Essential Questions and Answers:

Teacher Background Knowledge:

What is force?

A force is a push or pull upon an object resulting from the object's interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.

All forces (interactions) between objects can be placed into two broad categories:

- contact forces, and
- forces resulting from action-at-a-distance

Contact forces are those types of forces which result when the two interacting objects are perceived to be physically contacting each other. Examples of contact forces include frictional forces, tensional forces, normal forces, air resistance forces, and applied forces.

Action-at-a-distance forces are those types of forces which result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include gravitational forces. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation. Even when your feet leave the earth and you are no longer in physical contact with the earth, there is a gravitational pull between you and the Earth. Electric forces are action-at-a-distance forces. For example, the protons in the nucleus of an atom and the electrons outside the nucleus experience an electrical pull towards each other despite their small spatial separation. And magnetic forces are action-at-a-distance forces. For example, two magnets can exert a magnetic pull on each other even when separated by a distance of a few centimeters.
Examples of contact and action-at-distance forces are listed in the table below.

<table>
<thead>
<tr>
<th>Contact Forces</th>
<th>Action-at-a-Distance Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frictional Force</td>
<td>Gravitational Force</td>
</tr>
<tr>
<td>Tension Force</td>
<td>Electrical Force</td>
</tr>
<tr>
<td>Normal Force</td>
<td>Magnetic Force</td>
</tr>
<tr>
<td>Air Resistance Force</td>
<td></td>
</tr>
<tr>
<td>Applied Force</td>
<td></td>
</tr>
<tr>
<td>Spring Force</td>
<td></td>
</tr>
</tbody>
</table>

Force is a quantity which is measured using the standard metric unit known as the Newton. A Newton is abbreviated by a "N." To say "10.0 N" means 10.0 Newtons of force. One Newton is the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Thus, the following unit equivalency can be stated:

\[
1 \text{ Newton} = 1 \text{ kg} \cdot \frac{m}{s^2}
\]

A force is a vector quantity. A vector quantity is a quantity which has both magnitude and direction. To fully describe the force acting upon an object, you must describe both the magnitude (size or numerical value) and the direction. Thus, 10 Newtons is not a full description of the force acting upon an object. In contrast, 10 Newtons, downwards is a complete description of the force acting upon an object; both the magnitude (10 Newtons) and the direction (downwards) are given.

Because a force is a vector which has a direction, it is common to represent forces using diagrams in which a force is represented by an arrow. The size of the arrow is reflective of the magnitude of the force and the direction of the arrow reveals the direction which the force is acting. Furthermore, because forces are vectors, the affect of an individual force upon an object is often canceled by the affect of another force. For example, the affect of a 20-Newton upward force acting upon a book is canceled by the affect of a 20-Newton downward force acting upon the book. In such instances, it is said that the two individual forces balance each other; there would be no unbalanced force acting upon the book.

Other situations could be imagined in which two of the individual vector forces cancel each other ("balance"), yet a third individual force exists that is not balanced by another force. For example, imagine a book sliding across the rough surface of a table from left to right. The downward force of gravity and the upward force of the table supporting the book act in opposite directions and thus balance each other. However, the force of friction acts leftwards, and there is no rightward...
force to balance it. In this case, an unbalanced force acts upon the book to change its state of motion.

**How can forces be used to make objects move, change direction, or stop?**

To do work, an effort or force greater than the resisting force of the object being moved must be applied. The resisting force is gravity, friction, or inertia that prevents the object from being moved.

**How is the motion of an object related to the size of the object and the amount of force that is applied to the object?**

One thing to know is how much a force will change the motion of something. That thing is called mass. Mass is a measure of how much matter is in something. The more mass a things has the less a force will change its motion. A brick has more mass than an empty tin can. Suppose you kicked a can and a brick with the same force. The brick would speed up less than the can because it has more mass. It is also harder to slow something down if it has a lot of mass. Suppose you saw a car rolling down a hill with no one in it/ You wouldn’t even try to stop the car, because you know you couldn’t exert enough force to slow down something with that much mass. You could easily stop a runaway skateboard, because it has much less mass than a car.

- The greater a force, the more it changes the motion of something.
- The smaller a force, the less it changes the motion of something.
- The more mass something has, the less a force will change its motion.
- The less mass something has, the more a force will change its motion.

**What is gravity and how does it affect things on the earth?**

The force of gravity is an attraction between any two things made of matter. Every bit of matter in the world is attracted to every other bit of matter. Gravity only pulls; it never pushes. Gravity is a very weak force. We don’t notice gravity unless something has a lot of mass. Earth’s gravity pulls everything toward it. It pulls on you so hard that you can only jump a few feet above the Earth before gravity pulls you back. The more mass two things have, the stronger will be the force of gravity pulling them together. The farther apart two things are, the weaker will be the force of gravity pulling them together.

