LESSON 7
Lifting with Levers

Goal 2. Simple Machines – The student will use scientific skills and processes to explain that simple machines such as levers, pulleys, and inclined planes reduce the amount of effort required to do work.

Essential Objective:
The student will be able to identify the relationship between the distance of a fulcrum from a load and the amount of force needed to lift a load by using levers.

The student will use the following skills and processes of science:
• Use metric units when measuring or collecting data. (MLO)
• Analyze data to identify possible trends and form conclusions. (MLO)
• Provide supporting evidence when forming conclusions, devising a plan, or solving a practical problem. (MLO)
• Demonstrate and explain that tools enable scientists and other to observe, estimate, measure, collect, and communicate scientific data and information (i.e., size, distance, motion). (MLO)

Teacher Background:
A fulcrum is a fixed point on which a lever is supported and turns (pivots). Resistance is the weight that is being lifted or moved or the force that opposes motion, such a friction. Effort is the force which is applied to move the resistance. With a lever, as the distance of the force from the fulcrum increases, the force needed to move the resistance also increases.

Teacher Preparation:
• Assign student partners.

Materials Provided in the Kit:

For Teacher Demonstration - None

For Each Group of Two Students:
• Triangular pivot
• Wood block with hook
• Spring scale
• Ruler

For Each Student – none

Materials Provided by Your School:

For Teacher Demonstration
• Masking tape
• Ruler
• Large book (like a dictionary)
• One unsharpened pencil

For Each Group of Two Students – None

For Each Student
• Student Response Booklet
About Levers

Use information from the text on SRP p. 5, "About Levers," to complete the following:

1. Did the information in the text, "About Levers," clarify or change your understanding of how levers are used to do work? Explain your answer using two examples from the text.

   __________________________________________________________
   ____________________________
   ____________________________
   ____________________________
   ____________________________
   ____________________________
   ____________________________
   ____________________________

2. List three examples of levers similar to the one described in the first paragraph of the text.

   A. ______________________________________________________
   B. ______________________________________________________
   C. ______________________________________________________

3. List two examples of simple machines that have two levers similar to the scissors described in the second paragraph.

   A. ______________________________________________________
   B. ______________________________________________________
Lifting with Levers – Part II

Answer the questions below using evidence from this investigation to support your responses.

1. What trend did you notice as the distance from the block to the fulcrum was increased? What effect did this trend have on the amount of work required to lift the block parallel with the top of the desk?

2. If a young child and an adult are sitting on a seesaw, what should the young child do to lift the adult?

3. Why is it easier to pull out a nail with a long handled hammer than a short handled hammer?

4. How do levers make work easier?
**LEVERS**

**What I Need To Know About Levers**

**lever**- a simple machine made up of a bar that turns, or pivots around a fixed point

**fulcrum**- the fixed point

![Diagram of a lever with labels E, R, and Fulcrum]

You apply a force called the **effort force** on one side of the lever. The effort force causes the lever to pivot, or turn, around the fulcrum.

On the other side of the lever is a force called the **resistance force**. This force must be overcome if work is to be done!

The **resistance force** might be the weight of an object to be moved, or it might be friction to be overcome, as when a nail is removed from a wall.

When the **FULCRUM IS CLOSE** to the resistance, a **SMALL EFFORT** on one end of the lever will move a large resistance at the other end.

The **LONGER THE LEVER**, the **LESS FORCE** needed to lift an object.
Part A

1. View the Calvin and Hobbes comic. What simple machine is used?

2. Label the parts on the simple machine below using the terms, fulcrum, force, and resistance.

3. Use arrows to show the direction of movement of the force and the resistance.
SEEK AND FIND LEVERS

The word search puzzle contains 24 words related to levers. Words may be printed across or down.

- pried
- fishing pole
- load
- seesaw
- extension
- pliers
- lever
- bottle opener
- move

- fulcrum
- second
- crowbar
- nutcracker
- wheelbarrow
- hammer
- third-class
- first
- tongs

- direction
- distance
- lift
- weight
- scissors
- speed
- force
- handle
- effort(s)

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Word Search

The words in the box are hidden in the puzzle below. To find them, look up, down, across, and backwards. Draw a ring around each word in the puzzle. Then write the word next to its meaning.

