

Assess Your Understanding

The Nature of Force

How Are Forces Described?

got it?

I get it! Now I know that forces are described by _____

I need extra help with _____

How Do Forces Affect Motion?

1a. **CALCULATE** You push on a desk with a force of 120 N to the right. Your friend pushes on the same desk with a force of 90 N to the left. What is the net force on the desk?

b. **PREDICT** Your friend increases her force on the desk by 30 N. She doesn't change the direction of her push. What happens to the net force on the desk? Will the desk accelerate?

got it?

I get it! Now I know that changes in motion are caused by _____

I need extra help with _____

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Key Concept Summaries

The Nature of Force

How Are Forces Described?

A **force** is a push or a pull. When one object pushes or pulls another object, the first object exerts a force on the second object. You exert a force on a chair when you pull it away from a table.

which it acts. Pushing to the left is a different force from pushing to the right. The direction and strength of a force can be represented by an arrow. The arrow points in the direction of the force. The length of the arrow tells you the strength of the force—the longer the arrow, the stronger the force. The strength of a force is measured in an SI unit called the **newton (N)**.

Like velocity and acceleration, a force is described by its strength and by the direction in

How Do Forces Affect Motion?

Often more than one force acts on an object at the same time. The combination of all the forces acting on an object is called the **net force**. It determines if and how an object will accelerate. **A nonzero net force causes a change in the object's motion.**

0, the forces are balanced. Balanced forces do not change the motion of an object.

You can find the net force on an object by adding together the strengths of all the individual forces on the object. When the total is a nonzero number, the forces are said to be unbalanced. When the total is

When forces on an object act in opposite directions, you find the strength of the net force by subtracting the strength of the smaller force from the strength of the larger force. When forces act in opposite directions, the net force is in the same direction as the larger force.

You push on one side of an open door with a force of 120 N. Your friend pushes on the other side of the door with an equal force. On a separate sheet of paper, explain how these two forces affect the motion of the door.

Lesson Quiz

The Nature of Force

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

- _____ Balanced forces do not change the motion of an object.
- _____ Forces cause some changes in motion.
- _____ A net force causes no change in an object's motion.
- _____ If Manuel exerts a force of 10 N to push a desk to the right at the same time Lynn exerts a force of 15N to push the desk to the left, the desk will move to the left.

Fill in the blank to complete each statement.

- When you pull on a window shade, you exert a(n) _____.
- A(n) _____ can be used to represent the direction and strength of a force.
- The strength of a force is measured in _____.
- The net force determines how and if an object will _____.
- When two forces act in opposite directions, the object will accelerate in the same direction as the _____ force.
- A force is described by its _____ and by the direction in which it acts.

Assess Your Understanding

Friction and Gravity

What Factors Affect Friction?

1a. LIST Name four types of friction and give an example of each. _____

b. CLASSIFY What types of friction occur between your bike tires and the ground when you ride over cement, through a puddle, and when you apply your brakes? _____

got it?

I get it! Now I know that friction is affected by _____

I need extra help with _____

What Factors Affect Gravity?

2a. DESCRIBE What happens to the gravitational force between two objects when their masses are increased? What happens when the distance between the objects increases? _____

b. RELATE CAUSE AND EFFECT If the mass of Earth increased, what would happen to your weight? What about your mass? _____

got it?

I get it! Now I know that factors that affect the gravitational force between objects are _____

I need extra help with _____

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Key Concept Summaries

Friction and Gravity

What Factors Affect Friction?

The force that two surfaces exert on each other when they rub against each other is called **friction**. Friction acts in a direction opposite to the direction of the object's motion. **Two factors that affect the force of friction are the types of surfaces involved and how hard the surfaces are pushed together.**

There are four types of friction. **Sliding friction** occurs when two solid surfaces slide over each other. **Static friction** acts between objects that aren't moving. **Fluid friction** occurs when a solid object moves through a fluid. **Rolling friction** occurs when an object rolls across a surface.

What Factors Affect Gravity?

Gravity is a force that pulls objects toward each other. Gravity keeps the moon orbiting Earth. It keeps all the planets in our solar system orbiting the sun.

