Warm-Up | Momentum

Lesson Question

Lesson Goals

Define and **calculate** ______________ .

Explain how momentum is ______________ .

Apply Newton's ______________ to momentum.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

	a quantity that has both a size and direction
	the total momentum of all interacting objects is the same before and after an event
	the measure of the motion of an object found by multiplying the object's mass and velocity

Warm-Up | Momentum

Newton's Third Law of Motion

- Newton's [ ] of motion states that forces come in pairs that are equal in strength and opposite in direction.
- Man [ ] on car ←→ Car pushes on man
- Ball pushes on racket [ ] Racket pushes on ball
- Books push on desk ←→ Desk [ ] on books

Instruction | Momentum

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Momentum

$$p = mv$$

- [blank] is the measure of the motion of an object found by multiplying the object's mass and velocity.
  - Symbol: p
  - [blank] : a quantity that has both a size and direction.
  - Units: kg • m/s

Momentum of a Hammer

EXAMPLE

What is the [blank] of a 2 kg hammer swung at 0.8 m/s?

- [blank] :
  - M = 2 kg
  - V = 0.8 m/s
- [blank] : p
- [blank] to use: $p = mv$

Solve the equation:

- $p = mv$ = (2 kg)(0.8 m/s)
- p = 1.6 kg • m/s

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Mass, Velocity, and Momentum

- If two objects have the same ______, the object with the greater velocity will have the greater momentum.
- If two objects have the same ______, the object with the greater mass will have the greater momentum.

Equal Momentum

Car:

- $p = mv$
- $p =$ (1,000 kg)(25 m/s)
- $p =$ ______ kg • m/s

$m = 1{,}000 \text{ kg}$
$v = 25 \text{ m/s}$

Truck:

- $p = mv$
- $p =$ (5,000 kg)(5 m/s)
- $p =$ ______ kg • m/s

$m = 5{,}000 \text{ kg}$
$v = 5 \text{ m/s}$

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Law of Conservation of Momentum

- The ______ states that the total momentum of interacting objects does not change.

$$p_i = pf$$

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Collisions in Which Objects Stick Together

- Two or more objects collide and ______ to become one object with one velocity.
    - They individual masses ______ .
    - All objects have the ______ .

Before Collision

Green train car:

- $p = mv$
- $p =$ (600 kg)(10 m/s)
- $p =$ ______ kg • m/s

Purple train car:

- $p = mv$
- $p =$ (400 kg)(−5 m/s)
- $p =$ ______ kg • m/s

Total momentum before collision:

- 6,000 kg • m/s + (−2,000 kg • m/s)

  ______ kg • m/s

Before Collision

$m_1 = 600\ \text{kg}$
$v_1 = 10\ \text{m/s}$

$m_2 = 400\ \text{kg}$
$v_2 = -5\ \text{m/s}$

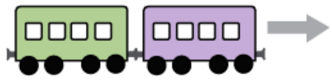
After Collision

Total momentum after collision:

- $p = mv$
- $p =$ (1000 kg)(4 m/s)

  $=$ ______ kg • m/s

After Collision



$m_f = 1{,}000\ \text{kg}$
$v_f = 4\ \text{m/s}$

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Collisions in Which Objects Bounce Apart

- Two or more objects collide together and ________ with separate velocities.
  - They ________ their original masses.
  - The velocities may ________ .

Before Collision

Green train car:

- $p = mv$
- $p =$ (600 kg)(2 m/s)
- $p =$ ________ kg • m/s

Purple train car:

- $p = mv$
- $p =$ (400 kg)(−4 m/s)
- $p =$ ________ kg • m/s

Total momentum before collision:

- 1,200 kg • m/s + (−1,600 kg • m/s) = ________ kg • m/s

Before Collision

$m_1 = 600\ \text{kg}$ $v_1 = 2\ \text{m/s}$

$m_2 = 400\ \text{kg}$ $v_2 = -4\ \text{m/s}$

After Collision

Green train car:

- $p = mv$
- $p =$ (600 kg)(−2 m/s)
- $p =$ ________ kg • m/s

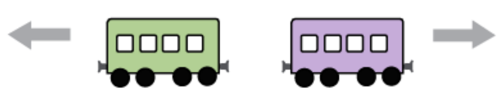
Purple train car:

- $p = mv$
- $p =$ (400 kg)(2 m/s)
- $p =$ ________ kg • m/s

Total momentum after collision:

- −1,200 kg • m/s + (800 kg • m/s) = ________ kg • m/s

After Collision



$m_1 = 600\ \text{kg}$ $v_1 = -2\ \text{m/s}$

$m_2 = 400\ \text{kg}$ $v_2 = 2\ \text{m/s}$

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Newton's Third Law of Motion and Momentum

- Newton's [ ] of motion can be applied to the conservation of momentum.
- Newton's third law describes action and reaction [ ].
  - Cannon [ ] cannonball ←→ Cannonball pushes cannon
  - $m_c(-v_c)$ [ ] $m_{cb}v_{cb}$ (The momentum of the cannon moving left equals the momentum of the cannonball moving right.)

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Force, Momentum, and Collision Time

- [ ] or transferring momentum requires a force.
  - Faster objects require greater changes in momentum to [ ].
- Minimizing the force exerted in action-reaction force pairs [ ] damage.
- Reducing the force exerted by action-reaction force pairs is done by extending the [ ] of a collision.

Summary | Momentum

Lesson Question What is momentum?

Answer

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Review: Key Concepts

- ______ is the product of an object's mass and velocity, found by the ______ $p = mv$.
- The ______ states that the total momentum of all objects in a collision or explosion must be the same before and after the collision or explosion.
- Newton's ______ of motion about action and reaction forces means that objects will also have equal and opposite momenta when momentum is conserved.
- Forces cause ______ in momentum.
- The ______ exerted on an object during a collision decreases if the time of the collision increases.

Summary | Momentum

Use this space to write any questions or thoughts about this lesson.