Physics 30 Worksheet # 1: *Momentum*

1. Calculate the momentum of a 1.60 x 10^3 kg car traveling at 20.0 m/s.

2. Calculate the momentum of a 2.50 x 10^3 kg truck traveling at 110 km/h.

3. How fast is a 1.50 kg ball moving if it has a momentum of 4.50 kg.m/s?

4. A 75.0 g ball is rolling at a speed of 57.0 cm/s. Calculate the ball's momentum.

5. A 5.00 kg ball accelerates at a rate of 2.00 m/s^2 for 1.50 seconds. Calculate the ball's momentum after the acceleration.

6. A 2.00 kg rock is dropped from the top of a 30.0 m high building. Calculate the ball's momentum at the time that it strikes the ground.

7. A 1.00 kg rock is thrown up into the air from ground level at a speed of 8.00 m/s. The ball travels up to a maximum height, then returns to the ground. Calculate the rock's momentum as it strikes the ground.

8. A 1.50 kg rock is thrown up into the air from ground level, reaches a maximum height of 7.00 m, then returns to the ground. Calculate the rock's momentum as it strikes the ground.

Physics 30 Worksheet # 2: *Impulse*

1. A force of 20.0 N is applied to a 3.00 kg object for 4.00 seconds. Calculate the impulse experienced by the object.

2. A 1200 kg car traveling at 20.0 m/s speeds up to 30.0 m/s. What is the impulse experienced by the car?

3. A 1500 kg car accelerates from 55.0 km/h to 90.0 km/h. Calculate the impulse experienced by the car.

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4. A 1200 car accelerates from rest to 10.0 m/s in a time of 4.50 seconds. Calculate the force that the car's tires exerted on the road.

5. A 1500 kg car traveling at 80.0 km/h comes to a screeching halt in a time of 4.00 seconds. Calculate the force of friction experienced by the car.

6. A 1.00 kg ball traveling towards a soccer player at a velocity of 5.00 m/s rebounds off the soccer player's foot at a velocity of 8.50 m/s. If the time of contact between the ball and the player's foot was 2.00×10^{-2} seconds, what was the force that the foot applied on the ball?

7. A 1.50 kg rock falls from the top of a 10.0 m high building and strikes the ground below. Calculate the impulse experienced by the rock during its fall.

8. A 1.50 kg rock falls from the top of a 10.0 m high building and strikes the ground below. What is the force of the ground acting on the rock if it comes to a stop in 0.350 seconds.

9. Calculate the impulse experienced by the 4.00 kg object represented in the graph below. Calculate the object's change in velocity.

Force vs. Time
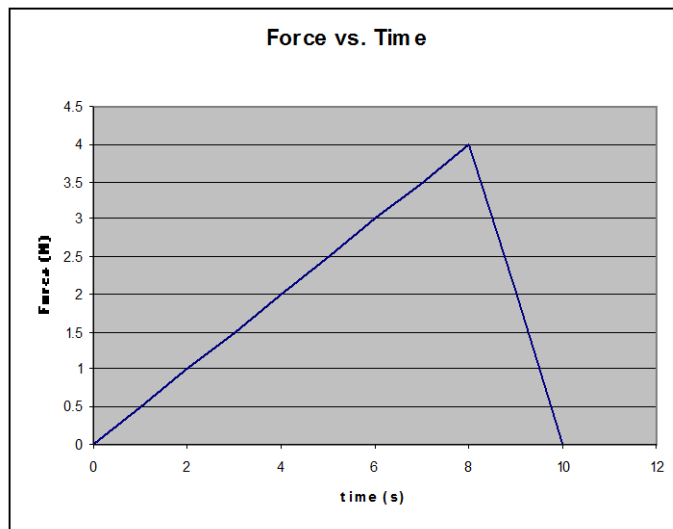
Physics 30 Worksheet # 3: *Conservation of Momentum (1)*

1. A 2.50 kg ball moving at 7.50 m/s is caught by a 70.0 kg man while the man is standing on ice. How fast will the man / ball combination be moving after the ball is caught by the man?

2. A 1200 kg car traveling North at 20.0 m/s collides with a 1400 kg car traveling South at 22.0 m/s. The two cars collide and entangle. What is the resulting velocity of the wreckage?

