Simple Machines

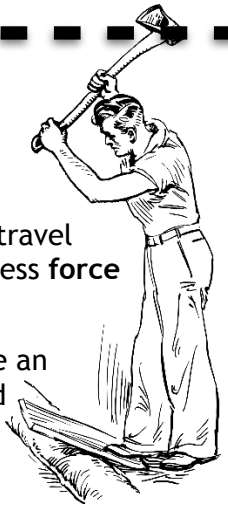
In this packet, we will be learning the basic physics behind simple machines! We are then going to practice these principles in easy and fun activities that can be done in the classroom or at home.

Contact the National Museum of the U.S. Navy for Field Trip and School Visit opportunities!

*This packet is intended for elementary schools, to be used in groups of three or fewer and/or individually.

National Museum of the United States Navy

What is a Simple Machine?



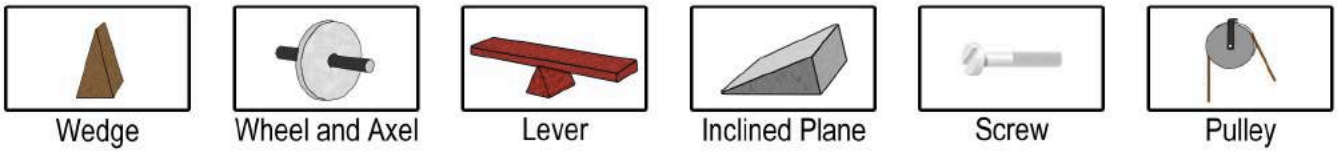
Machines help make our lives easier. We use them to complete tasks more quickly or efficiently than we could on our own. This can be as complicated as using an airplane to travel from New York to California, or as simple as opening a door. With their help, we can use less **force** to move an object.

A **force** is a push or a pull on an object. Two forces you may have to work against to move an object are **friction** and **gravity**. **Friction** is the force of two objects rubbing together, and **gravity** is the force of two objects pulling on each other. The more force that acts on an object, the harder it is to move. Scientists all the amount of these forces **work**. You do **work** when you push or pull a simple machine.

If you get more get more force out of a simple machine than you put into it, that machine has a **mechanical advantage**. That means the machine is making your work easier because you can use less force than you would without the machine. You are still doing the same amount of work, but the machine helps you spread the work over a longer period of time.

Simple machines are the most basic machines. So basic, you might not even realize they were machines! Simple machines are devices with very few parts. There are six different kinds of simple machines: *levers, pulleys, inclined planes, wedges, screws, and wheels and axles*. Simple machines can work together to build a more complex machine like a bicycle, or even an air craft carrier. These are known as a **compound machines**.

Simple Machines



Guiding Question:

How many simple machines have you used today?

Let's learn about these simple machines on the next page!

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Levers

A lever has two parts: a **fulcrum**, and a sturdy flat object that rotates on the fulcrum to lift an object. In rowing, for example, your arm is a lever, your elbow is the fulcrum, and your forearm is the sturdy object. When you bend your elbow, you are using a lever. When you place the sturdy object under something heavy, like a box or a crate, and then push down on the opposite side, the fulcrum helps the other side of the object lift the box. The object or objects you are trying to lift are called the load. The force you use to move the lever is called the effort.

Oars are also levers, and were very important to sailors before the invention of steam powered ships. During the Age of Sail, U.S. Navy sailors often used oars to power small boats. These smaller vessels were important in communicating between other ships, delivering mail, or bringing people to shore.

Rowing a boat is an excellent example of a First Class Lever!

Let's Check it Out!

There are three classes of levers, and we use all three everyday! Let's look at these "classes" of levers and some examples:

1. **First Class:** The fulcrum is between the weight and your energy. This is probably the most commonly known class of lever. Examples include: see-saws and scissors
2. **Second Class:** The fulcrum is at one end, the weight is in the middle, and your energy is in the middle. Examples include: wheelbarrows and can openers
3. **Third Class:** The fulcrum is at one end, the weight at the other end, and your energy is in the middle. Examples include: brooms and baseball bats

Fun Fact:
Rowing a boat utilizes First Class levers! Notice in the image above that the fulcrum is in the middle, between your energy and the weight, just like a see-saw!

