2.00 m/s) $\hat{i}$ + (-1.00 m/s) j at time t = 1.00 s.

(a) What is the total momentum of the system at time t = 0.00 s?
(b) What is the velocity of the first object at t = 1.00 s?

Answer: (a) (1.00 kg·m/s) $\hat{i}$ + (5.00 kg·m/s) j
(b) (-2.50 m/s) $\hat{i}$ + (4.00 m/s) j

Diff: 2 Page Ref: Sec. 9-2

2) A 900-kg car traveling east at 15.0 m/s collides with a 750-kg car traveling north at 20.0 m/s. The cars stick together.

(a) What is the speed of the wreckage just after the collision?
(b) In what direction does the wreckage move just after the collision?

Answer: (a) 12.2 m/s
(b) 48.0° N of E

Diff: 2 Page Ref: Sec. 9-7

3) A long thin rod of length L has a linear density $\lambda(x) = Ax$ where x is the distance from the left end of the rod.
(a) How far is the center of mass of the rod from the left end of the rod?
(b) What is the mass of the rod?
Answer: (a) $2L/3$
(b) $AL^2/2$
Diff: 1 Page Ref: Sec. 9-8

4) A long thin rod of length L has a linear density $\lambda(x) = A(L-x)^2$ where x is the distance from the left end of the rod.
(a) How far is the center of mass of the rod from the left end of the rod?
(b) What is the mass of the rod?
Answer: (a) $L/4$
(b) $AL^3/3$
Diff: 1 Page Ref: Sec. 9-8

5) At what speed must a 150-kg football player be moving to have the same momentum as a 15.0-g bullet traveling at 300 m/s?
A) 10.0 m/s B) 3.00 cm/s C) 3.00 m/s D) 30.0 m/s E) 1.00 m/s
Answer: B
Diff: 1 Page Ref: Sec. 9-1

6) A golf club exerts an average force of 1000 N on a 0.045-kg golf ball which is initially at rest. The club is in contact with the ball for 1.8 ms. What is the speed of the golf ball as it leaves the tee?
A) 30 m/s B) 35 m/s C) 40 m/s D) 45 m/s E) 50 m/s
Answer: C
Diff: 1 Page Ref: Sec. 9-1

7) A 0.140-kg baseball is dropped and reaches a speed of 1.20 m/s just before it hits the ground. It rebounds with a speed of 1.00 m/s. What is the change of the ball's momentum?
A) 0.0280 kg·m/s upwards
B) 0.0280 kg·m/s downwards
C) 0.308 kg·m/s upwards
D) 0.308 kg·m/s downwards
E) 0 kg·m/s
Answer: C
Diff: 1 Page Ref: Sec. 9-1

8) Two air track carts move along an air track towards each other. Cart A has a mass of 450 g and moves toward the right with a speed of 0.850 m/s and air track cart B has a mass of 300 g and moves toward the left with a speed of 1.12 m/s. What is the total momentum of the system?
A) 0.047 kg·m/s toward the right
B) 0.719 kg·m/s toward the right
C) 0.719 kg·m/s toward the left
D) 0.750 kg·m/s toward the right
E) 0.750 kg·m/s toward the left
Answer: A
Diff: 1 Page Ref: Sec. 9-1

9) A firecracker breaks up into two pieces, one has a mass of 200 g and flies off along the x-axis with a speed of 82.0 m/s and the second has a mass of 300 g and flies off along the y-axis with a speed of 45.0 m/s. What is the total momentum of the two pieces?

A) 361 kg·m/s at 56.3° from the x-axis
B) 93.5 kg·m/s at 28.8° from the x-axis
C) 21.2 kg·m/s at 39.5° from the x-axis
D) 361 kg·m/s at 0.983° from the x-axis
E) 21.2 kg·m/s at 56.3° from the x-axis

Answer: C
Diff: 2 Page Ref: Sec. 9-1

10) Two objects are moving in the xy-plane. Object A has a mass of 3.2 kg and has a velocity $\overrightarrow{v_A}$ = (2.3 m/s) $\hat{i}$ + (4.2 m/s) j and object B has a mass of 2.9 kg and has a velocity $\overrightarrow{v_B}$ = (-1.8 m/s) $\hat{i}$ + (2.7 m/s) j . What is the total momentum of the system?

