PP226

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SIMPLE MACHINES LAB

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Targets standards in these areas:

- Understanding how simple machines help move objects and make work easier
- Recognizing that machines convert energy to motion
- Building and using simple machines to make work easier
- Knowing that tools and machines are used to apply forces—pushes and pulls—to make things move

What's Included

- 7 experiment cards
- Lever (arm and fulcrum)
- Wheel and axle
- Fixed pulley
- Movable pulley
- 2 inclined planes (one-inch and three-inch) and landing base
- Four-ounce weight
- 2 eight-ounce weights
- String (18 feet)
- 6 plastic hooks
- 20 rubber bands
- Ruler
- Wooden display stand

Before You Begin

- Reproduce the experiment cards for students to complete in pencil. Then gather the required materials listed at the top of each card.
- For the following experiment cards, cut the length of string indicated:
  - *Inclined Plane* – one 12″ piece
  - *Wheel and Axle* – two 12″ pieces
  - *Fixed Pulley* – one 36″ piece
  - *Fixed and Movable Pulleys* – two 36″ pieces

Investigate the Concept

■ Perfect for science centers, our hands-on lab is a fun, engaging way for students to explore simple machines! Children just display one of the seven experiment cards in the wooden stand and follow the step-by-step instructions to complete the activity. Plus, the back of each card features background information on the concept covered by the experiment—so students learn important facts as they work.

■ Discuss simple machines with your students. You may want to briefly explain the scientific method and how scientists use experimental evidence to answer questions. Point out that each experiment answers a specific question about simple machines and demonstrates how each machine is designed to make work easier.

■ Now discuss the following terms, which students will read on the backs of the experiment cards:

- **arm:** the part of a lever that holds the load and receives effort force
- **effort:** the amount of energy you have to use to move a load
- **effort force:** the force you use to move a load with a lever
- **first-class lever:** a lever whose fulcrum is between its load and effort force
- **fixed pulley:** a pulley that is fixed to a surface and changes the direction of the force used to move a load
- **friction:** the force between objects that are touching each other
- **fulcrum:** the part of a lever that the arm turns on
- **inclined plane:** a simple machine with a flat surface and one raised end
- **lever:** a simple machine that uses an arm and a fulcrum to move an object
- **load:** an object that you move from one place to another with a simple machine
- **movable pulley:** a pulley that is not fixed in place and does not change the direction of the force used to move a load
- **pulley:** a simple machine made up of a wheel and a cord that helps you lift and lower things
- **second-class lever:** a lever whose load is between the effort force and fulcrum
- **simple machine:** a machine that changes a force's direction or strength and makes work easier

(continued)

- **third-class lever:** a lever whose effort force is between the load and fulcrum
- **wheel and axle:** a simple machine that is made up of one or more wheels with a rod, or axle, through the center

■ Before students work independently, model how to complete one of the experiments. Place one of the experiment cards on a document camera and demonstrate how to complete several of the steps.

■ Finally, select an experiment for students to conduct, and place the card in the wooden stand. Then set out the required materials (including a photocopy of the experiment card for each student). Remind students to read the information on the back of the card before beginning the experiment on front.

Talk About Your Thinking

As students work through the experiments, ask them the following questions to prompt discussion and engage their thinking:

- What are some everyday examples of simple machines?
- How do simple machines make work easier?
- Have you used any of these simple machines in your daily activities?

Extend the Learning

Encourage students to create science journals to keep a record of what they've learned from the simple machines experiments. Have children write down the important terms from the backs of the cards, and prompt them to illustrate each term. After students complete each experiment, prompt them to look for real-world examples of that card's topic. Invite children to write these examples next to the corresponding vocabulary terms in their journals. Then ask students to share their real-world examples and explain how they relate to the experiments.

Integrate Technology

■ **Internet** Encourage students to research simple machines on the Internet. Explain that they will compile a list of reputable websites as a resource for the class. Instruct students to scrutinize the reliability of a site by having them consider questions such as the following:

- Does the site provide good real-life examples?
- Is the information correct and easy to understand?
- What kind of site is it?

To get students started, have them visit the Exploratorium® at http://www.exploratorium.edu/explore/motion-matter.

Meeting Individual Needs

❑ ELL
Before students conduct an experiment, review the important terms on the back of the card. You can also use the pictures on the back of the card to help explain the terms. Encourage children to write the terms in a science journal or on index cards. Ask students to draw a picture for each term. Then introduce each of the experiment's required components. Allow students to refer to their notes as they complete the experiment. Have students conduct the experiment with a partner.

❑ Reteach/Extra Support
With a small group or one-on-one, read the passage on the back of an experiment card, checking for understanding as you go. Then review the important terms and their definitions. Ask students to provide an oral summary of the passage and explain the important terms. Now review the directions on front to make sure children understand the task. Invite children to complete the experiment and direct them to keep in mind the concepts from the back of the card.

❑ Challenge
Encourage students to do independent research to learn more about the simple machines covered in this lab. Invite children to get nonfiction books from the school library or search the Internet for information on simple machines and their real-world uses. After students complete their research, have them expand on the experiments in the lab. For example, students can use different weights and adjust the fulcrum of the lever to see which configuration makes work easiest.

- **Computer** Have students create a slide show presentation about a type of simple machine. Instruct students to include photos and information about how the simple machine moves loads, how it makes work easier, and real-life examples of it.

