



Physical Science

Force and Motion

Advanced Level

Force, Motion, and Simple Machines

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FOR:

Core Curriculum
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•
Assessments and
Reading Activities

Force, Motion, and Simple Machines

How do simple machines help us move objects?

CORE CURRICULUM STATEMENTS

Energy and matter interact through forces that result in changes in motion.

The position or direction of motion of an object can be changed by pushing or pulling.

The force of gravity pulls objects toward the center of Earth.

The amount of change in the motion of an object is affected by friction.

Mechanical energy may cause change in motion through the application of force and through the use of simple machines such as pulleys, levers, and inclined planes.

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Force, Motion, and Simple Machines

How do simple machines help us move objects?

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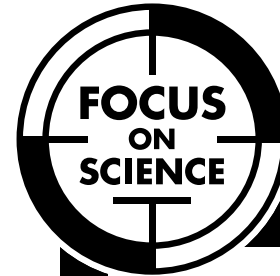
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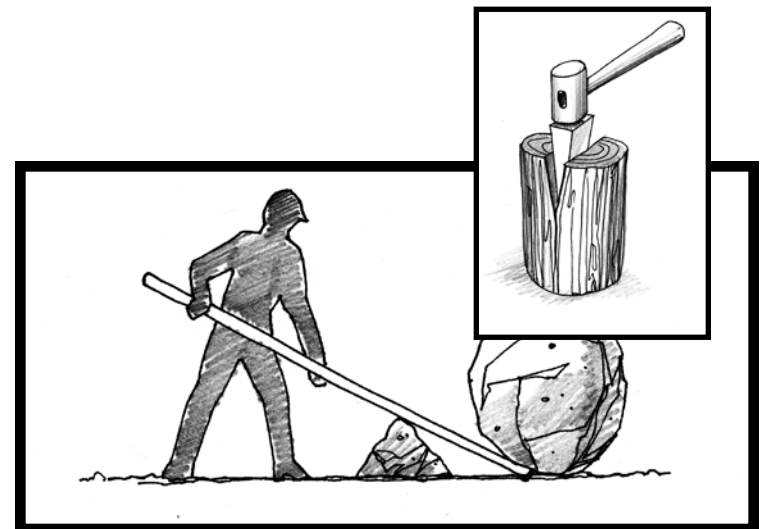


Physical Science

Force and Motion

Force, Motion, and Simple Machines

by Michael Silverstone





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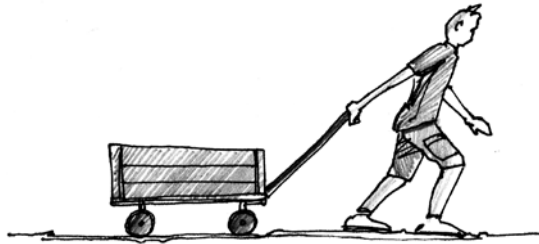
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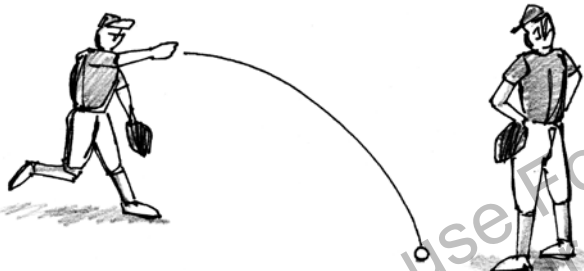
–Predict–

*What do you think you will
learn from this book?*

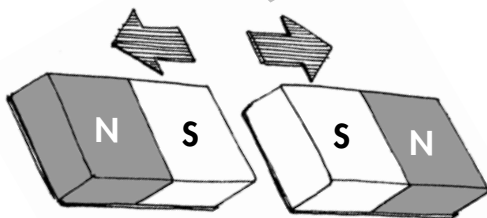
Objects Move When Forces Push or Pull on Them



A pull from an outside force



A pull from gravity



A push from the force of magnets

INTRODUCTION

Motion Is Caused by Force

At a playground, a ball is set in motion when a girl kicks it. Bikes roll along the sidewalk. Muscles and gravity set swings moving. Gravity pulls a boy down a slide. All of these events are examples of **mechanical energy** causing changes in motion.

Everything that moves is put into motion by a force applied to it. A force is a push or pull upon an object as a result of the object's interaction with another object. There are different types of forces that affect motion.