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Levers Activity

You will need:

- Metric ruler
- Plastic sandwich bag
- Tape
- Scissors
- Pen or pencil
- Bar of soap (still in its packaging)
- Dry Beans

1. Tape the bar of soap to one end of the ruler.
2. Put a piece of tape approximately 1 centimeter (cm) from the zipper part of the top of a plastic sandwich bag. Do this on both the inside and the outside of one side of the plastic bag.
3. Fold the taped section in half, width-wise. Using a pair of scissors, cut a slit long enough to allow the ruler to slip through.
4. Slip the free end of the ruler into the slit. Tape the bag to the ruler to hold it in place. Be careful not to tape the bag closed!
5. Tape a pen or pencil to the edge of a table; this will be the fulcrum for your lever.
6. Place your lever on the fulcrum. The bar of soap (the load) should be resting on the table, and the bag for the pennies (the effort) should be dangling over the edge of the table.
7. Fill the bag with beans one at a time until the bar of soap lifts off the table. Be careful, the lever may fall off the table!
8. Experiment by moving the lever on the fulcrum. Is it easier to lift the bar of soap when you move the lever further off the table? What if more of it rests on the table?

Fun Fact:

The USS Constitution once used its whale boats to escape from enemy ships during the War of 1812. There was no wind to power their sails, so sailors rowed the Constitution far enough away to escape.

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Wheels and Axles

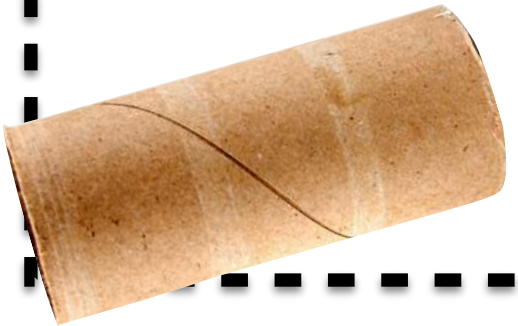
A wheel and axle is a wheel with a rod sticking out of the middle. When you turn or spin the wheel, it turns or spins the rod. The wheel helps make the rod easier to turn. Wheels help make work easier because they cut down on friction. With wheels and axles working together, you can control the direction of a force more easily.

A ship's wheel is an example of a wheel and axle. Turning the wheel of the ship helps control what direction it goes in. The U.S. Navy also uses wheeled vehicles like trucks and cars to help transport equipment and personnel.

You Will Need:

- Toilet Paper Tube
- Two CDs
- Two Pencils
- One Jumbo Paperclip
- About 5 size 14 Rubber Bands
- Masking Tape
- Scissors
- A Ruler
- A Single-Hole Punch
- 2 pieces of Cardboard cut into front heels 2½ inches in diameter

1. Use the hole punch to make holes for the axles, two straight across from each other on either end. You will need two holes punched on the front and back of the car.
2. Use the big end of the jumbo paper clip to enlarge all the axle holes in the paper towel tube.
3. Put the cardboard front wheels against the holes in the tube and push one pencil through both of them.
4. Push your second pencil through the back holes on the cardboard tube.
5. Wrap masking tape around the second pencil on either side of the tube. Make sure the masking tape is not touching the cardboard on either side.
6. Push the CDs on the pencil over the masking tape.
7. Using five rubber bands, make a rubber band chain.
8. Attach the paperclip to the end of the rubber band chain.
9. Use the weight of the paper clip to drop one end of the rubber band part way down on one side of the rear axle.
10. Flip the car over and tilt it up so the paper clip comes back out again on the other side of the rear axle.
11. Thread the paper clip through the very end rubber band in the chain and pull it through all the way.
12. Next, drop the paper clip back into the tube so that you can grab it when it comes out of the front end.
13. Snip two little slits a half inch deep into one side of the front of the tube. Hook the rubber band through the slits.
14. **Done! You are ready to test out your car.**



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Pulleys

A pulley is a wheel with a groove in it. When you put a rope over the pulley, pulling on one end of the rope makes the other end go up on the other side. You can use this to lift a heavy object by tying one end of the rope to the object, and pulling on the other side.

When you use many pulleys working together, you can lift even heavier objects. Groups of pulleys help lift you when you ride in an elevator. In the U.S.Navy, sailors used pulleys to help raise or lower sails, and to help pull heavy objects like whale boats or cargo onto ships. Today, the U.S. Navy still uses pulleys to pull heavy objects on board, usually with the help of a crane. Can you think of other ways the U.S. Navy uses pulleys?

Did you know? In the U.S. Navy, groups of pulleys are called blocks!

Pulleys Activity

What You'll Need:

String or rope
Rolling pin
Something to lift, like a bucket

1. Tie the rope or string to your heavy object. Try lifting the object using only the rope. Is it difficult?
2. Next, have a friend or grown up hold the rolling pin at chest height. Loop the rope over the rolling pin.
3. Try lifting the object by pulling on the end of the rope now.
4. What is different when you use the rolling pin? Is it easier or harder to lift the object?

Pulleys are used at the ends of cranes to help lift heavy objects, like this WWI mine.