<table>
<thead>
<tr>
<th>machine</th>
<th>metric</th>
<th>inclined plane</th>
<th>compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>wheel and axle</td>
<td>wedge</td>
<td>screw</td>
<td>unit</td>
</tr>
<tr>
<td>newton</td>
<td>work</td>
<td>newton-meter</td>
<td>fulcrum</td>
</tr>
<tr>
<td>pulley</td>
<td>lubricant</td>
<td>lever</td>
<td>friction</td>
</tr>
</tbody>
</table>

C S R E T E M • N O T W E N
I N C L I N E D P L A N E W
X O O G A R B U N T Y R D E
L I M U R C L U F N R B U D
X T P R E N I H C A M M S G
E C O L E V E R B C A E N E
T I U I T T K S U I R T O O
S R N K R O W R G R H R T Z
C F D S R E T O J B K I W Y
R K A T P Y E L L U P C E G
E U N I T S I M P L E Q N S
W H E E L A N D A X L E L E
Before being shipped to its final destination, a mammoth must be weighed. I was fortunate enough in one village to witness the procedure at first hand. The center of a tree trunk was placed directly on a boulder. One end of the trunk was then pulled down and the mammoth encouraged to sit on it. No sooner did the beast seem reasonably comfortable than a number of villagers scrambled onto the other end of the trunk. Slowly their end sank and, as it did, the startled mammoth rose into the air. I was told that when the trunk reached a horizontal position, the combined weight of the people would equal that of the mammoth. This seemed reasonable enough.

THE PRINCIPLE OF LEVERS
The tree trunk is acting as a lever, which is simply a bar or rod that tilts on a pivot, or fulcrum. If you apply a force by pushing or pulling on one part of the lever, the lever swings about the fulcrum to produce a useful action at another point. The force that you apply is called the effort, and the lever moves at another point to raise a weight or overcome a resistance, both of which are called the load.

Where you move a lever is just as important as the amount of effort you apply to it. Less effort can move the same load, provided that it is applied further from the fulcrum; however, the effort has to move a greater distance to shift the load. As with the inclined plane, you gain in force what you pay in distance. Some levers reverse this effect to produce a gain in distance moved at the expense of force.

With levers, the distances moved by the effort and load depend on how far they are from the fulcrum. The principle of levers, which relates the effort and load, states that the effort times its distance from the fulcrum equals the load times its distance from the fulcrum.
Lifting with Levers

Answer Key

Answer the questions below using evidence from this investigation to support your responses.

1. What trend did you notice as the distance from the block to the fulcrum was increased? What effect did this trend have on the amount of work required to lift the block parallel with the top of the desk?

   Responses should indicate that as the distance from the fulcrum to the resistance increased so did the amount of force needed to lift the block. Therefore, the work increased as well.

2. If a young child and an adult are sitting on a seesaw, what should the young child do to lift the adult?

   The child should move farther away from the fulcrum. Or the child should ask the adult to move closer to the fulcrum.

3. Why is it easier to pull out a nail with a long handled hammer than a short handled hammer?

   The resistance (nail) is closer to the fulcrum, so as the distance from the fulcrum to the force increases, the effort force decreases.

4. How do levers make work easier?

   When you apply the appropriate distance of a resistance from the fulcrum, less effort force is needed to move the resistance.
### Examples of stations may include:

<table>
<thead>
<tr>
<th>Station #</th>
<th>Object(s)</th>
<th>Directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scissors and index card</td>
<td>Use the scissors to cut the index card on one of the lines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use the tweezers to pick up the cotton ball and place it in the container.</td>
</tr>
<tr>
<td>2</td>
<td>Tweezers, cotton ball, container</td>
<td>Open and close the door gently one time.</td>
</tr>
<tr>
<td>3</td>
<td>Door with hinges</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Tongs, crayon, container</td>
<td>Use the tongs to pick up the crayon and place it in the container.</td>
</tr>
<tr>
<td>5</td>
<td>Golf club, small ball (Or use a meter stick)</td>
<td>Place one hand in front of the other on the golf club and gently hit the</td>
</tr>
<tr>
<td>6</td>
<td>Bottle opener, empty bottle with cap</td>
<td>Use the bottle opener to remove the cap. (Replace the cap when done.)</td>
</tr>
</tbody>
</table>

