Momentum

- Momentum: $p = mv$
- The rate of change of momentum of an object is equal to the net force applied to it.
- $F = \frac{dp}{dt} = \frac{d(mv)}{dt} = mdv/dt = ma$
Conservation of Momentum

- Momentum is conserved!
- $p_{1,i} + p_{2,i} = p_{1,f} + p_{2,f}$
- $m v_{1,i} + m v_{2,i} = m v_{1,f} + m v_{2,f}$
Conservation of Momentum

- $F_{\text{ext}} = \frac{dp_i}{dt} = \frac{dP}{dt}$
- When the net external force on a system is zero, the total momentum remains constant.
- The total momentum of an isolated system of bodies remains constant.
**Impulse**

- \( F = \frac{dp}{dt} \)
- \( dp = F \, dt \)
- \( \Delta dp = p_f - p_i = \Delta F \, dt \)
- \( J = \Delta F \, dt \)
- \( J = p_f - p_i \)
# Momentum vs Energy

<table>
<thead>
<tr>
<th>Momentum: ( p = mv )</th>
<th>Energy: ( K = \frac{1}{2} mv^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse: ( J = \int F , dt )</td>
<td>Work: ( W = \int F , dr )</td>
</tr>
<tr>
<td>Impulse-Momentum Theorem: ( J = p_f - p_i )</td>
<td>Work-Energy Theorem: ( W = K_f - K_i )</td>
</tr>
<tr>
<td>If ( J=0 ), ( p ) conserved</td>
<td>If ( W=0 ), ( K ) conserved</td>
</tr>
<tr>
<td>( p_{1,i} + p_{2,i} = p_{1,f} + p_{2,f} )</td>
<td>( K_{1,i} + K_{2,i} = K_{1,f} + K_{2,f} )</td>
</tr>
</tbody>
</table>

If both valid: elastic, if only \( p \)-conservation: inelastic