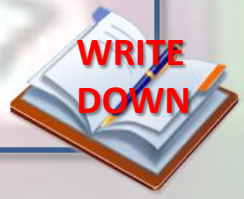
Momentum

Collisions

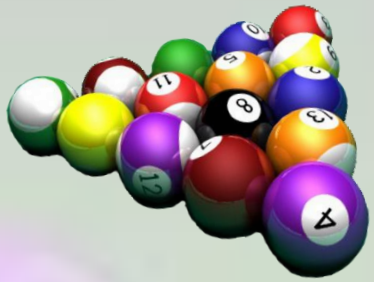
- There is a collision!

- Now what?!
- What happens during a collision depends on the masses and velocities of the colliding objects before the collision.



Collision Scenarios

- Consider a game of pool:



- The cue ball collides with another pool ball:
  - A collision can change the motion of either or both objects.
  - A collision can cause a change in speed, direction, or both for any of the objects involved.

Comparing Collisions

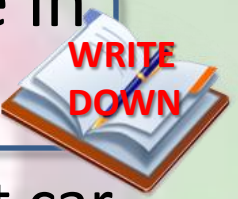
- In a collision between a cue ball and a pool ball, the masses are about the same.
- In a collision between a smart car and a garbage truck they are not.
- This affects the outcome.

Inertia and Mass

- The garbage truck has more mass than the smart car.
  - Mass = the amount of matter in an object

- It is harder to slow the garbage truck down.
  - The more mass an object has, the harder it is to change its motion.

- Inertia = tendency of matter to resist a change in its motion.



  - The garbage truck has more inertia than the smart car.

Inertia and Speed

- A sports car moves faster than a smart car.

- It would be easier to stop a slow smart car than a speedy sports car.
  - It has less inertia.
    - The faster an object is moving, the harder it is to change its motion.
    - Faster objects have more inertia.

Defining Momentum

- Momentum = measure of the difficulty in stopping a moving object.
- Momentum is the product of the mass and velocity
  - If p is momentum,
  - m is mass,
  - and v is velocity
  - $p = mv$

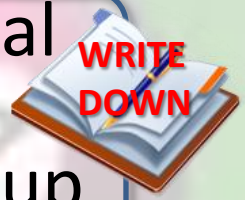
It's the Law!

CONSERVATION OF MOMENTUM

Defining Conservation

- In billiards, when one billiard ball hits another, it slows down, and/or reverses direction, but the other speeds up making the total momentum constant.

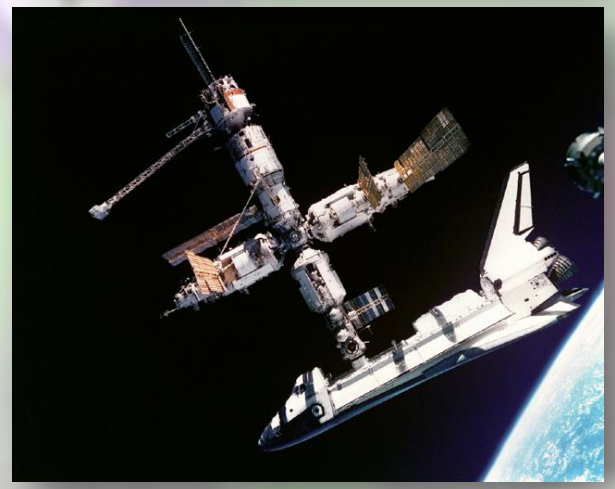
- It's not always obvious that the momentum is constant, because eventually the billiard balls slow down due to friction, an outside force.
- **Law of Conservation of Momentum** = the total momentum of a group of objects remains constant unless outside forces act on the group.



Examples of Conservation

- Objects bounce off each other.
  - Billiards
  - Bowling

- Objects stick together.
  - Coupling train cars
  - Space shuttle docking with space station
  - Colliding snowballs



Sample Problem

Example: You are standing still on skates. Your mass is 48 kg. Some one tosses you a 2 kg back pack with a velocity of 5 m/s east. What is your velocity after you catch the back pack?

- **Step 1:** Find the total momentum by adding the momentums of each object.
  - $p_{total} = p_{backpack} + p_{yours}$
  - $p_{total} = m_{backpack}v_{backpack} + m_{yours}v_{yours}$
  - $p_{total} = (2\ kg)(5 m/s\ east) + (48\ kg)(0\ m/s) = 10\ kg \bullet m/sec\ east$
- **Step 2**: Use the total momentum and the total mass to solve for the velocity.
  - $p_{total} = m_{total}v_{total}$
  - $10 kg \bullet m/s\ east = (2\ kg + 48\ kg)v_{total}$
  - $10 kg \bullet m/s\ east = (50\ kg)v_{total}$
  - $0.2\ m/s\ east = v_{total}$