3. A 5.00 kg ball hits a 75.0 kg man standing at rest on ice. The man catches the ball. How fast does the ball need to be moving in order to send the man off at a speed of 3.00 m/s?

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4. A 1.50×10^3 kg car traveling at 100 km/h South collides with a 1.20×10^3 kg car traveling North at 100 km/h. The heavier car continues to move South after the collision, but slows to 25.0 km/h. How fast is the lighter car moving after the collision?

5. A 92.0 kg football player running at 6.50 m/s North collides with an 85.0 kg football player running at 6.00 m/s South. The 92.0 kg football player continues moving at a velocity of 2.00 m/s after the collision. What is the velocity of the 85.0 kg football player after the collision?

6. A 75.0 kg man is standing at rest on ice while holding a 4.00 kg ball. If the man throws the ball at a velocity of 3.50 m/s forward, what will his resulting velocity be?

7. A person holding a 15.0 kg gun containing one 50.0 g bullet is riding on a train that is traveling at 75.0 km/h East. If the man fires the gun and the bullet moves with a velocity of 350 m/s East (relative to the train), what is the velocity of the gun relative to the ground?

Physics 30 Worksheet # 4: *Conservation of Momentum (2)*

1. A 1000 kg car traveling South at 20.0 m/s collides with a 1200 kg car traveling East at 20.0 m/s. The two vehicles entangle after the collision and head off as one. What is the velocity of the combined wreckage immediately after the collision?

2. A 1500 kg car traveling West at 90.0 km/h collides with a 1400 kg truck traveling North at 72.0 km/h. The two vehicles entangle after the collision and head off as one. What is the velocity of the wreckage immediately after the collision?

3. A 4.00 kg ball traveling North with a momentum of 11.2 kg.m/s collides with a 6.0 kg ball traveling West with a momentum of 18 kg.m/s. The two balls stick together and head off as one. What is the momentum of the combined masses? What is the velocity of the combined masses?

—— —— —— —— ——

4. A 400 kg bomb sitting at rest on a table explodes into three pieces. A 150 kg piece moves off to the East with a velocity of 150 m/s. A 100 kg piece moves off with a velocity of 200 m/s [30.0^0 S of W]. What is the velocity of the third piece?

5. A bomb sitting at rest on a table explodes into four pieces of equal mass. The first piece travels to the South at a velocity of 55.0 m/s. The second piece travels to the West at a velocity of 80.0 m/s. The third piece travels at a velocity of 40.0 m/s [30.0^0 W of N]. What is the velocity of the fourth piece?

6. A 200 kg bomb moving at a velocity of 10.0 m/s to the West explode into three pieces. The first piece has a mass of 100 kg and moves to the West with a velocity of 90.0 m/s. The second piece has a mass of 55.0 kg and moves at an angle of 30.0^0 N of E with a velocity of 55.0 m/s. What is the velocity of the third piece?

— — — — —

7. A stationary 300 kg puck is struck by a 200 g puck moving with a velocity of 2.00 m/s West. After the collision, the 200 g puck has a velocity of 1.00 m/s [53.0° N of W]. Calculate the velocity of the 300 g puck.

8. Two balls of equal mass are involved in a glancing collision. Before the collision, the first ball is moving at a velocity of 1.00 m/s East and the second ball is at rest. After the collision, the first ball is moving at a speed of 5.50 x 10⁻¹ m/s [24.0° S of E]. The second ball heads off at an angle of 24.2° N of E. What is the speed of the second ball after the collision?

Physics 30 Worksheet # 5: *Elastic and Inelastic Collisions*

1. Refer to question #1 on Worksheet #10. Is this collision elastic or inelastic?

2. Refer to question #2 on Worksheet #10. Is this collision elastic or inelastic?

3. Refer to question #4 on Worksheet #10. Is this collision elastic or inelastic?

4. Refer to question #5 on Worksheet #12. Is this collision elastic or inelastic?

5. Refer to question #1 on Worksheet #11. Is this collision elastic or inelastic?

6. Refer to question #7 on Worksheet #11. Is this collision elastic or inelastic?

Diploma Exam Review Questions

Momentum

Use the following information to answer the next question.

