Elastic and Inelastic Collisions

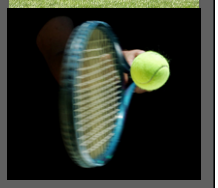
Perfectly Inelastic Collision a collision in which two objects stick together after colliding

Elastic Collision a collision in which the total momentum and the total kinetic energy are conserved

MCHS Honors Physics 2014-15

Collisions

- Day-to-day activities include collisions.
- In some collisions, two objects collide and stick together so that they travel together after the impact.
- In other collisions, two objects collide and bounce so that they move away with two different velocities.



Collisions

- Total *momentum* remains constant in any type of collision.
- Total *kinetic* energy is generally not conserved in a collision because some kinetic energy is converted to internal energy when the objects *deform*.
- We can examine different types of collisions and determine whether kinetic energy is conserved in each type.
- We will focus on the two extreme types of collisions: elastic and perfectly inelastic collisions.

Perfectly Inelastic Collisions

- Perfectly inelastic collisions can be analyzed in terms of momentum.
- When two objects, such as the two football players, collide and move together as one mass, the collision is called a perfectly inelastic collision.
- Likewise, if a meteorite collides head on with Earth, it becomes buried in Earth and the collision is perfectly inelastic.

Perfectly Inelastic Collisions

- Perfectly inelastic collisions are easy to analyze in terms of momentum because the objects become essentially one object after the collision.
- The final mass is equal to the combined masses of the colliding objects.
- The combination moves with a predictable velocity after the collision.

PERFECTLY INELASTIC COLLISION

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = (m_1 + m_2)\,\mathbf{v_f}$$

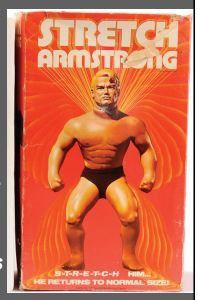
- Watch your signs! They indicate velocity direction.

Kinetic Energy Isn't Always Conserved

- In an inelastic collision, the total kinetic energy does not remain constant when the objects collide and stick together.
- Some of the kinetic energy is converted to sound energy and internal energy (heat) as the objects deform during the collision.
- In other words, some of the work done on an *inelastic* material is converted to other forms of energy (such as heat and sound).

Kinetic Energy Isn't Always Conserved

- This phenomenon helps make sense of the special use of the words "*elastic*" and "*inelastic*" in physics.
- *Elastic* refers to something that always returns to its original shape.
- In physics, an elastic material is one in which the *work done to deform* the material during a collision is equal to the work *the material does* to return to its original shape.



Kinetic Energy Isn't Always Conserved

- The decrease in the total kinetic energy during an inelastic collision can be calculated by using the formula for kinetic energy.

$$\Delta KE = KE_f - KE_i$$

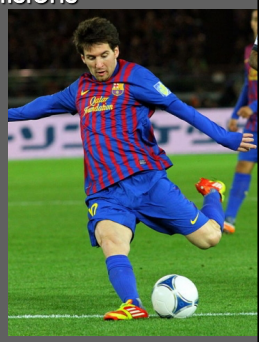
$$KE_i = KE_{1,i} + KE_{2,i} = \tfrac{1}{2}m_1 v_{1,i}^2 + \tfrac{1}{2}m_2 v_{2,i}^2$$

$$KE_f = KE_{1,f} + KE_{2,f} = \tfrac{1}{2}(m_1 + m_2)v_f^2$$

- It is important to remember that not all of the initial kinetic energy is necessarily lost in a perfectly inelastic collision.

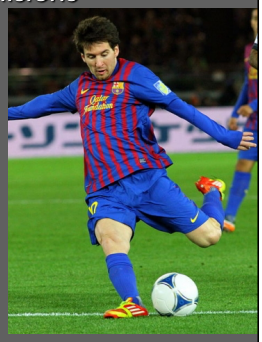
Elastic Collisions

- When a player kicks a soccer ball, the collision between the ball and the player's foot is much closer to elastic than the collisions we have studied so far.
- In this case, *elastic* means that the ball and the player's foot remain separate after the collision.



Elastic Collisions

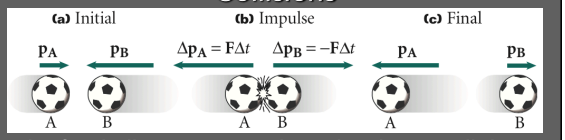
- In an elastic collision, two objects collide and return to their original shapes with no loss of total kinetic energy.
- After the collision, the two objects move separately.
- In an elastic collision, both the total momentum and the total kinetic energy are conserved.



Most Collisions…

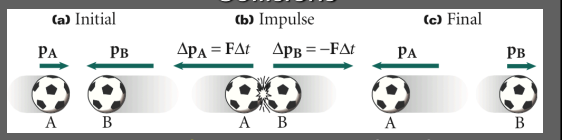
- Most collisions are neither elastic nor perfectly inelastic.
- Colliding objects do not usually stick together and continue to move as one object.
- Most collisions are not elastic, either. Even *nearly* elastic collisions, such as those between billiard balls or between a football player's foot and the ball, result in some decrease in kinetic energy.
- In fact, any collision that produces sound is not elastic; the sound signifies a decrease in kinetic energy.

Kinetic Energy Is Conserved In Elastic Collisions



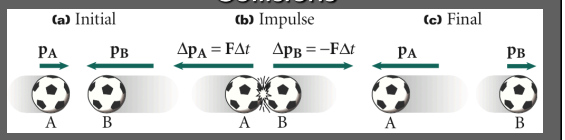
- The first ball is moving to the right when it collides with the second ball, which is moving to the left. When considered as a whole, the entire system has momentum to the left.
- After the elastic collision, the first ball moves to the left and the second ball moves to the right.

Kinetic Energy Is Conserved In Elastic Collisions



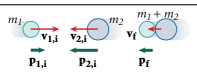
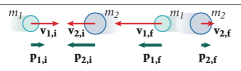
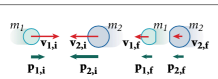
- The magnitude of the momentum of the first ball, which is now moving to the left, is greater than the magnitude of the momentum of the second ball, which is now moving to the right.
- The entire system still has momentum to the left, just as before the collision.

Kinetic Energy Is Conserved In Elastic Collisions



- The total momentum is always constant throughout the collision.
- In addition, if the collision is perfectly elastic, the value of the total kinetic energy after the collision is equal to the value before the collision.

Types of Collisions

Type of collision	Diagram	What happens	Conserved quantity
perfectly inelastic		The two objects stick together after the collision so that their final velocities are the same.	momentum
elastic		The two objects bounce after the collision so that they move separately.	momentum kinetic energy
inelastic		The two objects deform during the collision so that the total kinetic energy decreases, but the objects move separately after the collision.	momentum