UNIT OVERVIEW

Simple and complex machines help us do work with less force, or effort. The Machines unit explains what work is as well as the relationship between force and distance. It covers in detail the seven traditional simple machines and how they function. One or more simple machines may be combined to form complex machines capable of doing many repetitive, difficult, complicated, or dangerous tasks.

Certain reading resources are provided at three reading levels within the unit to support differentiated instruction. Other resources are provided as a set, with different titles offered at each reading level. Dots on student resources indicate the reading level as follows:

- low reading level
- middle reading level
- high reading level

THE BIG IDEA

Every day, students do activities that involve motion. Whether they prepare a sandwich for lunch, write on paper, ride a bicycle, create arts and crafts, or brush their teeth, students do work. Machines help them do activities like these more quickly, easily, and/or safely. In modern life, machines are an integral part of many activities, from eating to sports to construction to travel. Students may not realize that many of the items they use every day are actually simple or complex machines. Understanding how various machines work will help students choose appropriate machines and use them properly.

Other topics

This unit also addresses topics such as: earthmoving machines, bicycles, waterwheels, Rube Goldberg machines, and how machines use forces to move.

SPARK

The spark is designed to get students thinking about the unit's topics and to generate curiosity and discussion.

Materials

- rigid rulers
- crayons
- various objects of different weights that are small and stable enough to rest on top of the ruler (for example, coins, blocks, and rocks)

Activity

Place students in pairs and distribute materials to each pair. Ask students to share what happens when they play on a seesaw, or teeter-totter. Explain that they are going to make mini-seesaws to learn how they can move different objects up and down.

Have students place the crayon under the midpoint of the ruler. Instruct them to place different objects on one end of the ruler and gently push the other end down (using *force,* or effort) with their fingers. Students will observe that it is easier to raise lighter objects and harder to raise heavier ones.

Then allow students to select just one of their objects and experiment with changing the placement of the crayon (the *fulcrum*) under the ruler (the *beam* or *arm*). They should find it easier to raise the object when the crayon is closer to the object (the *load*) than when it is far from it. Students may also try keeping the crayon centered under the ruler while moving the object closer to it. This, again, should make it easier to raise the object.

Finally, allow students to choose two different objects to place on the ends of the ruler at the same time, with the crayon placed under the midpoint of the ruler. Ask them to predict which object will rise and which will fall before testing it. Then ask students to reflect on their predictions and the results.

Below are questions to spark discussion.

Why was it easier to raise some objects than others?

What happened when you tried to raise an object that was placed very far from the crayon? Why do you think this was so?

What happened when you tried to raise an object that was placed very close to the crayon? Why do you think this was so?

When two objects are on the ends of the ruler, how can you tell which will go down and which will go up?

Why do you need more than one person to play on a real seesaw?

How could you use something shaped like a seesaw to help you do work?

Use this activity to begin an introductory discussion about work and machines. Explain that the seesaw is helping to lift something, which is a type of work. This playground toy is an example of a simple machine called a *lever.* Throughout the unit, students will learn more about simple and complex machines.

Many of the unit's vocabulary terms are related to the spark activity and can be introduced during the spark. For vocabulary work, see the Vocabulary section in this *Unit Guide*.

PRIOR KNOWLEDGE

Invite students to explain their understanding of what it means to do work (in a scientific sense) and to identify examples of machines. Discuss how each machine they identify helps people do work.

Probing Questions to Think About

Use the following questions to have students begin thinking of what they know about machines.

- What is *work?*
- What kinds of work do machines do for us?
- How are machines important?
- What is a *simple machine?*
- What are some examples of simple machines?
- How is a flyswatter a similar machine to a hammer?
- What kind of machine would you use to hold two pieces of wood together?
- How do the moving parts of a bicycle help you ride it from one place to another?
- Which takes more work: cutting bread or cutting down a tree? Why? What kind of machine would you use for each of these tasks?

Tell students they will learn more about these topics soon.

UNIT MATERIALS

Each unit provides a wide variety of resources related to the unit topic. Students may read books and other passages, work in groups to complete hands-on experiments and investigations, discuss science ideas as a class, watch videos, complete writing tasks, and take assessments.

Resources are available for printing or projecting, and many student resources are also available for students to access digitally on Kids A–Z.

Selected unit resources are available in more than one language.

For a complete list of materials provided with the unit, see the Machines unit page on the Science A–Z website.

VOCABULARY

Use the terms below for vocabulary development throughout the unit. They can be found in boldface in the *Nonfiction Book*, the *Quick Reads*, and/or other unit resources. These terms and definitions are available on *Vocabulary Cards* for student practice. Additional vocabulary lists are provided in the teaching tips for *Investigation Packs* and *FOCUS Books*.

Core Science Terms

These terms are crucial to understanding the unit.

