Land Explorations



PURPOSE

Students will investigate and understand the seven different simple machines and their uses through hands-on experiments and observations of the world around them. Experiments involving levers and pulleys are designed to incorporate mathematics and measurement. Using simple machines to build Rube Goldberg devices extends the thinking process for students beyond simple rote knowledge and comprehension to application, analysis, synthesis and evaluation. Key concepts include: force, work, power, load and mechanical advantage.

BACKGROUND

While visiting the exhibition: From Here to There by Land, Sea and Air, students were able to use several different simple machines to move objects from one place to another. A machine is any device that can apply mechanical energy at one point and deliver it in a more useful form at another point. Simple machines are all around us and help us accomplish work faster and more easily many times each day. The seven simple machines are: lever, screw, wedge, gear, wheel &axle, pulley and inclined plane.

VOCABULARY

Energy – The ability to do work. Forms of energy include electrical, heat, mechanical (moving parts), and potential (stored energy).

Force – A push or a pull.

Load – A weight to be moved.

Mass – A measure of the amount of matter that an object contains.

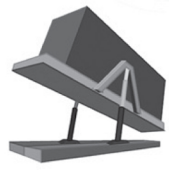
Mechanical Advantage – The benefit created by a machine that enables people to do work while using less force.

Power – The amount of work done in a certain amount of time (Power = Work divided by Time).

Simple Machine - Any device that requires the application of a single force to work. Tools used to make work easier (see chart for details).

Work – The energy transferred by a force to a moving object (Work = Force multiplied by Distance).

Simple Machines Chart

SIMPLE MACHINES	WHAT IT IS	HOW IT HELPS US WORK	EXAMPLES
LEVER 	A stiff bar that rests on a support called a fulcrum	Lifts or moves loads	Shovel, nutcracker, seesaw, crowbar, elbow, tweezers, bottle opener
INCLINED PLANE 	A slanting surface connecting a lower level to a higher level	Things move up or down it	Slide, stairs, ramp, escalator, slope
WHEEL AND AXEL 	A wheel with a rod, called and axel, through its center: both parts move together	Lifts or moves loads	Car, wagon, doorknob, pencil sharpener, bike
SCREW 	An inclined plane wrapped around a pole	Holds things together or lifts	Screw, jar lid, vise, bolt, drill, corkscrew
PULLEY 	A grooved wheel with a rope or cable around it	Moves things up, down, or across	Curtain rod, tow truck, mini-blind, flag pole, crane
WEDGE 	An object with at least one slanting side ending in a sharp edge	Cuts or spreads an object apart	Knife, pin, nail, chisel, axe, snowplow, front of a boat
GEAR 	A toothed wheel designed to transmit motion to another object.	Turns an object	Inside a bicycle, clock, toys, VCR

Activities

Activities have been grouped according to grade level, but you can combine or change the activities to fit the ability and interest level of your class.

Grades K – 2

Simple machines are all around us, and we use them every day. The following activity engages students in a game to locate and identify simple machines they might find in a school, home and/or a work environment based on their design and function of the object.

- [1a]*Simple Machine Scavenger Hunt* -

Materials:

- Scavenger Hunt page (attached)
- Photographs or real examples of simple machines and other machines (see web address in reference 1a)

Teacher Preparation:

Print out and laminate (optional) the simple machine cards from reference 1 (print in color), or take photographs of your own to use. Be sure to have multiple examples of each type (enough for one per group of students). Tape the cards around the classroom. As an alternative to the cards, have multiple real examples of each machine placed around the room. You can use a multimedia projector to utilize the computer game as a full-class experience rather than as individuals or small groups.

Activity:

- Separate students into groups of 4 or 5. Hand out the scavenger hunt page to each group and explain that the goal of the activity is to find examples of simple machines and fill the scavenger hunt sheet.
- Students must find 2 examples of levers, 2 wheel and axles, 1 pulley, 1 wedge, 1 screw, 1 inclined plane, and 2 examples of objects that are ***not*** simple machines.
- Explain that only one person at a time can leave the group to find an item for the list, and when that person finds something she or he can return for the next person in the group to take a turn.
- Give students 15 minutes to search for items. Circulate and help students who are having difficulty.
- When all groups are finished, have each group stand and share the simple machines they found.