Assessment

- After students complete an experiment, collect their papers and review their work. Keep the papers in students' files.
- Create a quiz to check students' understanding of the important terms on the cards. For easy reference, the terms and definitions are listed on pages 1–2 of this guide.

Summary of Experiment Outcomes

- **Inclined Plane** Students will learn that an inclined plane is a flat surface with one raised end. Students will also learn that a ramp is an inclined plane that helps us move things from one level to another. They will understand that the angle of the inclined plane affects the amount of force required to move the load.
- **First-Class Lever** Students will learn that a first-class lever's fulcrum is between its load and effort force. Students will also learn that a first-class lever helps us lift objects, and the amount of effort force required to lift a load can be changed.
- **Second- and Third-Class Levers** Students will learn that a second-class lever's load is between the effort force and fulcrum, and that a third-class lever's effort force is between the load and fulcrum. Students will also learn that both second- and third-class levers help us lift objects.
- **Wheel and Axle** Students will learn that a wheel and axle is made up of one or more wheels with a rod, or axle, through the center. Students will also learn that a wheel and axle helps the user move objects. Students will understand how a wheel and axle reduces friction between a load and the surface that load is moving on.
- **Fixed Pulley** Students will learn that a pulley is made up of a wheel and a cord, and that a fixed pulley is attached, or fixed, to a surface. Students will also learn that a fixed pulley changes the direction of the force that is used to move the load.
- **Fixed and Movable Pulleys** Students will review what they already know about fixed pulleys and learn that, unlike a fixed pulley, a movable pulley is not fixed in place, moves with the load, and does not change the direction of the force that is used to move the load. Students will also learn that a movable pulley requires less force than a fixed pulley does to move the same load.
- **Making Work Easier with First-Class Levers** Students will review what they already know about first-class levers and learn that it is easiest to lift a load with a first-class lever when the effort force side of the arm is long because less force is required to lift the load.

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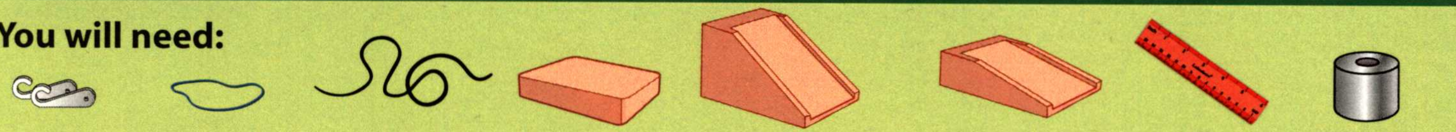
INCLINED PLANE

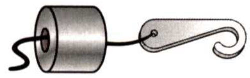
Name ____________________

You will need:

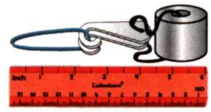


2 Hooks | Rubber Band | String (12") | Base | Inclined Plane (3") | Inclined Plane (1") | Ruler | Weight (8 oz.)

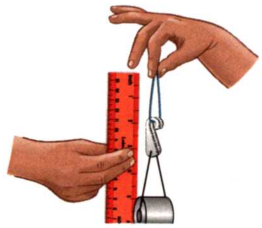
1. Read the back of this card. Tie a hook to one end of the 12-inch string. Thread the other end of the string through the hole in the weight.



2. Tie a second hook to the other end of the string. Attach both hooks to a rubber band. Measure and record the length of the rubber band at rest.



3. Lift the weight off the table using the rubber band. **How long is the rubber band now?** Measure and record the length of the hanging rubber band.



4. Place the three-inch inclined plane against the base as shown. Place the base against a stack of books. Pull the weight, or the load, up the inclined plane using the rubber band. **How long is the rubber band now?** Measure and record the length of the rubber band when the weight is midway up the inclined plane. Compare the measurement to the measurement you got in Step 3. **Did the rubber band stretch more or less with the inclined plane?**

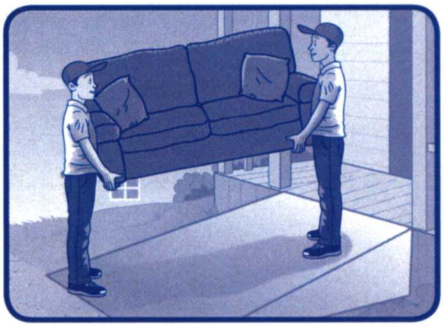
5. Place the one-inch inclined plane next to the base as shown. Place the base against a stack of books. Using the rubber band, pull the weight up the inclined plane. **How long is the rubber band now?** Measure and record the length of the rubber band when the weight is midway up the inclined plane. Compare the measurement to the measurements you got in Steps 3 and 4. **What was the easiest way to move the load?**

LENGTH OF RUBBER BAND

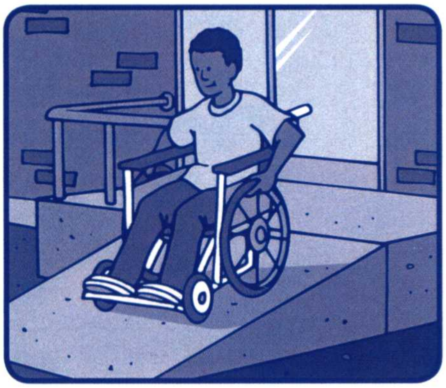
At Rest	Hanging (No Inclined Plane)	3" Inclined Plane	1" Inclined Plane

HOW DOES AN INCLINED PLANE WORK?

