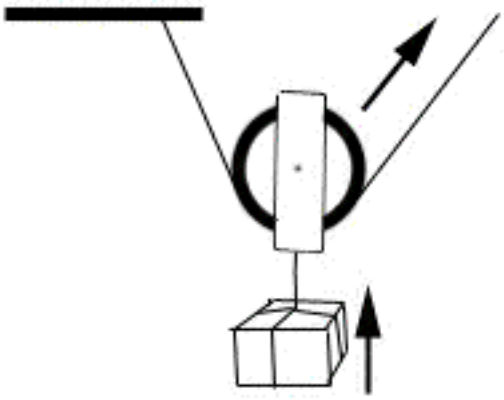
Work, Energy and the Simple Machines: Lever, Wheel and Axle, Pulley



Instructor’s Guide

Work, Energy and the Simple Machines: LEVER, WHEEL AND AXLE, PULLEY

INSTRUCTOR'S GUIDE

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Published and Distributed by

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Evanston, Illinois 60201
(800) 323-9084, Fax (847) 328-6706
http://www.unitedlearning.com

LEVER, WHEEL AND AXLE, PULLEY

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LEVER,
WHEEL AND AXLE,
PULLEY

GRADE LEVELS: 5-8

INTRODUCTION

This live-action program is designed for use with the intermediate and middle school grades (5-8).

The lever, wheel and axle, and pulley have been grouped together to show how they are related, but at the same time different from one another. The lever is presented first and is described as one of the very first simple machines. The three main parts of a lever are shown and identified. They include the resistance, the effort or force, and the fulcrum. The three kinds of levers are also described and illustrated with everyday common tools or devices. The wheel and axle is presented next and is described as a lever that has been wound up. The large wheel represents the effort arm and the axle represents the resistance arm. Finally pulleys are described. The two kinds of pulleys, fixed and movable, are demonstrated. Block and tackles, which are combinations of many pulleys working together are also presented. The mechanical advantage of these simple machines is calculated.

INSTRUCTIONALNOTES

Before presenting this lesson to your students, we suggest that you preview the program and review this guide and the accompanying blackline master activities in order to familiarize yourself with their content.

As you review the materials presented in this guide, you may find it necessary to make some changes, additions, or deletions to meet the specific needs of your class. We encourage you to do so, for only by tailoring this program to your class will they obtain the maximum instructional benefits afforded by the materials.

It is also suggested that the program presentation take place before the entire group under your supervision. The lesson activities grow out of the context of the program; therefore, the presentation should be a common experience for all students.

LINKS TO CURRICULUM STANDARDS

This **Unit of Study** addresses the following National Science Education Standards for grades 5-8:

Science as Inquiry
Content Standard A:

* Abilities necessary to do scientific inquiry
* Understandings about scientific inquiry

Physical Science
Content Standard B:

* Motions and forces
  The motion of an object can be described by its position, direction of motion, and speed.
* Transfer of Energy
  Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Science and Technology
Content Standard E:

* Understanding about Science and Technology
  Many different people in different cultures have made and continue to make contributions to science and technology

History and Nature of Science
Content Standard G:

* Science as a Human Endeavor
* Nature of Science
* History of Science

STUDENT OBJECTIVES

After viewing the program and participating in the follow-up activities, students/participants should be able to...

- Identify the six simple machines.
- Identify the main part of a lever.
- List examples of levers.
- Describe how a wheel and axle make work easier.
- Describe the differences between a fixed and movable pulley.
- Calculate the mechanical advantage of these three simple machines.

ASSESSMENT TOOLS

This lesson provides you with three different assessment tools. Together they

make it possible to follow closely the progress of your students and to judge their mastery of the subject matter.

The **Pre-Test Blackline Master #1** can be used to get some idea of students' understanding of the topic before the program is presented.
The **Post-Test**, presented as **Blackline Master#11**, can be used as a final test for the lesson.

The **Video Quiz** and its accompanying answer sheet **(Blackline Master #2)** can be used as a follow-up to the program.

TEACHER PREPARATION

View the program and review the accompanying activities. Duplicate any blackline masters you wish to distribute. If you plan to use the Video Quiz, which immediately follows the program presentation, you may wish to have copies of the quiz ready to distribute at the completion of the program. Also, plan to pause the program between questions if students require more time.

INTRODUCING THE PROGRAM

Ask the class to think of all the different kinds of tools and machines that are used in our modern world. Ask for some examples such as hammers, huge cranes, etc. Then tell the students that all the machines we use today are based on six simple machines that were discovered and used thousands of years ago.