Questions:

What are some different simple machines you found? What are they each used for? Can you think of any simple machines that make up your body? *Lots of levers*

Simple Machines
Scavenger Hunt

LEVER



LEVER



WHEEL & AXLE



WHEEL & AXLE



PULLEY



WEDGE



INCLINED PLANE



SCREW



- [1b]Simple Machines Computer Game -

Materials:

- Computer(s) with internet access (optional) directed to http://www.edheads.org/activities/simple%2Dmachines
- Multimedia projector (optional)

Teacher Preparation:

Connect computers to the website listed and test to be sure the game works. If it does not, follow the links within the site to install the Flash Plug-in. Students can play this game as individuals during class breaks, as groups, or as a class with teacher facilitation using a multimedia projector.

Activity:

- Have students play the Simple Machines computer game to search for simple or compound machines in a house and/or a tool shed.

Questions:

What are some simple machines you might find in your bedroom? In your kitchen? What do they do, and how do they work?

[1]**These projects adapted from:**

a) Mike Wampole, Harrisonburg City Public Schools. Harrisonburg, VA: http://staff.harrisonburg.k12.va.us/~mwampole/1-resources/simple-machines/0-lesson.html

b) Edheads, 2007: http://www.edheads.org/activities/simple%2Dmachines/

Grades 3 – 5/6 – 8

Many simple machines can help you move heavy loads. They help us do work by trading force for distance. They do not increase the amount of work done, but they make work easier by spreading the force out over a longer distance.

Levers are made of a stiff bar that pivots (or turns) on a support called a fulcrum. By changing the location of the fulcrum – moving it farther away from where you are applying the force and closer to what you are trying to move, levers can make the job feel easier. Inclined planes, pulleys, and gears all provide a work/distance trade-off.

Grades 3 – 5/6 – 8

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- Lever Lab-

Materials:

Per Group:

- 1 lever (ruler)
- 20 pennies or (½" washers)
- 2 stickers
- 1 fulcrum (hexagon-shaped pencil or binder clip)

Teacher Preparation:

Copy the "Lever Lab" worksheet double-sided, one per student. Have students work in teams of 2-3. Younger students may have difficulty using the worksheet. This can be omitted if desired.

Activity:

- Have groups pick up their materials and one "Lever Lab" worksheet for each student.
- Have students label one sticker "F" for EFFORT FORCE and stick it on the 1-inch end of the lever (not on the number). Label the other sticker "L" for LOAD END and stick it on the 12-inch end (not on the number).
- Put the fulcrum under the lever at the 6-inch mark.
- Have each group put a load of one weight on the end of the LOAD END of the lever. Put the load as close as possible to the end of the lever (on the "12"). Be careful that the fulcrum stays in place.
- Have students put 1 weight as close as possible to the end of the FORCE END of the lever and be careful that the fulcrum stays in place. The lever should rise and balance evenly.
- Have students take notice of the number of weights needed to lift the load (1) and how many inches away from the center the load and force are (6 each).
- Point out to students how to record their information in the worksheet. This first experiment has already been recorded in the table as an example.
- Have students try more experiments by following the worksheet and changing the position of the load and the fulcrum.
- Guide students through the next 2 experiments as they record their results.

Questions:

Did it take more weight or less weight to balance the load when it got closer to the fulcrum? What changed when the fulcrum was moved? Based on this experiment, where would you put the fulcrum, and where would you push if you had to use a giant lever to lift a truck? What is the maximum number of pennies you can lift with only 1 penny on the effort force end?

- Inclined Plane Lab -

Materials:

Per Group:

- 5-7 books
- Various lengths of wood (each roughly the width of the books)
- Ruler
- Small bag filled with about 1 cup of rice or dried beans closed with a twist tie
- Rubber band
- Spring scale (optional)

Teacher Preparation:

Have students work in groups of 3-4. You may need to secure (tie) the stacks of books into bundles prior to class so that they are less likely to fall over.

Activity:

- Stack 5 books and lean one of the books against the stack to make an inclined plane.
- Cut the rubber band and tie it to the neck of the small bag. (If you have a spring scale, attach it to the end of the rubber band).
- Pull the rubber band (or scale) so that it is straight, but not stretched. Measure and record the length of the rubber band (the force on the scale should read "0").
- Holding one end of the rubber band (or scale), begin to lift the bag straight up to the top of the books.
- Measure and record the length of the stretched rubber band once the bag is as high as the stack (also record the force reading on the scale).
- Put the bag at the bottom of the inclined plane. Record the length of the rubber band, (and the force on the spring scale).
- Holding the end of the rubber band, slowly pull the bag up the inclined plane.
- Measure the length of the stretched rubber band when the bag is almost at the top. Record the length of the rubber band (and the force on the scale).
- Try the experiment again, this time changing the length of the inclined plane, and/or the height of the stack.