An **inclined plane** is a **simple machine**. It is a flat surface with one raised end. When you need help moving an object, or **load**, from one height to another height, you can use an inclined plane. With an inclined plane, you have to move a load a greater distance than if you were to lift it straight up. But the amount of **effort** you use to lift a load with an inclined plane is less than you would use if you were to lift the load directly up.



The steeper an inclined plane is, the easier it is for gravity to pull an object down its surface. This means you have to use more force to pull an object up a steep inclined plane than you have to use to pull an object up a flatter inclined plane.



Inclined planes are all around us every day! Furniture movers use inclined planes to carry heavy objects in and out of trucks and homes. When a wheelchair user needs to move from the sidewalk to a higher area, he uses an inclined plane. And when people need to drive over mountains or hills in their cars, they travel on roads that are inclined planes. A lot of tasks would be much harder without inclined planes!

Important Terms	
inclined plane	A simple machine with a flat surface and one raised end
simple machine	A machine that changes a force's direction or strength and makes work easier
effort	The amount of energy you have to use to move a load
load	An object that you move from one place to another

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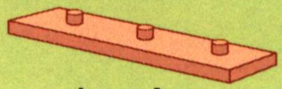
FIRST-CLASS LEVER

Name ______________________

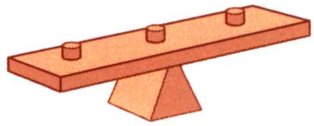
You will need:


Lever Arm

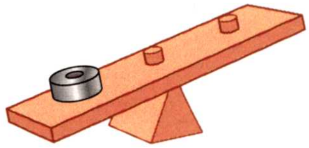

Fulcrum


Weights (4 oz. and 8 oz.)

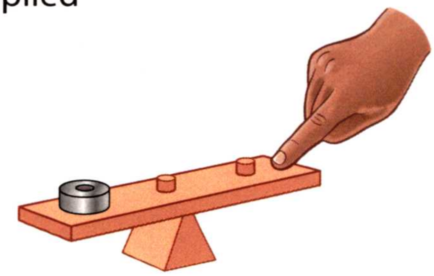
1. Read the back of this card. Place the fulcrum—with the rounded edge on top—on the table. Then place the center notch of the lever arm on top of the fulcrum. It should look like the picture at right.



2. Place the four-ounce weight onto one end of the lever arm. This will be the lever's load, or the object you will lift. The force you use to lift the load is called effort force. The effort force is applied on the opposite side of the lever arm.



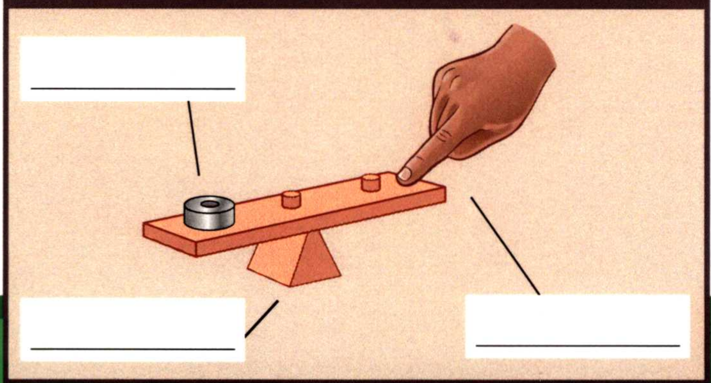
3. Use your finger as the effort force to lift the weight. **What happens?**



4. Replace the four-ounce weight with the eight-ounce weight. Use your finger to lift the weight. **What happens? How was it different than lifting the four-ounce weight?**

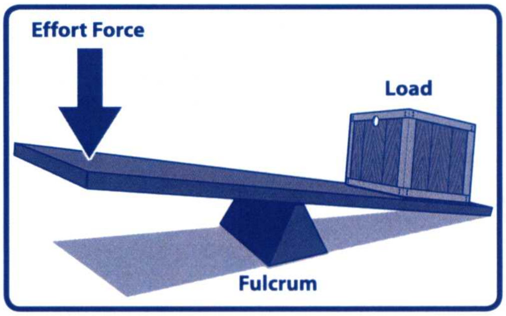
5. In the diagram at right, label the **fulcrum**, **load**, and **effort force**.

First-Class Lever

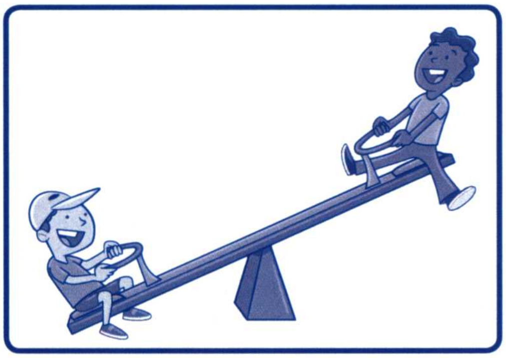


HOW DOES A FIRST-CLASS LEVER WORK?

A **first-class lever** is a **simple machine** that uses an **arm** and a **fulcrum** to help you lift an object. The fulcrum is the part of a lever that the arm turns on. The object you lift with a lever is called a **load**, and the force you use to lift the load is called **effort force**. On a first-class lever, the fulcrum is between the load and the effort force. To lift a load on the left side of the arm, you push *down* on the arm's right side. This means that a first-class lever's load moves in the opposite direction of the effort force.



