Simple and Complex Machines

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Simple and Complex Machines

Written by Ned Jensen

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KEY ELEMENTS USED IN THIS BOOK
The Big Idea: Machines help us do work more quickly, easily, and/or safely. Machines reduce the amount of force required to do work but often require working over a greater distance. Seven types of simple machines can be found in familiar devices. One or more simple machines may be combined to form a complex machine. Understanding how various machines work will help students to choose appropriate machines and use them properly.
Key words: axle, block and tackle, complex machine, distance, energy, first-class lever, force, friction, fulcrum, gear, hammer, inclined plane, knife, lever, lift, load, machine, pull, pulley, push, ramp, robot, screw, second-class lever, seesaw, simple machine, slope, third-class lever, tool, turn, wedge, weight, wheel, wheel and axle, work **Key comprehension skill:** Cause and effect *Other suitable comprehension skills:* Compare and contrast; classify information; main idea and details; identify facts; elements of a genre; interpret graphs, charts, and diagrams; using a glossary and boldfaced terms; using a table of contents and headings **Key reading strategy:** Summarize *Other suitable reading strategies:* Ask and answer questions; connect to prior knowledge; visualize; retell

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Introduction

How do you do **work**? How do you eat cereal or loosen the lid of a jar? You probably use tools.

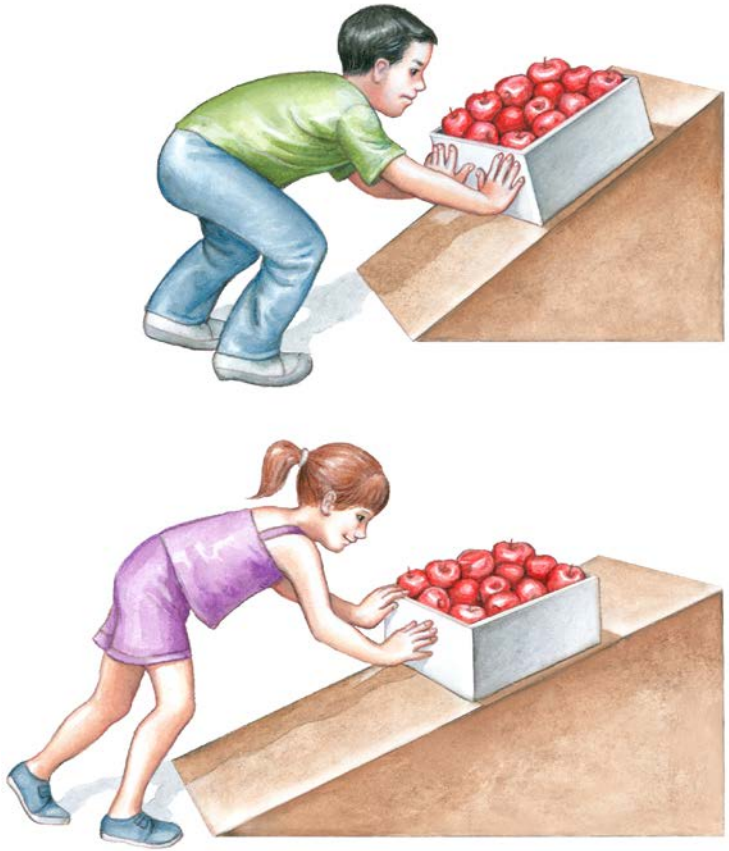
Tools make work easier to do. A **machine** is a device that uses energy to do work. Tools that have only a few parts are called **simple machines**. A hammer is a simple machine. Some machines combine several simple machines. Clocks and bicycles are **complex machines**. In this book, you will learn how machines make work easier.

Do You Know?

Animals use tools, too! Apes use sticks to get ants out of anthills. Sea otters use rocks to crack open clamshells. Crows can make wire hooks to get food out of a tall, thin container.

What do we mean by work? In science, *work* means moving something. To move something, you use **force**. The more force it takes to move an object, the more work is done. The more distance something moves, the more work is done.

