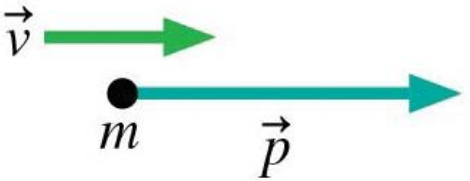
Chapter 11 – Impulse and Momentum

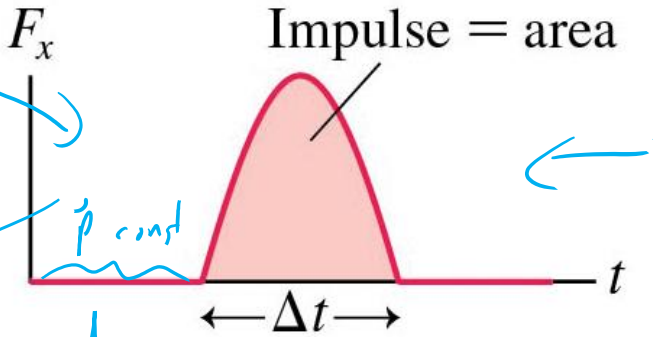
- Momentum, impulse
- When is momentum conserved?
- Collisions and explosions
- Rockets

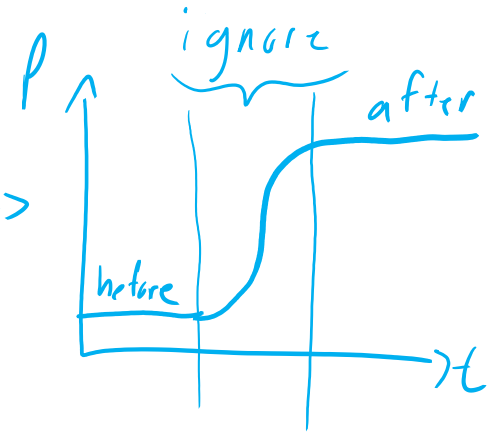
Momentum $\vec{p} = m\vec{v}$



Impulse $J_x = \int_{t_i}^{t_f} F_x(t)\, dt$ = area under force curve

Impulse and momentum are related by the **momentum principle**





$\Delta p_x = J_x$

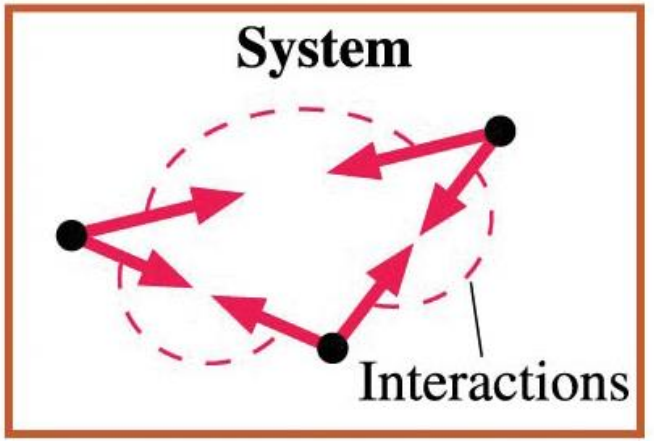
$\frac{d\vec{p}}{dt} = \frac{d}{dt}\int \vec{F}(t)\, dt = \vec{F}$

The impulse delivered to an object causes the object's momentum to change. This is an alternative statement of Newton's second law.

Is momentum conserved?

$\rightarrow \sum \vec{F}_{ext} = 0$

The total momentum of an **isolated system** is conserved. The particles of an isolated system interact with each other but not with the environment. Regardless of how intense the interactions are, **the final momentum equals the initial momentum.**

