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ACTIVITY : 50 MINS

Simple Machine Challenge

Students are challenged, using everyday objects, to create simple machines to complete specific tasks.

GRADES

2 - 8

SUBJECTS

Physics

CONTENTS

5 Images

OVERVIEW

Students are challenged, using everyday objects, to create simple machines to complete specific tasks.

For the complete activity with media resources, visit:

<http://www.nationalgeographic.org/activity/simple-machine-challenge/>

Program



DIRECTIONS

1. Introduce the concept that simple machines make work easier.

Tell the class the definition of work used in science may differ from what most people think of as work. Work can be defined as force times distance ($\text{Work} = \text{Force} \times \text{Distance}$). Ask a student to move a book from one desk to another. Ask: *Is this work by the scientific definition?* (Yes, this is work.) You are applying force for a certain distance. Ask: *Is doing homework work by this definition?* (No, homework is not work.) Pushing a book across a desk is work because you are applying a force (a push) on a book for a certain distance (the length of the desk). You are not pushing homework anywhere.

Imagine that you want the same amount of work to get done using less force. In this example, this means you still want the book to move from one side of the desk to the other, but you don't want to push as hard. If you use half as much force to push the book, then you will have to push the book twice as far to do the same amount of work. Or, you could use a simple machine to make up the difference in the force you are applying. Explain that people often use simple machines to make work easier.

Introduce the class to the names of various simple machines and show them a picture of each from the Simple Machines photo gallery: levers, the wheel and axle, pulleys, screws, and inclined planes. Tell the class simple machines make work easier by increasing mechanical advantage. Tell students that an example of mechanical advantage is using the claw of a hammer to remove a nail. A small force applied to the handle of the hammer produces a greater force at the claw end of the hammer, allowing for the removal of stubborn nails.

Explain that complicated machines, such as robots and cars, are made up of combinations of simple machines and other parts. Robots are complex machines that contain many simple machines. Some examples of simple machines that are used in robot construction are wheels and axles for mobility, allowing robots to move from place to place, and robot arms, which are levers, enable them to manipulate objects.

Explain that students are going to try simple experiments with simple machines, and then use those simple machines to solve challenges.

2. Demonstrate how levers work.

Construct a lever by taping a marker parallel to the edge of the table. Tear off a piece of masking tape, loop it, and attach it to the end of the ruler. Place the ruler on the marker at the center point, like a seesaw, and then press a tennis ball firmly to the tape. Invite a student volunteer to demonstrate the lever; first, have the student gently lift the ball by applying force to the end of the lever (ruler) opposite the ball. Second, instruct the student to reposition the lever (ruler) so the ball is as close to the fulcrum (marker) as possible. Have the student press the lever again to lift the ball. Lastly, reposition the lever (ruler) so the ball is as far away from the fulcrum (marker) as possible while still leaving a portion of the lever (ruler) to be pressed down. Have the student press the lever to lift the ball again. A photo of each lever situation is available in the Simple Machines Demonstrations photo gallery.

Discuss what the class saw and what the volunteer observed. Ask: *Which lever configuration made the ball easiest to lift? Which lever configuration made it the most difficult to lift the ball? Which lever configuration moved the ball the farthest from its starting position? How does the lever provide a mechanical advantage when moving the ball?*

3. Students complete a challenge using levers.

Introduce the lever challenge. Explain that each group will attempt to move a tennis ball from the table to the center of a roll of masking tape at varying distances. Introduce the rules. Hands may not be used to move the ball to the goal, but hands may be used to place the ball on the lever and to operate the lever. Nothing may be used to secure the ball to the lever. The marker may not be moved from the edge of the table. The masking tape roll may not be moved unless the teacher instructs it. The winner will be the group that moves the ball to the center of the masking tape roll from three different distances with the least amount of attempts.

Separate the class into groups of 2-4. Distribute the following items to each group: a tennis ball, a rigid ruler, a cylindrical marker, and a roll of masking tape. Instruct students to tape the marker parallel to the edge of a desk or table, as was demonstrated earlier by the teacher.

Now, instruct groups to measure 24 cm (9.5 in) out from the marker and place the edge of the masking tape roll, flat on its side, at this point.

Allow groups a few minutes to collaborate on different ideas for getting the ball into the goal. Next, allow five minutes of exploration and experimentation. Instruct students to record the distance of 24 cm (9.5 in) in their journal and sketch the lever configuration that worked best at this distance directly beneath the number. Follow the same steps at a distance of 15 cm (6 in) and 5 cm (2 in). Lastly, the teacher will observe as groups demonstrate their lever configurations at the different distances. The group with the lowest total attempts after completing all three distances wins.