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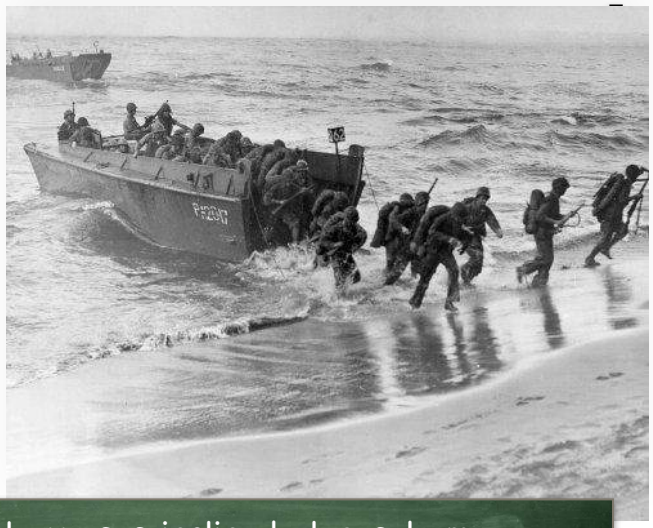
Inclined Planes and Wedges

Have you ever climbed up a flight of stairs, or used a ramp? These are both examples of inclined planes. As you go up an inclined plane, you are not only going up, but you are also going forward. This takes a lot less energy to do than if you tried to climb straight up to the second story of a building.

In the Navy, inclined planes can help make loading and unloading heavy objects off ships, boats, and trucks easier.

A wedge is an object with an inclined plane on both sides. It can be used to help cut through another object more easily. A ship's bow is a wedge, and so are knives and axes. Can you think of the last time you may have used a wedge? (Hint: you probably have some in your mouth!)



The U.S. Navy uses inclined planes to move trucks, ships, and even people! In World War II, ramps on landing craft like this LCVP helped soldiers and Marines land more safely on enemy beaches.

Inclined Planes and Wedges Activity

What You'll Need:

- Foam Board
- Dry Beans
- Plastic bag
- Rubber band
- Ruler
- Stack of Books

1. Fill the plastic bag with beans and tie a heavy duty rubber band around it.
2. Cut another rubber band and tie it around the plastic bag.
3. Try to lift the plastic bag. How far does the rubber band stretch? _____ **cm**
4. Make a stack of books and rest the foam board against the top of the books. This will create your inclined plane.
5. Put the plastic bag at the bottom of the plane and pull it to the top using the rubber band.
6. How far does the rubber band stretch when you use the inclined plane to move the bag? _____ **cm**

Extra Credit:
List 5 wedges and inclined planes we see everyday. Some may surprise you!

_____

_____

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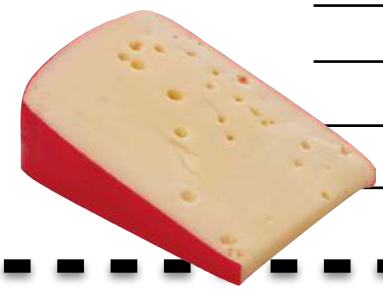

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Screws

A screw is an inclined plane with a twist! Have you ever looked closely at a screw? You can see there is an inclined plane wrapped around and around the base of a screw. This helps a screw hold two objects together more tightly than a nail would be able to. This makes it harder to remove and less likely to fall out.

Screws can also be much, much bigger. A spiral staircase is a screw, and so is a parking garage that uses ramps to guide cars from floor to floor. These designs help save space, while still letting you climb to the top of a building without the effort of going straight up.

U.S. Navy mechanics help keep airmen and sailors safe by removing screws from bigger machines, cleaning the mechanisms, and carefully replacing them to make sure everything runs smoothly.

Screws Activity

What You'll Need:
Notebook Paper
A Pen or Pencil

1. Cut 2.5 inches off a sheet of paper to make a square.
2. Fold the top corner over until it meets the opposite bottom corner to make a triangle.
3. Use your pencil to draw a line across the diagonal edge of the paper triangle.
4. Starting from one of the short sides of the triangle, wrap the paper once around the pencil or marker, then start rolling until the whole piece of paper is wrapped around the marker.
5. Put a finger on the end of paper to keep it from unrolling, and carefully pick up the screw you have made. Do you see how the long edge of the triangle is now traveling around and up the marker? This is just like the inclined plane on a real screw!

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Vocabulary

Match the image with the associated vocabulary word.
Draw a line to connect the two.

Pulley

Lever

Wedge

Screw

Wheel and Axle

Scavenger Hunt!

Simple Machines in the NMUSN

Simple machines are everywhere. The U.S. Navy has always relied on simple machines to help make tasks easier for sailors, airmen and even people working in offices. We have lots of examples of simple machines here in the museum's collection.

Simple Machines in the NMUSN		
What is the Artifact?	**When was it used?**	**How does it help the U.S. Navy?**

What was your favorite simple machine you found in the Museum?

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Why is it your favorite?

.....

NATIONAL MUSEUM of the UNITED STATES NAVY