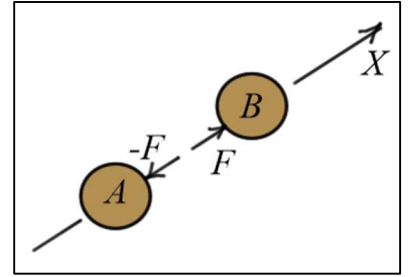**Elementary Dynamics**
Conservation of Linear Momentum for Particles

Under certain circumstances, the ***net impulse*** on a particle (or system of particles) is ***zero***, so the ***linear momentum*** of the particle (or system of particles) is ***conserved***. For example, consider the case of two particles in contact. The diagram shows the two particles separated with the contact force F acting along the X-axis.

Assuming no other forces act in this direction, we can write

$$m_A(v_{Ax})_1 + \int_{t_1}^{t_2} -F\,dt = m_A(v_{Ax})_2 \qquad \text{and} \qquad m_B(v_{Bx})_1 + \int_{t_1}^{t_2} F\,dt = m_B(v_{Bx})_2$$

Summing these two equations gives

$$\boxed{m_A(v_{Ax})_1 + m_B(v_{Bx})_1 = m_A(v_{Ax})_2 + m_B(v_{Bx})_2}$$

The linear momentum of the system is ***conserved*** in the X-direction. Note that if other forces act in the X-direction, but their impulses are ***small*** in comparison to $\int_{t_1}^{t_2} F\,dt$, they may be neglected.

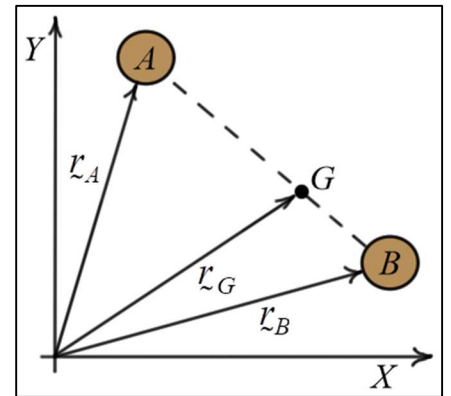This is often true when F is due to the ***impact*** of the two particles.

Motion of a System's Mass Center

Consider a system with two particles as shown. From the definition of mass center,

$$\boxed{(m_A + m_B)\underset{\sim}{r}_G = m_A\underset{\sim}{r}_A + m_B\underset{\sim}{r}_B}.$$

If linear momentum is conserved for the system, then by differentiating this equation with respect to time, we see that

$$\boxed{(m_A + m_B)\underset{\sim}{v}_G = m_A\underset{\sim}{v}_A + m_B\underset{\sim}{v}_B = \text{constant}}.$$

So, the system's ***mass center*** moves at a ***constant velocity***.