Whenever you push, pull, turn, or lift an object, you use force. The amount of force it takes depends on how heavy the object is. It takes a lot more force to move a big rock than to move a small rock.



Both ramps do the same amount of work. The top ramp requires twice as much force as the bottom ramp, but the bottom ramp covers twice as much distance. Which ramp would you rather use?

Machines make work easier by reducing the amount of force it takes to move an object, or **load**.

But there is a trade-off. Machines make your work easier, but you have to work over a longer distance.

Types of Simple Machines

There are only a few types of simple machines. Some have no moving parts. Some have just a few moving parts. Below are the seven simple machines you will read about in this book.

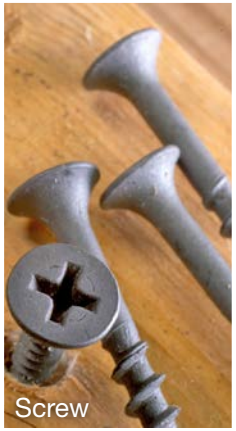

Inclined plane


Wedge

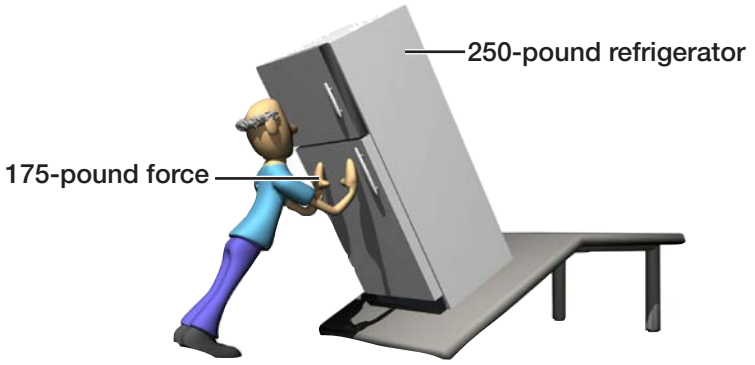

Gear


Lever


Wheel and axle


Screw


Pulley



Inclined Plane

The **inclined plane** is a very simple machine. It is a surface with a slope, or incline. Inclined planes help us change the height of heavy objects. A common inclined plane is a **ramp**.

Furniture movers use ramps. It is easier to slide a heavy box up a ramp than it is to lift the box straight up. Moving the box up the slope of a ramp takes less force.

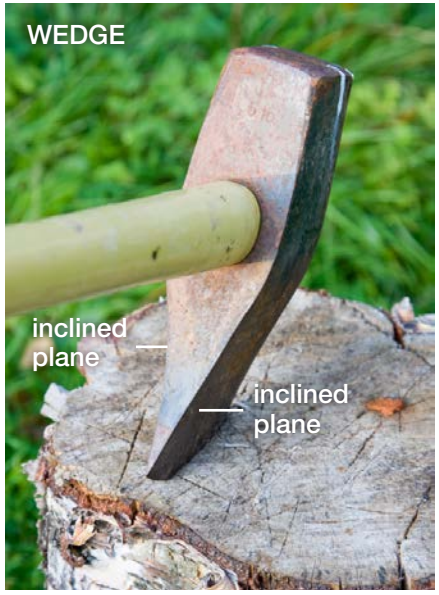
The longer the ramp is and the gentler its slope, the less force it takes to move a box up it. But remember the trade-off. The gentler and longer the slope, the farther you have to push or pull the load.

Do You Know?

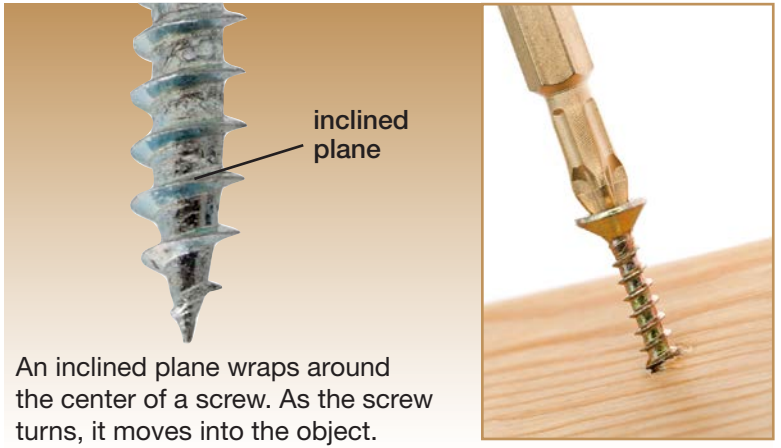
Over 3,000 years ago, the Egyptians used inclined planes to build pyramids. They used long ramps to move heavy stones uphill.

