SECTION 1 (PP. 345-351): FORCES CHANGE MOTION.

Georgia Standards: S8P3b – *Demonstrate the effect of balanced and unbalanced forces on an object in terms of gravity, inertia, and friction*; S8CS6a – *Write clear, step-by-step instructions for conducting scientific investigations, operating a piece of equipment, or following a procedure.*

1. **A force is a push or pull.**

   Force in physics is defined as "a push or pull." Some forces:
   - Require contact between objects, such as friction; and
   - Act at a distance, such as gravity and electromagnetic forces.

1 Contact Force When one object pushes or pulls another object by touching it, the first object is applying a contact force to the second. The skater applies a contact force as she pushes against the ground. The ground applies a contact force that pushes the skater forward.

2 Gravity Gravity is the force of attraction between two masses. Earth's gravity is pulling on the skater, holding her to the ground. The strength of the gravitational force between two objects depends on their masses. For example, the pull between you and Earth is much greater than the pull between you and a book.

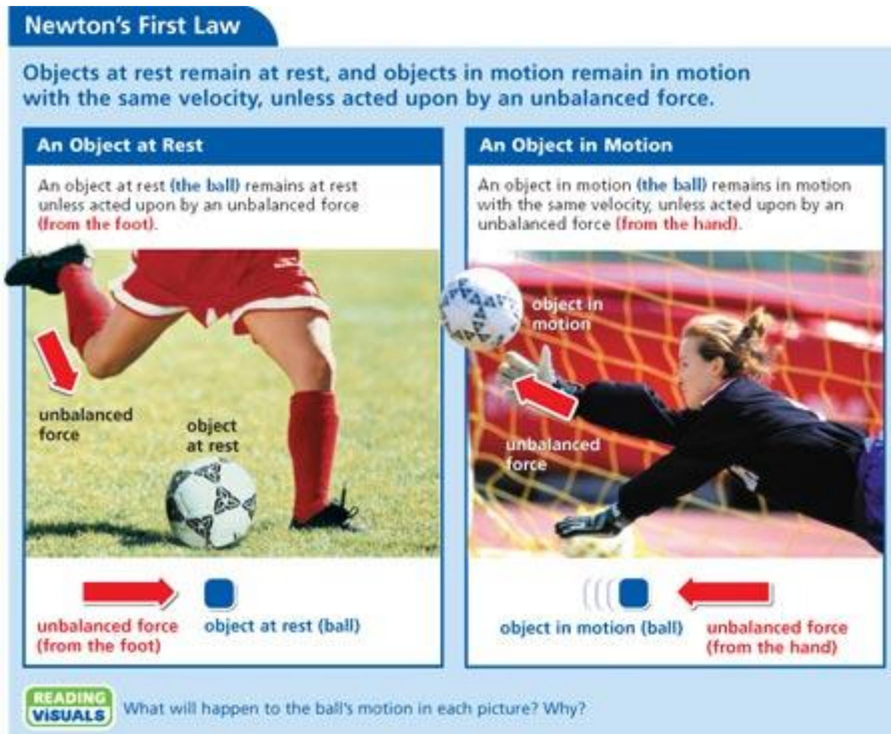
3 Friction Friction is a force that resists motion between two surfaces that are pressed together. Friction between the surface of the ground and the wheels of the skates exerts a force that resists the skater's forward motion.

Net force is the total force that affects an object when multiple forces are combined. The net force depends on both direction and the size of the individual forces.

READING VISUALS COMPARE Compare the net force on the balls in these two photographs. Which photograph shows a net force of zero?

2. **Newton's First Law of Motion relates to force and motion (Law of Inertia).**
   ***An object at rest will remain at rest unless acted upon by an outside force. An object in motion will remain in motion unless acted upon by an outside force*.**
   The key points of Newton's First Law of Motion are:
   - Objects with no net force acting on them have either constant or zero velocity; and
   - Force is needed to start or change motion

   Inertia is the resistance of an object to any change in its motion. It is directly proportional to the object's mass.

