

**Lesson Outline****LESSON 1****Gravity and Friction****A. Types of Forces**

1. A push or a pull is called a(n) \_\_\_\_\_.
2. A(n) \_\_\_\_\_ is a push or a pull on an object by another object that is touching it.
3. A force that one object can apply to another object without touching it is a(n) \_\_\_\_\_.
4. Gravity, \_\_\_\_\_, and electric forces are examples of noncontact forces.
5. Forces have \_\_\_\_\_ and \_\_\_\_\_.
6. An arrow can be used to show a force; the \_\_\_\_\_ shows the strength of the force, and the direction of the arrow shows the \_\_\_\_\_ of the force.
7. Forces are measured in units called \_\_\_\_\_.

**B. What is gravity?**

1. \_\_\_\_\_ is the amount of matter in an object.
2. \_\_\_\_\_ is an attractive force that exists between all objects that have mass.
3. Mass is often measured in \_\_\_\_\_.
4. According to the law of \_\_\_\_\_, all objects are attracted to one another with a gravitational force that is proportional to the mass of the objects and the distance between them.
  - a. When the mass of one or both objects increases, the gravitational force between the objects \_\_\_\_\_.
  - b. When the distance between two objects increases, the attraction between the objects \_\_\_\_\_.
5. \_\_\_\_\_ is the gravitational force exerted on an object.
  - a. Near Earth's surface, an object's weight is the gravitational force exerted on the object by \_\_\_\_\_.
  - b. The \_\_\_\_\_ of an object on Earth decreases significantly only when the object moves a great distance away from Earth.

## Lesson Outline continued

### C. Friction

1. \_\_\_\_\_ is a force that resists the motion of two surfaces that are touching.
2. \_\_\_\_\_ friction prevents surfaces from sliding past each other.
3. Up to a limit, the \_\_\_\_\_ of static friction changes to match the applied force.
4. \_\_\_\_\_ friction opposes the motion of surfaces sliding past each other.
  - a. When an object is sliding, the force of sliding friction does not \_\_\_\_\_; for this reason, increasing the applied force makes a sliding object move \_\_\_\_\_.
  - b. If you stop pushing a sliding object, the object will eventually \_\_\_\_\_ due to sliding friction.
5. \_\_\_\_\_ is friction between a surface and a fluid, such as air or water.
  - a. Fluid friction between an object and air is called \_\_\_\_\_.
  - b. Decreasing an object's surface area by changing its shape \_\_\_\_\_ the object's air resistance.
6. One reason for friction between surfaces is the \_\_\_\_\_, or the dips and bumps on one surface that catch on those of the other surface.
7. One reason for friction between surfaces is that atoms and molecules with \_\_\_\_\_ charges attract each other.
8. \_\_\_\_\_ decrease friction by causing a slight separation between solid surfaces, so they don't contact each other.

**Lesson Outline****LESSON 2****Newton's First Law****A. Identifying Forces**

1. To understand the motion of an object, you need to understand the \_\_\_\_\_ acting on it.
2. When two or more forces act on an object, the forces \_\_\_\_\_.
  - a. The combination of all the forces that act on an object is the \_\_\_\_\_.
  - b. When the forces applied to an object act in the same direction, the net force is the \_\_\_\_\_ of the individual forces.
  - c. Because forces have direction as well as strength, when you combine forces, you also have to specify a(n) \_\_\_\_\_.
  - d. When you combine forces in two opposite directions, one force is \_\_\_\_\_ and the other force is \_\_\_\_\_.
  - e. When the forces applied to an object act in exact opposite directions, the net force is the \_\_\_\_\_ of the individual positive and negative forces.
3. Forces that combine and form a net force of zero are \_\_\_\_\_.
  - a. Balanced forces have no effect on the \_\_\_\_\_ of an object.
  - b. Forces that combine and form a net force that is not zero are \_\_\_\_\_.

**B. Newton's First Law of Motion**

1. According to \_\_\_\_\_, if the net force on an object is zero, the motion of the object does not change.
2. When \_\_\_\_\_ forces act on an object, the object's velocity does not change.
3. If unbalanced forces act on an object at rest, the object will start \_\_\_\_\_.
4. If unbalanced forces act on a moving object, the object will change its \_\_\_\_\_.

## Lesson Outline continued

5. The tendency of an object to resist a change in its motion is called \_\_\_\_\_.

C. Why do objects stop moving?

1. A book sitting on a table stays in place because of \_\_\_\_\_.
2. If you want to make the book move, you have to push the book hard enough to overcome the \_\_\_\_\_ between the book and the table.
3. On Earth, \_\_\_\_\_ can be reduced, but it never goes away completely.
4. On Earth, to keep an object in motion, a(n) \_\_\_\_\_ that balances friction must be applied continuously to it.