> A batter hits a fly ball. The 0.130 kg baseball moves at a rate of 20.0 m/s at the point where it is 5.00 m above the ground.

1. What is the magnitude of the momentum of the baseball the instant before it reaches the ground?

A. 1.29 kg•m/s
B. 1.41 kg•m/s
C. 2.60 kg•m/s
D. 2.90 kg•m/s

Use the following information to answer the next question.

> A particular supertanker is fully loaded with oil and has a mass of 1.00×10^9 kg. The supertanker has a cruising speed of 20.0 km/h. One way to stop the ship is to reverse its engines. At maximum reverse thrust, the ship takes 32.0 min to stop.

2. The momentum of the supertanker at cruising speed, expressed in scientific notation, is $b \times 10^w$ kg.m/s. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

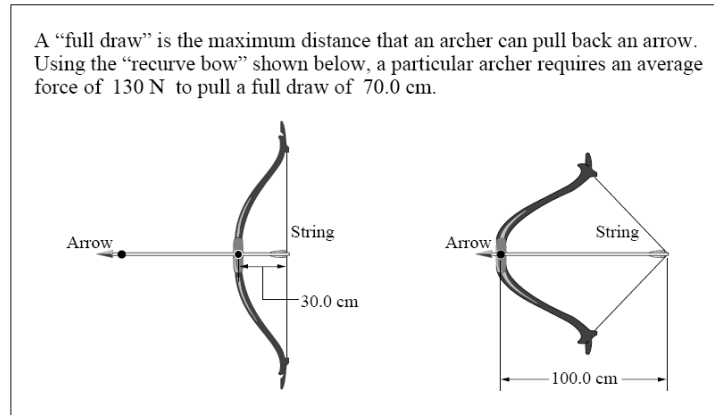---

Impulse

3. In an automobile collision, the severity of injury to the driver can be reduced by an airbag. In a car initially traveling at 100 km/h, the airbag stops a 62 kg driver in 90 ms. The magnitude of average force exerted by the airbag on the driver is

A. 6.9×10^4 N
B. 1.9×10^4 N
C. 9.6×10^3 N
D. 6.1×10^2 N

4. The SI units for **impulse** may be written as

A. $\dfrac{kg\text{-}m^2}{s^2}$

B. $\dfrac{kg\text{-}m}{s}$

C. $\dfrac{kg\text{-}m^2}{s}$

D. $\dfrac{kg\text{-}m}{s^2}$

A "full draw" is the maximum distance that an archer can pull back an arrow. Using the "recurve bow" shown below, a particular archer requires an average force of 130 N to pull a full draw of 70.0 cm.

Arrow   String

30.0 cm

Arrow   String

100.0 cm

5. Assuming the maximum speed of a 20.6 g arrow, when released from full draw, is 94.0 m/s, the magnitude of the impulse that the bow gives to the arrow when released from full draw is _____ N•s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

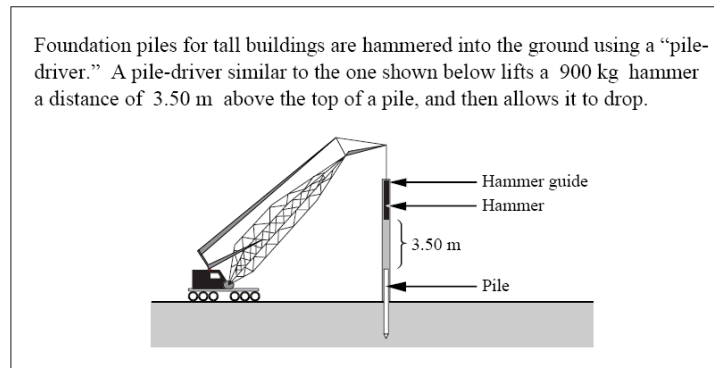---

Communication satellites require rocket thrusters that must be fired periodically, in short bursts, to keep the satellites from drifting out of their orbits. Usually, a gas such as ammonia is heated using electrodes. The expanding hot gas is allowed to escape, which provides the thrust. Unfortunately, the ammonia erodes the electrodes, eventually rendering them useless.

