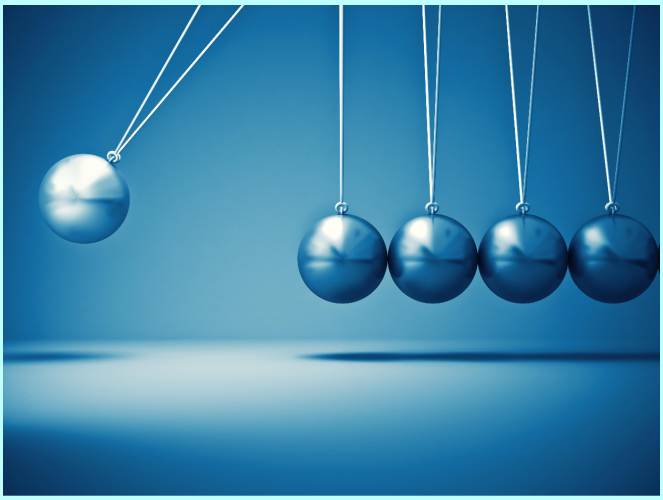
Energy and Momentum
Key Concepts (big ideas)



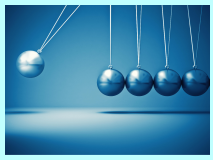
Conservation Laws

What is momentum?

Conservation of Linear Momentum

- 1 Dimensional and 2 Dimensional

Key Concepts (big ideas)



Conservation Laws

1. Conservation of mass/energy
2. Conservation of charge
3. Conservation of momentum
4. Conservation of angular momentum
5. Conservation of Baryons
6. Conservation of Leptons

Momentum

Momentum is a property of the mass and velocity of an object .

$$\vec{p} = m\vec{v}$$

Characteristics of Momentum:

1. momentum is a vector.
2. units on momentum kgm/s or $N \cdot s$
3. momentum is a property of an object or group of objects.

$momentum \quad \vec{p} = m\vec{v}$

Compare the momentum of the following three objects all moving at the same velocity of 5.00 m/s [N]?

i. shotput - mass = 7.26kg 36.3 kgm/s [N]

ii. hockey puck – mass = 160 grams 0.80 kgm/s [N]

iii. ping pong ball – mass = 2.70 grams 0.0135 kgm/s [N]

Conservation of Momentum

If no external forces are applied to a closed system, the total momentum remains constant.