**Lesson Outline****LESSON 3****Newton's Second Law****A. How do forces change motion?**

1. Forces change an object's motion by changing its \_\_\_\_\_, its \_\_\_\_\_, or both.
2. Only \_\_\_\_\_ forces can change the velocity of an object.
3. You know unbalanced forces are acting on an object that is at rest when the object starts \_\_\_\_\_.
4. Unbalanced forces change the \_\_\_\_\_ of a moving object.
  - a. If a net force acts on a moving object in the direction that the object is moving, the object will \_\_\_\_\_.
  - b. If a net force acts on a moving object in the direction that is opposite to the direction that the object moves, the object \_\_\_\_\_.
  - c. Another way unbalanced forces can change the velocity of a moving object is to change the \_\_\_\_\_ of the object's motion.
5. The force of gravity acts on a ball that is thrown by changing the direction of the ball, pulling it \_\_\_\_\_.
6. Another name for change in velocity over time is \_\_\_\_\_.
7. Unbalanced forces can make an object accelerate by changing the object's \_\_\_\_\_, \_\_\_\_\_, or both.

**B. Newton's Second Law of Motion**

1. According to \_\_\_\_\_, the acceleration of an object is equal to the net force acting on the object divided by the object's mass.
2. The direction of acceleration is the same as the direction of the \_\_\_\_\_.
3. The units for Newton's second law are SI units—force is measured in \_\_\_\_\_; mass is measured in \_\_\_\_\_; acceleration is measured in \_\_\_\_\_.
4. One newton is the same as one \_\_\_\_\_.

## Lesson Outline continued

### C. Circular Motion

1. \_\_\_\_\_ is any motion in which an object is moving in a curved path.
2. \_\_\_\_\_ causes objects to tend to move along a straight path.
3. In circular motion, a force that acts perpendicular to the direction of motion toward the center of the circle is called a(n) \_\_\_\_\_.
4. An object that is moving in a curve accelerates in the \_\_\_\_\_ of the centripetal force.
5. Any object that circles a larger object is called a(n) \_\_\_\_\_.
  - a. Satellites move in a circle because a(n) \_\_\_\_\_ acts on them.
  - b. \_\_\_\_\_ is the centripetal force that acts on satellites by continuously changing their direction of motion; this results in \_\_\_\_\_ motion.
6. Earth's \_\_\_\_\_ keeps the Moon in orbit around Earth.
7. The planets remain in orbit because the \_\_\_\_\_ gravity pulls on them.

**Lesson Outline****LESSON 4****Newton's Third Law****A. Opposite Forces**

1. When an object applies a force on another object, the second object applies a force of the same \_\_\_\_\_ on the first object.
2. When an object exerts a force on another object, the second object exerts a force on the first object in the \_\_\_\_\_ direction.

**B. Newton's Third Law of Motion**

1. According to \_\_\_\_\_, when one object applies a force on a second object, the second object applies an equal force in the opposite direction on the first object.
2. Any time a person \_\_\_\_\_ against a stationary object, the object exerts an equal and opposite force on the person.
3. A(n) \_\_\_\_\_ is the forces that two objects apply to each other.
  - a. The forces in a force pair are equal in strength and act in \_\_\_\_\_ directions. They do not cancel each other out because each acts on a different \_\_\_\_\_.
  - b. For every action force, there is a reaction force that is equal in \_\_\_\_\_ but opposite in \_\_\_\_\_ of the action force.

**C. Using Newton's Third Law of Motion**

1. When you push against an object, the force you apply is called the \_\_\_\_\_ force.
2. Newton's third law establishes that the object you push on applies an equal and opposite \_\_\_\_\_ force against you.
3. According to Newton's second law of motion, when the reaction force results in an unbalanced force, there is a(n) \_\_\_\_\_ force, and the object accelerates.

**D. Momentum**

1. \_\_\_\_\_ is a measure of how hard it is to stop a moving object.
2. Momentum is the product of an object's \_\_\_\_\_ and its \_\_\_\_\_.

## Lesson Outline continued

3. According to Newton's second law of motion, the force on an object is equal to the mass of the object multiplied by the acceleration, or the \_\_\_\_\_ in the object's velocity.
4. Because momentum is the product of mass and velocity, the force on an object equals its change in \_\_\_\_\_.

### E. Conservation of Momentum

1. In any collision, one object transfers \_\_\_\_\_ to another object.
2. According to the \_\_\_\_\_, the total momentum of a group of objects remains the same unless outside forces act on the objects.
3. One outside force is \_\_\_\_\_, which decreases the velocities of billiard balls and most other moving objects, and they lose momentum.
4. In a(n) \_\_\_\_\_ collision, the colliding objects bounce off each other.
5. In a(n) \_\_\_\_\_ collision, the colliding objects stick together.
6. In elastic and inelastic collisions, the total \_\_\_\_\_ of all the objects is always the same before and after any collision.