An alternative method to heat the ammonia uses microwaves. A 1.00×10^3 W microwave generator is used. The microwaves in the thrusters heat the gas to tens of thousands of degrees.

6. A satellite has a mass of 172 kg. To correct its orbit, a thruster is fired for 2.27 s, which changes the velocity of the satellite by 5.86×10^{-3} m/s. The force generated by the thrusters, expressed in scientific notation, is $b \times 10^{-w}$ N. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Foundation piles for tall buildings are hammered into the ground using a "pile-driver." A pile-driver similar to the one shown below lifts a 900 kg hammer a distance of 3.50 m above the top of a pile, and then allows it to drop.

7. The magnitude of the impulse delivered by the hammer to the pile is

A. 61.8 kN•s
B. 30.9 kN•s
C. 7.46 kN•s
D. 3.73 kN•s

8. The impulse is delivered by this pile-driver in 2.10×10^{-3} s. The magnitude of the force that the hammer exerts on the pile, expressed in scientific notation, is $b \times 10^w$ N. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

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9. A rock climber falls and is saved from injuries by a climbing rope that is slightly elastic. The importance of the elasticity of the climbing rope can be understood in
terms of impulse because elasticity results in

A. decreased force during an increased time interval
B. increased force during an increased time interval
C. decreased force during a decreased time interval
D. increased force during a decreased time interval
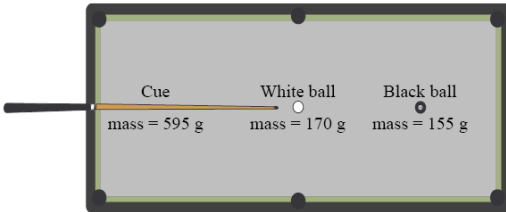
Conservation of Momentum (1D)

10. A 2 100 kg van collides with a 1 200 kg car that is at rest. They lock together and move together at a speed of 4.50 m/s. The initial speed of the van is _____ m/s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Pool Table

An illustration depicting an overhead view of a pool table is shown below.

The pool table has rubber cushions around the playing surface so that when a ball hits the side it will be deflected back to the playing surface. A simplified analysis of the physics of playing pool assumes that Hooke's Law is valid:

$$F = -kx \text{ and } E_p = \tfrac{1}{2}kx^2$$

11. Assume that the white ball is moving at a speed of 3.13 m/s when it collides with the black ball, which was initially at rest. The white ball continues in its original direction. The speed of the white ball after the collision is 0.147 m/s. The speed of the black ball immediately after the collision is _____ m/s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

A lump of clay with a mass of 50.0 g is moving south at a speed of 20.0 cm/s. It collides head on with a second lump of clay with a mass of 70.0 g that is moving north at a speed of 40.0 cm/s.

12. The two lumps stick together, and no external horizontal forces act on the system. The **velocity** of the combined lump after the collision is

A. 60.0 cm/s, south
B. 31.7 cm/s, south
C. 20.0 cm/s, north
D. 15.0 cm/s, north

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13. An empty freight car of mass m coasts along a track at 2.00 m/s until it couples to a stationary freight car of mass $2m$. The final speed of the two freight cars immediately after collision is

A. 1.50 m/s
B. 1.33 m/s
C. 1.15 m/s
D. 0.667 m/s

14. Two boys, Ted and Larry, initially at rest, push each other apart on a frictionless surface. Ted has a mass of 40 kg and Larry has a mass of 60 kg. After the boys push each other apart, Ted has a speed of 6 m/s. As the boys move apart, Larry has

A. more momentum than Ted
B. less momentum than Ted
C. more kinetic energy than Ted
D. less kinetic energy than Ted

Elastic / Inelastic Collisions

15. The following statements all relate to a collision between any two objects on a horizontal frictionless surface. Which of these statements is **always true?**

A. The kinetic energy of each object before and after the collision is the same.
B. The momentum of each object before and after the collision is the same.
C. The total momentum of the two objects before and after the collision is the same.
D. With respect to the surface, the gravitational potential energy of each object before and after the collision increases.

Use the following information to answer the next question.

