

## LEARNING SET 4 INTRODUCTION

**Learning Set 4****How Can You  
Combine Simple Machines?**

◀ 5 class periods\*

*Students investigate how mechanical advantage is affected by combining simple machines to form complex machines.*

**Overview**

Students pull together the information they gathered in the first three *Learning Sets* to investigate and gain understanding about complex machines, which are part of our everyday experiences. Students then use this information to develop and finalize their designs. The *Learning Set* begins with an overview of how simple machines can be combined to form complex machines. Students then investigate combining simple machines (an inclined plane and a set of pulleys) to form a complex machine. Comparing their measurements for the simple machines alone and the combined machines, they are able to qualitatively compare the mechanical advantage of the simple machines versus the complex machines. Then students are introduced to some more information about how simple machines are combined to create some common complex machines. Next, students apply what they know about machines to pick out the simple machines that compose more complex machines. They are briefly introduced to energy and energy transformations and the idea of energy conservation in the contest of the challenge. Finally, students plan, build, and test their final designs for the challenge.

\*A class period is considered to be one 40 to 50 minute class.

Targeted Concepts, Skills, and Nature of Science	Section
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.	4.1, BBQ
Criteria and constraints are important in design.	BBQ
Scientists must keep clear, accurate, and descriptive records of what they do so they can share their work with others and consider what they did, why they did it, and what they want to do next.	4.1, BBQ

Targeted Concepts, Skills, and Nature of Science	Section
Scientific investigations and measurements are considered reliable if the results are repeatable by other scientists using the same procedures.	4.1
In a fair test only the manipulated (independent) variable, and the responding (dependent) variable change. All other variables are held constant.	4.1
Scientists make claims (conclusions) based on evidence obtained (trends in data) from reliable investigations.	4.1
Explanations are claims supported by evidence, accepted ideas, and facts.	BBQ
Scientists use models to simulate processes that happen too fast, too slow, on a scale that cannot be observed directly (either too small or too large), or that are too dangerous.	BBQ
Machines provide mechanical advantage to assist in moving objects. Mechanical advantage is the tradeoff between force and distance.	4.1, BBQ
There are six different simple machines all of which provide mechanical advantage: Inclined plane, wedge, screw, wheel and axle, lever, and pulley.	4.1, 4.2, 4.3, BBQ
Energy cannot be created nor can it be destroyed, it can only be changed from one form to another through energy transformations.	4.3

**Students' Initial Conceptions and Capabilities**

There are many initial ideas that students have about energy; some are listed below. Keep in mind that we are only introducing the concept. The ideas of energy will be the focus of a different Unit. It is not expected for students to gain deep understanding of the concept of energy.

- Students usually believe that energy can be destroyed or created because they think that energy is something that makes things happen and is expended in process. (Watts, 1983a.)
- Students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again its original form. (Black & Solomon, 1983.)
- Some students associate energy with energy supply. (Brook & Driver, 1984.)

### Students' Initial Conceptions and Capabilities

- Students usually believe that energy is associated only or primarily, with animate objects such as living things need energy to live and be active. (Solomon, 1983.)
- Students tend to think that energy transformations involve only one form of energy at a time. (Brook & Wells, 1988.)
- Even when students are aware of the energy conservation principle and are able to use it to explain phenomena, it seems that most of them do not choose to use it when given a free choice. (Duit, 1981.)

## Understanding for Teachers

### Complex Machines

Complex machines are machines that combine two or more simple machines that work together. The complex machine gains the mechanical advantage of each simple machine as it functions. The machines we commonly use every day are complex machines such as can openers, pencil sharpeners, shovels, fishing poles, hammers, and most construction equipment.

An example of a complex machine is a shovel. A shovel is made of a lever (the handle) and a wedge (the blade). When you push down on the top of the handle, the bottom of the lever lifts the dirt up. The fulcrum is located at the point where the shovel pivots in the dirt. The advantage of using the handle of a shovel is that you need to apply less force and the handle changes the direction of the force. The tradeoff is that you need to apply the force through a greater distance. The second simple machine on a shovel is a wedge, which helps to push the scoop into the ground so it goes under the dirt that you want to lift up. When you apply a force to the shovel with your foot, the wedge is pushed down in the dirt. 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 go into the dirt that you want to lift. The advantage of using the wedge on the bottom of the scoop is that it changes the direction of the force that you apply.

The lever and the wedge on a shovel work together to make it easier to lift and move dirt. When you use a shovel, you gain the advantage of both simple machines. You need to apply less force than lifting the dirt without the machine and the force you apply is transformed from a downward direction to a sideways direction to move into the dirt. The advantage of using this complex machine is greater than using either simple machine alone. The lever and the wedge work together in a shovel to reduce the amount of applied force and change the direction of the applied force.



## LEARNING SET 4 IMPLEMENTATION

◀ 5 class periods



## Learning Set 4

## How Can You Combine Simple Machines?

**complex machine:** a machine that is a combination of two or more simple machines.

The *Big Question* for the Unit is *How do machines help move large, heavy objects?* You learned about the forces that make objects move. You know that to change the speed or direction of an object, forces must be unbalanced. If the forces are equal, or balanced, then the object's motion will not change. Often, human strength by itself is not enough to generate an unbalanced force. You need to use a machine. The mechanical advantage of a machine describes how much a specific machine can multiply the force applied by the person operating it. Machines can also change the direction or distance of an applied force. A machine, however, cannot change the amount of work required to move an object.



Scissors are made up of two first-class levers joined together at the fulcrum. The cutting edges are wedges.

You learned about six simple machines—the inclined plane, the wedge, the screw, the lever, the pulley, and the wheel and axle. A single simple machine cannot always provide enough mechanical advantage to perform a given task. In fact, very few of the machines you use everyday are simple machines. Most machines are made up of at least two, and often many more, simple machines. Machines that are made up of two or more simple machines working together are called **complex machines**.

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Project-Based Inquiry Science

## Learning Set 4

### How Can You Combine Simple Machines?

10 min.

*Introduce the Learning Set by eliciting students' ideas.*

### Engage

Briefly elicit students' ideas about the advantages of combining simple machines and what ideas they have about these machines. Record students' ideas.

#### TEACHER TALK

“This *Learning Set* focuses on combining simple machines. What are some examples of combined simple machines? What simple machines are they made of? What do you think the advantages or disadvantages are of combining these machines?”

