Crank It Up: A Program about Simple Machines
Presented by the Sciencenter in Ithaca, NY

Program Overview

Crank it up introduces students to simple machines. The program is designed for classes or home-school groups of up to 24 students in grades 4-6. Each program runs approximately 50 minutes, and is held in the Sciencenter's classroom.

Students begin by sharing and activating prior knowledge of force, work, and simple machines. They view several demonstrations before breaking into small groups to explore the properties of a lever. After observing and describing the work done by a lever, students are encouraged to look for patterns and draw conclusions about the movements of gears. *(For background information and simple machines basics, see page 3.)*

Although there are a number of learning objectives, students may not grasp them all during the program. Post-program activities will reinforce their learning and help broaden their understanding.

Learning Objectives:

Students will be able to:

- Define the following vocabulary: force, effort, load, resistance, work.
- Name and describe six simple machines and their parts.
- Explain how simple machines make work easier.

Students will practice the following process skills:

- Scientific observation.
- Making predictions.
- Measuring and recording data.
- Drawing conclusions.

New York State Math, Science and Technology Curriculum Standards:

Standard 1 Analysis, Inquiry and Design

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing creative process.
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Standard 4 Science

The Physical Setting

1. The Earth and celestial phenomena can be described by principles of relative motion and perspective.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

5. Energy and matter interact through forces that result in changes in motion.

Standard 6 Common Themes

Systems Thinking

1. Through systems thinking people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Background Information

In scientific terms, the word work refers to the application of force (a push or a pull) on an object to move it across a distance. Machines are devices with moving parts that make work easier. Machines can't reduce the total amount of work, but they help us do work by changing the amount or direction of force applied. Simple machines are called that because they usually have only one moving part. Compound machines are made up of two or more simple machines working together.

There are six types of simple machines, which are often divided into two families: the lever family (lever, wheel and axle, pulley) and the inclined plane family (inclined plane, wedge, screw).

Lever. A lever is a bar that pivots or turns on a point called a fulcrum. Levers are used to lift, pry and crush. An example of a lever would be a crowbar, a shovel, a wheelbarrow, or a nutcracker. Levers make work easier by changing the amount and direction of force needed to move an object. There are several classes of levers that differ in the relative positions of the load, the force, and the fulcrum. In first class levers, the load and the effort are on opposite ends of the fulcrum. An example of a first class lever would be a seesaw or crowbar. In second class levers, the load is between the fulcrum and the effort. An example of a second class lever would be a wheelbarrow. In third class levers the effort falls between the load and the fulcrum. An example of a third class lever would be a broom or tweezers.

Wheel and Axle. A wheel is a lever that rotates in a circle around a center point or fulcrum. The fulcrum may be a smaller wheel or rod (axle) or even a solid core (such as a screwdriver). A wheel is a lever that can turn 360 degrees and where the effort can be supplied at any point on the lever. The force can be applied to the inner wheel (making work easier by increasing the force and decreasing distance) or to the outer wheel (making work easier by decreasing force and increasing distance).

Pulley. A pulley is a wheel with a rope or cable wrapped around it. A fixed pulley occurs when one end of the cable is attached to the load and the cable is dragged around the wheel. An example of this would be when a cable is passed over a branch to lift a load. This arrangement makes work easier by changing the direction of the effort because it is easier to pull down in the direction of gravity than to lift.

In a moveable pulley, one end of the cable is anchored, and the load is situated along the cable attached to the pulley. A moveable pulley redistributes the effort, making work easier by reducing the amount of force needed to move the load.

Inclined Plane. An inclined plane is a flat surface connecting two points. The plane is set at an angle or slant between points to increase the distance between them and make work easier by reducing the force needed to move a load up or down. An example of an inclined plane is a ramp or slide.

Screw. A screw is an inclined plane wrapped around a cylinder. The threads on a screw make work easier by increasing the distance over which force is applied. The closer the threads on a screw, more turns are needed to tighten it but the less force is necessary.