Two cars collide at an unmarked intersection.
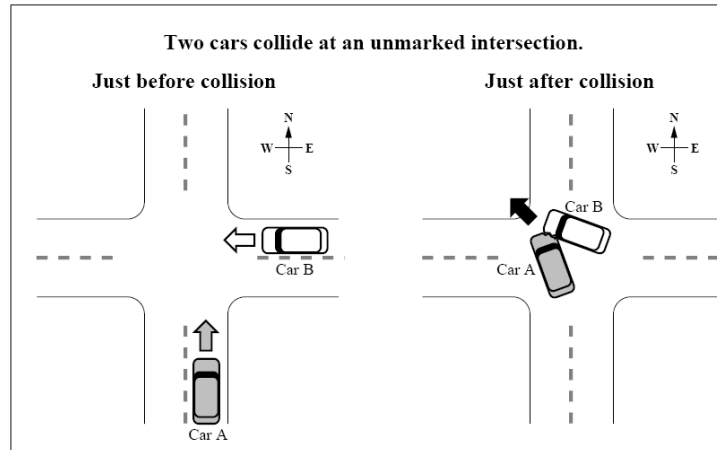
16. Which of the following statements **best** describes the inelastic collision shown above?

A. Momentum is not conserved, and kinetic energy is not conserved.
B. Momentum is conserved, but kinetic energy is not conserved.
C. Momentum is not conserved, but kinetic energy is conserved.
D. Momentum is conserved, and kinetic energy is conserved.

Conservation of Momentum (2D)

Use the following information to answer the next two questions.

A glass ornament of mass 575 g sitting on a table is subjected to a resonant frequency of 440 Hz. The ornament breaks into three pieces that travel horizontally across the frictionless tabletop. Fragment **A** has a mass of 168 g and fragment **B** has a mass of 212 g.

$m_B = 212$ g
$v_B = 9.00$ m/s
$p_{Bf} = 1.91$ kg•m/s

$m_A = 168$ g
$v_A = 15.0$ m/s
$p_{Af} = 2.52$ kg•m/s
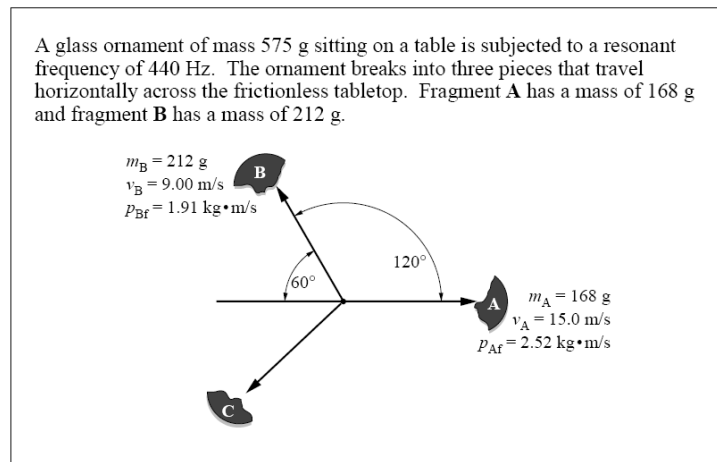
17. The magnitude of the momentum of the third piece of glass, fragment C, is

A. 5.19 kg•m/s
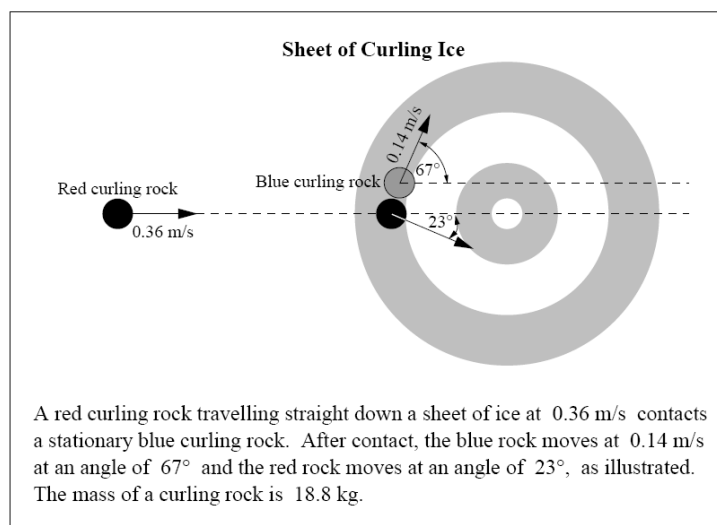**B.** 3.85 kg•m/s
C. 2.28 kg•m/s
D. 0.610 kg•m/s

18. The speed of the third fragment of glass, expressed in scientific notation, is b _ 10 w m/s. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Sheet of Curling Ice