The law of universal gravitation states that the force of gravity acts between all objects in the universe that have mass. So, any two objects in the universe that have mass attract each other. For example, you and your pencil are attracted to each other. However, you do not notice the attraction between such small objects as you and your pencil because these forces are extremely small compared to the force of Earth's attraction. You observe only the effects of the strongest gravitational forces.

Two factors affect the gravitational attraction between objects: mass and distance. The more mass an object has, the greater its gravitational force. The shorter the distance is between one object and another, the stronger the gravitational force between the objects.

Mass and weight have different meanings. **Weight** is a measure of the force of gravity on an object. **Mass** is a measure of the amount of matter in an object. At any given time, your mass is the same on Earth as it would be on any other planet. But your weight would vary on each planet, since the strength of each planet's gravitational force is different.

On a separate sheet of paper, define friction and identify four types of friction.

Lesson Quiz

Friction and Gravity

Write the letter of the correct answer on the line at the left.

- | | |
|--|---|
| <p>1. ____ When you swim in a pool,</p> <p>A sliding friction occurs.</p> <p>B static friction occurs.</p> <p>C rolling friction occurs.</p> <p>D fluid friction occurs.</p> | <p>2. ____ When you rub your palms together,</p> <p>A sliding friction occurs.</p> <p>B static friction occurs.</p> <p>C rolling friction occurs.</p> <p>D fluid friction occurs.</p> |
| <p>3. ____ When you skateboard on a ramp,</p> <p>A sliding friction occurs.</p> <p>B static friction occurs.</p> <p>C rolling friction occurs.</p> <p>D fluid friction occurs.</p> | <p>4. ____ When you push a desk that doesn't move,</p> <p>A sliding friction occurs.</p> <p>B static friction occurs.</p> <p>C rolling friction occurs.</p> <p>D fluid friction occurs.</p> |

Fill in the blank to complete each statement.

5. The _____ states that the force of gravity acts between all objects in the universe that have mass.
6. As distance increases, gravitational force _____.
7. When you stand on a bathroom scale, it displays the _____ that Earth is exerting on you.
8. Friction acts in a direction _____ to the direction of the object's motion.
9. When the irregularities of one surface come into contact with those of another surface, _____ occurs.
10. The applied force required to push something across a surface _____ as friction increases.

1. Fold the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Assess Your Understanding

Newton's Laws of Motion

What Is Newton's First Law of Motion?

got it?

I get it! Now I know that Newton's first law of motion states that _____

I need extra help with _____

What Is Newton's Second Law of Motion?

1a. **REVIEW** What equation allows you to calculate the force acting on an object? _____

b. **CALCULATE** What is the net force on a 2-kg skateboard accelerating at a rate of 2 m/s^2 ? _____

c. **PREDICT** If the mass of the skateboard doubled but the net force on it remained constant, what would happen to the acceleration of the skateboard? _____

got it?

I get it! Now I know that Newton's second law of motion describes the relationship _____

I need extra help with _____


Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Assess Your Understanding

Newton's Laws of Motion

What Is Newton's Third Law of Motion?

2a. **IDENTIFY** A dog pulls on his leash with a 10-N force to the left. Identify the reaction force.

b. **ANSWER**  Using all three of Newton's laws, explain how objects react to forces.

got it?

I get it! Now I know that Newton's third law of motion states that _____

I need extra help with _____

Key Concept Summaries

Newton's Laws of Motion

What Is Newton's First Law of Motion?

<p>If an object is not moving, it will not start moving until a force acts on it. If an object is moving, it will continue at a constant velocity until a force acts to change its speed or direction. Newton's first law of motion states that an object at rest will remain at rest unless acted upon by a nonzero net force. An object moving at a constant velocity</p>	<p>will continue moving at a constant velocity unless acted upon by a nonzero net force.</p> <p>All objects resist changes in motion. Resistance to change in motion is called inertia. The greater the mass of an object, the greater its inertia, and the greater the force required to change its motion.</p>
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What Is Newton's Second Law of Motion?