external

if $F_{net} = 0$, $\Delta \vec{p} = 0$

$$\vec{p}_{final} = \vec{p}_{initial}$$

$$\vec{p}_{TOT} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + \ldots$$

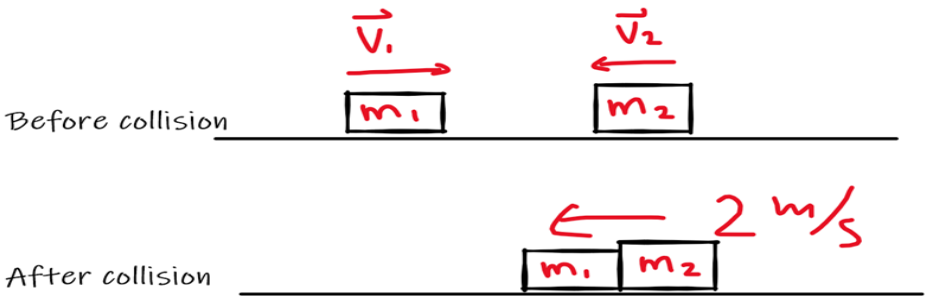
1, 2, 3 → objects #1, #2, #3

$$\vec{p}_{TOT} = \vec{p}_{TOT}'$$

' prime symbol means final

$$\vec{p}_1 + \vec{p}_2 + \vec{p}_3 = \vec{p}_1' + \vec{p}_2' + \vec{p}_3'$$

Example #1: Two Objects Collide and Stick Together



$m_1 = 2\,kg$

$m_2 = 5\,kg$

$\vec{v}_1 = 8\,m/s$

$\vec{v}_2 = -6\,m/s$

$$\vec{P}_{TOT} = \vec{P}'_{TOT}$$

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

$$2 \times 8 + 5(-6) = 2\vec{v}_1' + 5\vec{v}_2'$$

$$-14 = 2\vec{v}_1' + 5\vec{v}_2'$$

$$\vec{v}_1' = \vec{v}_2' = \vec{v}'$$

$$-14 = 2\vec{v}' + 5\vec{v}'$$

$$\vec{v}' = -2\,m/s$$

Example #2: Two Objects Collide and Bounce off Each Other

Same initial conditions as above

$$\vec{P}_{TOT} = \vec{P}'_{TOT}$$

$$-14 = 2\vec{v}_1' + 5\vec{v}_2'$$

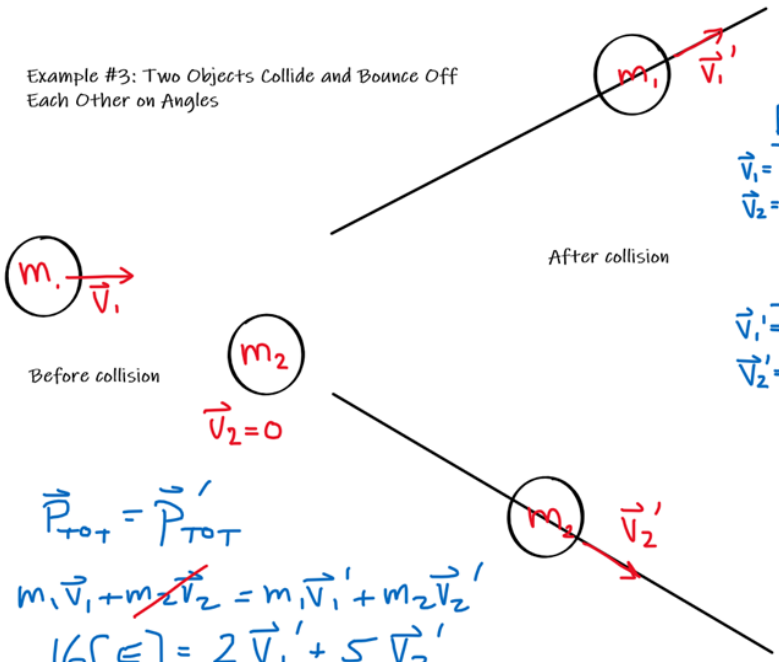
cannot be solved without additional information

let $\vec{v}_1' = -12\ m/s$ (assume it was measured in an experiment).

$$-14 = 2(-12) + 5\vec{v}_2'$$

$$\vec{v}_2' = 2\ m/s$$

Example #3: Two Objects Collide and Bounce Off Each Other on Angles



$m_1 = 2kg$ $m_2 = 5k$

Before collision

After collision

Before

$\vec{V}_1 = 8 m/s[E]$

$\vec{V}_2 = 0 m/s$

After

$\vec{V}_1' = 6 m/s[E30°N]$

$\vec{V}_2' = ?$

$\vec{P}_{TOT} = \vec{P}_{TOT}'$

$m_1\vec{V}_1 + m_2\vec{V}_2 = m_1\vec{V}_1' + m_2\vec{V}_2'$

$16[E] = 2\vec{V}_1' + 5\vec{V}_2'$

$16[E] = 12[E30N] + \vec{P}_2'$

x-component

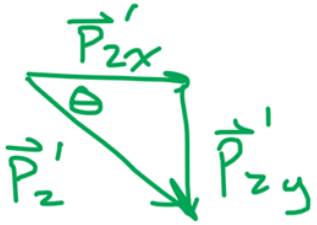
$16 = 10.39 + \vec{P}_{2x}'$

$\vec{P}_{2x}' = 5.61$

y component

$0 = 6 + \vec{P}_{2y}'$

$\vec{P}_{2y}' = -6$



$\vec{P}_2' = 8.2[E47°S]$

$\vec{V}_2' = \vec{P}_2'/m_2 = 1.6 m/s[E47°S]$