Wedge

A **wedge** is really just two inclined planes that meet. A wedge helps you push things apart. The blade of a knife is a wedge. Your front teeth are also wedges. Wedges cut through things by moving them apart. The narrower the wedge, the easier it is to move things apart.



A wedge can split a piece of wood.



An inclined plane wraps around the center of a screw. As the screw turns, it moves into the object.

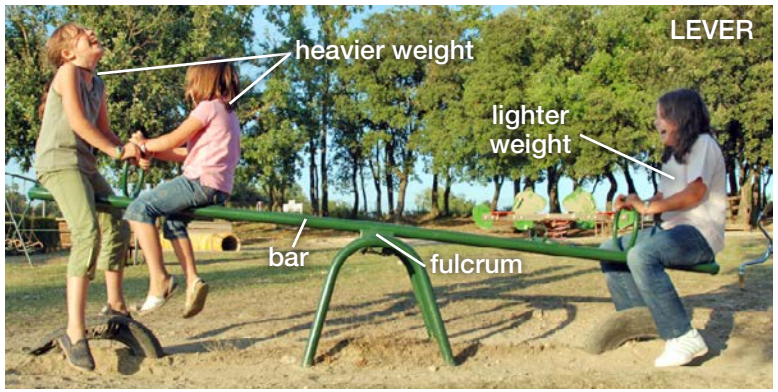
Screw

A **screw** is an inclined plane wrapped around a rod. The thread on a screw is the inclined plane. As you turn a screw, the thread forces the screw into wood or metal. Screws usually hold two things together, such as two pieces of wood. They can also move things by pushing them along using the thread.

Screws hold things together.

A **lever** is a machine that can move heavy things. A lever often has two parts. One part is a board or bar. The board rests on a point called the **fulcrum**. The board pivots, or turns, on the fulcrum. If you want to use a lever to lift something, place the thing on one part of the lever. Then push on another part of the lever.

If you've ever been on a seesaw, you've used a lever. On a seesaw, you can balance with someone much heavier than you. You sit far from the fulcrum, and the heavier person sits close to the fulcrum.



When the fulcrum is close to an object, the object can be lifted more easily but not as high.

With the fulcrum far away from an object, the object is harder to lift, but it can be lifted higher.

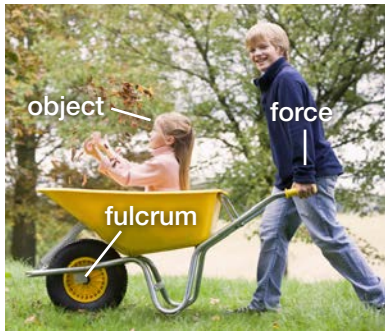
A fulcrum can be put anywhere along a lever, not just in the center. Changing where the fulcrum is can make your job easier. The closer the object is to the fulcrum, the easier it is to move. The farther the force is from the fulcrum, the easier it is to move the object. In the diagram above, the top lever requires half as much force as the bottom one does.

There are several ways to set up a lever. The fulcrum can be between the force and the object, as in a seesaw. Or the object can be between the force and the fulcrum. A wheelbarrow is an example. The force can also be between the fulcrum and the object.

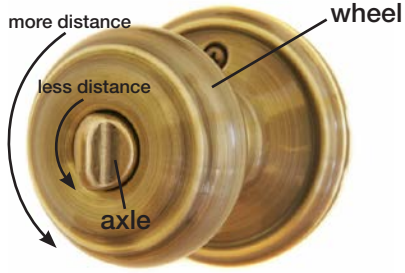
First-Class Lever

Third-Class Lever

Second-Class Lever



Moving the fulcrum and object on a lever can help you do different things.



