Levers and Pulleys

5th Grade Science Investigation
Unit
What Do We Already Know?

- A lever and pulley are mechanical advantages—makes work easier, and helps lift things you couldn’t normally lift.
- Combined simple machines can be put together to make compound machines.
- Levers and pulleys are used in curtains on stages.
- If you have a big pulley it would help you lift something on the other side.
- Ancient Egyptians used levers and pulleys to build the Great Pyramids.
- Levers are in everyday things such as light switches and faucets.
- Levers balance on the fulcrum.
- Ex: Scissors?, seesaw, patio umbrellas, stick shifter in car,
Levers are used to help you lift things – make work easier.

Gravity pulls down.

Have an idea of what motion and force are.

Levers and pulleys are both simple machines.

Simple machine: one step tools (ex. Levers).

Levers and pulleys are widely used today even without us realizing it.

Use of simple machines makes work easier because it spreads the effort over a longer distance.
What Do We Want to Know?

- Simple machine vs. compound machine?
- When do we get to build something?
- Do we get to decide what we want to build?
- Can we build a catapult?
- What is a lever and pulley most commonly used for?
- What is the fulcrum in a lever?
Investigation 1
Levers
Investigation One: Part One

- How can a lever make work easier?
- A lever is a simple machine.
- Simple machines provide advantage to the user.
- The unit used to measure the amount of force needed to lift a load or overcome a resistance is the Newton (N).
Part 1 Vocabulary

- Lever: simple machine that people use to gain a mechanical advantage, such as making work easier
- Lever arm: a stick or beam free to pivot at a point
- Fulcrum: the point where the lever arm pivots
- Load: the mass lifted or the resistance overcome by a lever is the load
- Effort: the force needed to move a load or overcome a resistance
- Newton: unit of measurement for force
Set up a lever system with the load hanging at 15 cm.

- Can you lift the load using only one finger?
- Does it always take the same amount of force to lift the load?
- Where should you press to lift the load with the LEAST force?
Inv. 1 Part 1

- Remove the loads from their levers
  - What advantage can be gained by using a lever to lift a load?
  - How can you measure the advantage provided by a lever?
Spring Scale

- Hang the spring scale right side up
- Newton is the unit used to measure force in the metric system, just as gram is the unit used to measure mass or liter is used to measure volume.
- Read the scale from the top of the metal indicator
- Each little line on the Newton scale represents 0.2 N. If the indicator is in between, you must round to the nearest 0.1 N.
- Stop before the scale goes past the 10-N limit!!!!
What is the relationship between the load and the effort that gives a lever user (you) the greatest advantage? (makes it easiest to lift the load?)
Summary of Discovery

- When the effort is applied at a great distance from the fulcrum, the load is easy to lift.
Part One: In Conclusion

- A lever can make a load easier to lift, it can move loads, and it reduces the effort.
- In a lever system the farther from the fulcrum the effort is applied, the greater the advantage to the lever user.
Investigation 1: Part 2
Lever Experiment A

- You will need:
  - No. 4 Student Sheet (Lever Experiment A Graph)
  - No. 5 Student Sheet (Response Sheet – Levers)

- Find your science group from Friday
Read Science Stories: Class-1 Levers
Review Levers
Lift the Load

- How much force (effort) is needed to lift the load?
- A scale is a useful tool for measuring the amount of force needed to lift a load. Force is always measured in newtons.
Set Up Lever System
Lever Experiment A

The load stays at 10 cm, and the effort is applied at various distances from the fulcrum (5 cm intervals except for the first (2.5 cm))
Reading and Recording Effort
The Force of the Scale

- Put the load 5 cm from the fulcrum
- Put the scales 25 cm from the fulcrum on the other side
- The load is 5 cm from the fulcrum. How much pull is being applied to lift the load?
- The load is being lifted with no effort. How is that possible?
- If the weight of the scale is lifting the load, how can we find out how many newtons that is?
Calculate Total Force
Begin the Experiment!
Let’s Discuss Advantage
Introducing the Two-Coordinate Graph
Let’s Graph the Results
Use the Graph to Describe Relationships
Vocabulary

- Two-coordinate graphs: shows relationships between two variables
- Advantage: a benefit obtained by using a lever (or other simple machine)
When the load is at a constant position on the lever arm, how can you make it easier to lift the load?
- The farther the effort is from the fulcrum, the easier it is to lift the load.