VIEW THE PROGRAM

Viewing time for this program is 10 minutes. The video quiz that follows the presentation will take about 5 minutes when you build in pauses for recording answers.

DISCUSSION QUESTIONS

You may wish to conduct a discussion after viewing the program based on the following:
This program concentrates on the lever, wheel and axle, and screw. Ask students to think of examples of each of those simple machines. Why were these three simple machines grouped together? (They are related to each other)

BLACKLINE MASTER DESCRIPTIONS

This program contains eleven blackline masters that can be used to reinforce ideas and information presented in the program.
• ***Blackline Master #1: Pre-Test*** provides a way of finding out how much students know about the material covered in this lesson before you present it. Student scores on the **Pre-Test** can be compared with their scores on the final **Post-Test Blackline Master #11**.

• ***Blackline Master #2: Video Quiz*** is to be used at the end of the program. At the completion of the program, there is a short quiz. The narrator will read the questions which are displayed on the screen. Students can use **Blackline Master #2: Video Quiz** to record their answers. Answers to the questions are provided in the Answer Key section of this teacher's guide.

• ***Blackline Master #3: Vocabulary*** asks students to match terms in column A with definitions in column B.

• ***Blackline Master #4: Levers*** asks students to identify the fulcrum, resistance, and effort for various levers.

• ***Blackline Master #5: Levers - Three Classes*** asks students to identify various levers as first, second, or third - class levers.

• ***Blackline Master #6: Two Arms*** contains information about calculating missing information from word problems dealing with levers.

• ***Blackline Master #7: Mechanical Advantage of a Lever*** provides information about how to calculate the mechanical advantage of a lever.

• ***Blackline Master #8: Mechanical Advantage of a Wheel and Axle*** is a worksheet that explains how to determine the mechanical advantage of a wheel and axle. Students are asked to measure some objects at home and determine the mechanical advantage of those wheel and axles.

• ***Blackline Master #9: Kinds of Pulleys*** is an experiment with two parts. Part A describes how to set up a fixed pulley and Part B describes how to set up a movable pulley.

• ***Blackline Master #10: Mechanical Advantage of Pulleys*** describes how the mechanical advantage of a pulley is calculated.

• ***Blackline Master #11: Post-Test.*** This is the post-test for this program.

ENRICHMENTACTIVITIES

• Have some students find out about the evolution of the bicycle. How has it changed over the years and why?

ANSWER KEY

• ***Blackline Master #1: Pre-Test***

1. lever, wheel and axle, pulley, inclined plane, wedge, screw

2. fulcrum, resistance, effort
3. fixed and movable
4. A wheel and axle is like a lever wound up.
5. When a machine has a mechanical advantage it means the machine makes the work easier and therefore a small effort can be used to accomplish a greater task.
6. The mechanical advantage of a movable pulley is determined by the number of supporting ropes.
7. The mechanical advantage of a wheel and axle is calculated by dividing the diameter of the wheel by the diameter of the axle.
8. A block and tackle is a combination of two or more pulleys used together.
9. 20 pounds
10. Energy is the ability to do work

• ***Blackline Master #2: Video Quiz***

1. c
2. a
3. a
4. d
5. a
6. Energy is the ability to do work
7. A fixed pulley is stationary and used only to change the direction of effort. A movable pulley is attached to the resistance or load and moves with it. A movable pulley provides a mechanical advantage.
8. A block and tackle is a combination of two or more pulleys.
9. lever, wheel and axle, pulley, inclined plane, wedge, screw
10. The location of the fulcrum, resistance arm, and effort arm

• ***Blackline Master #3: Vocabulary***

1. c
2. e
3. g
4. a
5. f
6. b
7. h
8. d

• ***Blackline Master #4: Levers***

pliers - resistance is the claws, the fulcrum is at nut, effort is in handles
hammer pulling a nail - resistance is nail, fulcrum is at hammer head where it touches wood, hammer handle is the effort
hammer nailing - hammer head is resistance, hand is effort and the fulcrum is

below the hand on the handle
nutcracker - nut is resistance, fulcrum is nut and bolt, effort is handles of nut-cracker
broom - resistance is what broom is sweeping, hands on handle are effort, fulcrum is above hands
moving a rock with a board - rock is resistance, end of board is effort and fulcrum is log.