**What is friction?**

Friction is a force which causes the motion between two surfaces to be reduced. Friction happens because most surfaces are not perfectly smooth. Even a table top which may appear smooth has little bumps in it if you looked at it with a really good microscope. When two surfaces try to move past each
other these little bumps collide and slow the motion of the surfaces down causing what we call friction. The rougher a surface is the more and bigger bumps it has and the more friction will affect it. Some examples of this are sliding a wood block down a ramp. If you slide a wooden block down a ramp it is slowed by friction. If you cover the block in sand paper (making it rougher) the block will slide slower because friction is slowing it down more. Friction also increases if you push the surfaces together more. So a full suitcase will have more friction opposing it’s motion if you try to slide it across the floor than an empty one. Other examples of friction are very numerous because friction happens any time you move two surfaces that are touching.

**Student Essential Questions:**

**What is force?**

A force is a push or pull upon an object resulting from the object's *interaction* with another object.

**How can forces be used to make objects move, change direction, or stop?**

To do work, an effort or force greater than the resisting force of the object being moved must be applied.

**How is the motion of an object related to the size of the object and the amount of force that is applied to the object?**

- The greater a force, the more it changes the motion of something.
- The smaller a force, the less it changes the motion of something.
- The more mass something has, the less a force will change its motion.
- The less mass something has, the more a force will change its motion.

**What is gravity and how does it affect things on the earth?**

The force of gravity is an attraction between any two things made of matter.

**What is friction?**

Friction is a force which causes the motion between two surfaces to be reduced.
Essential Questions and Answers for Teachers:

How do simple machines make work easier for people?

Simple machines make work easier, but they don’t change the amount of work a person has to do. What machines change is the effort you have to put out. The ways a machine makes work easier is by changing the direction and/or size of the force put into the machine. The amount of force you put into a machine is called the effort force, while the amount of force the machine needs to move something to do work is called the resistance force. When a machine is being used, you must do work on the machine, called the input work, while the machine itself does work, called the output work.

What are the six types of simple machines?

Simple machines are tools that make work easier. They have few or no moving parts. These machines use energy to work.

- Lever- A lever is a board or bar that rests on a turning point. This turning point is called the fulcrum. An object that a lever moves is called the load. The closer the object is to the fulcrum, the easier it is to move.
- Inclined Plane- It is a flat surface that is higher on one end. You can use this machine to move an object to a lower or higher place. Inclined planes make the work of moving things easier. You would need less energy and force to move objects with an inclined plane.
- Wheel and Axle- The axle is a rod that goes through the wheel. This lets the wheel turn. It is easy to move things from place to place with wheels and axles.
- Screw- A screw is a simple machine that is made from another simple machine. It is actually an inclined plane that winds around itself. A screw has ridges and is not smooth like a nail. Some screws are used to lower and raise things. They are also used to hold objects together.
- Wedge- A wedge is a simple machine used to push two objects apart. A wedge is made up of two inclined planes. These planes meet and form a sharp edge. This edge can split things apart.
- Pulley- This simple machine is made up of a wheel and a rope. The rope fits on the groove of the wheel. One part of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns and the load will move. Pulleys let you move loads up, down, or sideways. Pulleys are good for moving objects to hard to reach places. It also makes the work of moving heavy loads a lot easier.

How do simple machines work?

Simple machines allow us to do more work with less force involved.
Essential Questions and Answers for Students:

How do simple machines make work easier for people?

Simple machines make work easier, but they don’t change the amount of work a person has to do.

What are simple machines?

Simple machines are tools that make work easier.

How do simple machines work?

Simple machines allow us to do more work with less force involved.

What is a lever? How does it work? What are some examples of levers?

A lever is a board or bar that rests on a turning point. This turning point is called the fulcrum. An object that a lever moves is called the load. The closer the object is to the fulcrum, the easier it is to move. Some examples of levers include a wheelbarrow and sweeping with a broom.

What is an inclined plane? How does it work? What are some examples of inclined planes?

An inclined plane is a flat surface that is higher on one end. You can use this machine to move an object to a lower or higher place. Inclined planes make the work of moving things easier. You would need less energy and force to move objects with an inclined plane. An example of an inclined plane is a ramp or a stairway.

What is a wheel and axle? How does it work? What are some examples of a wheel and axle?

The axle is a rod that goes through the wheel. This lets the wheel turn. It is easy to move things from place to place with wheels and axles. Some examples of wheel and axles are a bicycle and the wheels on a car.
What is a pulley? How does it work? What are some examples of a pulley?

A pulley is made up of a wheel and a rope. The rope fits on the groove of the wheel. One part of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns and the load will move. Pulleys let you move loads up, down, or sideways. Pulleys are good for moving objects too hard to reach places. It also makes the work of moving heavy loads a lot easier. Some examples of pulleys are the gears on a bicycle and a well.

What is a wedge? How does it work? What are some examples of a wedge?

A wedge is a simple machine used to push two objects apart. A wedge is made up of two inclined planes. These planes meet and form a sharp edge. This edge can split things apart. Some examples of wedges are an ax and a shovel.

What is a screw? How does it work? What are some examples of screws?

A screw is a simple machine that is made from another simple machine. It is actually an inclined plane that winds around itself. A screw has ridges and is not smooth like a nail. Some screws are used to lower and raise things. They are also used to hold objects together. Some examples of a screw are a lid to a jar or a propeller on an airplane.

**Essential Vocabulary:**

- force, pull, motion, gravity, friction, speed, position, direction, pull, mass
- simple machines, lever, pulley, inclined plane, wheel and axle, wedge, screw