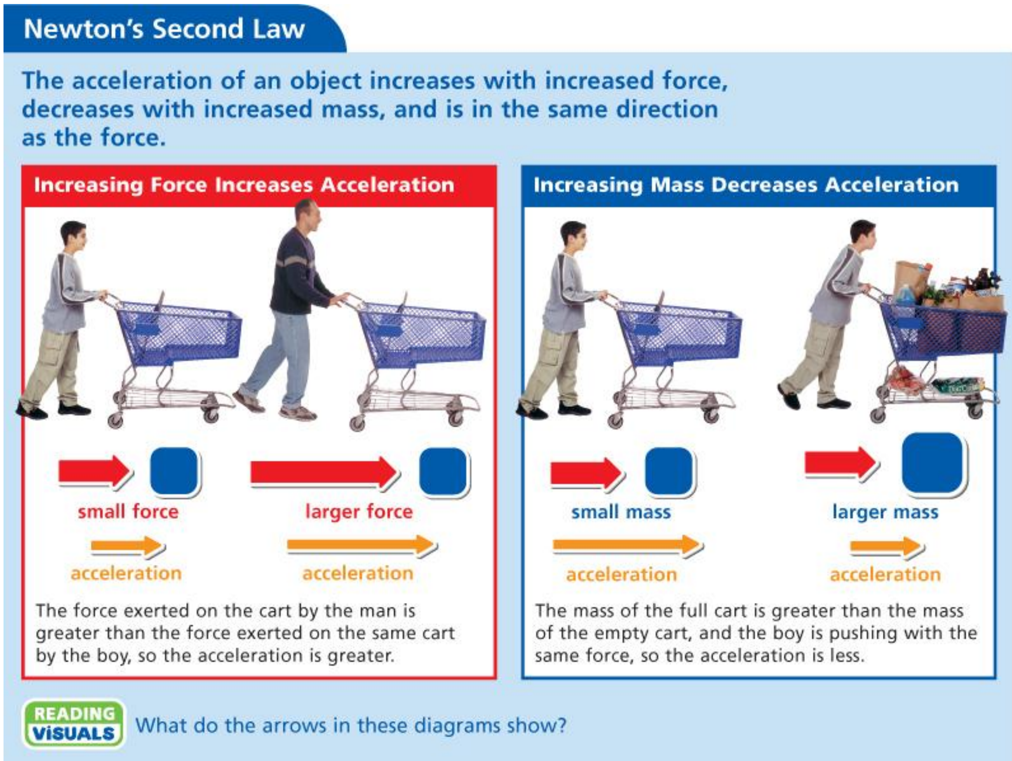


SECTION 2 (PP. 353-359): FORCE AND MASS DETERMINE ACCELERATION.

Georgia Standards: S8P3b – *Demonstrate the effect of balanced and unbalanced forces on an object in terms of gravity, inertia, and friction*; S8CS3f – *Use ratios and proportions, including constant rates, in appropriate problems.*

1. **Newton's Second Law of Motion relates to force, mass, and acceleration.**
   The acceleration of an object increases with increased force and decreases with increased mass, and is in the same direction as the force.
   The key points of Newton's second law are that the acceleration of an object is:
   - Directly proportional to the force acting upon the object;
   - Inversely proportional to the mass of the object; and
   - In the same direction as the net force acting upon the object.

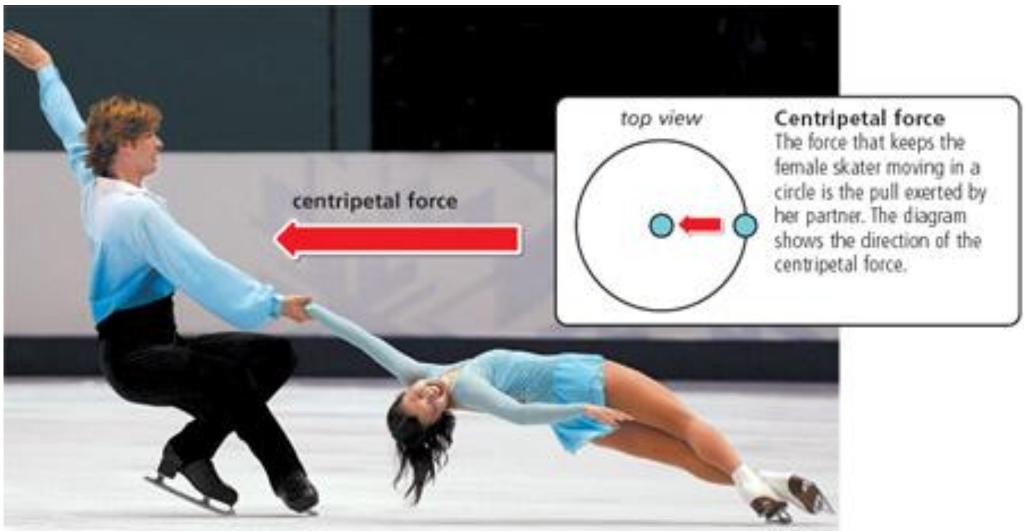
   Newton's second law is summed up by the equation; **Force = mass • acceleration (F = ma)**.