Can you think of examples of first-class levers? You might be surprised to know that a teeter-totter is a first-class lever! On a teeter-totter, each person's weight is an effort force that raises the other person. What happens when one person on a teeter-totter is a lot heavier than the other person? The lighter person probably has a fun time going up in the air, but it might be hard to lift the heavier person!



Important Terms	
first-class lever	A lever whose fulcrum is between its load and effort force
simple machine	A machine that changes a force's direction or strength and makes work easier
arm	The part of a lever that holds the load and receives effort force
fulcrum	The part of a lever that the arm turns on
load	The object that you move with a lever
effort force	The force you use to move a load with a lever

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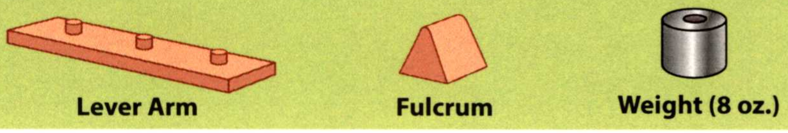
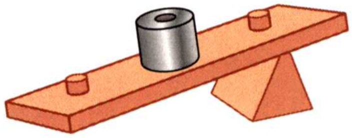
SECOND- AND THIRD-CLASS LEVERS

Name ______________________

You will need:

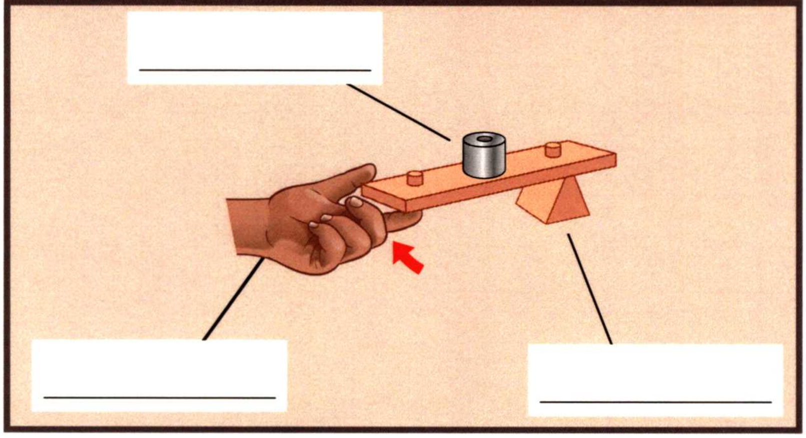


1 Read the back of this card. To make a second-class lever, place the fulcrum—with the rounded edge on top—on the table. Then place one of the outer notches of the lever arm on top of the fulcrum. Put the eight-ounce weight on the center notch of the arm.



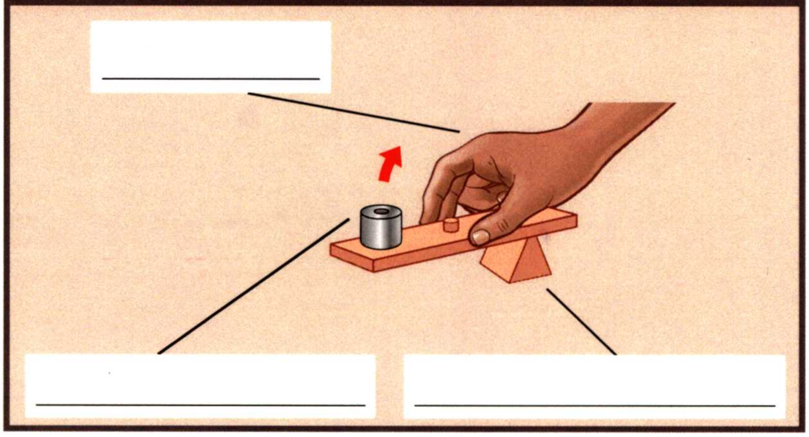
2 Use your thumb and index finger to lift the lever arm from the end farthest from the fulcrum. This is where the effort force occurs. In the diagram at right, label the **fulcrum**, **load**, and **effort force**.

Second-Class Lever



3 To turn the second-class lever into a third-class lever, move the weight, or the load, to the notch farthest from the fulcrum. Resting your hand on the arm and using your thumb and index finger, gently pull up on the center of the lever arm to lift the load. In the diagram at right, label the **fulcrum**, **load**, and **effort force**.

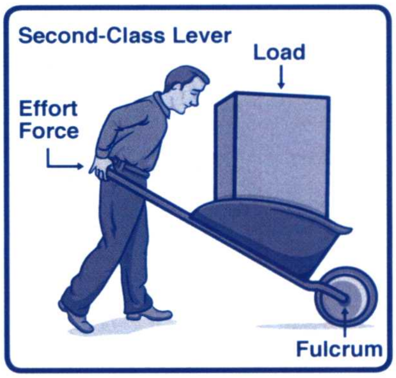
Third-Class Lever



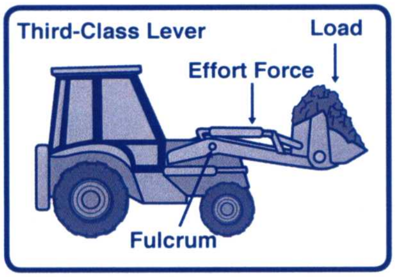
HOW DO SECOND- AND THIRD-CLASS LEVERS WORK?

