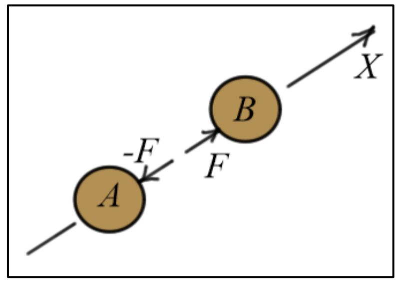
Elementary Dynamics
Conservation of Linear Momentum for Particles



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

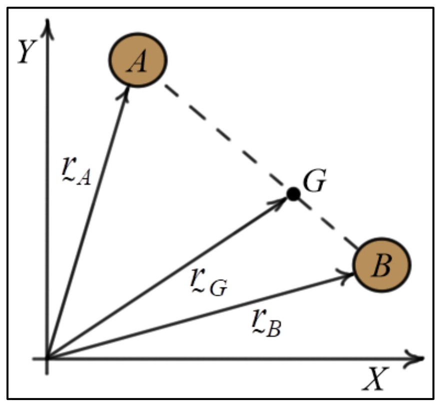
$$m_A\left(v_{Ax}\right)_1+\int_{t_1}^{t_2}-F\,dt=m_A\left(v_{Ax}\right)_2 \qquad \text{and} \qquad m_B\left(v_{Bx}\right)_1+\int_{t_1}^{t_2}F\,dt=m_B\left(v_{Bx}\right)_2$$

Summing these two equations gives

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

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,

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

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

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

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