Chapter 9

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- The center of mass of a system of n particles is defined to be the point whose coordinates are given by $x_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i, x_i, y_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i, y_i, z_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i, z_i$ or $\vec{r}_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i\vec{r}_i$ where M is the total mass of the system.
- Newton's second law for a system of particles is given by $\vec{F}_{net} = M\vec{a}_{com}$, wher $\vec{F_{net}}$
- Linear momentum is defined as $\vec{p} = m\vec{v}$. Newton's second law can be written in terms of this momentum: $\vec{F}_{net} = \frac{d\vec{p}}{dt}$.
- For a system of particles this becomes $\vec{P} = M\vec{v}_com$
- Applying Newton's second law in momentum form to a particle-like body involved in a collision leads to the impulse-linear momentum theorem: $\vec{p}_f - \vec{p}_i = \Delta\vec{p} = \vec{J}$.
- Impulse is defined as $\vec{J} = \int_{t_i}^{t_f} \vec{F}(t)dt$, and has units of $kg\dot{m}/s$
- If a system is isolated so that no net external force acts on it, the linear momentum $\vec{P}$, which can be written as $\vec{P}_i = \vec{P}_f$ of the system remains constant
- For an inelastic collision of two bodies, the kinetic energy of the two-body system is not conserved (is not a constant). If the system is closed and isolated, the total linear momentum of the system must be conserved, which means that $\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$.
- The center of mass of a closed, isolated system of two colliding bodies is not affected by a collision.
- Elastic collisions in one dimension (for a target body 2 and a incoming body 1) are bound by the equation $v_{1f} = \frac{m_1 - m_2}{m1 + m_2} v_{1i}$ and $v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$
- If two bodies collide and the motion is not along a single axis (collision isn't head-on), the collision is two-dimensional. If the two-body system is closed and isolated, the law of conservation of momentum applies to the collision and cab be written as

  $$\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$$

  If the collision is elastic, the conservation of kinetic energy during the collision gives a third equation

  $$K_{1i} + K_{2i} = K_{1f} + K_{2f}$$