A) (2.1 kg m/s) $\hat{i}$ + (21 kg m/s) j
B) (0.50 kg m/s) $\hat{i}$ + (6.9 kg m/s) j
C) (4.8 kg m/s) $\hat{i}$ + (3.2 kg m/s) j
D) (92 kg m/s) $\hat{i}$ + (9.4 kg m/s) j
E) (13 kg m/s) $\hat{i}$ + (5.6 kg m/s) j

Answer: A
Diff: 2 Page Ref: Sec. 9-1

11) Two objects are moving in the xy-plane. Object A has a mass of 3.5 kg and has a velocity $\overrightarrow{v_A}$ of 5.3 m/s at an angle of 30° from the x-axis and object B has a mass of 1.9 kg and has a velocity $\overrightarrow{v_B}$ of 6.2 m/s at an angle of 72° from the x-axis. What is the total momentum of the system?

A) 55 kg m/s at an angle of 5.7°
B) 5.1 kg m/s at an angle of 45°
C) 32 kg m/s at an angle of 23°
D) 11 kg m/s at an angle of 53°
E) 28 kg m/s at an angle of 46°

Answer: E
Diff: 2 Page Ref: Sec. 9-1

12) Two objects are moving in the xy-plane. No external forces are acting on the objects. Object A has a mass of 3.2 kg and has a velocity $\overrightarrow{v_A}$ = (2.3 m/s) $\hat{i}$ + (4.2 m/s) j and object B has a mass of 2.9 kg and has a velocity $\overrightarrow{v_B}$ = (-1.8 m/s) $\hat{i}$ + (2.7 m/s) j . Some time later, object A is seen to have a velocity $\overrightarrow{v_A}$ ' = (1.7 m/s) $\hat{i}$ + (3.5 m/s) j . What is the velocity of object B at that instant?

A) (-3.3 m/s) $\hat{i}$ + (10 m/s) j
B) (3.3 m/s) $\hat{i}$ + (-10 m/s) j
C) (1.1 m/s) $\hat{i}$ + (-3.5 m/s) j
D) (3.3 m/s) $\hat{i}$ + (10 m/s) j
E) (-1.1 m/s) $\hat{i}$ + (3.5 m/s) j

Answer: E
Diff: 3 Page Ref: Sec. 9-2

13) A batter hits a 0.140-kg baseball that was approaching him at 40.0 m/s and, as a result, the ball leaves the bat at 30.0 m/s in the direction of the pitcher. What is the magnitude of the impulse delivered to the baseball?

A) 9.80 Ns B) 1.40 Ns C) 5.60 Ns D) 4.90 Ns E) 7.00 Ns

Answer: A

Diff: 1 Page Ref: Sec. 9-3

14) A 0.250-kg rubber ball is dropped from a height of 2.00 m. It hits the floor and rebounds to a height of 1.80 m. What is the magnitude of impulse the floor applies to the ball?

A) 0.950 N·s B) 1.14 N·s C) 0.0804 N·s D) 1.33 N·s E) 3.05 N·s

Answer: E

Diff: 1 Page Ref: Sec. 9-3

15) During a collision with a wall, the velocity of a 0.200-kg ball changes from 20.0 m/s toward the wall to 12.0 m/s away from the wall. If the time the ball was in contact with the wall was 60.0 ms, what was the magnitude of the average force applied to the ball?

A) 40.0 N B) 107 N C) 16.7 N D) 26.7 N E) 13.3 N

Answer: B

Diff: 1 Page Ref: Sec. 9-3

16) A 1000-kg car is traveling at 20.0 m/s toward the north. During a collision the car receives an impulse of 1.00×10^4 N·s toward the south. What is the velocity of the car after the impulse is applied to the car?

A) 0.00 m/s

B) 20.0 m/s north

C) 30.0 m/s north

D) -10.0 m/s south

E) 10.0 m/s north

Answer: E

Diff: 1 Page Ref: Sec. 9-3

17) A batter hits a foul ball. The 0.140-kg baseball that was approaching him at 40.0 m/s leaves the bat at 30.0 m/s in a direction perpendicular to the line between the batter and the pitcher. What is the magnitude of the impulse delivered to the baseball?

