

Teacher Guide: Levers



Learning Objectives

Students will:

- Identify the parts of a lever.
- Discover that a lever can be used to lift heavy objects using less force.
- Describe the relationship between the applied force (effort) needed to lift a load and the distance from the fulcrum to the applied force.
- Calculate mechanical advantage.
- Diagram a first, second, and third-class lever.



Vocabulary

effort, first-class lever, fulcrum, lever, load, mechanical advantage, second-class lever, third-class lever

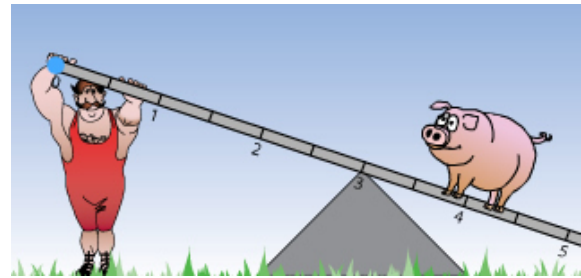


Lesson Overview

The *Levers Gizmo*™ allows students to experiment with levers by changing the location of the load, the effort and the fulcrum as well as the magnitude of the effort. A circus strongman supplies the effort, and various farm animals represent the load.

The Student Exploration contains three activities.

- Activity A – Students discover the benefits of first class levers.
- Activity B – Students calculate the mechanical advantage of a first class lever.
- Activity C – Students explore the properties of second and third-class levers.



Trying to lift a pig



Suggested Lesson Sequence

1. **Pre-Gizmo activity** (🕒 10 – 15 minutes)
To provide a dramatic demonstration of levers, you will need a long, sturdy board (such as a 2" x 4" or a 2" x 6"). For a fulcrum you could use a cement block or a brick. Lay the board on the fulcrum unevenly so that there is a "long" end and a "short" end. Ask one or two students to stand on the long end of the lever and challenge other students to lift them up by pushing down on the short end. They probably will not succeed.

Now repeat the experiment. This time, ask the students to stand on the *short* end of the lever. By pushing down on the long end, student volunteers will easily lift the heavy load!
2. **Prior to using the Gizmo** (🕒 10 – 15 minutes)
Before students are at the computers, pass out the Student Explorations and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers yet. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activities** (🧠 15 – 20 minutes per activity)
 Assign students to computers. Students can work individually or in small groups. Have them work through the Student Exploration with the help of the Gizmo. Walk around to check student progress and answer questions as students work. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (🧠 10 – 20 minutes)
 As students are working or just after they are done, discuss the following questions:

- How can you use a lever to lift heavy objects?
- What is the price that you pay for having to use less force to lift a heavy object? [Expected answer: you have to exert the force over a longer distance.]
- The Greek mathematician Archimedes once said “Give me a lever long enough and a fulcrum on which to place it, and I shall move the world!” Discuss whether a long lever could move something as heavy as the Earth.
- How are mechanical advantage and distance from the fulcrum related?

5. **Follow-up activity: Everyday levers** (🧠 20 – 30 minutes)
 Ask your students to try to find examples of levers around the classroom, school, and home. Identify each lever as a first-, second-, or third-class lever. Some examples:

First-class levers

Seesaw
 Scissors
 Pliers/bolt cutters
 Oar
 Balance
 Human arm (see below)

Second-class levers

Door
 Paper cutter
 Bicycle hand-brake
 Wheelbarrow
 Hand truck
 Stapler

Third-class levers

Fishing rod
 Canoe paddle
 Baseball bat
 Hockey stick
 Tweezers
 Human arm (see below)

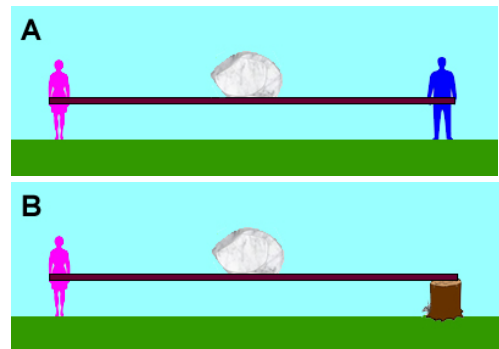


Scientific Background

Lever is one of the six simple machines. Usually, levers are used to lift heavy objects using less force than it would take to lift the object directly. In some cases levers are used to change a large force applied over a short distance to a small force exerted over a great distance.