4. Students are introduced to the pulley using a demonstration.

Tell the class that pulleys make work easier by reducing the effort needed to lift an object. Instruct a student to lift a milk jug filled with water using only his or her hand. Next, have two additional students hold a broom handle at shoulder level between them. Now, tie a thin rope to the handle of the jug and let it rest on the floor. Instruct the student who earlier lifted the jug to pull the rope over the broomstick and pull down on the end of the rope to lift the jug. Ask the student to describe the difference between the two experiences. Now, untie the rope from the jug and tie one end of the rope to the broomstick. Have the two students continue to hold the broomstick at shoulder level while the other volunteer slips the free end of the rope through the handle of the jug and then back over the broomstick. Have the same student pull the end of the rope to lift the jug. Ask the student to describe the differences in the three experiences. A photo of the second and third situations are available in the Simple Machines Demonstrations photo gallery.

5. Students complete a challenge using pulleys.

Introduce the pulley challenge. Each group will lift metal objects from the floor using a pulley system they design. Introduce the rules. Only materials provided may be used in the design. Hands may not be used to pick up objects. An object lifted to at least 10 cm (4 in) in the air

may be removed from the pulley using the hands. At least two spools must be incorporated into the design. No more than 15 cm (6 in) of tape may be used. Part of the pulley system may be taped to a fixed object, such as a desk.

Separate the class into groups of 2-4. Distribute the following items to each group: three plastic spools; a meter (3.2 ft) of string; a 1¼-inch donut magnet; various small metal objects, such as paper clips; masking tape; and three pencils. Allow groups time to collaborate on different ideas for pulley construction. Next, allow five to ten minutes of exploration and experimentation with the materials. Encourage students to make sketches of ideas in their journal. At the conclusion, each group will demonstrate for the teacher the most successful pulley system the group designed.

6. Students are introduced to the wheel and axle.

Tell students the wheel and axle uses rotational movement to make work easier. When effort is applied to the wheel, it produces movement in the axle, and when it is applied to the axle, it produces movement in the wheel. Ask a student to hold the narrow end of a funnel and use it to roll the large end of the funnel along the table. Ask: *Is this an example of effort being applied to the axle or the wheel?* (Effort applied to the axle.) Next, have a student tape the end of a 1 m (3.2 ft) piece of string to the narrow end of the funnel. Now have the student turn the funnel in a circular motion using the large end of the funnel. Ask: *Is this an example of effort being applied to the axle or wheel?* (Effort applied to the wheel.)

7. Students apply knowledge of the wheel and axle to complete a challenge.

Introduce the wheel and axle challenge. Each group will attempt to move a tennis ball 3 meters (roughly 10 ft) using a design incorporating the wheel and axle. Introduce the rules. Only materials provided may be used. The ball may not be touched after it begins to move. The wheel and axle must be the primary mechanism by which movement of the ball is achieved.

Separate the class into groups of 2-4. Distribute the following items to each group: two pieces of cardstock paper, approximately 57 g (2 oz) of modeling clay, two drinking straws, 30 cm (12 in) of masking tape, and 30 cm (12 in) of string. Allow groups time to collaborate on different ideas for moving the ball. Next, allow ten minutes of exploration and experimentation. Encourage students to make sketches of ideas in their journals. When all groups are ready, they will compete to determine which design can move the ball the greatest distance. Give groups five minutes to reengineer or repair their vehicles after the first test, and test a second time.

8. Students use simple machines to design a robot on paper.

Ask the class to imagine how the simple machines they experimented with could be used to construct various working parts of a robot. Ask the following questions: *How could a lever be used?* (Perhaps as part of the arm or leg.) *How about a pulley?* (It could be used to operate the gripper on a robot's arm.) *What about the wheel and axle?* (It could be used as part of the mobility unit.) Instruct students to create drawings of their own robots incorporating all of the simple machines they experimented with in class.

Modification

For older grades, include ways to calculate work by measuring force and recording distance. Have students create word problems to be solved by classmates that incorporate using force and distance to calculate the amount of work done. Students can practice solving the equations submitted by their classmates. To make this activity cross-curricular, have students create these problems and associate them with an historical or current event. For example, how much work would it take to move one of the blocks used in the construction of the Great Pyramid from point A to point B?

Modification

If resources are limited, each group can be assigned one machine to experiment with and then report on their findings to the class. Other objects may be substituted for the listed objects as long as they work in similar ways.

Modification

Older students can construct some of the simple machines on their own, or the review of each type of simple machine can be shortened.

Informal Assessment

Collect student robot drawings to be sure all the required simple machines were included and applied appropriately.

Extending the Learning

Encourage students to find examples of levers, pulleys, and the wheel and axle in the classroom. Some common examples of levers are scissors, hole-punchers, and the flusher on the toilet in the bathroom. Common examples of pulleys include the lifting mechanism on blinds, and the mechanism used to raise the flag on the flagpole. Some unexpected examples of the wheel and axle are tape dispensers, doorknobs and the inner workings of pencil sharpeners. More common examples of the wheel and axle are the wheels on carts and the blade mechanism on fans. Encourage students to share instances where they used levers, pulleys, and/or the wheel and axle to accomplish work.