1. The classes of levers for the above stations are:
   - Station 1: Scissors - first class lever.
   - Station 2: Tweezers - third class lever.
   - Station 3: Door with hinges - second class lever.
   - Station 4: Tongs - first class lever.
   - Station 5: Golf club hitting a ball - third class lever.
   - Station 6: Bottle opener - second class lever.

The following examples of the three classes of levers could be substituted for any of the stations mentioned above:
- **First Class** – pliers, tongs, triangular can opener (pushing down direction)
- **Second Class** – nutcracker, wheelbarrow
- **Third Class** – ice tongs, lacrosse stick, hockey stick, fishing pole with a weight at end of line (If a fishing pole is unavailable, tie a string on a meter stick and add a weight at the end to represent the fish. The task must be to pull up the fish in order to represent a third class lever), shovel (the shovel is not considered a lever when used to break the surface of the ground. However, when the shovel is used to lift the dirt, it is being used as a third class lever.)

### Materials Provided in the Kit:

For Teacher Demonstration – None

For Each Group of Four Students – None

For Each Student – None
Engagement:

1. Gather students in the discussion area.
2. Display the transparency, “Classes of Levers.” Have students name the three parts of a lever. (Fulcrum, effort, resistance).
3. Have students identify what each part does. The fulcrum is the fixed point at which the lever is free to move. Explain to students that in the case of double levers (such as scissors or tongs), it is the place where the two levers are attached. Effort is a force, which is applied to cause the lever to turn or move. Resistance is a force acting against the effort. Resistance could include the weight of an object to be moved or overcoming friction.
4. Ask the following question, “What is the main difference in each type of lever displayed on the transparency?” (the placement of the fulcrum, effort, and resistance)
5. Show students a book, pencil, and ruler. Have them positioned as shown in the diagram below.

![Diagram of a first class lever: Resistance, Fulcrum, and Effort]

Push down gently on the ruler to lift the block. Have students identify the fulcrum, resistance, and effort. (This will be an example of a first class lever.)
6. Show students a wheelbarrow. (This can be constructed prior to demonstration by attaching craft sticks to a box and adding a paper cut out wheel to front.) Place a small object like a cotton ball or eraser in the wheelbarrow and lift. Have students identify the fulcrum, resistance, and effort. (This will be an example of a second class lever.)

![Diagram of a second class lever: Resistance, Effort Applied, Fulcrum]
Extension:

2. Have them generate a list of additional first, second, and third class levers.
3. Chart students’ responses.

Evaluation:

1. SRB pp. 23-24, “Classy Levers” (Answer Key TRG pp. 50-51)
2. Observation of students’ participation and discussion
3. Examples generated from extension.
Station 4: *Tongs – First Class*

Station 5: *Golf Clubs – Third Class*

Station 6: *Bottle Opener – Second Class*
First Class Levers

Which class of levers are these?

First Class Lever

Weight \(\uparrow\)  
Fulcrum \(\downarrow\)  
Force \(\uparrow\)

Second Class Lever

Weight \(\uparrow\)  
Fulcrum \(\downarrow\)  
Force \(\uparrow\)

Third Class Lever

Weight \(\uparrow\)  
Force \(\uparrow\)  
Fulcrum \(\downarrow\)
THE THREE CLASSES OF LEVERS

First Class

\[
\begin{align*}
\text{Resistance} & \quad \triangle \quad \text{Effort} \\
\text{Force} & \quad \text{Fulcrum} \\
R & \quad E
\end{align*}
\]

crowbar

scissors

punch

Second Class

\[
\begin{align*}
\triangle & \quad R \quad E
\end{align*}
\]

paper cutter

nutcracker

wheelbarrow

Third Class

\[
\begin{align*}
E & \quad R
\end{align*}
\]

broom

crane

forceps
LEVERS IN ACTION

Oh, Lever! How do I use thee?
Why not count the ways?