One type is contact forces, where objects physically come into contact with each other. Examples include friction and collision. Another type is noncontact forces, also known as action-at-a-distance force, where objects do not come into contact with each other. Gravity and magnetism are examples. Keep reading to learn more about these forces.

mechanical energy: energy an object has due to its motion, position, or condition

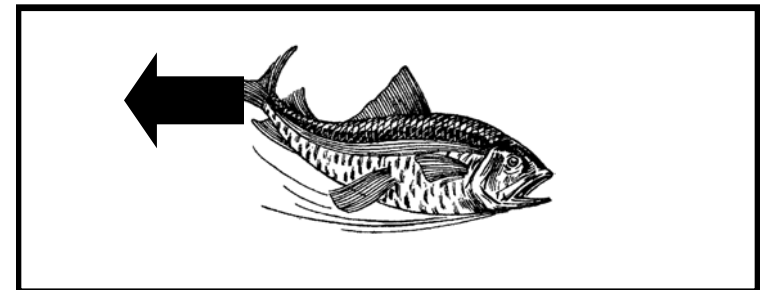
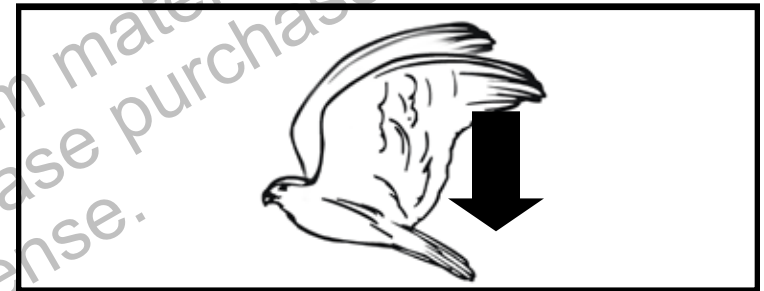
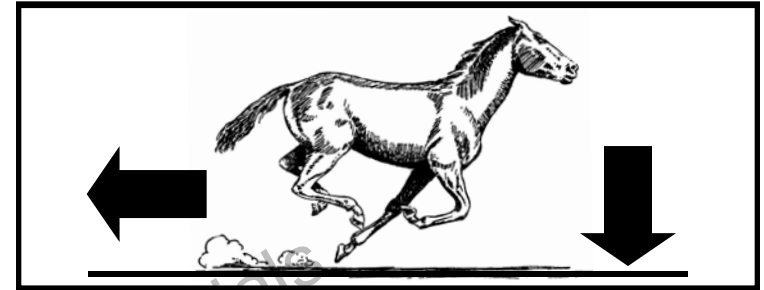
CHAPTER 1

Pushes and Pulls

Pushes and pulls are forces that usually start objects moving. Think of animals that move well, such as cheetahs, horses, sharks, and condors. All of these creatures have special physical structures that allow them to push on the ground, the air, or the water with great force.

Cheetahs and horses have muscles and joints that let them push hard against the ground with their feet and legs to move forward. Condors and other birds thrust themselves into the air by flapping their open wings. Their wings push air downward. In turn, the air reacts by pushing the bird upwards. Sharks swing their tail fins from side to side and up and down to push backwards against water. In turn, the water reacts by pushing the fish forwards, propelling the fish through the water.

The use of machines has allowed humans to move faster and farther than we could using only the power of our muscles. All of these, from bicycles to rockets, rely on pushes and pulls to cause an object to move.



Thrust is the push or pull that starts a movement. People and animals push against the ground with their feet and legs. A bird's wings push the air. A fish's tail pushes water to start movement.

–Apply–

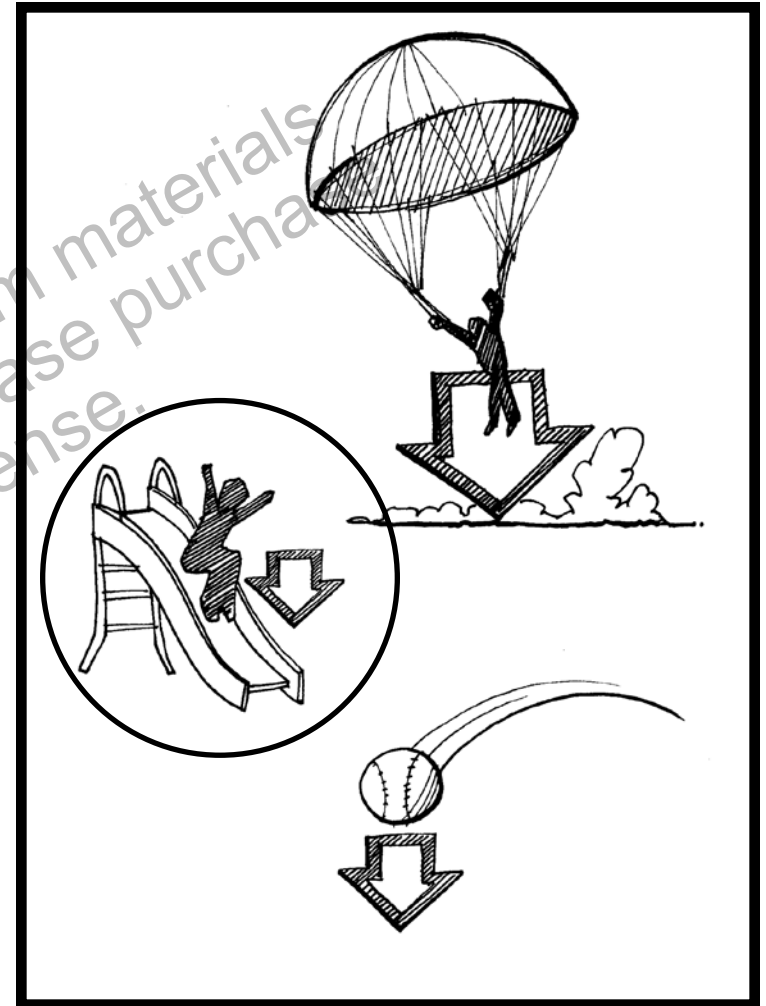
What creates thrust when you walk?

