Energy

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In a Newton's cradle, if one ball hits, then one ball will be come out the other side. If two balls hits, two balls come out the other end. This effect is due to conservation of energy. If one ball hits and two balls come out the other end, the velocity would have to be halved to conserve the momentum, but that would mean that kinetic energy is lost.

In a collision, momentum is conserved throughout the entire collision. Kinetic energy in a elastic collision is constant before and after the collision but not during. This is because the kinetic energy is converted into elastic potential energy during the collision and is then released back into kinetic energy.

The state of a system is the condition of an object completely specified by a set of parameters such as shape and temperature. Transformations of a system from an initial state to a final state is called a process. A closed system is a system where no energy is transferred into or out of it. The chosen system should include all the objects undergoing these changes in state or motion.

Properties of Collisions

Inelastic collisions are irreversible processes: the changes that occur in the state of the colliding objects cannot spontaneously undo themselves. In inelastic collisions, the relative speed changes and therefore the total kinetic energy of the system changes. In inelastic collisions, the kinetic energy is transformed into internal energy. The sum of the kinetic energy and internal energy remains constant.

Elastic collisions are reversible processes: there are no permanent changes in the state of the colliding object. In elastic collisions the magnitude of the relative velocity remains the same before and after the collision. If a small object hits a much more massive object, the small object will bounce back. If a massive object hits a small object, the massive object will continue at approximately the same velocity.

In explosive separations, there is some stored internal energy that gets converted into kinetic energy. In explosive separations, momentum and total energy is conserved, but kinetic energy is increased. The internal energy could be elastic potential, chemical, etc.

Coefficient of Restitution

The coefficient of restitution is the ratio between the final relative velocity and the initial relative velocity.

$$e = \left| \frac{v_{2f} - v_{1f}}{v_{2i} - v_{1i}} \right|$$

$$e = -\frac{v_{2f} - v_{1f}}{v_{1i} - v_{2i}}$$

For a perfectly inelastic collision, the final velocity is zero, thus the coefficient of restitution is zero. When the collision is inelastic, the coefficient of restitution is between zero and one. In a perfectly elastic collision, the coefficient of restitution is one. In explosive separation, the coefficient of restitution is greater than one.