AP Physics Study Guide

Momentum

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

All images are from the Openstax college physics textbook

Momentum is defined as the product of a system's mass multiplied by its velocity

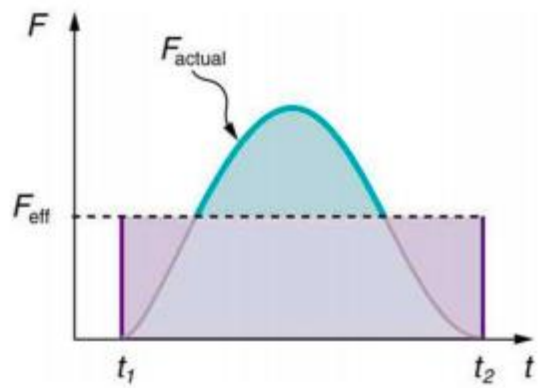
- $p = mv$
  - The greater an object's mass or velocity, the greater its momentum
  - Momentum is a vector having the same direction as the velocity

Newton's **second law of motion** in terms of momentum states that the net external force equals the change in momentum of a system divided by the time over which it changes

- $F_{net} = \Delta p/\Delta t$
- It can be applied to systems where the mass is changing as well as to systems of constant mass

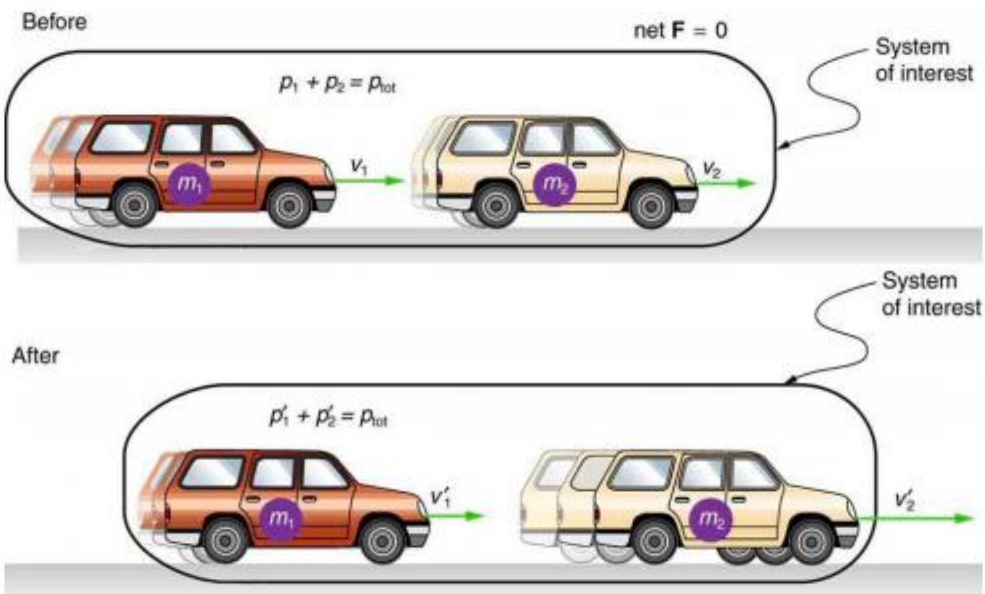
Impulse is the change in momentum

- $\Delta p = F_{net}\Delta t$
  - A small force could cause the same impulse as a large force, but it would have to act for a much longer time
- Our definition of impulse includes an assumption that the force is constant over the time interval
  - However, forces are usually not constant
  - It is possible to find an average effective force that produces the same result as the the corresponding time-varying force



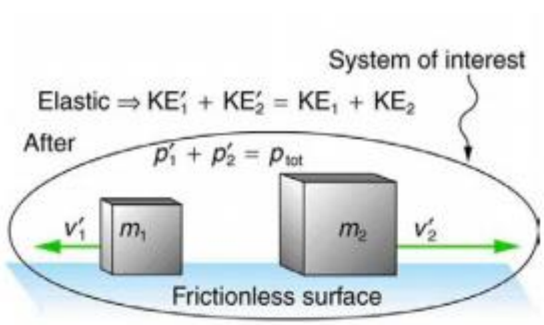
The **conservation of momentum principle** states that when the net external force is zero, the total momentum of the system is conserved or constant

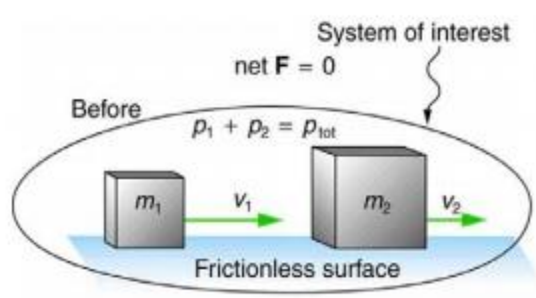
- $p_{tot} = constant$
- $p_{tot} = p'_{tot}$(isolated system)
    - An **isolated system** is defined to be one in which the net external force is zero



An **elastic collision** is one that also conserves internal kinetic energy

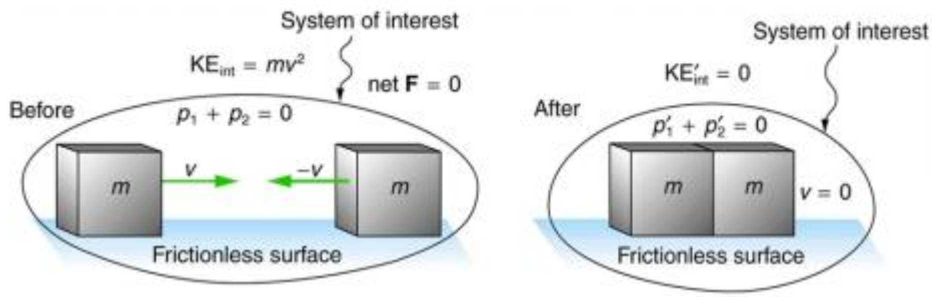
- **Internal kinetic energy** is the sum of the kinetic energies of the objects in the system





An **inelastic collision** is one in which the internal kinetic energy changes (it is not conserved)

- A collision in which the objects stick together is called **“perfectly inelastic collision”**
    - It reduces internal kinetic energy more than does any other type of elastic collision



Two-dimensional collisions might cause objects to rotate before or after the collision

- To avoid rotation, we consider only the scattering of **point masses** - structureless particles that cannot rotate or spin
    - The conservation of momentum for the x-axis is $p_{1x} + p_{2x} = p'_{1x} + p'_{2x}$
        - This then leads to $m_1 v_1 = m_1 v'_1 \cos\theta_1 + m_2 v'_2 \cos\theta_2$
    - The conservation of momentum for the y-axis is $p_{1y} + p_{2y} = p'_{1y} + p'_{2y}$
        - This then leads to $0 = m_1 v'_1 \sin\theta_1 + m_2 v'_2 \sin\theta_2$