A wheel turns farther than the axle, but with less force.

Wheel and Axle

A **wheel and axle** is another simple machine. It is made of a **wheel** that is attached to a rodlike **axle**. When the wheel turns, the axle also turns.

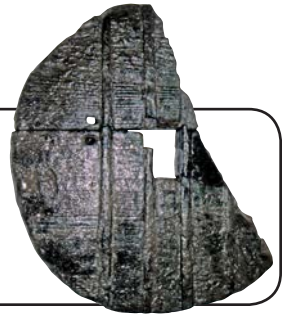
The wheel is wider than the axle. When a force turns the wheel, the force transfers to the axle. The wheel turns a greater distance with less force. The axle turns a lesser distance with more force, so it can move heavy objects. A doorknob is a wheel and axle. It makes opening a door easier. Wheels and axles are used in cars and bicycles.

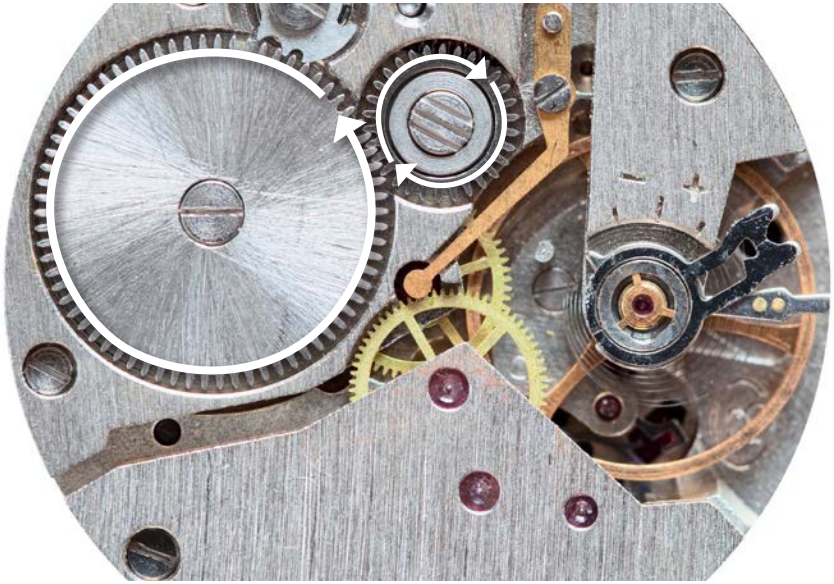
A wagon with wheels creates less friction than a wagon without wheels.

Wheels reduce the amount of **friction** between things. Friction is a force that happens whenever two surfaces rub against each other. It makes it harder to move an object. The more surface that rubs together between objects, the more friction there is. The more friction there is, the harder it is to move the objects past each other. A wheel only has one small part touching the ground at any time, causing friction. Without wheels, there would be a lot more friction between a wagon and the ground.

Do You Know?

The oldest wheel ever found was discovered by archeologists in Slovenia. It is believed to be over 5,100 years old.





