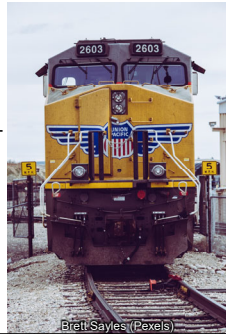




- Momentum is a property that depends on the mass and the velocity of the object.
 - All moving objects have momentum.
 - A train traveling at 20 km/h is harder to stop than a mosquito traveling at the same speed.
 - The mass of the train is bigger therefore, more momentum.



Merk Minge (Pixabay)



Brett Sayles (Pexels)

- Small objects moving very fast are also hard to stop
 - A bullet shot from a gun has a very small mass, but its large speed gives it a large momentum.



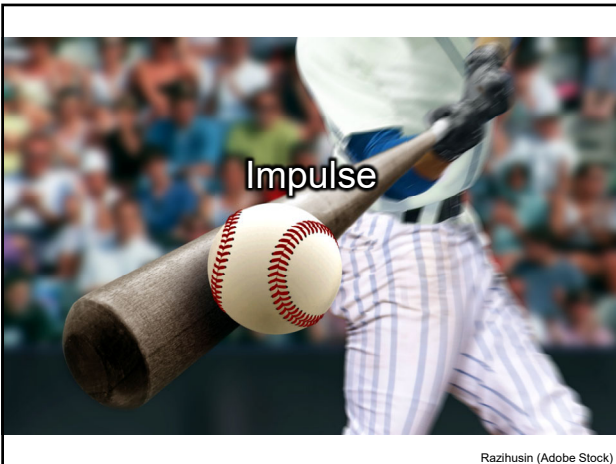
Wikimages (Pixabay)



Ralf Vetterle (Pixabay)

- Momentum gives us an idea of how hard it is to accelerate (speed up, slow down, change direction) a **moving** object.





- The momentum of an object can be changed by changing the velocity.
 - Acceleration
- According to Newton's second law, a force is required to accelerate an object.
- Therefore, a force is needed to change the momentum.
- The force will be applied for a period of time.
- A force exerted over a period of time is referred to as **impulse**.

- The force is usually a very large force and can deform the object.
 - This deformation can be temporary or permanent.



Marcel Langthim (Pixabay)

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Bouncing Rubber Ball Filmed in High Speed

<https://youtu.be/N8gxND1kX6k>

142mph Serve - Racquet hits the ball 6000fps

<https://youtu.be/VHV1YbeznCo>

Time Warp – baseball bat

<https://youtu.be/uxlldMoAwbY>

Dropping a Car from a Crane

<https://youtu.be/nVOb3RzS5t4>

Head on Car Crash in Slow Mo

https://youtu.be/_lhibYD39Gs

Football to the Face 1000x slower

<https://youtu.be/On1CsbTwiDs>

- A larger impulse will result in a larger change in momentum.
- An impulse can be increased in only two ways.
 - Increasing the force.
 - Increasing the time of contact.

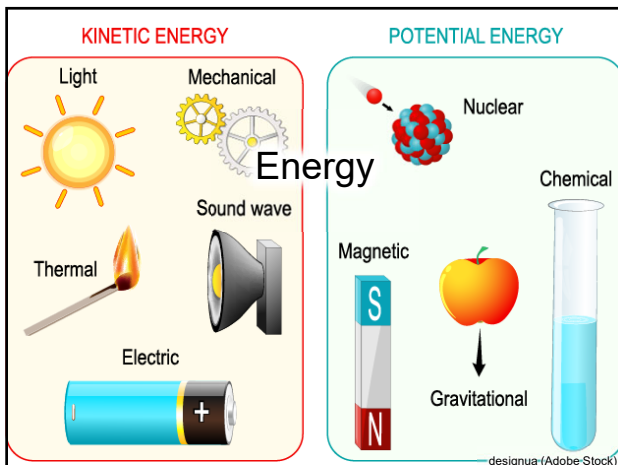
The Impulse-Momentum Theorem

<https://youtu.be/fdeH6Ksedwk>

Reducing Injury in a Car Crash

- When a car crashes, the velocity goes to zero in fractions of a second.
- This is a large change in momentum and thus a large impulse.
- Since the time is very short, there is a very large force on the car and its occupants.
- Reducing that force requires lengthening the time of the collision.

- Safety features have been added to cars to lengthen the time of the collision.
 - Crumple zones
 - The car is designed to bend during the collision in predictable ways such that the time is extended and the passengers are protected.
 - Air bags
 - A pillow of air slows the passenger down before hitting the car, thus reducing the force and lessening the injury.
 - Seat belt tensioners
 - The passenger is allowed to move forward at a controlled rate to lengthen the time of the collision and thus reduce injury from the seat belt.



Conservation of Energy

- The conservation of energy is a fundamental concept of physics.
- Total energy is constant in any process. It may change in form or be transferred from one system to another, but the total remains the same.

Types of Energy

- All energy can be divided into two basic types
 - Kinetic
 - Energy of motion
 - Potential
 - Energy held by an object because of its position relative to other objects, stresses within itself, its electric charge, or other factors.

Kinetic

- Mechanical
 - Moving objects
- Light
 - Moving photons
- Electrical
 - Moving electrons
- Thermal/Heat
 - Moving atoms
- Sound
 - Moving air

Potential

- Gravitational
 - Energy of position
- Chemical
 - Potential to burn
- Magnetic
 - Causes electrons to move
- Nuclear
 - Cause subatomic particles to move

Example

- Describe the energy transfers and transformations that occur on a ball that is dropped from some height above the earth.

- The ball starts with gravitational potential energy.
- As the ball falls, the gravitational potential energy is transformed into kinetic energy.
- When the ball hits the ground, the kinetic energy will be transferred to the earth, with some energy possibly being transformed into heat and sound.