Gravity

All objects on Earth are pulled toward the center of Earth. The force that pulls things to Earth is invisible. Still, we can see the results of gravity everywhere. Acorns fall from trees. Water pours over a waterfall. Dandelion seeds blow in the wind until they settle on the ground. Snow, mud, or rocks tumble downward in an avalanche. Meteorites burn through the sky and hit the ground.

This pull toward Earth is the result of the force of gravity. Gravity is the pull that one object has on another object. The more massive the object, the stronger gravity's pull will be. It may sound funny to say, but Earth is the biggest thing in our world. Its gravity is so strong that it pulls everything on it toward its center.

The Force of Gravity



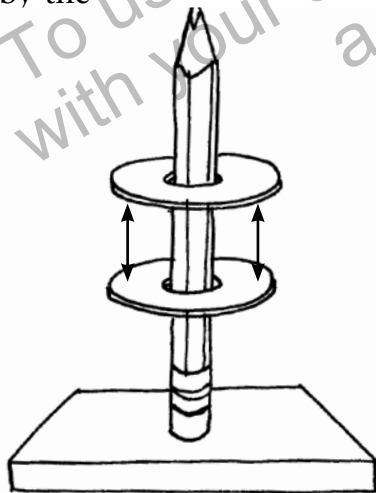
The force of gravity pulls all objects on Earth toward the planet's center.

Magnetism

In ancient China and Greece, people noticed that iron passing close by certain rocks was pulled toward the rocks. These rocks contained magnetite, a raw material that people now use to make magnets.

Magnets pull strongly on metals such as iron and steel. Magnets can also attract or repel each other with a force that can be stronger than gravity. The reason for the pull or push is an electric current flowing through the magnetite and a similar electric flow through the iron and steel.

For example, the magnet on the bottom is fixed to the pencil. The magnet on top is being forced away by the bottom magnet. The magnetic force is stronger than the force of gravity, so the top magnet will not drop.



Collision

In outer space, moving things keep going, just about forever. There is nothing to push or pull on them. However, on Earth, moving things are always slowing down or stopping.

For example, objects will slow down or stop if they bump against other objects that are going in another direction. This is called a collision.

When one object collides with another, the energy of movement changes. If two objects collide from opposite directions, whichever has more energy and **mass** will affect the direction of the other.



What will happen if these two marbles roll at the same speed and collide directly into each other? What if the small one is going much faster? What if one hits the other from the side while the other is going straight ahead? Make a prediction and try it to see what happens.

