4.2 Read

How Do Simple Machines Work Together?

Think about some of the machines you have seen. You have looked at big machines, such as cranes and backhoes. You have also examined pictures of handheld machines, such as drills and screwdrivers. You have discovered that some of the things you use every day, such as scissors and pencil sharpeners, are also machines. Sometimes it is easy to see that a machine is made up of different simple machines. At other times, it is not as easy. The photographs on this page show complex machines. Each one is made up of two or more simple machines.

As you can see in these examples, in a complex machine, two or more simple machines work together. The arm of a backhoe is actually a lever and a wedge working together to get the job done. A wheel and axle and a wedge work together, to make up a screwdriver.





Crane



Screwdriver



Drill



Pencil sharpener





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Some machines, such as a pocketknife or multi-purpose tool, look like complex machines, but they are not. They are made of several different simple machines, but the simple machines are each used separately. For example, you would use the file on a pocketknife at a different time than you would use the knife blade. These two simple machines do not work together, so the pocketknife is not a complex machine.

A shovel is an easy machine to use. It does not have any wheels, knobs, or other moving parts. It seems pretty simple. However, a shovel is a complex machine. It is made of two simple machines working together.

One simple machine that makes up a shovel is a lever. When lifting dirt out of the ground, the handle of a shovel acts as a lever. As you push down on the handle, the bottom of the lever lifts up the dirt. The fulcrum is located at the point where the shovel pivots in the dirt. In this way, the handle changes the direction of the applied force.

You apply less force to the shovel than you would to pull up the dirt and lift it out of the ground. However, your hands move down a larger distance than the dirt moves up. You are applying the force though a greater distance. The mechanical advantage of using the handle of a shovel is that you need to apply less force. Also, the handle changes the direction of the force. The trade-off is that you need to apply the force through a greater distance.

A shovel would not be a good machine for digging if it had only a handle. In order for a shovel to help you dig up dirt, it also needs a second simple machine. The second simple machine on a shovel is a wedge. The bottom of the shovel scoop is shaped like a wedge. The wedge helps push the scoop into the ground, so it can go under the dirt you want to lift up. When you apply a downward force to the scoop, it pushes down on the top of the wedge. The wedge then changes the direction of the force, from a downward direction to a sideways direction. The force pushing sideways pushes the dirt out of the way so the scoop can move through the dirt. The mechanical advantage of using the wedge on the bottom of the scoop is that it changes the direction of the force you apply.

4.2 **Read**

A shovel shows how two simple machines, the lever and the wedge, work together to make it easier to lift and move dirt. You gain the mechanical advantage of both simple machines. The lever and the wedge work together in a shovel to reduce the amount of applied force needed and change the direction of the applied force. Together, this makes it easier to dig dirt than if you were just using your hands. Other complex machines work in the same way. Every complex machine has two or more simple machines working together to make the job they were designed for easier. By looking at what each simple machine does, you can figure out how they work together to make the complex machine work.

Stop and Think

- 1. Draw one complex machine you use every day. Show the simple machines that make it up.
- 2. What is the mechanical advantage of each simple machine that makes up the complex machine in your drawing?
- **3.** What is the mechanical advantage of the complex machine in your drawing? How do the simple machines that make it up work together?
- 4. How can you tell if a machine is a complex machine or not?

What's the Point?

Machines with few, if any, moving parts are called simple machines. These machines can be combined to create a complex machine. A complex machine can be a heavy-duty backhoe or a hand shovel. Both of these are at least two simple machines combined into one machine. Simple machines and complex machines all have a mechanical advantage. For example, when you use a shovel, you trade force for distance. Mechanical advantage makes the moving or lifting of heavy things easier.