A **second-class lever** is a **simple machine** that uses an **arm** and a **fulcrum** to help you lift an object. The fulcrum is the part of a lever that the arm turns on. The object you lift with a lever is called a **load**, and the force you use to lift the load is called **effort force**. On a second-class lever, the load is between the effort force and the fulcrum. To lift the load, you pull up on the end of the arm that is opposite the fulcrum. This means a second-class lever's load moves in the same direction as the effort force.

A wheelbarrow is a common second-class lever. When a gardener wants to move a load of dirt with a wheelbarrow, he first puts the dirt into the wheelbarrow's bucket. Then he lifts up on the wheelbarrow's handles and pushes the wheelbarrow to the place where he would like to dump the dirt. The wheelbarrow's wheel is a fulcrum (and it also makes it easy to move the load once it is lifted).



A **third-class lever** also uses an arm and a fulcrum to help you move or hold an object. On a third-class lever, the effort force is closer to the middle of its arm, between the load and the fulcrum. You push or pull on the arm, and the load moves in the direction of your force. The arm of a shovel truck is a third-class lever that lets construction workers lift mounds of dirt. To use a shovel truck, the driver controls the arm, lowering the scoop to the ground. Then, to lift the arm up, the effort force between the fulcrum and the scoop pulls up to raise the load (the dirt-filled scoop).



Important Terms	
second-class lever	A lever whose load is between the effort force and fulcrum
simple machine	A machine that changes a force's direction or strength and makes work easier
arm	The part of a lever that holds the load and receives effort force
fulcrum	The part of a lever that the arm turns on
load	The object that you move with a lever
effort force	The force you use to move a load with a lever
third-class lever	A lever whose effort force is between the load and fulcrum

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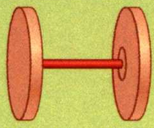
WHEEL AND AXLE

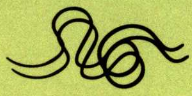
Name ____________________

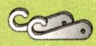
You will need:


2 Rubber Bands

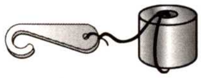

2 Weights (8 oz.)


Wheel and Axle

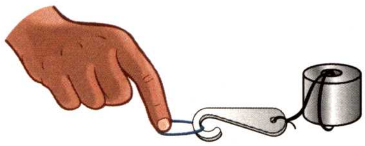

2 Strings (12")


2 Hooks

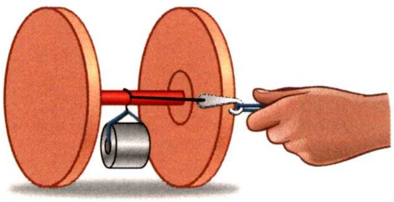
1. Read the back of this card. Tie a hook to one end of a 12-inch string. Feed the other end of the string through the hole in an eight-ounce weight, and tie a knot around the weight.



2. Attach a rubber band to the hook. Use the rubber band to drag the weight along the table. Notice how much the rubber band stretches when dragging the weight across the table.



3. Tie the other string to the second weight like you did in Step 1. Carefully tie the weight around the axle so the weight doesn't touch the table. Attach a rubber band to the hook. Use the rubber band to pull the weight along the table. **How does the wheel and axle move the weight across the table?**



4. Compare moving the weight with and without the wheel and axle. **Which method required less effort to move the weight?** Explain your answer below.

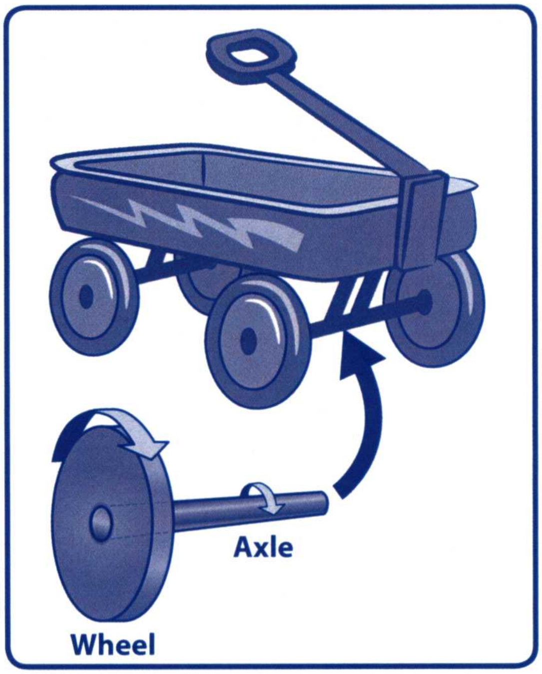
Describe what happened!

Without the Wheel and Axle	
With the Wheel and Axle	

HOW DOES A WHEEL AND AXLE WORK?

A **wheel and axle** is a **simple machine** used for moving objects, or **loads**. It is made up of one or more wheels with a rod, or axle, through the center. A wheel and axle helps you do work by taking away some of the **friction** between a load and the surface that the load is moving on. Like most simple machines, the wheel and axle is very common! In fact, it would be hard to get around if it weren't for the wheel and axle! It's used on everything from wagons and skateboards to cars and bicycles.