• ***Blackline Master #5: Levers - Three Classes***
pliers - first-class
broom - third-class
nutcracker - second-class
hammer nailing - third-class
hammer pulling nail - first-class
moving rock - first-class

• ***Blackline Master #6: Two Arms***
1. 37.5 newtons
2. 6 feet
3. 125 newtons

• ***Blackline Master #7: Mechanical Advantage of a Lever***
1. M.A. = 2
2. M.A. = 2
3. M.A. = 4

• ***Blackline Master #8: Mechanical Advantage of a Wheel and Axle***
Answers will vary

• ***Blackline Master #9: Kinds of Pulleys***
Observations Part A: Answers will vary but will be the same for one and two.
Part B: The reading on the scale should be one half the weight of the book.

• ***Blackline Master #10: Mechanical Advantage of Pulleys***
M.A. = 4 five pounds of effort to lift 20 pound object
M.A. = 6 12.5 newtons of effort to lift 75 newtons

•***Blackline Master #11: Quiz***
1. lever, wheel and axle, pulley, inclined plane, wedge, screw
2. a. turning point on a lever
   b. the load on a lever
   c. a push or pull
   d. the length of the effort arm on a lever

e. the length of the resistance arm on a lever

3. The location of the fulcrum, resistance, and effort.
4. pliers - claws resistance, handles effort, nut and bolt fulcrum
   hammer - nail resistance, hand on handle effort, head of hammer fulcrum
   fishing pole - fish resistance, effort in hands, fulcrum below hands
5. 25 pounds of effort
6. The diameter of the wheel is divided by the diameter of axle.
7. the number of supporting ropes
8. a combination of two or more pulleys
9. A fixed pulley doesn't provide any mechanical advantage.
10. Energy is the ability to do work

INTERNET RESOURCE

The following website may be a valuable source of additional information to reinforce the objectives of this lesson:

1.) **Work, Energy and the Simple Machines at http://www.unitedlearning.com** will be designed as an electronic learning module specifically correlated to this Unit of Study. It will support and enhance the content and ideas presented in this series of vide tapes. This will add a new dimension to instruction and learning.

Lever, Wheel and Axle, Pulley
Script of Narration

This man is straining to lift the weights on the exercise equipment. The weights aren't moving, so to a scientist this man has done no work.

Work is only accomplished when an object is moved a distance. A force is needed and to provide the necessary force energy is required.

Energy is the ability to do work. In our machine orientated world we have many tools and devices that help to get work done easier or faster, but as complicated as so many of these machines seem they are all based on just six simple machines that were developed a very long time ago.

The six simple machines are the lever, wheel and axle, pulley, inclined plane, wedge, and the screw. Today we'll take a close look at three of these simple machines; the lever, wheel and axle, and the pulley.

The lever was one of the first simple machines. It is made up of two main parts. A bar that rotates or turns around a support point called a fulcrum. A lever is used to move a resistance or load. The force necessary to move a load doesn't have to equal the weight of that load.

The idea is to try and have the resistance close to the fulcrum and the effort as far from the fulcrum as possible. The longer the effort arm the greater the leverage; which means a small effort is required to produce a great force.

Notice that the adult is easily lifted with one hand. The effort moves through a great distance while the resistance only moves a short distance. The advantage is that the effort needed to lift the load is much reduced.

There are actually three kinds or classes of levers.

This board is being used as a first-class lever. The fulcrum is located somewhere between the resistance and the effort.
A nutcracker is an example of a second-class lever. This time the resistance is between the fulcrum and the effort.

A third-class lever is set up with the effort between the resistance and fulcrum. This rake is an example of a third-class lever.

If a hammer is being used to drive a nail what kind of lever do you think it represents?

The effort is the person's hand, the resistance is the hammer head.

The fulcrum is below the hand so the effort is between the resistance and the fulcrum. It is a third-class lever.

What kind of lever is a hammer that is being used to pull a nail?(pause)

It's a first-class lever.

The person's hand is providing the effort, the nail is the resistance and the fulcrum is located somewhere between the effort and resistance.

A crowbar is used to pry two boards apart. The crowbar is being used as a lever. Think of where the resistance is the effort and the fulcrum. It's a first-class lever. The fulcrum is between the effort and resistance.

The wheel was one of the most important inventions of all times. No one knows where the wheel was invented, but there is evidence that people living 6,000 years ago used wheels.

The wheel and axle is related to the lever. It is like a lever that has been wound up.

The larger wheel represents the effort arm and the axle represents the resistance arm. The bigger the wheel compared to the axle the easier it is to use the wheel and axle.

