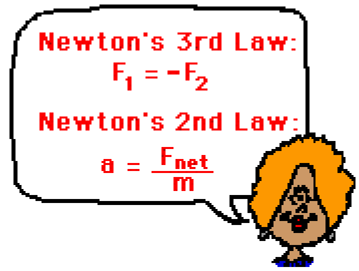
The Law of Momentum Conservation

The Law of Action-Reaction (Revisited)

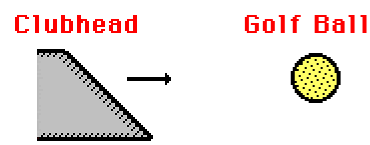
A collision is an interaction between two objects that have made contact (usually) with each other. As in any interaction, a collision results in a force being applied to the two colliding objects. Newton's laws of motion govern such collisions. In the second unit of The Physics Classroom, Newton's third law of motion was introduced and discussed. It was said that...

... in every interaction, there is a pair of forces acting on the two interacting objects. The size of the force on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Newton's third law of motion is naturally applied to collisions between two objects. In a collision between two objects, both objects experience forces that are equal in magnitude and opposite in direction. Such forces often cause one object to speed up (gain momentum) and the other object to slow down (lose momentum). According to Newton's third law, the forces on the two objects are equal in magnitude. While the forces are equal in magnitude and opposite in direction, the accelerations of the objects are not necessarily equal in magnitude. In accord with Newton's second law of motion, the acceleration of an object is dependent upon both force and mass. Thus, if the colliding objects have unequal mass, they will have unequal accelerations as a result of the contact force that results during the collision.



Consider the collision between the club head and the golf ball in the sport of golf. When the club head of a moving golf club collides with a golf ball at rest upon a tee, the force experienced by the club head is equal to the force experienced by the golf ball. Most observers of this collision have difficulty with this concept because they perceive the high speed given to the ball as the result of the collision. They are not observing unequal forces upon the ball and club head, but rather unequal accelerations. Both club head and ball experience equal forces, yet the ball experiences a greater acceleration due to its smaller mass. In a collision, there is a force on both objects that causes an acceleration of both objects. The forces are equal in magnitude and opposite in direction, yet the least massive object receives the greatest acceleration.



The rightward-moving clubhead experiences a leftward force. The golf ball experiences a rightward force. The forces have equal magnitude and opposite direction.

Consider the collision between a moving seven ball and an eight ball that is at rest in the sport of table pool. When the seven ball collides with the eight ball, each ball experiences an equal force directed in opposite directions. The rightward moving seven ball experiences a leftward force that causes it to slow down; the eight ball experiences a rightward force that causes it to speed up. Since the two balls have equal masses, they will also experience equal accelerations. In a collision, there is a force on both objects that causes an acceleration of both objects; the forces are equal in magnitude and opposite in direction. For collisions between equal-mass objects, each object experiences the same acceleration.

The rightward moving 7-ball experiences a leftward force. the 8-ball experiences a right-ward force. The forces have equal magnitude and opposite directions.

Consider the interaction between a male and female figure skater in pair figure skating. A woman (m = 45 kg) is kneeling on the shoulders of a man (m = 70 kg); the pair is moving along the ice at 1.5 m/s. The man gracefully tosses the woman forward through the air and onto the ice. The woman receives the forward force and the man receives a backward force. The force on the man is equal in magnitude and opposite in direction to the force on the woman. Yet the acceleration of the woman is greater than the acceleration of the man due to the smaller mass of the woman.

Many observers of this interaction have difficulty believing that the man experienced a backward force. "After all," they might argue, "the man did not move backward." Such observers are presuming that forces cause motion. In their minds, a backward force on the male skater would cause a backward motion. This is a common misconception that has been addressed elsewhere in The Physics Classroom. Forces cause acceleration, not motion. The male figure skater experiences a backwards force that causes his backwards acceleration. The male skater slows down while the woman skater speeds up. In every interaction (with no exception), there are forces acting upon the two interacting objects that are equal in magnitude and opposite in direction.

Collisions are governed by Newton's laws. The law of action-reaction (Newton's third law) explains the nature of the forces between the two interacting objects. According to the law, the force exerted by object 1 upon object 2 is equal in magnitude and opposite in direction to the force exerted by object 2 upon object 1.

http://www.physicsclassroom.com