A wagon's bucket is attached to two axles, which each go through two wheels. When you put a load in a wagon and then pull the wagon by its handle, its wheels spin, turning the axles. And because the bucket is connected to the axles, it moves in the direction the wheels are spinning.



Vehicles work the same way. A truck's body is attached to two axles that are each connected to two wheels. Trucks can haul very heavy loads because the friction between their wheels and the road is much less than the friction that would happen between the ground and the loads themselves.

Important Terms	
wheel and axle	A simple machine that is made up of one or more wheels with a rod, or axle, through the center
simple machine	A machine that changes a force's direction or strength and makes work easier
load	The object you move with a wheel and axle
friction	The force between objects that are touching each other

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FIXED PULLEY

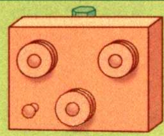
Name ____________________

You will need:


Hook

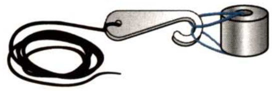

Rubber Band


String (36")


Fixed Pulley

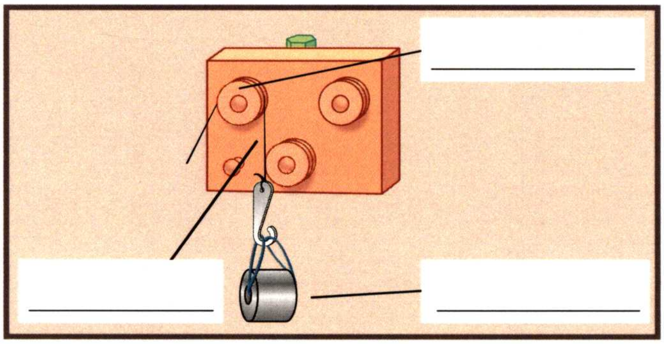

Weight (8 oz.)

1. Read the back of this card. Tie a hook to one end of the 36-inch string. Thread a rubber band through the hole in the weight, and join the ends of the rubber band together with the hook.

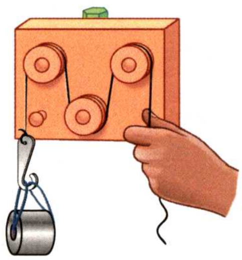


2. Lift the weight from the table using the string. Notice the direction that you moved the string to lift the weight.

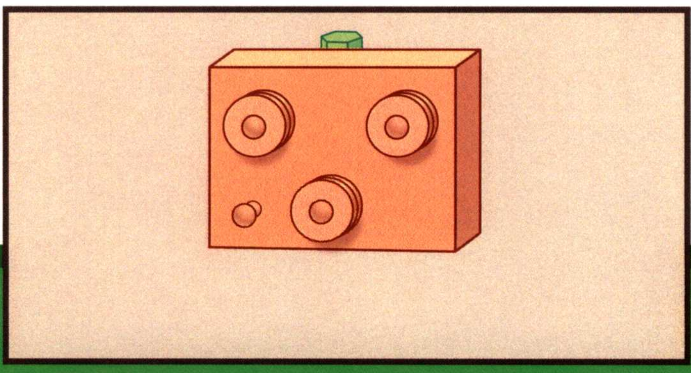
3. Attach the fixed pulley to the table. Then place the string along the groove of a pulley wheel. Now pull on the string. **What direction did you pull the string to move the weight up?** In the diagram at right, draw an arrow to show the direction that you pulled the string and label the **wheel**, **cord**, and **load**.

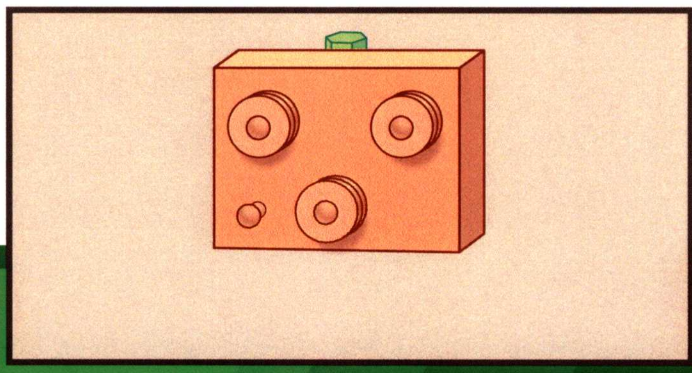


4. Now try using all three pulley wheels to lift the weight. Place the string along the top of the first wheel, then along the bottom of the middle wheel, and finally along the top of the last wheel. Pull the string to lift the weight. **What direction did you pull the string to move the weight up?**



5. Place the string on the wheels in different arrangements. **What other directions can you pull the string?** Use the boxes below to draw two of your arrangements. Add an arrow in each one showing the direction you pulled the string. **How does a pulley change the direction of the force used to move the load?**