Wedge. A wedge is like two inclined planes placed back to used to separate or split. Wedges makes work easier by taking a single force applied to one surface and split into two sideways forces. An example of a wedge is a doorstop or an axe head.

Resources

Websites

Kid-friendly sites with basic information about simple machines:

http://www.ed.uri.edu/SMART96/ELEMSC/SMARTmachines/machine.html
http://sln.fi.edu/qa97/spotlight3/spotlight3.html

Great interactive site where students learn about simple machines to solve a problem:

http://www.beaconlearningcenter.com/WebLessons/MoveOurPrincipal/default.htm

Elementary simple machines units including many teacher resources and literature connections:

http://www.ieee.org/web/education/preuniversity/tispt/lsmach.html
http://www.henry.k12.ga.us/cur/simp-mach/resources.htm

Books

Hodge,Deborah. *Starting with Science: Simple Machines.* Toronto: Kids Can Press, Ltd., 1997.

Maton, Anthea, et al. Prentice Hall. *Science: Motion, Forces, and Energy.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc, 1993.

VanCleave, Janice. P. *Janice VanCleave's Physics for Every Kid: 101Easy Experiments in Motion, Heat, Light, Machines, and Sound.* New York: John Wiley & Sons, Inc., 1991.

Videos

Simple Machines (Bill Nye the Science Guy Episode No. 10). Disney Productions,1995.

Classroom Activities

KWL Chart
A great way to build excitement for your *Crank it Up* program at the Sciencenter is to create a "KWL" chart with your students. This activity is effective as a whole-class discussion, or as an individual assignment.

Simple Machines

K: What I **know**	**W**: What I **want** to know	**L**: What I **learned**

Before your field trip, fill in the "K" and "W" columns. After the field trip, fill in the "L" column.

Simple Machines Scavenger Hunt
Challenge yourself to find the simple machines in your daily life.

Procedure
1. Ask students to estimate how many times a day they use simple machines.
2. Send them on a simple machines scavenger hunt. Ask them to spend one day or a portion of a day recording all the simple machines they encounter. Most students will be amazed to discover the difference between their estimates and the actual number they find.

Up a Ramp
Use rubber bands to demonstrate the difference in force when lifting a weight vs. dragging it up an inclined plane.

Materials
- Stack of books or boxes
- Large book or board to form a ramp
- Bag of beans or other weight
- Long rubber bands
- Meter stick or tape

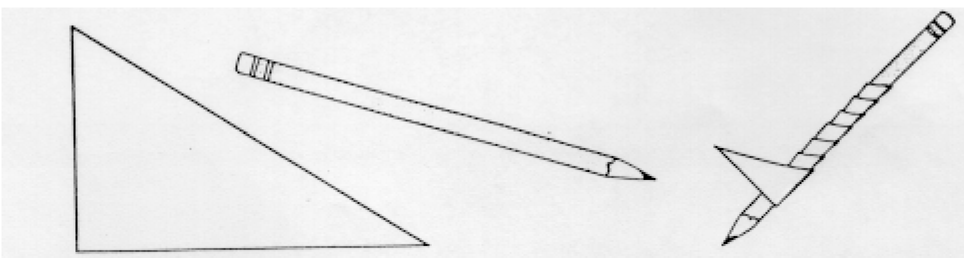
Procedure
1. Hand out rubber bands. Demonstrate to students that the greater the force pulling the rubber band, the longer the band will be.
2. Stack the books and lay the board on them to form an inclined plane.
3. Snip a rubber band and tie one end to the weight bag.
4. Hold the other end of the rubber band and lift the weight bag up the height of the stack of books. Measure the length of the rubber band.
5. Now drag the weight up the inclined plane and measure the length of the rubber band.
6. Compare the length of the rubber band while lifting straight up vs. dragging the weight up the ramp, and discuss the reason for the difference.

