Momentum Formula Sheet:

Impulse: $(N \cdot s)$

$$J = F\Delta t \qquad J = \Delta p$$

Impulse Momentum Theorem:

$$F\Delta t = m\Delta v$$

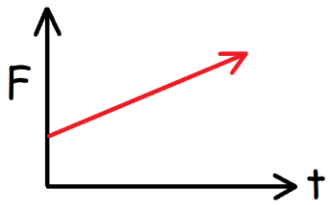
Momentum: $(kg \cdot m/s)$

$$p = mv$$

Change in Momentum:

$$\Delta p = m\Delta v$$

Force-Time Graphs:



Impulse from a Variable Force:

$$J = \int_a^b F(t)dt$$

Force-Time Graphs:

$$J = Area = \Delta p$$

Newton's 2nd Law in Terms of Momentum:

$$F_{net} = \frac{d}{dt}p(t) \qquad F(t) = p'(t)$$

$$F_{net} = ma \qquad F(t) = m \cdot a(t)$$

The Force exerted by a Fluid:

$$F_{net} = \left(\frac{\Delta m}{\Delta t}\right)v$$

Mass Flow Rate:

$$\frac{\Delta m}{\Delta t} \rightarrow kg/s$$

The Momentum Function:

$$p(t) = m \cdot v(t)$$

Average Net Force:

$$\overline{F_{net}} = \frac{\Delta p}{\Delta t}$$

Inelastic Collisions:

1. Momentum is conserved.
2. Kinetic energy is not conserved.

Conservation of Momentum:

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

Final Velocity of Two Objects Sticking Together:

$$v_F = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$$

Elastic Collisions:

1. Momentum is conserved.
2. Kinetic energy is conserved.

Conservation of Momentum:

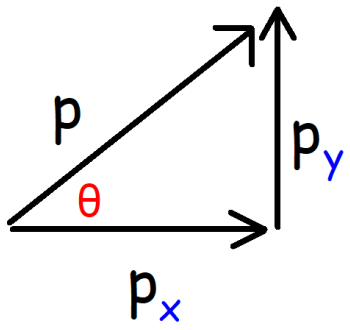
$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

Conservation of Kinetic Energy:

$$v_1 + v_1' = v_2 + v_2'$$

$$v_1 \rightarrow initial\ velocity \qquad v_1' \rightarrow final\ velocity$$

Momentum Vectors:



Momentum Vector Formulas:

$$p_x = mv_x \qquad p_y = mv_y$$

$$p_x = p\cos\theta \qquad p_y = p\sin\theta$$

$$p_{net} = \sqrt{{p_x}^2 + {p_y}^2}$$

$$\theta = tan^{-1}\left(\frac{p_y}{p_x}\right)$$

Center of Mass:

$$x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2} \qquad y_{cm} = \frac{m_1y_1 + m_2y_2}{m_1 + m_2}$$

Recoil Velocity:

$$v_2' = -\frac{m_1{v_1}'}{m_2}$$

Elastic Collision – The Shortcut Formula:

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2}v_1 + 2\frac{m_2}{m_1 + m_2}v_2$$

$$v_2' = \frac{2m_1}{m_1 + m_2}v_1 - \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_2$$

$v_1' \rightarrow final\ velocity\ of\ ball\ 1$
$v_2' \rightarrow final\ velocity\ of\ ball\ 2$
$v_1 \rightarrow Initial\ velocity\ of\ ball\ 1$
$v_2 \rightarrow Initial\ velocity\ of\ ball\ 2$

Ballistic Pendulum - Initial Speed of the Bullet:

$$v = \frac{m + M}{m}\sqrt{2gy}$$

The Height of the Block:

$$y = \frac{1}{2g}\left[\frac{mv}{m + M}\right]^2$$

$m \rightarrow mass\ of\ the\ bullet$
$M \rightarrow mass\ of\ the\ block$
$v \rightarrow initial\ speed\ of\ the\ bullet$
$y \rightarrow height\ achieved\ by\ the\ block$

Note: These formulas apply online when the bullet remains embedded in the block.

The Coefficient of Restitution:

1. Completely Inelastic Collision: $e = 0$
2. Inelastic Collision: $0 < e < 1$
3. Elastic Collision: $e = 1$

The Coefficient of Restitution:

$$e = \frac{v_1' - {v_2}'}{v_2 - v_1}$$