A steering wheel makes it easy to steer a car.

A truck or a bus has a bigger wheel to help steer the larger vehicle.
Skateboards, in line skates, and bicycles all use wheels and axles.

A door knob is another common example of a wheel and axle. It is easy to open a door because the door knob is like a wheel.

If we remove the door knob we can see the axle that operates the door clasp.

A bicycle uses the wheel and axle idea to make peddling easier. The peddles turn in a wide circle. The chain connects the peddle with the rear sprocket, which is smaller, and therefore turns many times each time the peddle goes around once.

Another simple machine that is related to the wheel and axle is the pulley. The pulley has a wheel and axle built into it. There are two kinds of pulleys.

One is called a fixed pulley which means the pulley is attached to something.

The object being lifted is attached to one end of a rope. The other end of the rope is fed through the pulley, and then a force is used to pull on the rope. The fixed pulley doesn't make lifting easier; it changes the direction of effort.

The other kind of pulley is the movable pulley. In this case the pulley moves with the object being lifted. Because of the way the rope is used it takes only half the effort to lift the load.

For example, this block of wood weighs 240 grams, but when lifted by a movable pulley the effort needed is half as much.

A combination of pulleys used together is called a block and tackle. A block and tackle can be used to lift heavy objects.

When a machine makes work easier because it multiplies the effort being applied we say the machine is providing a mechanical advantage.

To find the mechanical advantage of a lever you need to measure the length of the effort arm and the length of the resistance arm. Then, divide the effort arm length by the resistance arm length.

Remember lifting the adult with the first class lever? Let's measure the effort and resistance arms. The adult who is the load in this case is 1 meter from the fulcrum. The effort arm is four meters long. If we divide the effort effort arm by the resistance arm we find the mechanical advantage is four.

Another way of thinking of the mechanical advantage of four is to take the adults weight, which is 180 pounds, and divide it by four. The answer is 45 pounds of effort to lift the 180 pound adult.

The mechanical advantage for a wheel and axle is determined by dividing the diameter of the wheel by the diameter of the axle.

Let's calculate the mechanical advantage of this doorknob. The diameter of the wheel part is five centimeters. The diameter of the axle is two centimeters. Therefore the mechanical advantage is two and a half.

It's very easy to determine the mechanical advantage of a pulley setup. The mechanical advantage is equal to the number of supporting strands. So a movable pulley has a mechanical advantage of two while a fixed pulley has a mechanical advantage of one.

When more pulleys are added the mechanical advantage increases dramatically. What this means is that if a block and tackle set up has four supporting strands its mechanical advantage is four. The amount of effort needed to lift an object is 1/4 of the objects weight. If the object weighs 40 grams it will take only ten grams of effort to lift it.

The six simple machines have been important contributors to our advancement through the ages. However, not every application has succeeded. Take for instance this invention:

You probably recognize the bike. What you probably didn't notice was the rocket strapped to it.

This inventor felt a rocket propelled bicycle would revolutionize our means of travel.

I guess he wasn't right.

Now it's time for a video quiz. There will be ten questions. The first five will be multiple choice and the last five are fill-in the blank or short answer.

Question number one.
The turning point of a lever is called the _____.

a. resistance
b. effort
c. fulcrum
d. arm

Question number two.
The load or object being moved on a lever is called the _____.

a. resistance
b. effort
c. fulcrum
d. arm

Question number three.
The mechanical advantage of a wheel and axle is determined by _____

a. dividing the diameter of the wheel by the diameter of the axle.
b. dividing the axle radius by the wheel radius.
c. measuring the length of the effort arm.
d. dividing the resistance arm by the effort arm.

Question number four.
How do we calculate the mechanical advantage of a movable pulley?

a. Divide the length of the effort arm by the length of the resistance arm.
b. Divide the wheel radius by the axle radius.
c. Measure the length of the effort arm.
d. Count the number of supporting strands of rope.

Question number five.
How do we calculate the mechanical advantage of a lever?

a. Divide the length of the effort arm by the length of the resistance arm.
b. Divide the wheel radius by the axle radius.
c. Divide the length of the resistance arm by the length of the effort arm.
d. Divide the weight of the load by the effort arm.

Question number six.
What is energy?

Question number seven.
How is a fixed pulley different from a movable pulley?

Question number eight.
What is a block and tackle?

Question number nine.
Name the six simple machines.

Question number ten.
There are three kinds of levers. What makes them different from each other?