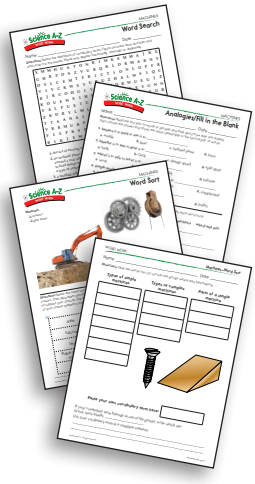
axle	a pin or pole around which a wheel revolves
complex machine	any device made up of more than one simple machine; a compound machine
force	the strength or energy that moves an object
friction	the force that builds up when two objects rub against each other
fulcrum	the point around which a lever pivots or turns
gear	a toothed wheel that connects with another toothed object to change speed or direction; a type of simple machine
inclined plane	a slanted surface that makes it easier to move an object between a lower level and a higher level; a type of simple machine
lever	a rigid bar that pivots or turns around a fulcrum; a type of simple machine
load	something that is lifted or carried
machine	any device that uses energy to help a person do work
pulley	a circular lever, usually a wheel with a rope around it; a type of simple machine
ramp	a sloped path used to move things between a lower level and a higher level
screw	an inclined plane wrapped around a rod, often used to hold things together; a type of simple machine
simple machine	any basic device that works with the use of a single force
wedge	a simple machine with one narrow or pointed end and one wide end, used to separate two objects or parts
wheel	a round object that turns around a central point
wheel and axle	a round object that turns around a pin or pole; a type of simple machine
work	the act of moving something

Other Key Science Terms

The following vocabulary is not essential for comprehending the unit but may enrich students' vocabulary.

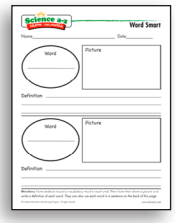
block and tackle	a group of two or more pulleys; used to lift or pull heavy objects
earthmover	a very large complex machine used to dig, push, or move large quantities of earth
excavator	a large complex machine that removes dirt from the ground, either at a building site or to locate underground resources
first-class lever	a lever in which the fulcrum is between the force and the object being lifted
robot	a machine that performs tasks for people on its own
Rube Goldberg machine	a machine named for the creator of a comic-strip character who invented very complex machines to do simple tasks
second-class lever	a lever in which the load is between the force and the fulcrum
slope	an upward or downward slant
third-class lever	a lever in which the force is between the fulcrum and the load
tool	any object or device that makes a job or a task easier

Vocabulary Activities



You may choose to introduce all the terms that will be encountered in the unit before assigning any of the reading components. *Vocabulary Cards* with the key science terms and definitions are provided. Dots on the cards indicate the reading levels of the *Nonfiction Book* or the *Quick Reads* in which each term can be found. If all level dots appear, the term may come from another resource in the unit. Students can use these cards to review and practice the terms in small groups or pairs. The cards can also be used for center activity games such as Concentration.

The *Word Work* activity sheets offer fun puzzles and practice with key vocabulary terms from the unit. For further vocabulary practice and reinforcement, you can choose from the vocabulary *Graphic Organizers*. To build customized vocabulary lessons with terms related to the topic, see Vocabulary A-Z.



Students can use the *Word Smart* vocabulary *Graphic Organizer* to organize information on the science terms. You may want to assign each student one to three words to share his or her *Word Smart* knowledge with classmates. Students who have the same word should first compare their *Word Smart* sheets with each other and then report to the larger group.

The science terms can be used in oral practice. Have students use each term in a spoken sentence.

As students read, encourage them to create a science dictionary by recording new vocabulary terms and definitions in their *SAZ Journal*.

BACKGROUND AND MISCONCEPTIONS

Use this section as a resource for more background knowledge on unit content and to clarify the content for students if misconceptions arise. Refer to Using the Internet below for more ways to extend the learning.

Q: *How can a tool with no moving parts—such as a ramp or a hammer—be a machine?*

A: Many simple machines—including many inclined planes, wedges, levers, and screws—have no moving parts, but they still make work easier by reducing the force required to do a job. Whether they change the direction of the force (screw and wedge) or reduce the force by increasing the distance moved (lever and inclined plane), these simple machines get work done.

Q: *I use force when I push on something very large and heavy that doesn't move, such as a house or a boulder. Why isn't this considered work?*

A: In order for work to take place, it's true that a force must be used, but by definition, something also must move. No matter how much force you use, if it doesn't move, it isn't work. There must be both a force applied and a distance traveled for work to occur.

Q: *Are all machines made of metal? Do they all run on electricity?*

A: The classic image some children have of a machine may be a piece of factory equipment or a large appliance, such as a washer/dryer or dishwasher. But machines take many forms, are made of many different materials, and are powered by a variety of forces. You might invite students to compare and contrast the properties of machines shown in photographs and illustrations throughout this unit.

Q: *If I use a machine, does that mean I won't have to use any force? Will the machine do the work for me?*

A: No, you still have to use some force, but using a machine might make your work easier. Machines often reduce the force needed to move something but increase the distance. When using a machine, you do the same total amount of work (less force, more distance) as you would by hand (less distance, more force). People often opt for reducing the force by using a machine.

