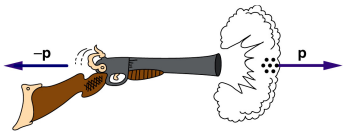
# Conservation of Momentum

| Learning Target | Description |
|---|---|
| 11.2 | I can define, interpret, and solve problems involving the Law of Conservation of Momentum. |




*Corrections to practice problems

**11.1 IMPULSE AND MOMENTUM**

1. A compact car, with mass 725 kg, is moving at 115 km/h toward the east.
   a. Find the magnitude and direction of its momentum.
   b. A second car, with a mass of 2175 kg, has the same momentum. What is its velocity?
2. A 0.150-kg baseball is dropped from rest. If the magnitude of the baseball's momentum is 0.780 kg·m/s just before it lands on the ground, from what height was it dropped?
3. Find the magnitude of the impulse delivered to a soccer ball when a player kicks it with a force of 1450 N. Assume that the player's foot is in contact with the ball for $5.80 \times 10^{-3}$ s.
4. In a typical golf swing, the club is in contact with the ball for about 0.0010 s. If the 45-g ball acquires a speed of 67 m/s, estimate the magnitude of the force exerted by the club on the ball.
5. When spiking a volleyball, a player changes the velocity of the ball from 4.2 m/s to -24 m/s along a certain direction. If the impulse delivered to the ball by the player is -9.3 kg·m/s what is the mass of the volleyball?

## Review Momentum and Impulse

Momentum

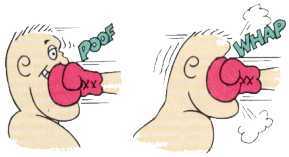
$$p = m v$$

Impulse-Momentum Theorem

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

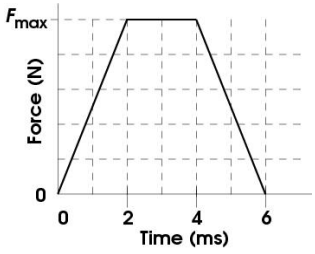
## Impulse-Momentum Theorem

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

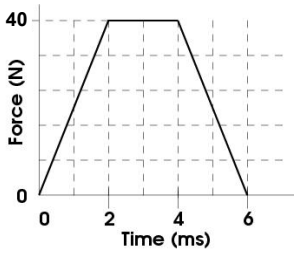



F t = change in momentum F t = change in momentum

## What's The Story?




## Force vs. Time Graph



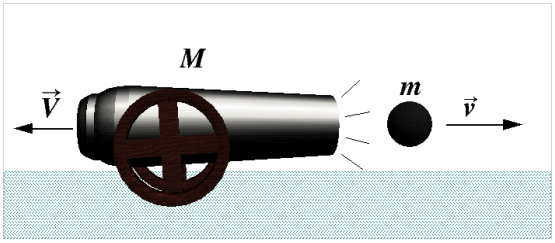

The **impulse** can also be found by finding the area under a force-time graph.

# Momentum

What if $F_{net} = 0$ ?

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

# Newton's 3rd Law



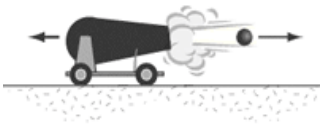

## Law of Conservation of Momentum

- If the net force acting on an object is zero, its momentum is conserved.
- In any closed system, the total momentum of the system remains constant.

$$p_{initial} = p_{final}$$

## Recoil

A cannon fires a 19.0 kg ball from its 4.00 m long barrel with a muzzle velocity of 125 m/s. If the cannon has a total mass of 855 kg, what is the resulting recoil speed of the cannon?



# Momentum Tables

In analyzing momentum problems, a momentum table can be a powerful tool for problem solving. To create a momentum table, follow these basic steps:

1. Identify all objects in the system. List them vertically down the left-hand column.
2. Determine the momenta of the objects before the event. Use variables for any unknowns.
3. Determine the momenta of the objects after the event. Use variables for any unknowns.
4. Add up all the momenta from before the event, and set them equal to the momenta after the event.
5. Solve your resulting equation for any unknowns.

## Recoil

A cannon fires a 19.0 kg ball from its 4.00 m long barrel with a muzzle velocity of 125 m/s. If the cannon has a total mass of 855 kg, what is the resulting recoil speed of the cannon?

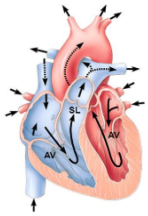
| OBJECTS | MOMENTUM BEFORE (kg·m/s) | MOMENTUM AFTER (kg·m/s) |
|---|---|---|
| CANNON | $mv$ | $(855)V_f$ |
| BALL | $(19+855)(0) = 0$ | $(19)(125) = 2375$ |
| TOTAL | 0 | 0 |

$(855)V_f + 2375 = 0$

$V_f = \frac{-2375 \frac{kg \cdot m}{s}}{855\ kg} = -2.78\ m/s$

## Examples of Recoil






## Ballistocardiograph


## Riverbend Maximum Security Institution

# PRACTICE

## PROBLEMS

## (9-13)