<p>Newton's second law of motion states that an object's acceleration depends on its mass and on the net force acting on it. This relationship can be written as:</p>	<p>Acceleration is measured in meters per second per second (m/s²). Mass is measured in kilograms (kg). Newton's second law shows that force is measured in kilograms times meters per second per second (kg.m/s²). This unit is also called the newton (N), which is the SI unit of force.</p>
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$$\text{Acceleration} = \frac{\text{Net force}}{\text{Mass}}$$

The formula can be rearranged to show how much force must be applied to an object to get it to accelerate at a certain rate.

$$\text{Net force} = \text{Mass} \times \text{Acceleration}$$

What Is Newton's Third Law of Motion?

<p>Newton's third law of motion states that if one object exerts a force on another object, then the second object exerts a force of equal strength in the opposite direction on the first object.</p>	<p>Another way to state Newton's third law is that for every action there is an equal but opposite reaction. Action and reaction forces do not necessarily cancel out because they may act on different objects.</p>
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On a separate sheet of paper, write Newton's first law of motion. Give examples to illustrate it.

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Lesson Quiz

Newton's Laws of Motion

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

1. _____ Newton's first law of motion states that an object will not experience a change in motion unless acted upon by a(n) balanced force.
2. _____ To increase acceleration of an object, you reduce its mass or increase the applied force.
3. _____ Newton's third law of motion states that if one object exerts a force on another object, then the second object exerts a force of equal strength in the same direction.
4. _____ Resistance to change in motion is called stasis.
5. _____ Action and reaction forces acting in opposite directions do cancel out because they act on different objects.
6. _____ If you lean against a wall, the wall pushes back on you with a(n) weaker force.

Fill in the blank to complete each statement.

7. Newton's second law of motion states that an object's acceleration depends on its _____ and on the net force acting on it.
8. Acceleration is measured in _____.
9. Force is measured in a unit called the _____.
10. The smaller the mass of an object, the _____ its inertia.

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Assess Your Understanding

Momentum

What Is an Object's Momentum?

1a. **EXPLAIN** How can a heavy moving van have the same momentum as a small motorcycle?

b. **CALCULATE** What is the momentum of a 750-kg car traveling at a velocity of 24 m/s? _____

c. **INFER** The total momentum of two marbles before a collision is 0.06 kg-m/s. No outside forces act on the marbles. What is the total momentum of the marbles after the collision? _____

got it?

I get it! Now I know that momentum is conserved unless _____

I need extra help with _____

1. Use the outside corner, the corner away from the bottom line, in the corner of your copy machine to copy onto letter-size paper.

Key Concept Summary

Momentum

What Is an Object's Momentum?

All moving objects have what Newton called a "quantity of motion." Today it is called momentum.

Momentum is a characteristic of a moving object that is related to the mass and the velocity of the object. **The momentum of a moving object can be determined by multiplying the object's mass by its velocity.**

The unit for momentum is kilograms times meters per second ($\text{kg} \times \text{m/s}$). Like velocity, acceleration, and force, momentum is described by both a direction and a strength. The momentum of an object is in the same direction as its velocity.

The more momentum a moving object has, the harder it is to stop. The mass of an object affects

the amount of momentum the object has. You can calculate the momentum of a moving object using the following formula.

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

The **law of conservation of momentum** states that in the absence of outside forces like friction, the total momentum of objects that interact does not change. A quantity that is conserved is the same after an event as it was before. **The total momentum of any group of objects remains the same, or is conserved, unless outside forces act on the objects.**

On a separate sheet of paper, explain how the mass and velocity of a moving object affects its momentum. Include examples.

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Lesson Quiz

Momentum

Write the letter of the correct answer on the line at the left.