What force is needed to accelerate a 10 kg shopping cart 3 m/s²?

What do you know?	mass = 10 kg, acceleration = 3 m/s^2
What do you want to find out?	Force
Write the formula:	$F = ma$
Substitute into the formula:	$F = 10\ kg \cdot 3\ m/s^2$
Calculate and simplify:	$F = 10\ kg \cdot \frac{3m}{s^2} = 30\ kg \cdot m/s^2$
Check that your units agree:	Unit is $kg \cdot m/s^2$. Unit of force is newton, which is also $kg \cdot m/s^2$. Units agree.
Answer:	$F = 30$ N

2. Forces can change the direction of motion.
Force can change the direction of an object, without changing its speed, if the force acts at right angles to the motion. A force that continually acts at right angles to the object's motion will pull the object into circular motion. Any force that keeps an object moving in a circle at a constant speed is called a centripetal force. The centripetal force needed to keep an object moving in a circle depends on the mass of the object, the speed of the object, and the radius of the circle.



SECTION 3 (PP. 361-365): FORCES ACT IN PAIRS.

Georgia Standards: S8P3b - *Demonstrate the effect of balanced and unbalanced forces on an object in terms of gravity, inertia, and friction*; S8CS4b – *Use appropriate tools and units for measuring objects and/or substances.*

1. **Newton's Third Law of Motion relates action to reaction forces.**
   For every action, there is an equal and opposite reaction.
   The key points of Newton's third law are that when objects A and B interact:
   - The force of A on B equals the force of B on A; and
   - The forces are opposite in direction.

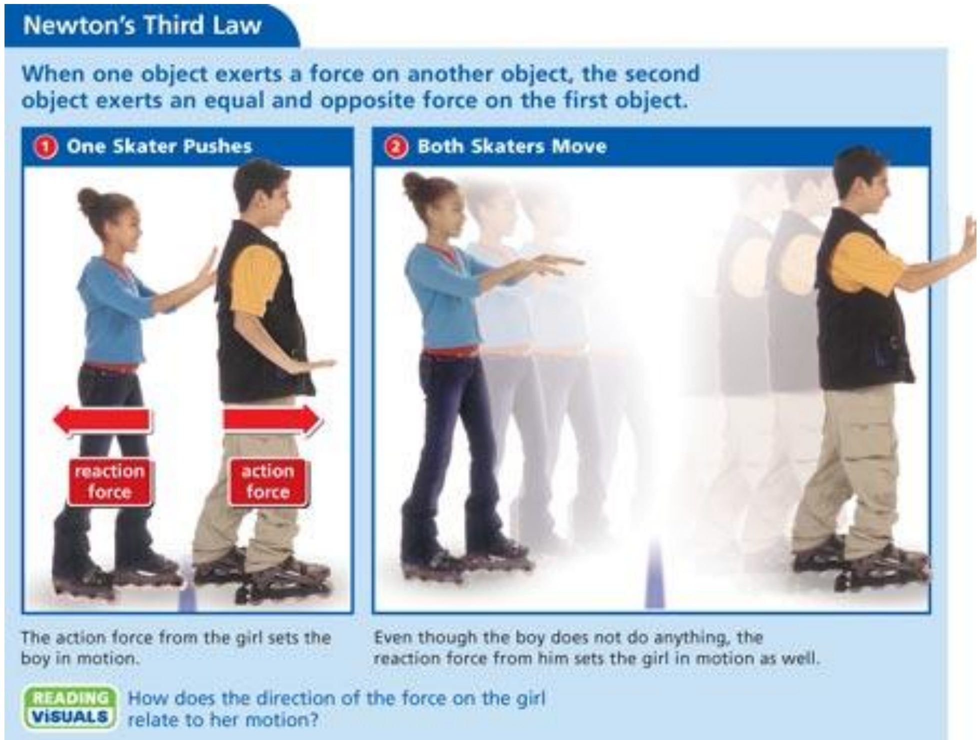
THINK ABOUT

How do jellyfish move?