Make a class chart to compare the information.

Questions:

How is force related to the length of the rubber band? What felt easier, lifting up or using the inclined plane? How did the length of the rubber band change, and why? Did you use less force or more force with a longer ramp? What kind of relationship can you find between the force you need to use and how far you had to pull?

LEVER LAB

Name: _____

Set up your lever as shown:



1) The 1-inch end of the ruler will be for the LOAD end.
2) The 12-inch end will be for the EFFORT FORCE.
3) Place the FULCRUM under the lever in the middle (the 6-inch mark).
4) Place weight(s) on the LOAD end of the lever, according to the table below. Be careful that the FULCRUM stays in place.
5) One at a time, place weights on the EFFORT FORCE end until the LOAD is lifted and the lever balances.

FULCRUM Position (in inches)	LOAD at end of Lever (number of weights)	Distance from FULCRUM to LOAD (inches)	Number of Weights Needed to Balance	Distance from EFFORT FORCE to FULCRUM (inches)
6	1	6	1	6
6	1	4		
6	1			
6	2			
6				

Try more experiments, changing where the fulcrum is.

5	1	5		
5	1			

- MORE ON OTHER SIDE -

FULCRUM Position (in inches)	LOAD at end of Lever (number of weights)	Distance from FULCRUM to LOAD (inches)	Number of Weights Needed to Balance	Distance from EFFORT FORCE to FULCRUM (inches)
5				
5				
4	1	4		
4	1			
4				
4				

Did it take more weight or less weight to balance the LOAD when it got closer to the FULCRUM? What changed when the FULCRUM was moved?

Based on this experiment, where would you put the FULCRUM, and where would you push if you had to use a giant lever to lift a truck?

Grade 6 – 8/ 9-12

Archimedes was a great mathematician and engineer who was born in 287 BC in Syracuse, Sicily. He is credited with the development of many of our modern day mathematical and mechanical principles (such as Archimedes' principle, the concept of pi (π) and geometric proofs) and machines like the lever, pump, and pulley. Archimedes understood the concept of mechanical advantage and how to use it to move or lift heavy objects with less force.

In mathematical terms the mechanical advantage (abbreviated as MA) is the ratio of the load to the applied force: MA = Load/Applied Force. A good mechanical advantage is greater than 1. The greater the mechanical advantage, the smaller the applied force needed to accomplish the task.

Reuben Garret L. Goldberg was one of the most famous cartoonists in history. He earned lasting fame for his Rube Goldberg machines, which are complex devices that perform simple tasks in indirect and convoluted ways.

Studying how simple machines are used to improve our lives, and how these machines can be creatively used and strung together to perform tasks can be exciting for students. It also helps to direct the students beyond the "simple machine vocabulary," extending the thinking process while showing simple machines' real usefulness.

- [2]Toy Dissection & Rube-Goldberg Design –

Materials:

- A class supply of:
- Screw drivers (Phillips and flat-head)
- Torque drivers (star-shaped screw driver)
- Hammers or small pry-bars (to be used as lever ONLY)
- Needle-nose pliers (preferably locking pliers)
- Jeweler's screw driver sets

Teacher Preparation:

Have each student bring in a small broken toy or broken appliance to disassemble. Have students work in groups of 2-3. Many electronic repair stores will donate broken appliances, and thrift stores will often donate broken things at a very inexpensive price. Be sure to have several large trash cans on hand.

Provide a worksheet or "lab book" so the students can keep track of all the parts removed by placing tally marks under the appropriate category of the identified simple machine. Sometimes it is necessary to determine how the part was used to know what section it should be counted under. Do not be surprised if you find a lot of screws and a few outside casings that do not fit the tally sheet.

Make a few copies of some of Rube Goldberg's drawings (available at www.rube-goldberg.com). For some, remove the descriptions of what the devices' purposes are.

Safety Guidelines:

Students must be supervised when working with tools. Be aware of the protocols for disposal/recycling of equipment involving microchips and circuit boards. Do not take apart older thermostats or other devices that may contain mercury.