A) 9.80 Ns B) 1.40 Ns C) 3.50 Ns D) 5.60 Ns E) 7.00 Ns

Answer: E

Diff: 2 Page Ref: Sec. 9-3

18) A 65-g handball is dropped to the floor from a height of 1 m, and bounces to a height of 0.80 m. What is the magnitude of the impulse received by the ball from the floor?

A) 0.030 N s B) 0.13 N s C) 0.55 N s D) 0.30 N s E) 0.013 N s

Answer: C

Diff: 2 Page Ref: Sec. 9-3

19) Two ice skaters push off against one another starting from a stationary position. The 45-kg skater acquires a speed of 0.375 m/s. What speed does the 60-kg skater acquire?

A) 0.500 m/s B) 0.281 m/s C) 0.375 m/s D) 0.750 m/s E) 0 m/s

Answer: B

Diff: 1 Page Ref: Sec. 9-4

20) A 4.00-kg mass and a 9.00-kg mass are being held at rest against a compressed spring on a frictionless surface. When the masses are released, the 4.00-kg mass moves to the east with a speed of 2.00 m/s. What is the velocity of the 9.00-kg mass after the masses are released?

A) 2.00 m/s west
B) 0.888 m/s west
C) 0.500 m/s east
D) 4.50 m/s west
E) 0.500 m/s west

Answer: B
Diff: 1 Page Ref: Sec. 9-4

21) A 2.00-kg mass object traveling east at 20.0 m/s collides with a 3.00-kg mass object traveling west at 10.0 m/s. After the collision, the 2.00-kg mass has a velocity 5.00 m/s to the west. How much kinetic energy was lost during the collision?

A) 0.00 J B) 458 J C) 516 J D) 91.7 J E) 175 J

Answer: B
Diff: 2 Page Ref: Sec. 9-4

22) A 0.400-kg ball approaches a very massive wall at 20.0 m/s perpendicular to wall and rebounds with 70.0% of its initial kinetic energy. What is the magnitude of the change in momentum of the wall?

A) 14.7 kg·m/s B) 13.6 kg·m/s C) 2.40 kg·m/s D) 1.31 kg·m/s E) 0.00 kg·m/s

Answer: A
Diff: 2 Page Ref: Sec. 9-4

23) A 2.3-kg object traveling at 6.1 m/s collides head-on with a 3.5-kg object traveling in the opposite direction at 4.8 m/s. If the collision is perfectly elastic, what is the final speed of the 2.3-kg object?

A) 0.48 m/s B) 7.1 m/s C) 3.8 m/s D) 4.3 m/s E) 6.6 m/s

Answer: B
Diff: 1 Page Ref: Sec. 9-5

24) A 620-g object traveling at 2.1 m/s collides head-on with a 320-g object traveling in the opposite direction at 3.8 m/s. If the collision is perfectly elastic, what is the change in the kinetic energy of the 620-g object?

A) It loses 0.23 J.
B) It gains 0.69 J.
C) It loses 0.47 J.
D) It loses 1.4 J.
E) The energy of the object is unchanged.

Answer: A
Diff: 2 Page Ref: Sec. 9-5

25) A 3.00-kg object traveling 20.0 m/s west collides with a 5.00-kg mass object traveling 12.0 m/s west. The collision is perfectly elastic, what is the velocity of the 3.00-kg object after the collision?

A) 20.0 m/s east
B) 8.00 m/s west
C) 12.0 m/s west
D) 12.0 m/s east
E) 10.0 m/s west

Answer: E
Diff: 2 Page Ref: Sec. 9-5

26) Two objects of the same mass move along the same line in opposite directions. The first mass is moving with speed v. The objects collide in a perfectly inelastic collision and move with speed $0.100v$ in the direction of the velocity of the first mass before the collision. What was the speed of the second mass before the collision?

