Edgenuity

Warm-Up | Impulse and Momentum

Lesson Question

How are impulse and momentum related?

Lesson Goals

Calculate mass, [velocity], or momentum given the other two quantities.

Describe impulse and how it relates to momentum.

Solve problems involving [impulse].

Analyze and compare the momentum and impulse of different objects.

Words to Know

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

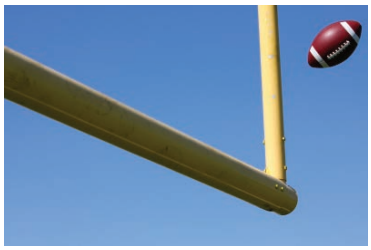
direct relationship	a relationship between two variables whereby both variables [increase] or decrease together
impulse	a [force] applied over an interval of time that causes a change in momentum
inverse relationship	a relationship between two variables whereby one variable increases and the other variable [decreases]
momentum	an object's [mass] multiplied by its velocity

Warm-Up | Impulse and Momentum

Newton's First Law of Motion

Newton's first law of motion describes [inertia], or the natural tendency of objects to resist a change in motion.

An object at rest will stay at rest unless acted on by an external force.



An object in motion will stay in motion with the [same] velocity unless acted on by an external force.

Instruction | Impulse and Momentum

Slide 2

Momentum

- **Momentum** (p) is an object's mass multiplied by its velocity.
  - Unit of $\text{kg} \cdot \frac{\text{m}}{\text{s}}$
- The momentum of an object has a [direct] **relationship** with both the object's mass and the object's velocity.
  - If mass or velocity increases, momentum [increases].
  - If mass or velocity [decreases], momentum decreases.

$$p = mv$$

4

Rearrangement of the Momentum Formula

Use	To Find	When You Know
$p = mv$	momentum	[mass] and velocity
$m = \frac{[p]}{v}$	mass	momentum and velocity
$v = \frac{p}{m}$	velocity	momentum and mass

Instruction | Impulse and Momentum

Slide 7

Impulse

- **Impulse** is a force applied to an object over a time interval that causes a [change] in momentum.
  - Unit of $\mathrm{N \cdot s}$ or $\mathrm{kg \cdot \frac{m}{s}}$.
- The impulse of an object has a [direct] relationship with both force and time.
  - If force or time increases, impulse increases.
  - If force or time decreases, momentum [decreases].

$$J = F\Delta t$$

$$\mathrm{N \cdot s}$$
$$\mathrm{kg \cdot m/s}$$

Slide 9

Impulse

- The **change** in momentum is equal to impulse.

$$a = \frac{[\Delta v]}{\Delta t}$$

$$F = ma$$

$$[J] = F\Delta t = m\Delta v$$

$$\frac{F\Delta t}{\Delta t} = \frac{m\Delta v}{\Delta t}$$

$$F = \frac{mv}{\Delta t}$$

$$J = F\Delta t = \Delta p$$

$$F = m[a]$$

Acceleration is equal to a change in velocity over a change in [time].

This formula tells us that a change in velocity indicates that there's a change in [momentum].

Instruction | Impulse and Momentum

Slide 11

Force and Time

- Force and time have an [inverse] **relationship**.
  - For a given impulse:
    - force decreases as time [increases].
    - force increases as time decreases.
- The inverse relationship between force and time is helpful in reducing injuries in a variety of situations.

Impulse (N · s)	Time (s)	Force (N)
30	2	15
30	3	10
30	6	5

Impulse and Safety

- Bringing a car to a stop requires an impulse.
  - Impulse remains the same regardless of the time it takes to bring a car from 60 mph to a stop.

$[J = \Delta p =$ [$m\Delta v$] $]$

- $F\Delta t = F\Delta t$
- The force exerted can be decreased if the time of the collision [increases].

Instruction | Impulse and Momentum

Slide 13

Rearrangement of the Impulse Formula

Use	To Find	When You Know
$\Delta v = \frac{F\Delta t}{m}$	change in velocity	force, time, and mass
$F = \frac{m\Delta v}{\Delta t}$	force	mass, change in velocity, and time
$\Delta t = \frac{m\Delta v}{F}$	time	mass, change in velocity, and force
$m = \frac{F\Delta t}{\Delta v}$	mass	force, time, and change in velocity

Instruction | Impulse and Momentum

Slide 13

Impulse and Momentum

A 60 kg cart is pushed with a force of 70 N for 6.0 seconds. If the cart was moving at a velocity of 2.0 m/s initially, what is the new velocity of the cart?

- Given:
  - $F = 70\ \text{N}$
  - $\Delta t = 6.0\ \text{s}$
  - $m = 60\ \text{kg}$
  - $v_i =$ 2.0 m/s
- Unknown: v_f
- Formula: $\Delta v = \dfrac{F\Delta t}{m}$

$$\Delta v = \frac{F\Delta t}{m}$$

$$\Delta v = v_f - v_i$$

$$\boxed{v_f} - v_i = \frac{F\Delta t}{m}$$

$$v_f = \frac{F\Delta t}{m} + v_i$$

$$v_f = \frac{F\Delta t}{m} + v_i$$

$$v_f = \frac{(70\ \text{N})(6.0\ \text{s})}{60\ \text{kg}} + 2.0\ \text{m/s}$$

$$v_f = \boxed{9\ \text{m/s}}$$

Instruction | Impulse and Momentum

Slide 16

Momentum Comparisons: Same Velocity but Different Masses

- When objects have the same velocity, the object with the greatest [mass] has the greatest momentum.
  - Momentum is [directly] proportional to mass.

Object	Mass (kg)	Velocity (m/s)	Momentum (kg · m/s)
Car 1	1,000	25	25,000
Car 2	2,000	25	50,000
Car 3	3,000	25	75,000

$$m \cdot v = p$$

Momentum Comparisons: Same Mass but Different Velocities

- When objects have the same mass, the object with the greatest [velocity] has the greatest momentum.
  - Momentum is directly proportional to velocity.

Object	Mass (kg)	Velocity (m/s)	Momentum (kg · m/s)
Car 1	1,000	25	25,000
Car 2	1,000	50	50,000
Car 3	1,000	75	75,000

Instruction | Impulse and Momentum

Slide 18

Impulse Comparisons: Same Force but Different Contact Times

- When the same force is applied to different objects, the object that has the longest contact time with the force has the greatest impulse.

Object	Force (N)	Time (s)	Impulse (N · s)
Ball 1	25	2	50
Ball 2	25	4	100
Ball 3	25	6	150

$$F \times t = J$$

Impulse Comparisons: Same Contact Time but Different Force

- When different objects experience the same contact time but different forces, the object that received the greatest force has the greatest impulse.

Object	Force (N)	Time (s)	Impulse (N · s)
Ball 1	25	3	75
Ball 2	50	3	150
Ball 3	75	3	225

Summary | Impulse and Momentum

Lesson Question

How are impulse and momentum related?

Answer

(Sample answer) Impulse is equal to change in momentum. The greater the impulse applied to an object, the greater the change in the momentum of the object. The lesser the impulse applied to an object, the lesser the change in the momentum of the object.

Slide 2

Review: Key Concepts

- Momentum is the measure of the motion of an object.
  - The mathematical relationship between [momentum], mass, and velocity is represented by this formula:
    - $p = mv$
- Impulse is equal to the [change] in momentum. Δp
  - The mathematical relationship between impulse and momentum is represented by these formulas:
    - $F\Delta t =$ [m] Δv
    - $F\Delta t = \Delta p$

Summary | Impulse and Momentum

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