1. ____ Which of the following, moving at the same speed, would be hardest to stop?
 - A car
 - B fire engine
 - C Frisbee
 - D stroller
2. ____ Which moving object, in all likelihood, will have the greatest momentum?
 - A volleyball hit by a fourth-grader
 - B volleyball hit by an Olympic volleyball player
 - C volleyball hit by a senior adult
 - D volleyball hit by a basketball coach
3. ____ Which formula is used to calculate momentum?
 - A Momentum = Mass \times Speed
 - B Momentum = Weight \times Speed
 - C Momentum = Volume \times Velocity
 - D Momentum = Mass \times Velocity
4. ____ In which situation does the law of conservation of momentum apply?
 - A in the absence of greatest velocity
 - B in the presence of least velocity
 - C in the absence of outside forces
 - D in the presence of outside forces

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

5. _____ The total momentum of any group of objects remains the same unless outside forces act on the objects.
6. _____ If outside forces such as friction are negligible, when two objects of the same mass collide and do not stick together, the objects multiply velocities.
7. _____ Newton's "quantity of motion" is conservation.
8. _____ The less momentum an object has, the easier it is to stop.
9. _____ Momentum, like velocity, is described by both a direction and a force.
10. _____ The momentum of a 1000-kg vehicle traveling at a velocity of 25 m/s is 40kg \times m/s.

Assess Your Understanding

Free Fall and Circular Motion

What Is Free Fall?

got it?

I get it! Now I know that free fall is _____

I need extra help with _____

What Keeps a Satellite in Orbit?

1a. IDENTIFY What is the force that causes objects to move in circles?

b. PREDICT If Earth's gravity could be turned off, what would happen to satellites that are currently in orbit? Explain your reasoning.

got it?

I get it! Now I know that satellites stay in orbit because _____

I need extra help with _____

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Key Concept Summaries

Free Fall and Circular Motion

What Is Free Fall?

When the only force acting on an object is gravity, the object is said to be in **free fall**. **In free fall, the force of gravity is an unbalanced force, which causes an object to accelerate.**

Near the surface of Earth, the acceleration due to gravity is 9.8 m/s^2 . This means that for every second an object is falling, its velocity increases by 9.8 m/s . All objects in free fall accelerate at the same rate no matter what their masses are.

What Keeps a Satellite in Orbit?

Satellites, which are objects that orbit around other objects in space, follow a curved path around Earth. **Satellites in orbit around Earth continuously fall toward Earth, but because Earth is curved they travel around it.** In other words, a satellite is a falling object that keeps missing the ground. It falls around Earth rather than onto it. Once it has entered a stable orbit, a satellite does not need fuel. It continues to move ahead due to its inertia. At the same time, gravity continuously changes the satellite's direction.

Many manufactured satellites orbit Earth in an almost circular path. Recall that an object traveling in a circle is accelerating because it constantly changes direction. If an object is accelerating, a force must be acting on it. A force that causes an object to move in a circular path is a **centripetal force**. The word centripetal means "center seeking." Centripetal forces always point toward the center of the circle an object is moving in.

You swing a bucket of water in a vertical circle. The bucket falls as fast as the water, so the water stays in the bucket. On a separate sheet of paper, explain why. In your answer, compare the motion of the bucket to the motion of a satellite orbiting Earth.

Lesson Quiz

Free Fall and Circular Motion

Write the letter of the correct answer on the line at the left.

1. ____ The state that exists when the only force acting on an object is gravity is called
 - A free fall
 - B inertia
 - C acceleration
 - D momentum
2. ____ The acceleration due to gravity near the surface of Earth is equal to
 - A 9.8 m/s
 - B 9.8 kg \times m/s
 - C 9.8 N
 - D 9.8 m/s²
3. ____ Satellites in orbit around Earth travel in an almost circular path because Earth is
 - A centripetal
 - B free falling
 - C curved
 - D massive
4. ____ The word *centripetal* means
 - A center seeking
 - B gravitational
 - C continuous
 - D free falling

Fill in the blank to complete each statement.

5. The force that causes an object to move in a circle is called _____.
6. Any object that travels around another object in space is a(n) _____.
7. An object traveling in a circle is accelerating because it is constantly changing _____.
8. _____ is the centripetal force that causes a satellite to move in a circle.
9. Satellites in orbit around Earth continually fall toward _____.
10. If you could turn off a centripetal force, _____ would cause the object to fly off in a straight line.