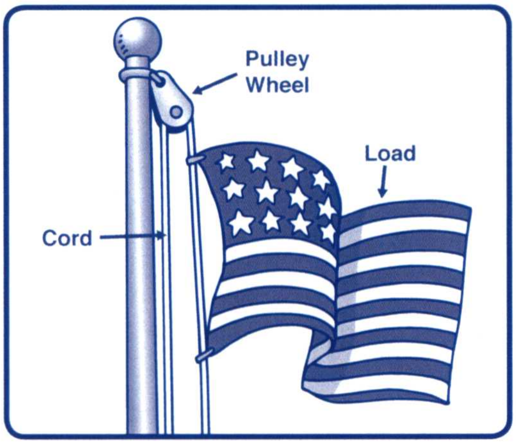


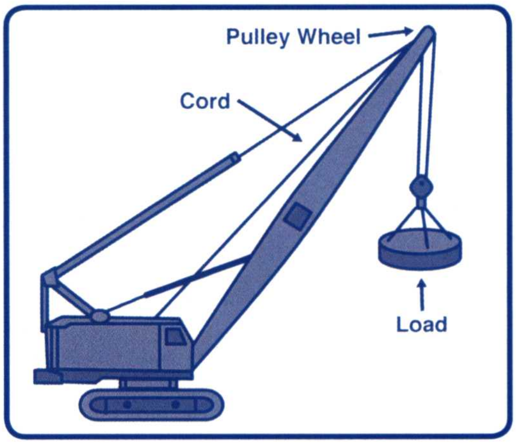


HOW DOES A PULLEY WORK?

A **pulley** is a **simple machine** that uses a wheel and a cord to help you lift or lower objects, or **loads**. Pulleys are so helpful that we use them every day—from flagpoles and cranes to tow trucks and fishing poles!

A pulley that is fixed in place changes the direction of the force you use to move a load. For example, when a construction worker needs to lift a heavy beam, he puts a pulley over the beam and then attaches the pulley's cord to it. Then he pulls *down* on the other end of the cord to lift the beam *up*! This type of pulley makes it easier to do work, but the amount of force you use to pull on the cord must be greater than the weight of the load.





Important Terms	
pulley	A simple machine made up of a wheel and a cord that helps you lift and lower things
simple machine	A machine that changes a force's direction or strength and makes work easier
load	The object you move with a pulley

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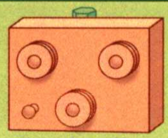
FIXED AND MOVABLE PULLEYS

Name ______________________

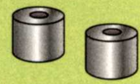
You will need:


2 Rubber Bands


Fixed Pulley

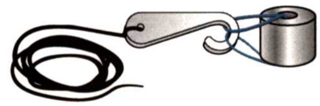

Movable Pulley


2 Strings (36")

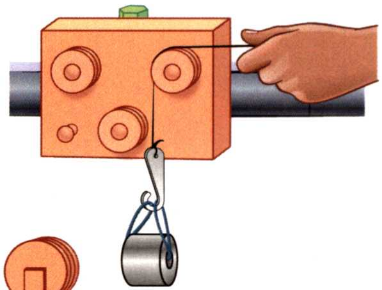

2 Weights (8 oz.)


2 Hooks

1. Read the back of this card. Tie a hook to one end of a 36-inch string. Feed a rubber band through the hole in an eight-ounce weight, and join the ends of the rubber band together with the hook. Lift the weight from the table using the string.

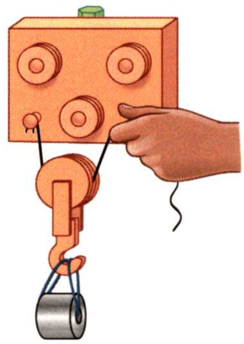


2. Attach the fixed pulley to the table. Now test lifting the weight with a fixed pulley. Notice the effort required to lift the weight.

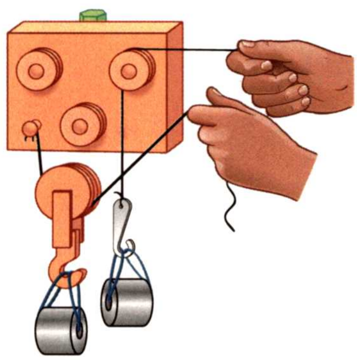


3. Feed a rubber band through the hole of the other eight-ounce weight. Use the hook on the movable pulley to join the ends of the rubber band together.

4. Tie one end of the second string to the peg on the fixed pulley. Thread the other end of the string through the underside of the movable pulley. Now pull the string to lift the weight. Notice the effort required to lift the weight. **What direction did you move the string to pull the weight up?**



5. Compare lifting the weight using the methods in Steps 1, 2, and 4. Describe the difference between the three methods. **Which is the easiest way to lift the weight?**

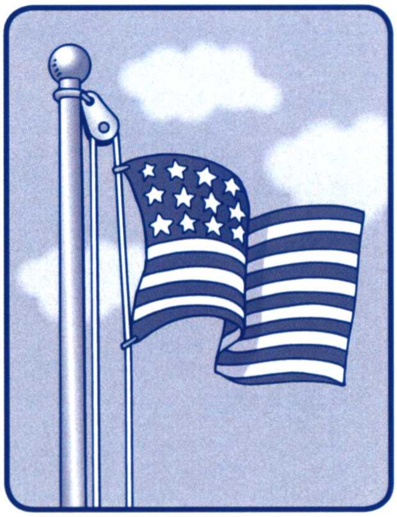


Without a Pulley	
With a Fixed Pulley	
With a Movable Pulley	

HOW DO PULLEYS HELP US DO WORK?

A **pulley** is a **simple machine**. It uses a wheel and a cord to help you lift or lower objects. Pulleys are so helpful that we use them every day—from flagpoles and cranes to tow trucks and fishing poles!

