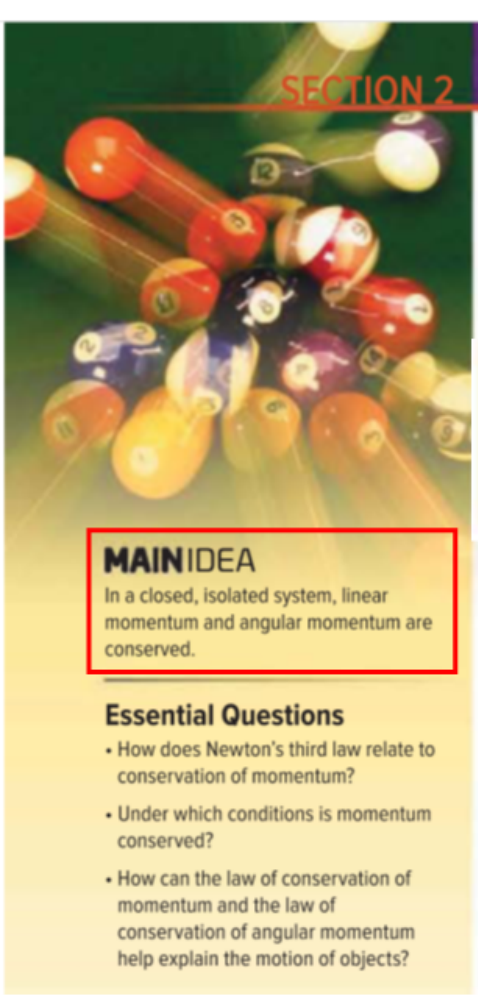


SECTION 2 Conservation of Momentum

PHYSICS 4 YOU When a game of billiards is started, the balls are usually arranged in a triangle. A player then shoots the cue ball at them, causing the balls to spread out in all directions. How does the motion of the cue ball before the break affect the motions of the balls after the break?

MAIN IDEA
In a closed, isolated system, linear momentum and angular momentum are conserved.

IMPULSE-MOMENTUM THEOREM
An impulse acting on an object is equal to the object's final momentum minus the object's initial momentum.

$$F\Delta t = p_f - p_i$$

Essential Questions
- How does Newton's third law relate to conservation of momentum?
- Under which conditions is momentum conserved?
- How can the law of conservation of momentum and the law of conservation of angular momentum help explain the motion of objects?

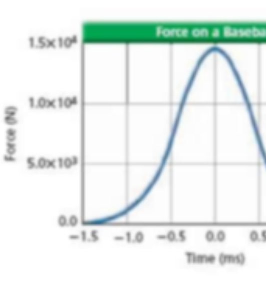
Section Self-Check **Impulse and Momentum**

1. _____ is the product of the average force on an object and the time interval over which it acts. Need a Hint?
   - A. Angular momentum
   - B. Impulse
   - C. Impulse momentum
   - D. Momentum

2. Which is represented by the equation $F\Delta t = p_f - p_i$? Need a Hint?
   - A. angular momentum
   - B. angular impulse-anglular momentum theorem
   - C. impulse theorem
   - D. impulse-momentum theorem

3. How does an air bag save lives? Need a Hint?
   - A. It reduces the surface area that a person's body strikes.
   - B. It reduces the force by increasing the time interval during which it acts.
   - C. It exerts the force over a smaller area of the person's body.
   - D. It reduces the force by decreasing the time interval during which it acts.

4. According to the graph, at which time is the force on a baseball the highest? Need a Hint?



   - A. - 1.5
   - B. - 1.0
   - C. 0.0
   - D. 1.5

MOMENTUM → $\vec{p} = m\vec{v}$

IMPULSE → $\Delta\vec{p} = \vec{F}\,\Delta t$

AVERAGE FORCE A 2200-kg vehicle traveling at 94 km/h (26 m/s) can be st[opped] by gently applying the brakes. It can be stopped in 3.8 s if the driver slams or in 0.22 s if it hits a concrete wall. What is the impulse exerted on the veh[icle] average force is exerted on the vehicle in each of these stops?

$\vec{p} = m\vec{v}$

$\Delta\vec{p} = \vec{F}\,\Delta t$

5. CHALLENGE Suppose a 60.0-kg person was in the vehicle that hit the concrete wall in Example Problem 1. The velocity of the person equals that of the car both before and after the crash, and the velocity changes in 0.20 s. Sketch the problem.

a. What is the average force exerted on the person?

b. Some people think they can stop their bodies from lurching forward in a vehicle that is suddenly braking by putting their hands on the dashboard. Find the mass of an object that has a weight equal to the force you just calculated. Could you lift such a mass? Are you strong enough to stop your body with your arms?