mass: the amount of matter in an object

Friction

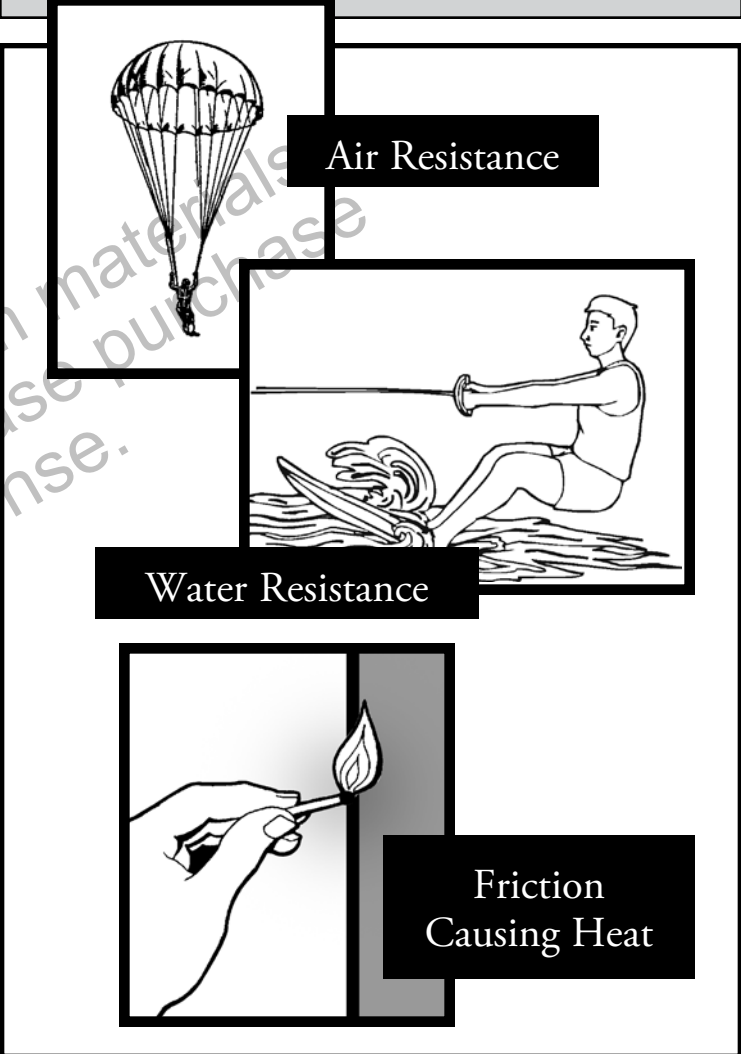
As mentioned earlier, friction is a contact force. It is caused by collisions of objects or by the rubbing of objects against each other. It is a force that slows down the movement of objects. Friction is what makes it hard to slide heavy things along the ground.

If you have ever tried to run underwater, you know that water's friction, or **resistance**, makes this hard. Even air has resistance. This is what makes a parachute work. The friction of air particles against the open parachute slows down the movement of a person pulled toward Earth by gravity.

Friction can also turn the energy of movement into heat. You can feel this for yourself when you rub your hands together quickly. Try it and explain what happens to a friend.

resistance: when something pushes against an object to slow it down or stop it from moving

Different Types of Friction and Resistance



The diagram illustrates three types of friction and resistance. At the top, a parachute is shown with a label 'Air Resistance'. Below it, a person is rowing a boat, with a label 'Water Resistance'. At the bottom, a hand is shown lighting a match, with a label 'Friction Causing Heat'.

–Analyze–
Where is the friction in each picture?

Reducing Friction

Sometimes things move more easily than at other times. Objects that can slide easily on ice are much harder to move on carpet. A heavy box of books is easier to move when it moves on ice. Thin pointed objects move faster through air or water than wider, fatter ones. Why? It is easier to move objects when the friction is reduced.

Reducing Friction Between Surfaces

Rough surfaces, such as a sidewalk, have more places to rub against. This causes more friction when a person's shoe touches the ground. The foot does not slip as easily.

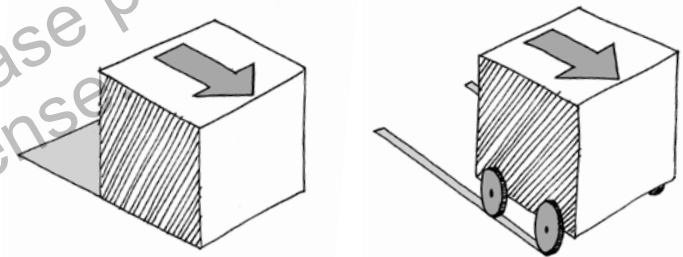
When a sidewalk is icy, the smooth surface of ice reduces the friction so much that people can slip and lose their balance trying to walk on it.

Applying a lubricant, such as oil or grease, to a surface also reduces friction. Lubricants minimize the contact between rough surfaces. The lubricant's particles slide easily against each other, causing less friction between the surfaces.

–Explain–

Identify and explain the forces that affect the motion of an object.

Here is another example. A box on wheels moves much more easily than one that does not have them. Wheels reduce the amount of matter that rubs against the floor. Only the small area at the bottom of each wheel is in contact with the ground. Without wheels, the whole surface of the box creates much more friction, making it harder to move.



Shapes that Help Things Move Faster in Air and Water

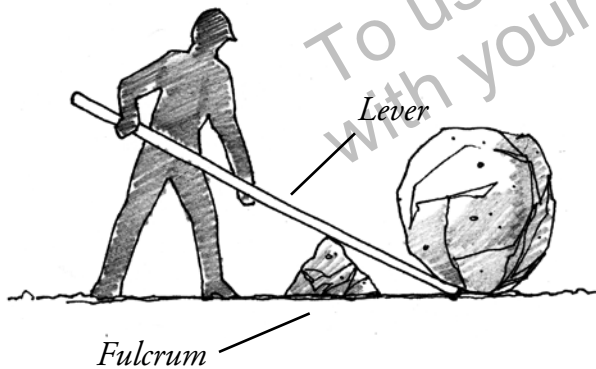
The size and shape of an object can change the amount of friction it creates as it moves through air or water. Smooth, rounded shapes move through the air more easily than flat or rough surfaces. That's because these shapes have fewer places for air or water to bump up against and slow them down. Think about it. Would a straight stick move as far as a rock when thrown in the water?