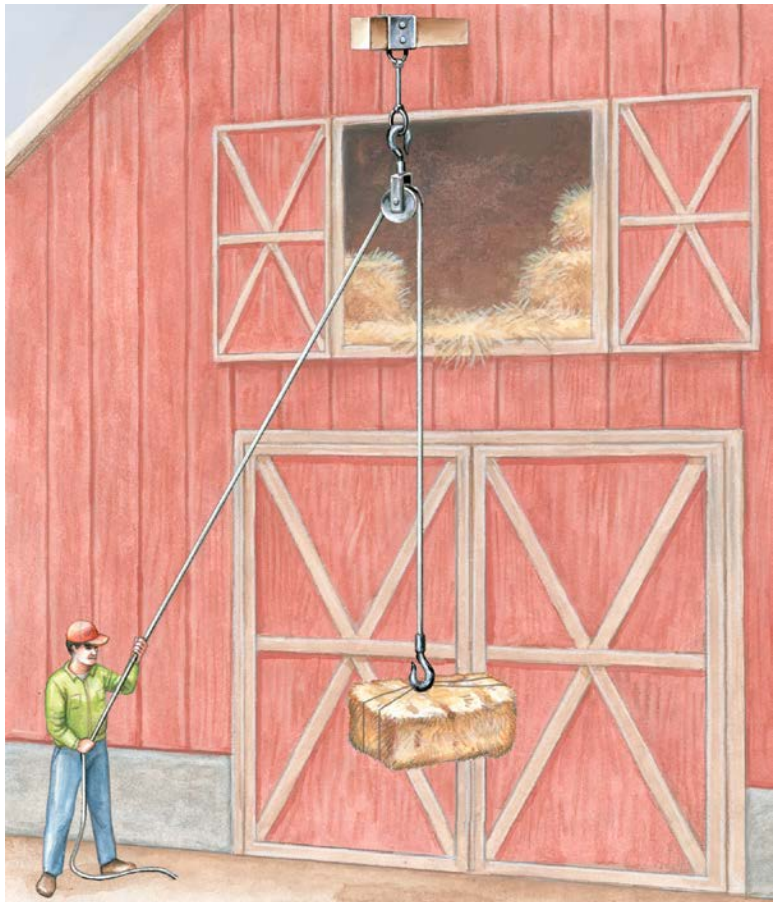
For every time the large gear turns, the small gear turns more than once. The large gear has more force, while the small gear moves faster.

Gear

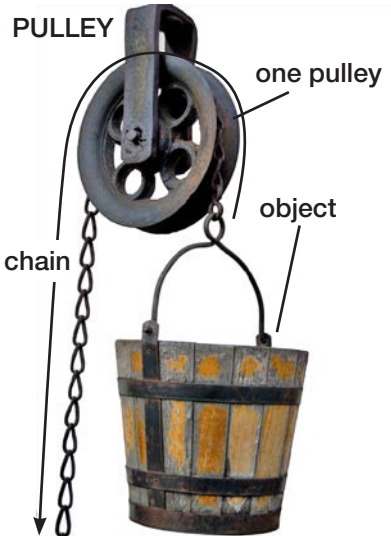
A **gear** is really just a wheel with teeth. Gears transfer force from one place to another. Gears are attached to axles. They can increase or decrease an object's speed or change the amount of force needed to move it. A large gear will turn more slowly than a small gear it is connected to. But the large gear will turn with more force.

Pulley

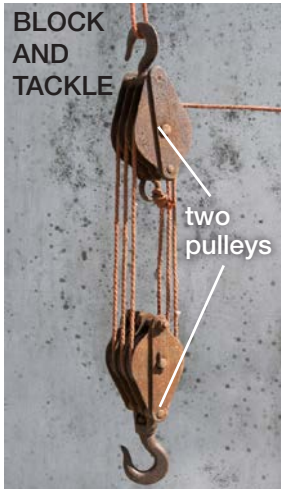
A **pulley** combines a wheel and a rope. The rope changes the direction of a force. Look at the diagram. Pulling down on the rope that is part of the pulley makes the hay rise on the other end.



Pulling down on the rope makes the hay rise.



A pulley changes the direction of the force. Pulling down raises the load.

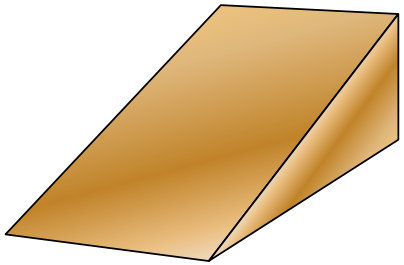
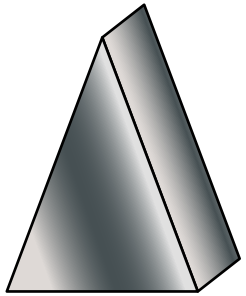
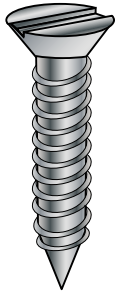