Q: *Do all machines need a person to provide the force?*

A: Directly, no, but indirectly, yes. Many machines operate automatically, or without a force from a person. However, the power that makes these machines move does come from people, indirectly. For example, an electric fan can operate without a person manually turning the blades, but it would not function without the electricity provided by people. Sailboats catch the wind, which is a natural force, but it takes force to install a mast and to raise the sails. A go-cart can roll down a hill without a push from a person, but before the go-cart can roll down the inclined plane, someone has to place it there, which requires a force.

Q: *Isn't friction always a bad thing that should be avoided?*

A: No. While friction can slow things down, it is also necessary in many situations. There are times when it's good to reduce friction, such as oiling a bike chain to make it turn more easily or waxing surfboards and skis to help them glide on the water or ice. But there are also times when friction comes in handy, such as on slippery surfaces. We place sand on ice to provide friction so people won't slip and fall. Cars need friction between the road and the tires to maintain traction.

Q: *If a simple machine is helpful, a complex machine must be even better, right?*

A: Not necessarily. Sometimes a simple machine is perfect for a job, such as the use of a ramp to load a moving truck. At other times, using several simple machines together may be helpful, such as the use of a hammer (lever) and nail (wedge) to hang a painting. Other tasks are made much easier with complex machines, such as the use of a sewing machine (wheel and axle, wedge, gears) as opposed to a needle and thread. It's the combination of simple machines that makes complex machines so valuable.

Q: *Can body parts be considered machines?*

A: Technically, a machine is a device or an apparatus that helps us do work. However, it might be a good educational exercise for students to consider whether any parts of their body, or the body parts of other animals, work in the same manner as any simple machines. (Teeth, fingernails, and claws are wedges. Arms, legs, wings, and fins can be used as levers. A rotating joint behaves like a wheel and axle. Students may even compare their nose to one of the simple machines!)

EXTENSION ACTIVITIES

Using the Internet

Most search engines will yield many results when you search for the term *machine* or *simple and complex machines.* Searching by machine type is likely to yield more targeted results. Be aware that some sites may not be educational or intended for the elementary classroom. More specific inquiries are recommended, such as:

- definition of work (or force)
- complex (or compound) machines
- How does a clothes dryer work?
- inclined plane, lever, pulley, screw, wedge, wheel and axle, or gear
- simple machines for kids
- block-and-tackle diagram
- parts of a lawn mower
- giant/enormous/ massive machines

Projects and Activities

- **Home Connection:** Invite students to look through their collection of toys to identify an example of each kind of simple machine. If they can't find all of them, they may expand their search to other things around the house, but caution students to get an adult's permission before selecting other items, as some machines may be dangerous. Ask students to share their findings with the class.
- **Engineering:** Rube Goldberg was a cartoonist who designed fantastically complicated contraptions to do simple things, such as removing cotton from a pill bottle. Students can learn more about this Pulitzer Prize-winning artist by reading one of this unit's *Quick Reads*.
- **Math:** Have students use the equation for work ($W = F \times d$) to solve several problems, with or without proper units of measure. Students can use force and distance measurements to solve for the amount of work (multiplication). Or they may solve for unknown force or distance factors when given the total amount of work (division). They might even identify several combinations of force and distance that all require an equal amount of work.

- **Social Studies:** Find pictures of machines from several different time periods that have a related function. Challenge students to sort them from oldest to most modern. For example: horse and cart, steam train, modern shipping truck; Wright Flyer, propeller plane, modern jet; needle and thread, antique sewing machine, modern sewing machine.
- **Arts/Engineering:** Challenge students to invent a complex (or Rube Goldberg) machine. Have them think of what they want the invention to do (for example, automatically give the dog water or squeeze toothpaste) and how it will work. They can draw a design of the invention or even make a working model.
- **Guest:** Invite someone who works with machines to come to your class and talk about the machines they use and what each one does. Construction workers, factory workers, plumbers, and farmers are just a few options.
- **Literature:** Recommended books for students include *Experiments with Simple Machines* by Salvaltore Tocci; the Amazing Science: Simple Machines series from Picture Window Books, which includes *Scoop, Seesaw, and Raise* and other titles by Michael Dahl; and the Machines at Work series from Dorling Kindersley, which features titles on complex machines such as trucks, tractors, and airplanes.
- **Field Trip:** Take students on a tour of a local factory. Ask them to look for examples of simple and complex machines and to ask questions about how the various machines help workers do their jobs. Back in class, students can summarize their trip in a journal entry or by diagramming the process that the factory used to make the product.
- **Writing:** Some people feel that there are too many machines in our lives and that people are too dependent on them. Others believe that more and better machines will only enhance our lives. Ask students to write a journal entry or essay about whether they agree or disagree with these ideas, and why. For extensive resources to teach writing, visit Writing A-Z.

- **Research/Home Connection:** Students can conduct research as a family/home project or in the library/media center to extend the learning about a topic in one of the *Quick Reads* or other unit resources.