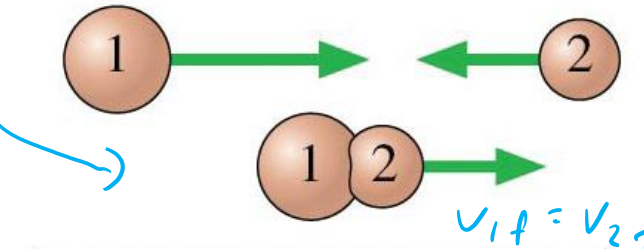


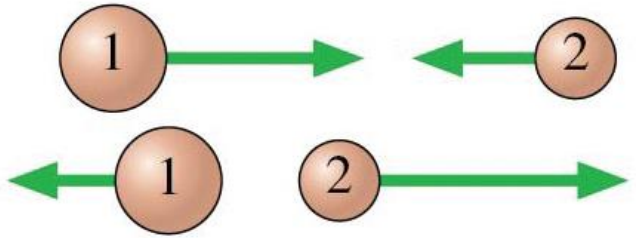
$\Delta \vec{p} = 0 \rightarrow \vec{p}_f = \vec{p}_i$

« **LOOKING BACK** Section 10.4 Energy conservation

In a **perfectly inelastic collision,** two objects stick together and move with a common final velocity. In a **perfectly elastic collision,** they bounce apart and conserve mechanical energy as well as momentum.

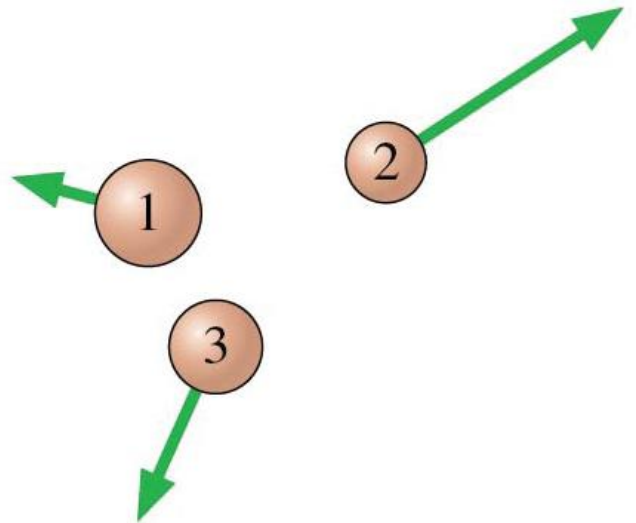
$v_{1f} = ?$ $v_{2f} = ?$





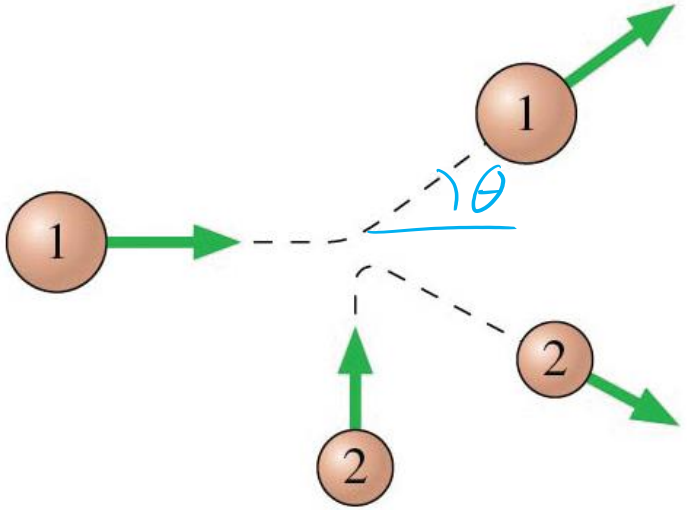
$\Delta K = 0$ $K_{1i} + K_{2i} = K_{1f} + K_{2f}$

In an **explosion,** two or more objects fly apart from each other. Their total momentum is conserved.



partially inelastic collisions

The same ideas apply in two dimensions. Both the x- and y-components of $\vec{P}$ must be conserved. This gives two simultaneous equations to solve.



Rockets

The momentum of the exhaust-gas + rocket system is conserved. **Thrust** is the product of the exhaust speed and the rate at which fuel is burned.

$$\vec{F}_{th} = \frac{d\vec{p}}{dt} = \frac{d}{dt}(m\vec{v}) = \frac{dm}{dt}\vec{v}_{ex} = m\vec{a}$$