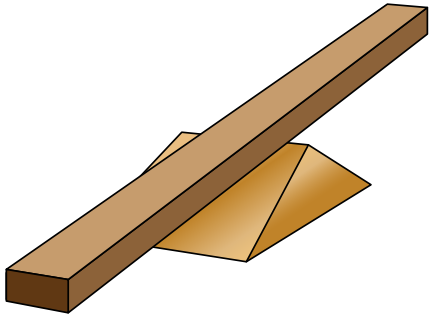
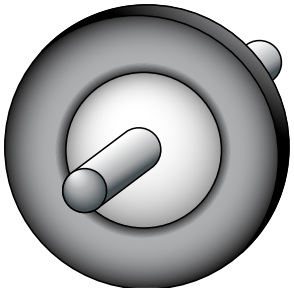
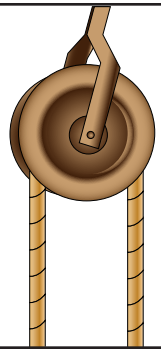
A group of two or more pulleys is called a *block and tackle.* The rope moves farther, but it takes less force to lift the load.

Pulleys can also be used to decrease the amount of force needed to move something. If you put two or more pulleys together, the rope will move farther. Now it will take less force to move it. But remember the trade-off: adding pulleys to reduce force means that you have to pull the rope farther to lift the load. If you add enough pulleys to reduce the force by four times, you must pull the rope four times farther.

Simple Machine Summary

The table below shows the seven major simple machines and their uses.

Simple Machine and Use	Drawing
Inclined Plane To raise or lower heavy objects	
Wedge To split things apart	
Screw To hold things together	

Lever To lift heavy things	
Wheel and Axle To reduce friction and make it easier to move something	
Gear To reduce the force needed to move something	
Pulley To lift heavy objects	

Complex Machines

Many machines combine several simple machines. For example, a wheelbarrow is a lever with a wheel and axle. A bicycle has wheels and axles, pulleys, and gears. A can opener uses a wedge, a lever, and a gear.

Complex machines make difficult or dangerous tasks easier. Electric mixers mix batter over and over. Cranes help us build buildings. Robots build cars and dig through rubble. Each of these machines combines simple machines to make work easier.

Machines do things that people can't. That's why we send robots to explore space and into the deepest parts of the ocean.

Robots like this one might explore the seas on Jupiter's moon Europa.

Conclusion

We use many machines to help us do work. Machines can be simple, with just one or a few parts. Simple machines include the inclined plane, wedge, screw, lever, wheel and axle, gear, and pulley. Complex machines combine simple machines. Many machines help us do tasks that are difficult, boring, or dangerous. All machines help us do work, either by using less force over more distance or more force over less distance. What machines have you used today?

Glossary

axle a pin or pole around which a wheel revolves (p. 14)

complex machines any devices made up of more than one simple machine; compound machines (p. 4)

force the strength or energy that moves an object (p. 5)

friction the force that builds up when two objects rub against each other (p. 15)

fulcrum the point around which a lever pivots or turns (p. 11)

gear a toothed wheel that connects with another toothed object to change speed or direction; a type of simple machine (p. 16)

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 (p. 8)

lever a rigid bar that pivots or turns around a fulcrum; a type of simple machine (p. 11)

load something that is lifted or carried (p. 6)

machine any device that uses energy to help a person do work (p. 4)

pulley a circular lever, usually a wheel with a rope around it; a type of simple machine (p. 17)

ramp a sloped path used to move things between a lower level and a higher level (p. 8)

screw an inclined plane wrapped around a rod, often used to hold things together; a type of simple machine (p. 10)

simple machines any basic devices that work with the use of a single force (p. 4)

wedge a simple machine with one narrow or pointed end and one wide end, used to separate two objects or parts (p. 9)

wheel a round object that turns around a central point (p. 14)

wheel and axle a round object that turns around a pin or pole; a type of simple machine (p. 14)

work the act of moving something (p. 4)

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