A red curling rock travelling straight down a sheet of ice at 0.36 m/s contacts a stationary blue curling rock. After contact, the blue rock moves at 0.14 m/s at an angle of 67° and the red rock moves at an angle of 23°, as illustrated. The mass of a curling rock is 18.8 kg.

19. The speed of the red rock, after contact, is

A. 0.15 m/s
B. 0.22 m/s
C. 0.33 m/s
D. 0.39 m/s

Unit 1 Mixed Review Questions

20. Which of the following quantities is a **scalar** quantity?

A. Force
B. Power
C. Impulse
D. Momentum

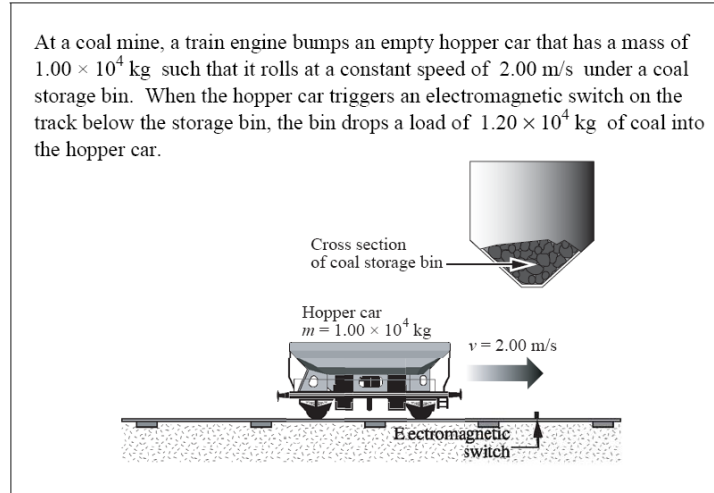**21.** A golf ball has a mass of 45.0 g. A golf club is in contact with the golf ball for 3.00×10^{-4} s, and the ball leaves the club with a speed of 72.0 m/s. The average force exerted by the club on the ball, expressed in scientific notation, is $b \times 10^w$ N. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

22. In a vehicle safety test, a 1 580 kg truck traveling at 60.0 km/h collides with concrete barrier and comes to a complete stop in 0.120 s. The magnitude of the change in the momentum of the truck, expressed in scientific notation, is $b \times 10^w$ kg•m/s. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

At a coal mine, a train engine bumps an empty hopper car that has a mass of 1.00×10^4 kg such that it rolls at a constant speed of 2.00 m/s under a coal storage bin. When the hopper car triggers an electromagnetic switch on the track below the storage bin, the bin drops a load of 1.20×10^4 kg of coal into the hopper car.

Cross section
of coal storage bin

Hopper car
$m = 1.00 \times 10^4$ kg

$v = 2.00$ m/s

Electromagnetic
switch

23. The speed of the hopper car immediately after receiving the load of coal, expressed in scientific notation, is $b \times 10^{-w}$ m/s. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)
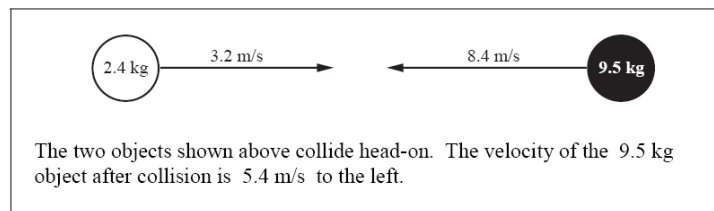

Use the following information to answer the next question.

2.4 kg   3.2 m/s →   ← 8.4 m/s   9.5 kg

The two objects shown above collide head-on. The velocity of the 9.5 kg object after collision is 5.4 m/s to the left.

