MOMENTUM

Engr Ghulam Raza

MOMENTUM

- Quantity of motion present in moving bodies

$$P=mv$$

- Unit: Nm

- Vector

04-02 CONSERVATION OF MOMENTUM

In this lesson you will…

- Describe the principle of conservation of momentum.
- Derive an expression for the conservation of momentum.
- Explain conservation of momentum with examples.

04-02 CONSERVATION OF MOMENTUM

- System
  - Usually only two objects

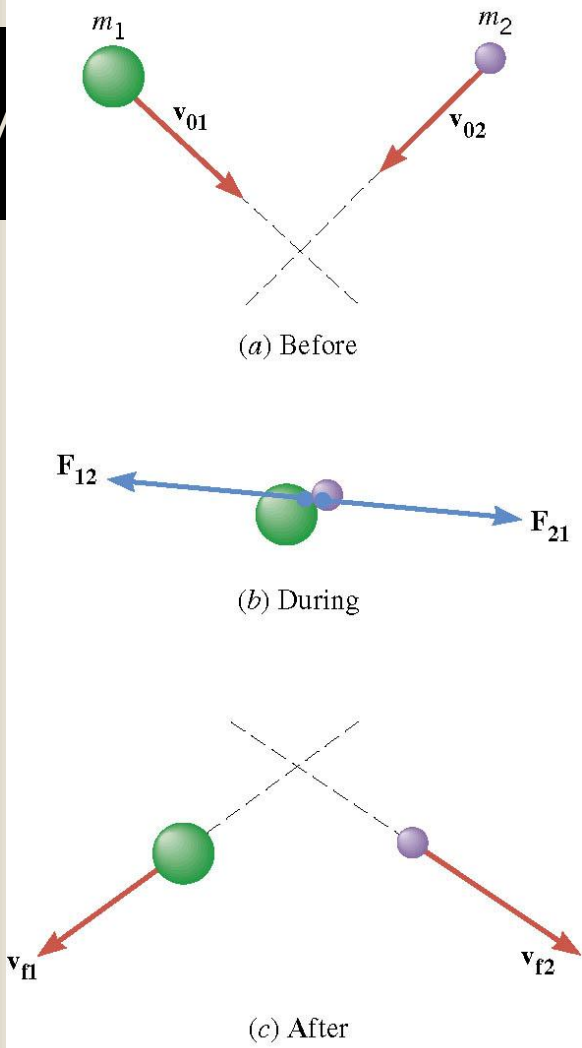
- Internal Forces – Forces that the objects exert on each other

- External Forces – Forces exerted by things outside of the system

04-02 CONSERVATION OF MOMENTUM

- Two balls hit in the air

- During the collision
  - Internal Forces = F_{12} and F_{21}
  - External Forces = Weight (W_1 and W_2)



04-02 CONSERVATION OF MOMENTUM

$F\Delta t = mv_f - mv_0$

- $F\Delta t = mv_f - mv_0$
- Object 1: $(W_1 + F_{12})\Delta t = m_1 v_{f1} - m_1 v_{01}$
- Object 2: $(W_2 + F_{21})\Delta t = m_2 v_{f2} - m_2 v_{02}$
- Add
- $(W_1 + W_2 + F_{12} + F_{21})\Delta t = (m_1 v_{f1} + m_2 v_{f2}) - (m_1 v_{01} + m_2 v_{02})$

- $(Ext\ F + Int\ F)\Delta t = p_f - p_0$

04-02 CONSERVATION OF MOMENTUM

$F\Delta t = mv_f - mv_0$

- Since F_{12} and F_{21} are equal and opposite
  - Sum of internal forces = 0

- (External Forces)$\Delta t = p_f - p_0$

- If Isolated system:

- $0 = p_f - p_0$ OR $p_0 = p_f$

04-02 CONSERVATION OF MOMENTUM

$$F\Delta t = mv_f - mv_0$$

- In an isolated system total momentum remains constant.
- **Formula:**
- Mathematically it is given by,
- m1u1 + m2u2=m1v1 + m2v2
- Note:m1u1≠m1v1
- Where,
- m_1 is mass of the A ball
- m_2 is the mass of B ball
- u_1 and u_2 are the initial velocities and v_1 and v_2 are the final velocities.

04-02 CONSERVATION OF MOMENTUM

$$F\Delta t = mv_f - mv_0$$

- Two billiard balls are colliding on a table. In order to apply the law of conservation of momentum, what should the system be? One ball or both billiard balls?
  - Two billiard balls.

- External Forces: Weight and Normal Force
  - If the table is horizontal these cancel.

04-02 CONSERVATION OF MOMENTUM

$$F\Delta t = mv_f - mv_0$$

- A hockey puck of mass 0.17 kg and velocity 5 m/s is caught by a 0.5 kg mitten laying on the ice. What is the combined velocity after the puck is in the mitten? (ignore friction)

- v = 1.27 m/s

04-02 CONSERVATION OF MOMENTUM

$$F\Delta t = mv_f - mv_0$$

- A 5 kg baseball pitching machine is placed on some frictionless ice. It shoots a 0.15 kg baseball horizontally at 35 m/s. How fast is the pitching machine moving after it shoots the ball?

- −1.05 m/s

- This is why you feel recoil when you shoot a gun

04-03 ELASTIC AND INELASTIC COLLISIONS

$$F\Delta t = mv_f - mv_0$$

- Elastic – kinetic energy conserved
- Inelastic – kinetic energy not conserved
- Completely inelastic – the objects stick together

04-04 ANGULAR MOMENTUM

In this lesson you will…

- Understand the analogy between angular momentum and linear momentum.
- Observe the relationship between torque and angular momentum.
- Apply the law of conservation of angular momentum.

04-04 ANGULAR MOMENTUM

- Linear momentum
  - $p = mv$
- Angular momentum
  - L = mvr
  - Unit:
  - kg m^2/s

- When you rotate something you exert a torque.
- More torque = faster change in angular momentum
- $\tau_{net} = \frac{\Delta L}{\Delta t}$
- Like $F = \frac{\Delta p}{\Delta t}$

04-04 ANGULAR MOMENTUM

- Linear momentum of a system is conserved if $F_{net} = 0$
  - $p_0 = p_f$

- Angular momentum of a system is also conserved if $\tau_{net} = 0$
  - $L_0 = L_f$

04-04 ANGULAR MOMENTUM

- Angular Momentum conserved if net external torque is zero
- Linear Momentum conserved if net external force is zero
- Kinetic Energy conserved if elastic collision

04-04 ANGULAR MOMENTUM

- Direction of angular quantities
  - Right-hand Rule
  - Hold hand out with thumb out along axis
  - Curl your fingers in direction of motion (you may have to turn your hand upside down)
  - vector in direction of thumb