Activity:

- Have students work in teams to carefully take apart their appliance or toy part by part.
- Have them keep track of all the parts removed by placing tally marks in a worksheet or lab book under the appropriate category of the identified simple machine.
- Introduce the work of Rube Goldberg and pass around some of his drawings. Next, take out the descriptions on a couple of the drawings and have students work in groups trying to decipher what is supposed to be happening.
- Have each student, or team of students, create a "rube-goldberg device," with the stipulation that it must perform a useful purpose and must incorporate at least 4 different simple machines.
- As homework, have students create their own machines. They would need to use at least three different types of simple machines, and the machine they create must perform some type of purpose. You may choose to provide a list of materials that they can use, or allow for completely open-ended design.

Questions:

How is each simple machine used (what is its function) in the appliance you took apart? What simple machines can you find in the different Rube Goldberg cartoons? What are some other "jobs" we could create a Rube-Goldberg device to do? What are some objects that we can use as simple machines in the device(s)?

[2]This project adapted from:

Robert L. Campbell, Holiday Park Elementary, Phoenix, AZ.

www.col-ed.org/cur/sci/sci09.txt

- PULLEYS -

Materials:

Per Group:

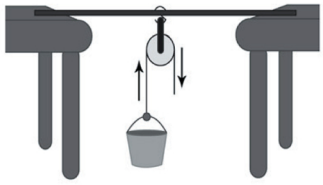
- 2 or more small pulleys (can be purchased at a hardware store)
- Weights (2 1/2 lb or 5 lb of rocks, washers or sand for example)
- Slat of wood
- Cup hook
- Medium weight twine
- Plastic bucket
- S-hook
- Opening between 2 tables
- 2 or more heavy books

Teacher Preparation:

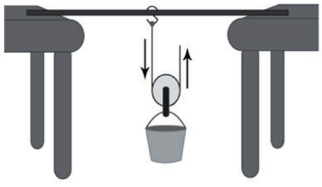
Screw a cup hook into each wooden slat. Cut a length of twine and put a slipknot in one end. This will make it easier to trade off from one pulley system to another. Place the materials on a central table for the students to access. Have students work in groups of 3-4.

Activity:

- Discuss the use of pulleys, emphasizing the difference between moveable and fixed pulleys, simple and complex pulley systems, and the concept of equilibrium.
- Have student groups collect their materials and guide them through the first 2 experiments.
- Single, fixed, pulley:
- Place one slat across the opening between 2 tables, hook down, with the books on either side to hold the slat secure.



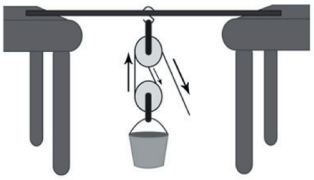
- Use the S-hook to hook one pulley to the cup hook of the slat.
- Using the slipknot, attach the length of twine to the bucket of weight and thread the twine up, through the pulley, and down so that the thread can be pulled down to lift the bucket up.
- Discuss the mechanical advantage (1) and how much force it takes to hold the weight up and steady. MA=1 because the Applied force = the Weight divided by 1, since only one length of rope is supported vertically (the length going up to the pulley).
- Single, moveable, pulley:



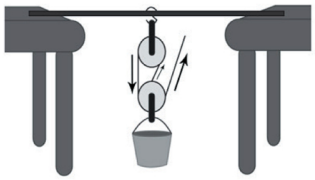
- Disassemble the first system, leaving the slat and cup hook in place.
- Use the S-hook to attach the bucket to the pulley.
- Attach the slipknot to the cup hook, so that the length of twine hangs free from the slat.
- Thread the twine down, around the bottom of the pulley, and back up so that pulling up on the string causes the pulley and bucket to lift.
- Ask students if it feels lighter than before (less effort needed to pull up). Have them compute the mechanical advantage (2). How much force are they using to hold it up? (W/2 because two lengths of rope are supported: the one going up to the pulley, and the length they are pulling up on.)
- Have students experiment with other ways to assemble pulley systems and calculate the resulting mechanical advantage. Some examples are:

One fixed pulley and one moveable pulley

MA = 2



MA = 3



Questions:

What is the relationship between the mechanical advantage and the length of the string you use? Could you use 3 pulleys? How would you put them together? Try lifting the weight without using any pulleys, then try the single, fixed, pulley again. If the mechanical advantage is only 1 for the single pulley, why did it feel easier to lift than without the pulley?

[3]This project adapted from:

F. Carroll Dougherty, Jani Macari Pallis and Chad Okamoto, Society of Women Engineers.

http://www.swe.org/iac/lp/pulley-01.html