Simple Machines

Simple machines are **devices** that help us perform work more easily. Simple machines allow us to use a smaller force to overcome a larger force. These machines include the lever, inclined plane, wheel and axle, screw, pulley, and wedge.

Lever

A lever is a straight, stiff bar that rests on a support or fixed point. This fixed point is called the **fulcrum**. An object that a lever lifts is called the **load**. The closer the load is to the fulcrum, the easier it is to lift.

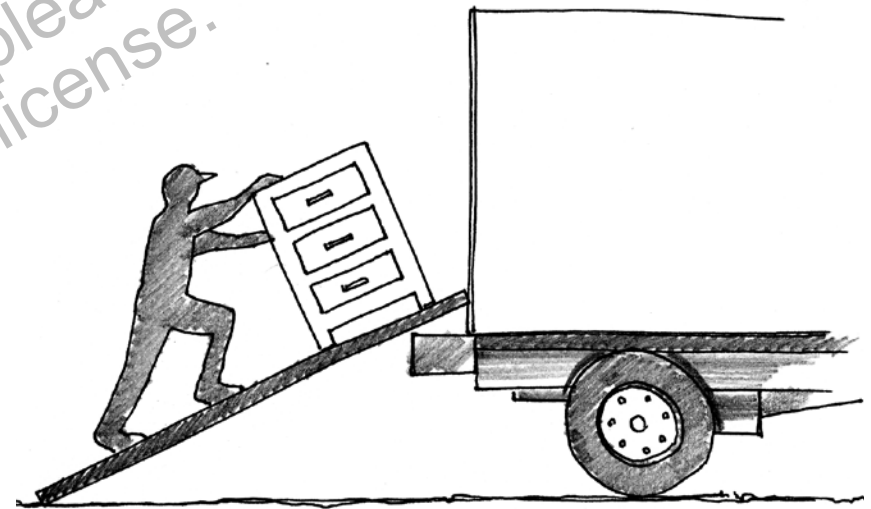


devices: things made or invented for a special use
fulcrum: the support or fixed point that a lever rests on
load: an object that is lifted or about to be lifted by a lever

Inclined Plane

An inclined plane is a slanting surface that allows you to move an object to a lower or higher place. It makes the work of moving the object easier.

An inclined plane allows you to overcome a large resistance by applying a smaller force over a longer distance. You need less energy and force to move objects with an inclined plane. Examples of inclined planes include ramps and slides.

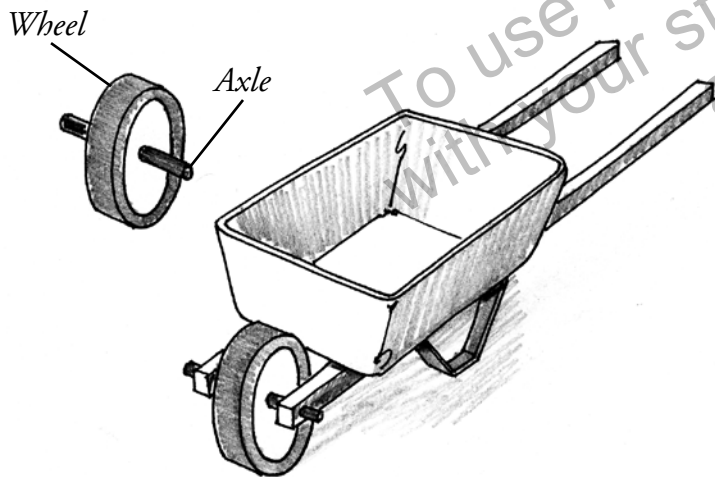


Less force is required to move this object because of the longer distance of the ramp.

Wheel and Axle

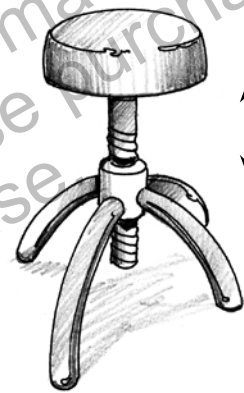
The wheel and axle is another simple machine. It is probably the single most important invention of all time. The oldest wheel known was discovered in Mesopotamia and probably dates back to 3,500 B.C.

The wheel and axle is made from two objects. A large wheel is secured to a post called an axle. The wheel turns around the axle. It makes it easier to move things from place to place. For example, a wheelbarrow makes it easier to move heavy loads of dirt.