Explanation
Because the force is spread out over a longer distance, less force is needed to move the load up a ramp than to lift it straight up.

Screws are Inclined Planes
Students can prove to themselves that a screw is an inclined plane wrapped around a cylinder.

Materials
- Pencil
- Paper
- Scissors
- Marker or crayon

Procedure
1. Cut paper into a right triangle.
2. Color the longest side to represent the ramp surface of an inclined plane
3. Tape the paper to the pencil and wrap the triangle around the pencil forming a spiral.



What's a Wedge?
Watch how a wedge changes the direction of force.

Materials
- Wedge (a doorstop works well)
- Books

Procedure
1. Set up several books with spines up between two piles of books or book ends.
2. Place the wedge between the two spine-up books and press it down to separate the books. Notice how the downward direction of the force pushes the books out to the sides.

Jumping Coin
Find out where to push on a lever to get the most lift.

Materials
- Ruler
- Pencil
- 2 Heavy Coins

Procedure

1. Place the ruler on the pencil forming a see-saw and place one of the coins at one end
2. Drop the second coin close to the fulcrum and watch how high the first coin jumps.
3. Now try dropping the coin closer to the end of the lever from the same height and compare the results.
4. Try moving the pencil to different locations under the ruler and comparing the results.

Explanation

Levers make work easier by multiplying the force applied. The longer a lever arm is, the greater the magnification of force. When the effort is applied further from the load, the lever arm is functionally longer thus making the work easier and sending the coin higher.

Book Lift

Demonstrate the effectiveness of a lever

Materials

- Stack of book
- 2 pencils

Procedure

1. Try lifting the stack of books by inserting your pinky finger under the stack and lifting straight up.
2. Now place one pencil under the bottom of the stack.
3. Place the second pencil under the first as a fulcrum close to the stack of books.
4. Push down on the end of the first pencil and try again to lift the stack of books.

Make Your Own Gears

Explore how gears change the direction of force.

Materials

- Bottle caps with crimped edges
- Corrugated cardboard
- Large and small nails
- Hammer
- Permanent marker

Procedure

1. Preparation: Hammer holes into the centers of bottle caps using the larger nails.
2. Press one of the smaller nails into the cardboard and drop a bottle cap onto the nail so the cap spins freely.
3. Place a second cap next to the first (close enough that when you turn one, it turns the other) and put a nail through the hole. Repeat with several caps.
4. Spin the first cap and watch how the others turn.

5. Make a mark on each cap near the edge. Using the mark, count the number of times each cap goes around.

Pulley UP

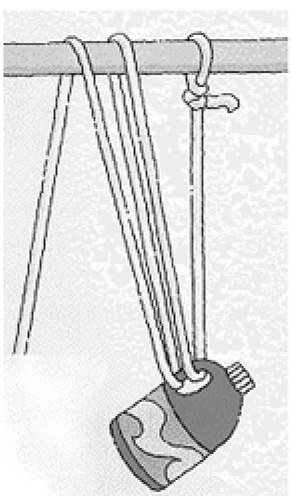
See how pulleys reduce force and change motion's direction.

Materials

- Broom Handle
- Rope
- Milk or laundry detergent jug containing sand, beans or other weight

Procedure

1. Tape the ends of the broom handle down between 2 desktops.
2. Try several ways to lift the jug using the rope and broom handle and discuss the results.
3. Tie one end of the rope to the broom handle and loop it through the jug handle. Try lifting by pulling the free end of the rope.
4. Loop the rope several more times through the handle of the jug and over the broom handle. Compare the amount of effort to a single loop.
5. Now loop the rope through the jug handle and over the broom handle a second time. Compare the effort needed to only one loop.



Explanation: Each loop of rope acts as a pulley. The total weight of the jug is distributed among the loops so that each loop holds a portion of the load. To raise the load, the rope has to go a greater distance, but the amount of effort is reduced.

Adapted from a NASA LTP teacher created lesson plan, "Simple Machines" by Carol Huddle.