OBJECTIVES

Subjects & Disciplines

- Physics

Learning Objectives

Students will:

- Understand how simple machines make work easier
- Use simple machines to accomplish challenges
- Understand that simple machines can be combined to make more complex machines

Teaching Approach

- Learning-for-use

Teaching Methods

- Demonstrations
- Discovery learning
- Hands-on learning

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
 - Learning and Innovation Skills
 - Critical Thinking and Problem Solving
- Critical Thinking Skills
 - Analyzing
 - Applying
 - Creating
 - Evaluating
 - Remembering
 - Understanding
- Science and Engineering Practices
 - Analyzing and interpreting data
 - Asking questions (for science) and defining problems (for engineering)
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Developing and using models
 - Obtaining, evaluating, and communicating information
 - Planning and carrying out investigations
 - Using mathematics and computational thinking

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

- (5-8) Standard A-1:

Abilities necessary to do scientific inquiry

- (5-8) Standard A-2:

Understandings about scientific inquiry

- **(5-8) Standard B-2:**

Motions and forces

- **(K-4) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(K-4) Standard A-2:**

Understandings about scientific inquiry

- **(K-4) Standard B-2:**

Position and motion of objects

- **(K-4) Standard E-2:**

Understanding about science and technology

NEXT GENERATION SCIENCE STANDARDS

- **Engineering Design:**

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

- **Engineering Design:**

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

- **Engineering Design:**

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

- **Engineering Design:**

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

- **Engineering Design:**

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

- **Engineering Design:**

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

- **Engineering Design:**

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

- **Motion and Stability: Forces and Interactions:**

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

• **Motion and Stability: Forces and Interactions:**

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of an object.

• **Motion and Stability: Forces and Interactions:**

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Markers
- Modeling clay
- Broomstick or thick wooden dowel
- Cardstock paper
- Donut magnets
- Empty spools (3 per group)
- Pens
- Journal or paper
- Large round funnel
- Masking tape
- Milk jug filled with water
- Rigid rulers
- Round pencils
- Small metal items like paper clips
- straws
- Tennis balls
- Thin rope
- String

REQUIRED TECHNOLOGY

- Internet Access: Required

PHYSICAL SPACE

- Classroom

SETUP

Set up the classroom so it is convenient for students to work in groups of 4 to 5. Reserve a space, like a hallway, to test the wheel and axle creations.

GROUPING

- Large-group instruction

BACKGROUND & VOCABULARY

Background Information

There are three ways simple machines make work easier: by increasing the distance through which force is applied, by changing the direction of applied force, or by multiplying force or speed of the energy applied.

The wheel and axle is a machine in which the wheel is attached to a central axle. This means that if the wheel turns, the axle must turn, and if the axle turns, the wheel must turn. Turning the wheel a greater distance produces a short and more powerful movement at the axle. Turning the axle a shorter distance moves the wheel a greater distance.

A single pulley reverses the direction that a force is applied, but does not make work easier. If two or more pulleys are used together, they allow a load to be lifted using less force, but the distance the end of the rope must travel to lift the load is greater than the distance that the load must travel.

An inclined plane provides an advantage by changing the direction a force is applied and increasing the distance that must be traveled in order to complete the work. A wedge is a type of inclined plane that works differently by concentrating force in a smaller area.

The screw is a machine that can be described as an inclined plane spiraled around a cylinder. When you turn a screw it converts the turning motion into a forward or backward motion.

A lever consists of a flat, stiff plane or rod which uses a fulcrum as a pivot point. Force applied to an end of the lever results in movement in the opposite direction on the other end. The location of the fulcrum determines whether the lever will multiply force or distance.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
force	<i>noun</i>	power or energy that activates movement.
inclined plane	<i>noun</i>	flat surface (plane) that makes an oblique angle (incline) with the horizon.
lever	<i>noun</i>	bar that pivots on a fixed support, or fulcrum, and is most often used to move an object at a second point by a force applied to a third point.
pulley	<i>noun</i>	wheel with a rope, band, or cable running around it used to generate power or transport goods over short distances.
screw	<i>noun</i>	nail-shaped instrument with a spiral groove and a slotted head designed to be inserted into material by rotating (as with a screwdriver) and used for fastening pieces of solid material together.
simple machines	<i>plural noun</i>	elementary mechanisms including the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw.
wheel and axle	<i>noun</i>	machine consisting of a grooved wheel turned by a cord or chain with a firmly attached shaft (axle, often used for winding).

Term	Part of Speech	Definition
work	<i>verb</i>	to use a force to move an object a distance (when both the force and the motion of the object are in the same direction.)

For Further Exploration

Interactives

- [Interactive Game](#)
- [Build a Robot Using Simple Machines Game](#)
- [Simple Machines Game](#)
- [Build and Test a Robot Game](#)

Websites

- [Enchanted Learning Lever Lesson](#)
- [Edheads](#)

FUNDER



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