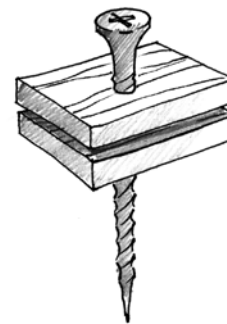


Screw

A screw is a simple machine made from another simple machine. A screw is an inclined plane wrapped around a pole. Some screws are used to lower and raise things. They are also used to hold objects together.



A screw can be used to raise or lower things.

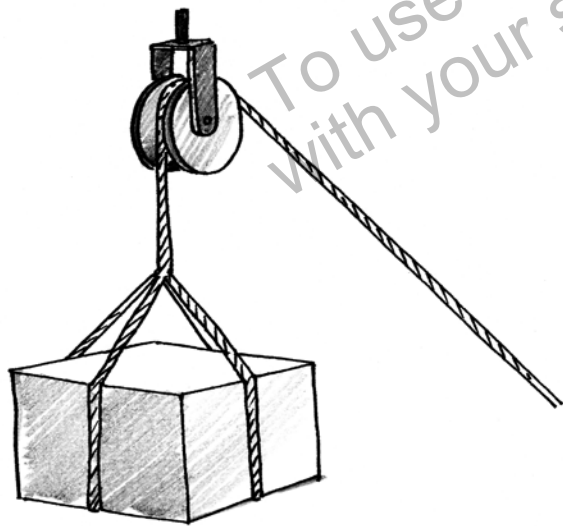


A screw can be used to hold things together.

Pulley

A pulley is a device that allows you to lift a large load with a much smaller force. This simple machine is made up of a grooved wheel, axle, and a rope. The rope fits on the groove of the wheel. One end 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 with less force.

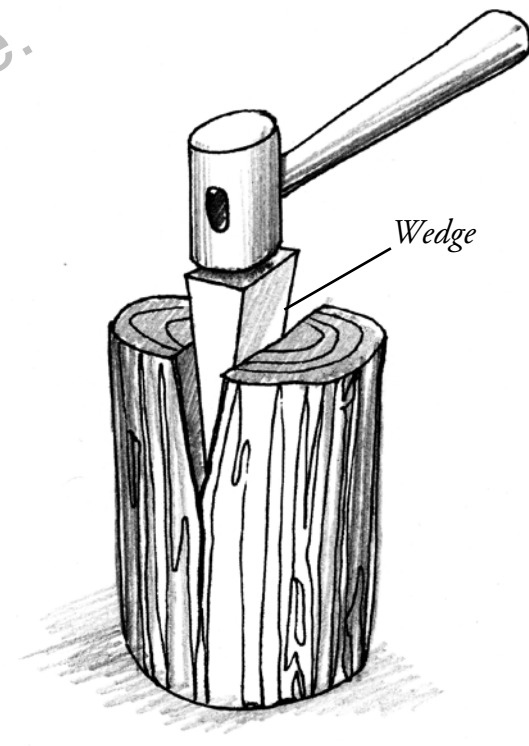
In a simple pulley, the grooved wheel is attached to an immovable object, such as a ceiling or beam. When a person pulls down on one end of the rope, the load at the opposite end of the rope is raised.



Wedge

A wedge is a simple machine used to separate two objects. A wedge is made up of two inclined planes. These planes meet and form a sharp edge.

A fairly weak force, applied to the wide end of a wedge will send a strong force to the narrow end pushing out at the sides. The wedge can then split things apart. The knife you use to eat with is a wedge. It cuts or split food apart. Forks, axes, chisels, and nails are other examples of wedges.



Glossary

devices—things made or invented for a special use

fulcrum—the support or fixed point that a lever rests on

load—an object that is lifted or about to be lifted by a lever

mass—the amount of matter in an object

mechanical energy—energy an object has due to its motion, position, or condition

resistance—when something pushes against an object to slow it down or stop it from moving

To Find Out More . . .

Want to learn more about force and motion?

Try these books

Force & Motion by Peter Lafferty. Dorling Kindersley, Inc., 1992

Speed and Acceleration by Richard Spilsbury. Heinemann Library, 2007.

Access these Web sites

The Little Shop of Physics
<http://littleshop.physics.colostate.edu/>

Fizzics Fizzle! An Interactive Guide to Physics
<http://library.thinkquest.org/16600/>

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Physical Science

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Assessments

Force, Motion, and Simple Machines

Print pages 20–22 of this PDF for the assessments.

Check Understanding

Shade the circle next to the correct answer or write your answers on the lines provided.

- Two balls are rolling toward each other at the same speed. The green ball is more massive than the pink ball. What will happen when the balls collide?
 - Both balls will change directions.
 - Neither ball will change direction.
 - The pink ball will change the direction of the green ball.
 - The green ball will change the direction of the pink ball.
- In the winter, the sidewalk to school becomes slippery. Sprinkling salt on the sidewalk helps to melt some of the ice. This makes walking to school easier. Which statement explains why walking is easier without the ice?
 - Friction is reduced.
 - Gravity is reduced.
 - Friction is increased.
 - Gravity is increased.