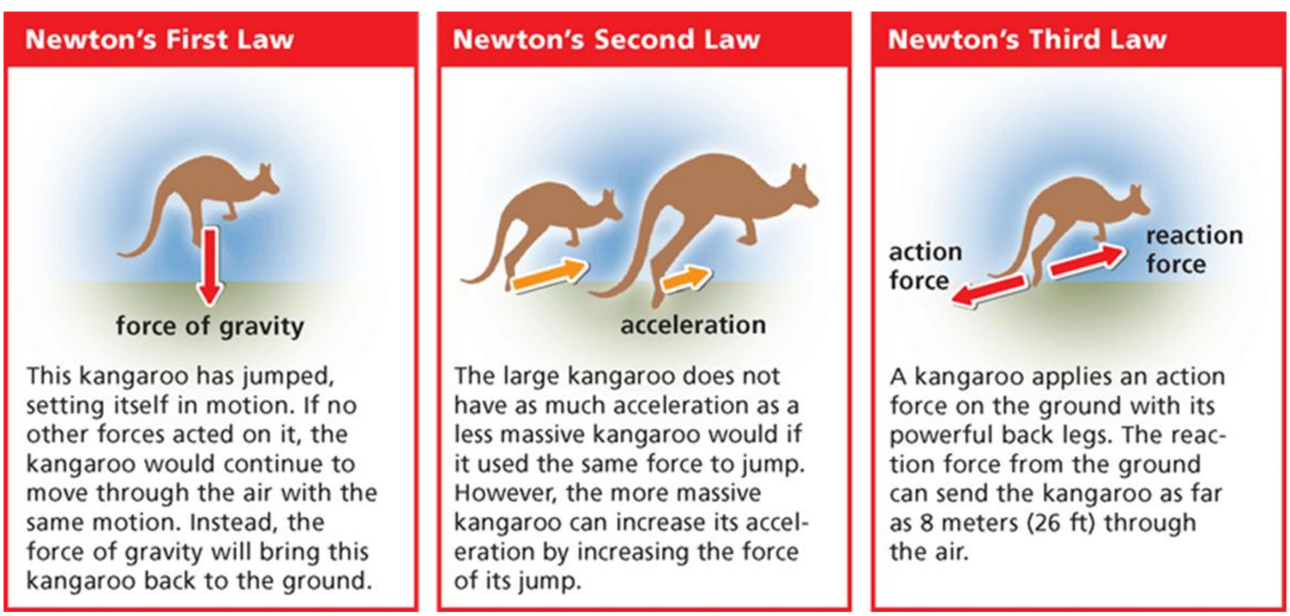
Jellyfish do not have much control over their movements. They drift with the current in the ocean. However, jellyfish do have some control over their up-and-down motion. By squeezing water out of its umbrella-like body, the jellyfish shown here applies a force in one direction to move in the opposite direction. If the water is forced downward, the jellyfish moves upward. How can a person or an object move in one direction by exerting a force in the opposite direction?

In ***action/reaction pairs*** either force can be considered the action force or the reaction force. The two forces simultaneously. ***Example:*** When you push down on a table, the force from the table's resistance increases instantly to match your force.

Action/reaction force pairs occur when any two objects interact, not just through contact forces. ***Example:*** The pull of Earth on a falling baseball is exactly that of the baseball on Earth. Earth is so much more massive however, that Earth's acceleration from the pull of the ball is nearly nothing. The acceleration of the baseball is quite noticeable.