24. The velocity of the 2.4 kg object after collision is

A. 15 m/s to the right
B. 8.7 m/s to the left
C. 8.0 m/s to the right
D. 6.2 m/s to the left

25. Two carts, each with a spring bumper, collide head-on. At one point during the collision, both carts are at rest for an instant. At that instant, the kinetic energy that the carts originally possessed is almost completely

A. lost to friction
B. transformed into heat and sound
C. converted into kinetic energy in the spring bumpers
D. converted into potential energy in the spring bumpers

26. A 1 575 kg car, initially traveling at 10.0 m/s, collides with a stationary 2 250 kg car. The bumpers of the two cars become locked together. The speed of the combined cars immediately after impact is _____m/s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

27. A 115 g arrow traveling east at 20 m/s imbeds itself in a 57 g tennis ball moving north at 42 m/s. The direction of the ball-and-arrow combination after impact is

A. 46^0 N of E
B. 46^0 E of N
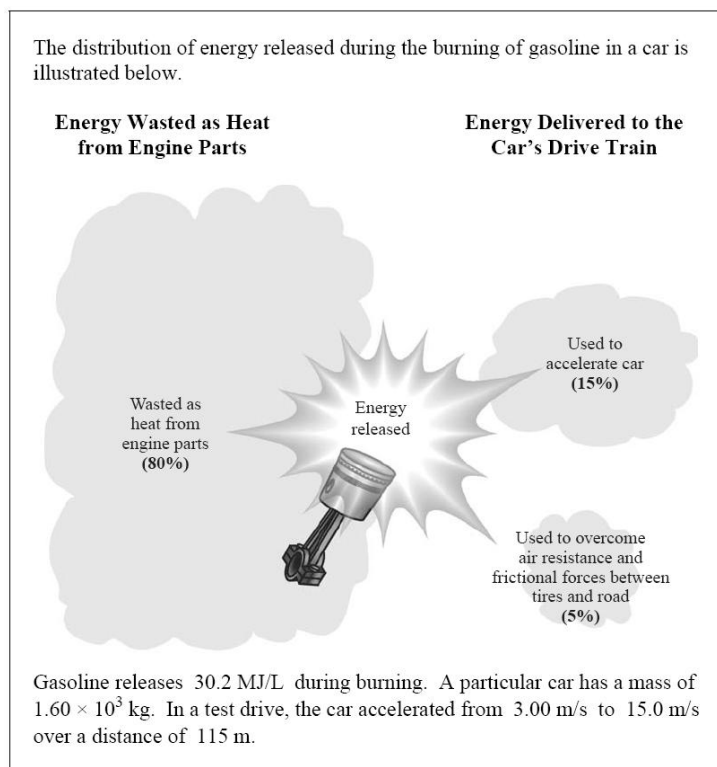**C.** 25^0 E of N
D. 25^0 N of E

28. In an inelastic collision, the energy that appears to be missing is converted into

A. sound and momentum
B. force and momentum
C. sound and heat
D. heat and force

29. Which of the following units are correct units for momentum?

A. J•s
B. N•m
C. N•s
D. N/J

Use the following information to answer the next two questions.

The distribution of energy released during the burning of gasoline in a car is illustrated below.

Energy Wasted as Heat from Engine Parts

Energy Delivered to the Car's Drive Train

Used to accelerate car
(15%)

Wasted as heat from engine parts
(80%)

Energy released

Used to overcome air resistance and frictional forces between tires and road
(5%)

Gasoline releases 30.2 MJ/L during burning. A particular car has a mass of 1.60×10^3 kg. In a test drive, the car accelerated from 3.00 m/s to 15.0 m/s over a distance of 115 m.

30. The magnitude of the impulse on the car during the test drive is

A. 4.80×10^3 kg•m/s
B. 1.92×10^4 kg•m/s
C. 2.40×10^4 kg•m/s
D. 2.88×10^4 kg•m/s

Use your recorded answer from the previous question to answer the next question.

31. The average net force on the car during the test drive, expressed in scientific notation, is $a.bc \times 10^d$ N. The values of a, b, c, and d are ____, ____, ____, and ____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)