- Contact forces and noncontact forces affect motion. Identify **one** contact force.

Explain how the contact force works.

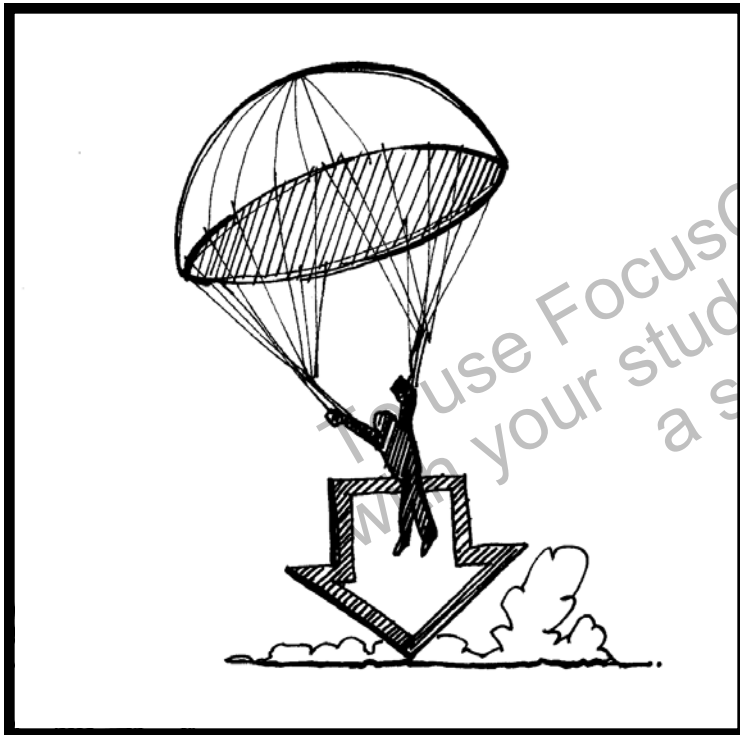
Note that question 4 has only three choices.

- A student rides a bike on smooth pavement. She then turns on to a rough gravel surface. The bicycle is likely to move
 - slower
 - faster
 - at the same speed

Check Understanding

Write your answers on the lines provided.

5. The diagram below shows a person parachuting to the ground.



Identify **two** forces acting on a jumper's parachute.

- 1) _____
2) _____

Explain why both forces are important.

Assessment Scoring Guidelines

1. Answer D is correct.

2. Answer C is correct.

3. **Collision**

Collision occurs when one object bumps into another.

Friction

Friction occurs when one object rubs against another.

4. Answer A is correct.

5. **Gravity**

Gravity pulls the jumper down, bringing him back to the ground.

Resistance

The air pushes against the parachute, causing friction, so that the jumper does not fall too quickly.

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Advanced Level

English Language Arts Activities

Force, Motion, and Simple Machines

Print pages 24–28 of this PDF for the reading activities.

Compare and Contrast

TRY THE SKILL

Comparing and contrasting is a skill that helps you better understand new ideas.

- Comparing tells how things are alike.
- Contrasting tells how things are different.

Read these definitions. Then look at the two-column chart that shows what is similar and what is different about gravity and magnetism.

gravity: the pull of attraction between large objects; the gravity of Earth is strong enough to give objects weight and keep them from floating or flying into space

magnetism: the attraction between magnetic material or between magnets and iron that pulls them toward each other; magnets are also able to push other magnets away

Gravity and Magnetism

Similarities	Differences
<ul style="list-style-type: none">• both forces pull things together	<ul style="list-style-type: none">• gravity works on any substance, magnets only on other magnets or iron
<ul style="list-style-type: none">• the force can be strong or weak	<ul style="list-style-type: none">• magnets can also push magnets away

Read the paragraph. Complete the graphic organizer.

Sometimes things move more easily than other times. Objects that can slide easily on ice are much harder to move on a brick floor. A heavy box of books is easier to move when it moves on ice. Thin pointed objects move faster through air or water than wider, fatter ones. Why? It is easier to move when the friction is reduced.

High Friction and Low Friction

Similarities	Differences

Question and Answer

TRY THE SKILL

Listing questions and identifying answers helps you practice finding meaning in what you have read and making connections to your own thinking.

Read this passage. Then list one or two questions that come to mind after you are done. List a possible answer to that question. Remember, you do not have to be right in your answer.

The use of machines has allowed humans to move faster and further than we could using only the power of our muscles. All of these devices, from bicycles to rockets, rely on pushes and pulls to cause objects to move.

Question

How have these inventions using pushes and pulls changed our lives?