A) $1.200v$ B) $10.0v$ C) $0.900v$ D) $0.800v$ E) $0.00v$

Answer: D

Diff: 1 Page Ref: Sec. 9-6

27) A 1000-kg car is traveling north at 20.0 m/s. A 1500-kg car is traveling north at 36.0 m/s. The 1500-kg collides with the rear of the 1000-kg car and they lock together. Ignoring external forces acting during the collision, what is the velocity of the cars immediately after the collision?

A) 56.0 m/s north
B) 29.6 m/s north
C) 13.6 m/s south
D) 8.00 m/s south
E) 28.0 m/s north

Answer: B

Diff: 1 Page Ref: Sec. 9-6

28) A 1000-kg car approaches an intersection traveling north at 20.0 m/s. A 1200-kg car approaches the same intersection traveling east at 22.0 m/s. The two cars collide at the intersection and lock together. Ignoring any external forces that act on the cars during the collision, what is the velocity of the cars immediately after the collision?

A) 29.7 m/s in a direction 47.7° east of north
B) 21.1 m/s in a direction 47.7° west of south
C) 15.1 m/s in a direction 52.8° east of north
D) 21.1 m/s in a direction 52.8° east of north
E) 21.1 m/s in a direction 47.7° east of north

Answer: C

Diff: 1 Page Ref: Sec. 9-7

29) A billiard ball traveling at 3.00 m/s collides perfectly elastically with an identical billiard ball initially at rest on the table. The initially moving billiard ball deflects 30.0°. What is the speed of the initially stationary billiard ball after the collision?

A) 2.00 m/s B) 0.866 m/s C) 1.50 m/s D) 2.59 m/s E) 0.750 m/s

Answer: C

Diff: 1 Page Ref: Sec. 9-7

30) Two automobiles traveling at right angles to each other collide and stick together. Car A has a mass of 1200 kg and had a speed of 25 m/s before the collision. Car B has a mass of 1600 kg. The skid marks show that, immediately after the collision, the wreckage was moving in a direction making an angle of 40° with the original direction of car A. What was the speed of car B before the collision?

A) 16 m/s B) 18 m/s C) 11 m/s D) 21 m/s E) 14 m/s

Answer: A

Diff: 2 Page Ref: Sec. 9-7

31) A particle with a mass of 400 g moving at 2.0 m/s collides elastically with a stationary particle whose mass is 240 g. After the collision, the 400 g mass is moving at 1.5 m/s. Through what angle is its path deflected?

A) 35° B) 15° C) 25° D) 30° E) 20°

Answer: D

Diff: 2 Page Ref: Sec. 9-7

32) A neutron with a mass of 1.67×10^{-27} kg traveling east with a kinetic energy of 2.00×10^{-21} J collides perfectly elastically with a helium nucleus with a mass 6.68×10^{-27} kg that is initially at rest. After the collision, the neutron has a kinetic energy 1.80×10^{-21} J. What angle was the neutron deflected during the collision?

A) 142° B) 117° C) 38.0° D) 180° E) 32.8°

Answer: A

Diff: 2 Page Ref: Sec. 9-7

33) A plate falls vertically to the floor and breaks up into three pieces, which slide along the floor. Immediately after the impact, a 200-g piece moves along the x-axis with a speed of 2.00 m/s and a 235-g piece moves along the y-axis with a speed of 1.50 m/s. The third piece has a mass of 100 g. In what direction does the third piece move?

A) 216.9° from the x-axis
B) 221.4° from the x-axis
C) 36.9° from the x-axis
D) 39.9° from the x-axis
E) 41.4° from the x-axis

Answer: B

Diff: 3 Page Ref: Sec. 9-7

34) Three masses are located in the x-y plane as follows: a mass of 6 kg is located at (0 m, 0 m), a mass of 4 kg is located at (3 m, 0 m), and a mass of 2 kg is located at (0 m, 3 m). Where is the center of mass of the system?

A) (1 m, 2 m) B) (2 m, 1 m) C) (1 m, 1 m) D) (1 m, 0.5 m) E) (0.5 m, 1 m)

Answer: D

Diff: 1 Page Ref: Sec. 9-8

35) A uniform piece of wire, 20 cm long, is bent in a right angle in the center to give it an L-shape. How far from the bend is the center of mass of the bent wire?