2. **Newton's three laws describe and predict motion.**
   Newton's laws work together to explain changes in the motion of objects, such as a jellyfish moving forward when squirting water backward; or a bird flying higher or changing directions. Newton's laws are also useful in calculating how objects move under the conditions found in everyday life. Scientists such as Albert Einstein have added to our understanding of motion since Newton's time. Under certain conditions, such as extreme speed or extreme gravity, Newton's laws need to be adjusted.



SECTION 4 (PP. 368-373): FORCES ACT TRANSFER MOMENTUM.

Georgia Standards: S8P3b - *Demonstrate the effect of balanced and unbalanced forces on an object in terms of gravity, inertia, and friction*; S8CS5a – *Observe and explain how parts can be related to other parts in a system such as the role of a simple machine in a complex machine.*

1. **Objects in motion have momentum.**
   Momentum can be thought of as inertia for moving objects. It is the tendency of a moving object to keep moving at a constant velocity, and depends on the mass and velocity of the object. The momentum of an object is the product of its mass and velocity.

   Momentum = mass • velocity
   (p = mv)

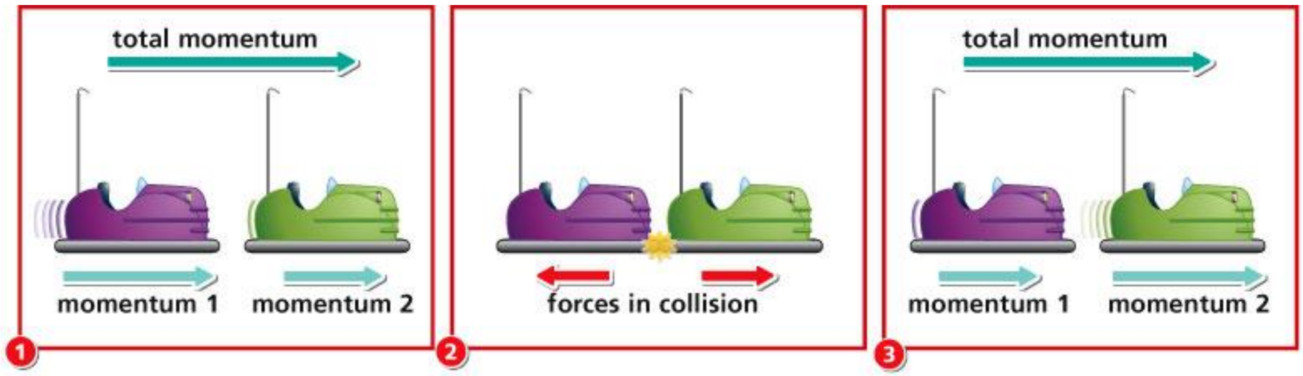
   - Momentum, like velocity, is a vector, so it has both size and direction.
   - Adding the momentum of two objects is similar to adding net forces.

   A force on an object changes the object's momentum. The change in momentum is equal to the force on the object multiplied by the time over which the force is acting.

   What is the momentum of a 1.5 kg ball moving at 2 m/s?

What do you know?	mass = 1.5 kg, velocity = 2 m/s
What do you want to find out?	momentum
Write the formula:	$p = mv$
Substitute into the formula:	p = 1.5 kg • 2 m/s
Calculate and simplify:	p = 3 kg • m/s
Check that your units agree:	Unit is kg • m/s. Unit of momentum is kg • m/s. Units agree.
Answer:	p = 3 kg • m/s

2. **Momentum can be transferred from one object to another.**
   Momentum is transferred during a collision. Colliding objects exert equal and opposite forces on each other while they are in contact. The forces in the collision will change the velocity of each object involved.



Before the collision The momentum of the first car is greater than the momentum of the second car. Their combined momentum is the total momentum of the system.

During the collision The forces on the two cars are equal and opposite, as described by Newton's third law. Momentum is transferred from one car to the other during the collision.

After the collision The momentum lost by one car was gained by the other car. The total momentum of the system remains the same as it was before the collision.

3. **Momentum is conserved.**
   In any case where no outside forces are acting on a system, the total momentum of the system will not change, even if the momentum of the individual parts of the system changes. This conservation of momentum is most easily seen in collisions. The forces acting are equal and opposite, and they act over the same time period. Therefore, the change in momentum for two colliding objects is equal and opposite, and the total change in momentum is zero.