Possible Answer

They have made it possible for people to travel across oceans, under oceans, in the sky, on the land, and even into space. Human life would be more like that of other animals if not for these machines.

Read the passage, then list one or two questions that come to mind. Try to answer the questions based on what you read and what you already know.

All objects on Earth are pulled toward the center of Earth. The force that pulls things to Earth is invisible. Still, we can see the results of gravity everywhere. Acorns fall from trees. Water pours over a waterfall. Dandelion seeds ride the wind until they settle on the ground. Snow, mud, or rocks tumble downward in an avalanche. Meteorites burn through the sky and hit the ground.

This pull to Earth is the result of the force of gravity. Gravity is a pull that matter has on other matter. The more massive the matter, the stronger gravity's pull will be. It may sound funny to say, but Earth is the biggest thing in our world. Its gravity is so strong that it pulls everything on it toward its center.

Question: _____

Possible Answer: _____

Use Context Clues

TRY THE SKILL

Some words have several meanings. You can use context clues to decide which meaning is being used in a certain sentence. For example, the word *spot* can mean “a mark,” and *spot* can mean “to notice something.”

Read the sentence below and decide which meaning is being used here.

The spots on a giraffe help it blend in with its surroundings.

In this sentence, *spots* means “marks.” The context—the rest of the sentence—tells you which meaning is being used.

Read each word and its meanings. Then read each sentence and write the letter of the correct meaning on the line.

swing A. to move with a sweeping motion B. a seat hanging from a rope

1. Sharks ____ their tail fins from side to side and up and down to push against water.

pulls A. moves an object B. handles

2. The force that ____ things to Earth is invisible.

burn A. an injury caused by heat B. to be on fire

3. Meteorites ____ through the sky and hit the ground.

raw A. not cooked B. in its natural condition

4. These rocks contained magnetite, a ____ material that people use to make magnets.

power A. the ability to control others B. a force that can be put to work

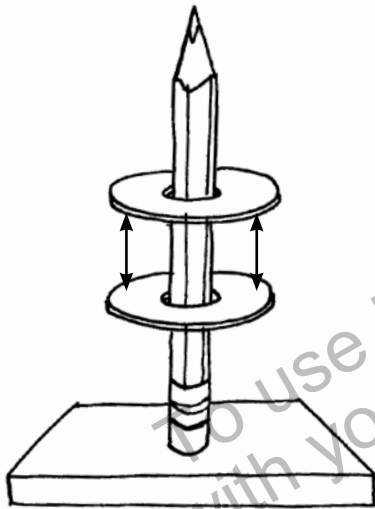
5. The use of machines has allowed humans to move faster and further than we could using only the ____ of our muscles alone.

Interpret Graphics

TRY THE SKILL

Graphics can give you information quickly and help you understand how something occurs or works.

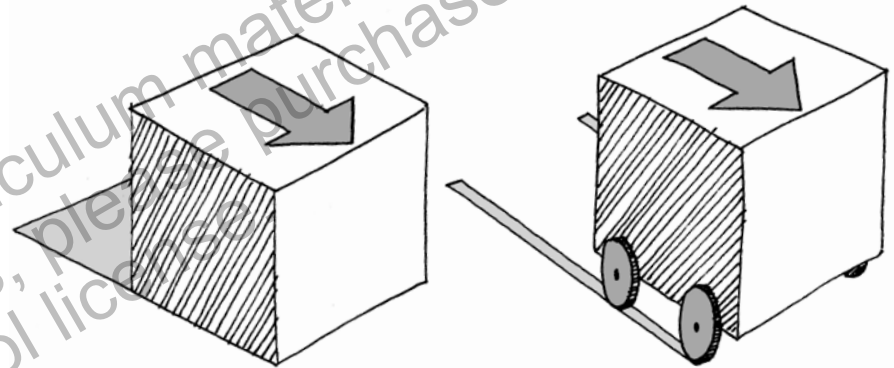
Look at the graphic showing two magnets repelling each other.



Why doesn't the top magnet fall down?

- The arrows between the magnets indicate that a force is keeping the magnets apart. Magnets can attract or repel each other with a force that can be stronger than gravity.

Study this picture from *Force, Motion, and Simple Machines*. What does it tell you about friction? Write about it.



Answer Key

Compare and Contrast

Similarities

All friction is a force that affects motion.

Differences

More force is required to move an object with high friction.

Less force is required to move an object with low friction.

Question and Answer

Question: How do we know gravity exists?

Answer: We can see evidence of gravity such as acorns falling from trees.

Use Context Clues

1. A
2. A
3. B
4. B
5. B

Interpret Graphics

A box on wheels moves more easily than one that does not have them. Wheels reduce the amount of matter that rubs against the floor. Only the small area at the bottom of each wheel is in contact with the ground. Without wheels, the whole surface of the box creates much more friction, making it harder to move.