FIRST-CLASS LEVERS

BALANCE
The object to be weighed is the load and the weights make up the effort. The two are equal, being at the same distance from the fulcrum.

BEAM SCALE
The fulcrum is off-center, and the weight is moved along the bar until it balances the object being weighed.

NAIL EXTRACTOR
The effort of the hand is magnified to pull out a nail. The load is the resistance of a nail to extraction.

HAND CART
Tipping the handle of the hand cart with a light effort raises a heavy load.

PLIERS
A pair of pliers is a compound lever (a pair of levers hinged at the fulcrum). The load is the resistance of an object to the grip of the pliers.

SCISSORS
A pair of scissors is a compound first-class lever. It produces a strong cutting action very near the hinge. The load is the resistance of the fabric to the cutting blades.

SECOND-CLASS LEVERS

WHEELBARROW
Lifting the handles with a light effort raises a heavy load nearer the wheel.

BOTTLE OPENER
Pushing up the handle overcomes the strong resistance of a bottle cap.

NUTCRACKERS
A pair of nutcrackers is a compound second-class lever. The load is the resistance of a shell to cracking.
THIRD-CLASS LEVERS

HAMMER
A hammer acts as a third-class lever when it is used to drive in a nail. The fulcrum is the wrist, and the load is the resistance of the wood. The hammer head moves faster than the hand to strike the nail.

FISHING ROD
One hand supplies the effort to move the rod, while the other hand acts as the fulcrum. The load is the weight of the fish, which is raised a long distance with a short movement of the hand.

TWEezERS
A pair of tweezers is a compound third-class lever. A small movement of the fingers produces a longer movement of the tweezer tips in order to grip a hair. The load is the resistance of the hair.

MULTIPLE LEVERS

EXCAVATOR
An excavator is a rotating assembly of three levers — the boom, dipper and the bucket — mounted on caterpillar tracks. The assembly swings round on the slew ring while the three levers, powered by hydraulic rams (see pp.136-7), combine to place the bucket in any position. The boom is a third-class lever that raises or lowers the dipper. The dipper is a first-class lever that moves the bucket in and out. The bucket is itself another first-class lever that tilts to dig a hole and empty its load.

NAIL CLIPPERS
Nail clippers are a neat combination of two levers that produce a strong cutting action while at the same time being easy to control. The handle is a second-class lever that presses the cutting blades together. It produces a strong effort on the blades, which form a compound third-class lever. The cutting blades move a short distance to overcome the tough resistance of the nail as they slice through it.
THE PRINCIPLE OF LEVERS

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SECOND-CLASS LEVERS

Both the mammoth-lifter and the wheelbarrow are examples of second-class levers. Here, the fulcrum is at one end of the bar or rod and the effort is applied to the other end. The load to be raised or overcome lies between them.

With this kind of lever, the effort is always further from the fulcrum than the load. As a result, the load cannot move as far as the effort, but the force with which it moves is always greater than the effort. The closer the load is to the fulcrum, the more the force is increased, and the easier it becomes to raise the load. A second-class lever always magnifies force but decreases the distance moved.

A wheelbarrow works in the same way as the mammoth-lifter, allowing one to lift and shift a heavy load with the wheel as a fulcrum. Levers can also act to press on objects with great force rather than to lift them. In this case, the load is the resistance that the object makes to the pressing force. Scissors and nutcrackers (see p.26) are first-class and second-class examples. These devices are compound levers, which are pairs of levers hinged at the fulcrum.

A SECOND-CLASS LEVER IN ACTION

Because the effort is three times as far from the fulcrum as the load, the force needed to raise the load is reduced to a third of the load.

A THIRD-CLASS LEVER IN ACTION

The load moves three times as far as the effort, because it is three times as far from the fulcrum. The load is a third of the effort.