Center of Mass, Momentum, and Impulse

The POSITION of the CENTER OF MASS ($\underline{\mathbf{r}}_{CM}$) of a system of N particles (AKA the position of the system), is

$$\underline{\mathbf{r}}_{CM} \equiv \frac{\sum_i m_i \underline{\mathbf{r}}_i}{M_{sys}} \qquad \text{with } \sum_i \equiv \sum_{i=1}^{N} \qquad \text{and } M_{sys} = \sum_i m_i$$

where particle i has mass m_i and position $\underline{\mathbf{r}}_i$.

The MOMENTUM ($\underline{\mathbf{p}}$) of a particle of mass m moving with velocity $\underline{\mathbf{v}}$ is defined by $\underline{\mathbf{p}} \equiv m\underline{\mathbf{v}}$.

The IMPULSE ($\underline{\mathbf{I}}$) acting on any system of particles is defined by $\underline{\mathbf{I}} \; \equiv \; \Sigma\underline{\mathbf{F}}_{\text{ext}}\Delta t$, where $\Sigma\underline{\mathbf{F}}_{\text{ext}}$ is the sum of all external forces acting on the system of particles and Δt is the time interval over which that net force acts; the net force is assumed to be constant over the interval Δt.

The IMPULSE acting on any system of particles always has the same magnitude and direction as the system's total CHANGE IN MOMENTUM. This result is derived from Newton's Second Law, and is known as the IMPULSE-MOMENTUM THEOREM.