$F \cdot \Delta t = \Delta P = \cancel{P} - P_0$ $\quad P = m \cdot v$

zero (stops)

$F \cdot \Delta t = -m \cdot v_0$

$F \cdot 0.20 = -60 \times 26$

$F = -7800\ N$

b) $m = ?$

$F = W = F_g = m \cdot g$

$7800 = m \cdot 9.8$

$\frac{7800}{9.8} = m = 796\ Kg$

(1751 lbs)

IMPULSE-MOMENTUM THEOREM
An impulse acting on an object is equal to the object's final momentum minus the object's initial momentum.

$$F\Delta t = p_f - p_i$$

external force

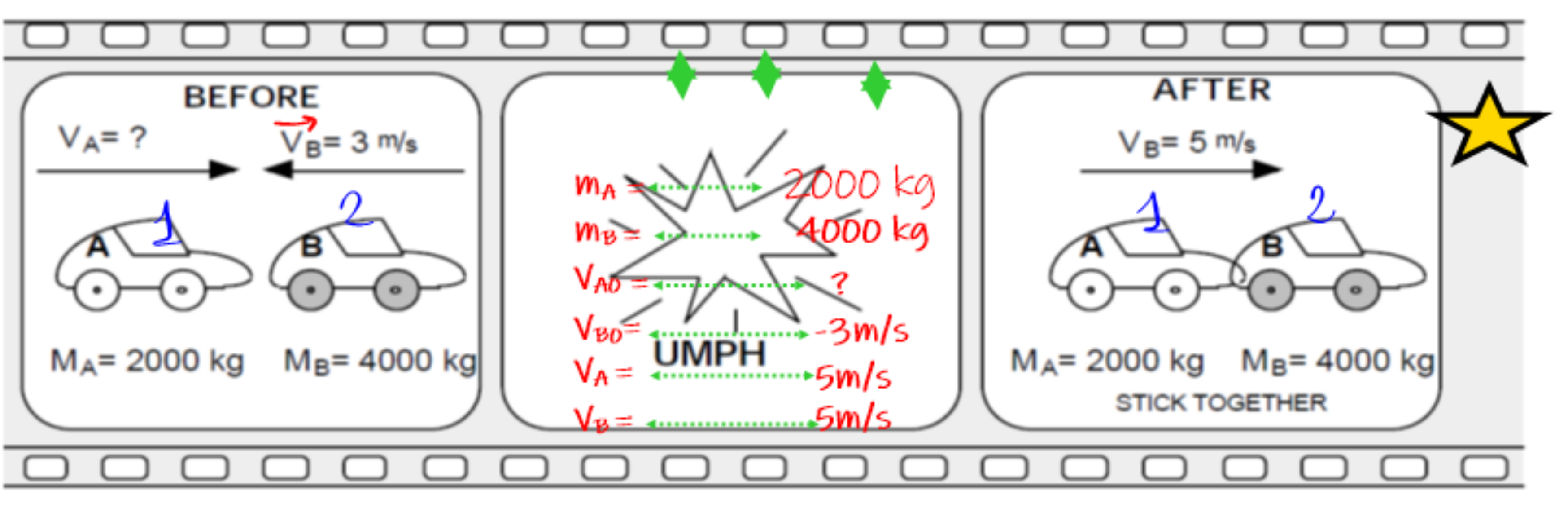
If during the collision no external force is acting, then $0 = P - P_o$

$$\boxed{\vec{p}_0 = \vec{p}}$$

$$m_1 \cdot \vec{v}_{10} + m_2 \cdot \vec{v}_{20} = m_1 \cdot \vec{v}_1 + m_2 \cdot \vec{v}_2$$

Types of Collisions

- Inelastic Collisions
  - $(K_0 \neq K)$
- Perfectly Inelastic
  - (after collision objects stick together)
- Elastic Collisions
  - $(K_0 = K)$



$$\vec{p}_0 = \vec{p}$$

$$m_1 \cdot \vec{v}_{10} + m_2 \cdot \vec{v}_{20} = m_1 \cdot \vec{v}_1 + m_2 \cdot \vec{v}_2$$

$2\cancel{000} \cdot V_{A0} + 4\cancel{000} \times (-3) = 2\cancel{000} \times 5 + 4\cancel{000} \times 5$

$2V_{A0} - 12 = 30$

$2V_{A0} = 42$

$V_{A0} = 21\ \frac{m}{s}$

b) the kinetic energy before the collision.
c) the kinetic energy after the collision.
d) Which type of collision is shown?
e) Energy lost at collision?

b) $K_0 = \frac{1}{2} m_1 v_{10}^2 + \frac{1}{2} m_2 v_{20}^2 = \frac{1}{2} \cdot 2000 \times 21^2 + \frac{1}{2} \cdot 4000 \times (-3)^2$

$K_0 = 459{,}000\ J$

c) $K = \frac{1}{2} \cdot 2000 \cdot 5^2 + \frac{1}{2} \cdot 4000 \cdot 5^2 = 75{,}000\ J$

d) Perfectly Inellastic (together after the collision)

e) $\Delta E = K - K_0 = (75{,}000 - 459{,}000)\ J = -384{,}000\ J$

lost

If you want to reduce the mathematical calculations, in perfectly inelastic collisions the final velocities are common factor!!!!!

$$\vec{p}_0 = \vec{p}$$

$$m_1 \cdot \vec{v}_{10} + m_2 \cdot \vec{v}_{20} = m_1 \cdot \vec{v}_1 + m_2 \cdot \vec{v}_2$$

if the collision is perfectly inelastic (objects stick together)

$$m_1 \cdot v_{10} + m_2 \cdot v_{20} = v_{1,2}\,(m_1 + m_2)$$