A) 2.5 cm B) 3.5 cm C) 4.5 cm D) 5.0 cm E) 7.1 cm

Answer: B

Diff: 1 Page Ref: Sec. 9-8

36) A 2.00-m rod of negligible mass connects two small objects. The mass of one object is 1.00 kg and the other is 1.50 kg. How far is the center of mass of this system from the 1.00 kg mass?

A) 0.800 m B) 0.670 m C) 1.25 m D) 1.33 m E) 1.20 m

Answer: E

Diff: 1 Page Ref: Sec. 9-8

37) A 2.00-m rod of negligible mass connects two small objects. The mass of one object is 1.00 kg and the mass of the other is unknown. The center of mass of this system is on the rod a distance 1.80 m from the 1.00-kg mass object. What is the mass of the other object?

A) 4.11 kg B) 3.22 kg C) 9.00 kg D) 0.111 kg E) 0.900 kg

Answer: C

Diff: 1 Page Ref: Sec. 9-8

38) A 10.0-kg mass is located at (2.00 m) $\hat{i}$ + (3.00 m) j. A 15.0-kg mass is located at (4.00 m) $\hat{i}$. A 25-kg mass is located at (2.00 m) j. What is the location of the center of mass of this system?

A) (3.20 m) $\hat{i}$ + (3.20 m) j

B) (1.60 m) $\hat{i}$ + (1.60 m) j

C) (80.0 m) $\hat{i}$ + (80.0 m) j

D) (3.20 m) $\hat{i}$ + (1.60 m) j

E) (1.60 m) $\hat{i}$ + (3.20 m) j

Answer: B

Diff: 1 Page Ref: Sec. 9-8

39) A 2.00-kg mass is located at (4.00 m) $\hat{i}$ +(-1.00 m) j. A 1.00-kg mass is located at (1.00 m) $\hat{i}$ + (2.00 m) j. Where must a 3.00-kg mass be located so that the center of mass of the system is located at (-1.00 m) $\hat{i}$ + (1.00 m) j?

A) (-4.00 m) $\hat{i}$ + (-0.600 m) j

B) (-8.00 m) $\hat{i}$ + (3.20 m) j

C) (-2.00 m) $\hat{i}$ + (2.00 m) j

D) (-5.00 m) $\hat{i}$ + (2.00 m) j

E) (-15.0 m) $\hat{i}$ + (6.00 m) j

Answer: D

Diff: 1 Page Ref: Sec. 9-8

40) A 320-g air track cart is traveling at 1.25 m/s and a 270-g cart traveling in the opposite direction at 1.33 m/s. What is the speed of the center of mass of the two carts?

A) 2.80 m/s B) 0.0693 m/s C) 0.131 m/s D) 1.47 m/s E) 1.29 m/s

Answer: B

Diff: 3 Page Ref: Sec. 9-9

41) A 1000-kg helicopter hovers over a forest fire and starts to squirt water downward with a speed of 10 m/s at a rate of 40 kg/s. What is the initial upward acceleration on the helicopter when it first starts to release the water?

A) 2.5 m/s^2 B) 0.40 m/s^2 C) 0.25 m/s^2 D) 4.0 m/s^2 E) 5.0 m/s^2

Answer: B

Diff: 1 Page Ref: Sec. 9-10

42) A toy rocket with a mass of 300 g takes off in a vertical direction under the influence of gravity. It burns fuel at the rate of 25 g/s. The exhaust speed of the gases is 80 m/s. What is the speed of the rocket at the end of 10 seconds?

A) 145 m/s B) 480 m/s C) 40 m/s D) 0 m/s E) 382 m/s

Answer: A

Diff: 2 Page Ref: Sec. 9-10

43) A rocket with a mass of 2.0×10^6 kg is designed to take off from the surface of the earth by burning fuel and ejecting it with an exhaust speed of 3500 m/s. What is the minimum rate at which the fuel should be consumed in order to attain liftoff?

A) 5.6×10^3 kg/s

B) 1.4×10^3 kg/s

C) 1.8×10^3 kg/s

D) 2.8×10^3 kg/s

E) 18×10^3 kg/s

Answer: A

Diff: 3 Page Ref: Sec. 9-10