To understand how a lever helps to lift heavy objects, imagine a person trying to lift a heavy rock. It is too heavy to lift herself, so she rolls the rock onto a plank, calls a friend, and they lift the rock together (A). Each person supports only half the weight of the rock, so it is much easier to lift the rock.

Now suppose the friend has to leave. He places his end of the plank on a stump (image B). The stump supports half the weight of the rock, as does the remaining person.

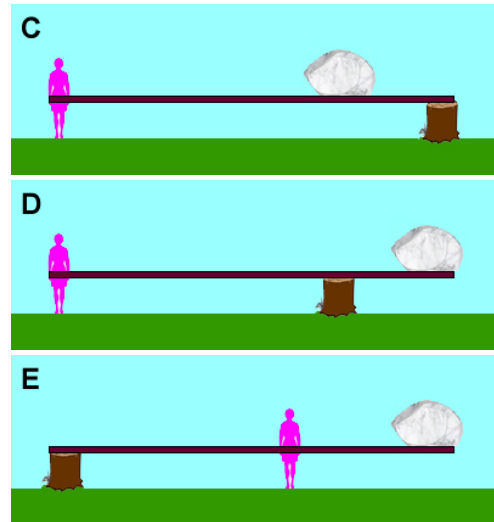


The closer the rock is to the stump, the more weight the stump supports and the easier it is for the person to lift the rock (C). However, the closer the rock is to the stump, the less high it can

be lifted. (Imagine the woman lifting her end of the lever above her head.) Images B and C show **second-class levers**, with the load (rock) between the effort (person) and the fulcrum (stump).

A **first-class lever** (D) works in much the same way—the closer the load is to the fulcrum, the easier it is to lift. However, in this case, to lift the rock, the person would need to push the lever down, not up.

In a **third-class lever** (E), the effort is between the fulcrum and the load. The load is farther from the fulcrum than the effort, so it takes *more* force to lift the load with a third class lever than it would take to lift it directly. Of course, if the person *could* lift the rock, it would go much higher than the person could lift it herself.



Mathematically, the angular force that each object exerts on the lever is called **torque**. Torque is equal to the force multiplied by the distance to the fulcrum. A 5 N load located 1 meter from the fulcrum has the same torque as a 1 N effort force exerted 5 meters from the fulcrum. Because the load is five times greater than the effort required to balance it, the **mechanical advantage** of the lever is 5.

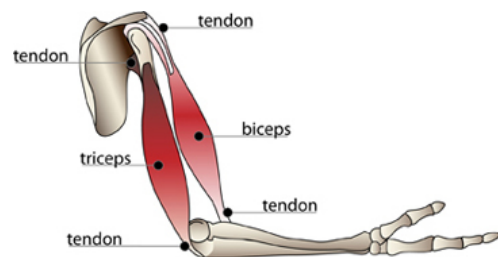


Health Connection

The musculo-skeletal system of the human body is almost entirely composed of lever systems. The forearm provides a clear example of how first- and third-class levers play a role in enabling common human movements. The elbow, where the bone of the upper arm meets the bones of the forearm, forms the fulcrum. The biceps and triceps muscles exert forces by contracting.

When the biceps muscle contracts, the effort causes the forearm to flex, or curl. This is an example of a third-class lever because the effort (biceps) is between the fulcrum (elbow) and the load (forearm).

When the triceps muscle contracts, the effort causes the arm to be extended. This is an example of a first-class lever—the fulcrum is between the effort and the load.



In either case, the effort is exerted close to the fulcrum. This is beneficial because muscles are strong but cannot contract very far. By having the muscle attach close to the fulcrum, the other end of the lever (the hand) can move through a much greater distance.



Selected Web Resources

Levers interactive simulation: <http://www.pbs.org/wgbh/nova/egypt/raising/lever.html>
Types of levers: <http://www.ee.nmt.edu/~tubesing/missionpossible/simplemachines.pdf>
Simple machines labs: <http://sunshine.chpc.utah.edu/javalabs/java12/machine/index.htm>
Simple machines interactive: <http://www.edheads.org/activities/simple-machines/>
Simple machines links: <http://edtech.kennesaw.edu/web/simmach.html>
Human body: <http://learning.covcollege.ac.uk/bin/search/dbm.pl?id=Biomechanics> Levers