The wheel of a **fixed pulley** is attached, or fixed, to a surface, such as a ceiling. It stays in place as you use it. Fixed pulleys are best for lifting things that you can't push upward. This is because a fixed pulley changes the direction of the force you use to move an object, or the load. For example, if a mechanic needs to lift a heavy engine out of a car, he uses a fixed pulley for help. He positions the car under the pulley and then attaches the pulley's cord to the engine. Then he pulls *down* on the other end of the cord to lift the engine *up*! A fixed pulley makes it easier to do work, but the amount of force you use to pull on the cord must be equal to or greater than the weight of the load.



Unlike a fixed pulley, a **movable pulley** moves with the load. Movable pulleys don't change the direction of your force—and that's why they are best for lifting objects that are below you. If a builder wants to lift a heavy box from the ground to a balcony, she first attaches the box to the hook on the bottom of the pulley. Then she attaches one end of the pulley's cord to the balcony where she is standing. Finally she pulls *up* on the other end of the cord to lift the pulley and box *up*. It may seem like a lot of work to lift a load with a movable pulley, but it requires less force than lifting the same load with a fixed pulley!

Important Terms	
pulley	A simple machine made up of a wheel and a cord that helps you lift and lower things
simple machine	A machine that changes a force's direction or strength and makes work easier
fixed pulley	A pulley that is fixed to a surface
movable pulley	A pulley that is not fixed in place

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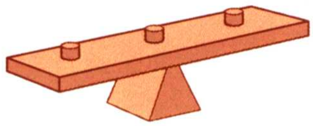
MAKING WORK EASIER WITH FIRST-CLASS LEVERS

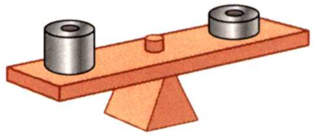
Name ____________________

You will need:

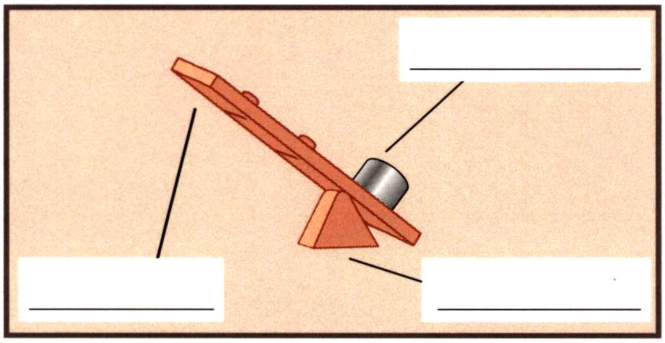
1 Read the back of this card. Place the fulcrum—with the rounded edge on top—on the table. Then place the center notch of the lever arm on top of the fulcrum.



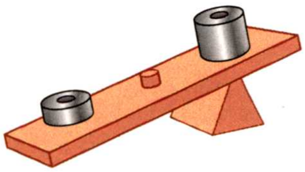
2 Place an eight-ounce weight on one end of the lever arm. Now place the four-ounce weight on the opposite end of the lever arm. Describe what happens in the box below.



3 Now remove the weights. Place one of the outer notches of the lever arm above the fulcrum. Place an eight-ounce weight on the end of the arm closest to the fulcrum. This makes the load side of the arm shorter and the effort force side of the arm longer. Label the **fulcrum**, **load**, and **lever arm**.



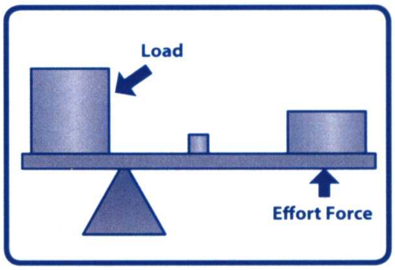
4 Now use the four-ounce weight as the effort force on the end of the lever arm opposite the eight-ounce weight. **What happens? How does lengthening the effort force side of the lever arm affect the effort force?** Write your answer in the box below.



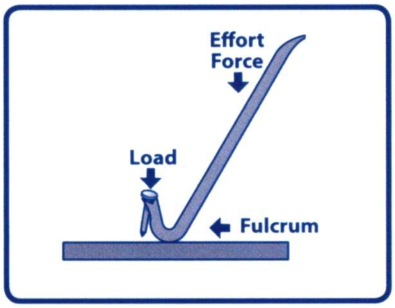
HOW DOES A FIRST-CLASS LEVER MAKE WORK EASIER?

A **lever** is a **simple machine** that uses an **arm** and a **fulcrum** to lift an object, or **load**. In a **first-class lever**, the fulcrum is between the load and the effort force of an arm. To lift the load, you need more effort, or weight, to tip the scale.

It's easiest to lift a load with a first-class lever when the effort force side of the arm is long. In the picture at right, the load is an eight-ounce weight placed near the fulcrum. This increases the length of the effort force side of the arm and makes it easier to lift the load. Less force is required to lift the load, which makes it easier for a lighter weight to lift the heavier weight.



A pry bar is a lever that works the same way! If a builder were using a pry bar with a short effort force side to pull a nail out of a board, it would be very hard to do! That's why the load side of the pry bar is short and the effort force side is long.



Important Terms	
lever	A simple machine that uses an arm and a fulcrum to move an object
simple machine	A machine that changes a force's direction or strength and makes work easier
arm	The part of a lever that holds the load and receives effort force
fulcrum	The part of a lever that the arm turns on
load	The object that you move with a lever
first-class lever	A lever whose fulcrum is between its load and effort force

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