What is the difference between the weight of the load and the amount of effort needed to lift it?
- The weight of the load remains constant; the effort needed to lift the load varies depending on where the effort is applied on the lever arm.
Investigation 1: Levers
Part 3: Lever Experiment B
Inv. 1 Part 3

- You will need:
  - Materials for lever experiment (same as for part 2)
  - Student Sheet no. 6 Lever Experiment B
Review the First Experiment
Propose Reversing the Experiment

What do you think would happen to the effort needed to lift the load if

a. the scale stayed at one location on the lever, and
b. The load moved farther and farther from the fulcrum

Would the results be the same as moving the location of the effort?
Predictions?
Let’s Begin Lever Experiment B!

- The scale must stay at 10 cm on your lever and the LOAD will move this time.
Two-Coordinate Graph

- Graph your results from Experiment B
- **PLEASE NOTE:**
  - X-axis: independent variable (what YOU changed during the experiment)
  - Y-axis: dependent variable (what you found out)
Let’s Discuss Our Results!

- How does your graph of experiment A compare to your graph from experiment B?
  - The graph of experiment B starts at (0,0) and is a straight inclined line - or it should be... : )
Let’s Discuss Our Results!

What is the relationship between the location of the load on the lever system and the effort it takes to move it?

- The effort needed to lift the load decreases as the load gets closer to the fulcrum; the effort increases as the load gets farther from the fulcrum.
1. What is the difference between Lever Experiment A and Lever Experiment B?

2. What do both the experiments help us understand about levers?

3. In a two-coordinate graph, do you place the independent variable on the horizontal line (x-axis) or the vertical (y-axis)?

4. What is a fulcrum?

5. What is advantage in simple machines?
The Wheel and Axle
Investigation Two

More Leverage
Review Levers

Consider the Force of the Load

- Remember, a force is a push or a pull. When the load hangs on the lever or the spring scale, it pulls down with a force. The load we use pulls with a force of 2.4 N
Set Up a Demonstration Lever

- Place the load at 20 cm
- Will the effort needed to lift the load be more, less, or the same as the pull of the load?
Move the Fulcrum

This lever has the fulcrum right in the middle of the lever arm. Is the fulcrum always right in the middle of the lever arm?

What might happen if the fulcrum was not in the middle? Would it still be a lever?

Is there any advantage to moving the fulcrum to new locations along the lever arm?
Form into your teams

GETTERS get the materials they need for two lever systems.

Experiment!

What did you find out?
You have been working with CLASS 1 LEVER SYSTEMS. Class 1 Lever Systems always have the fulcrum somewhere between the load and the effort.
Other Arrangements

- Can there be other arrangements of the load, effort, and fulcrum?
- The load in the middle?
- The effort in the middle?
New Levers?!

- Investigate New Levers!
  - Work with your team to see if you can set up a different kind of lever system. Try to find out what kind of advantage (if any) it provides.
Did You Discover Different Levers?

- **Class-1 Levers:** Levers with the fulcrum in the middle and load and effort at the ends.

- **Class-2 Levers:** Levers with the load in the middle and the fulcrum and effort at the ends.

- **Class-3 Levers:** Levers with the effort in the middle and the fulcrum and load at the ends.
Let’s Practice Setting Up Three Classes of Levers!

- Try to set up each of the three types

- Mnemonic Device: FLE—1-2-3
  - The FLE stands for the part of the lever system that is in the middle of the lever
  - It’s as easy as FLE—1-2-3!

- Bottom Line: Levers can be set up in three basic ways. They are called class 1, class 2, and class 3.
Diagram
- A drawing that explains the relationship of the parts of the system, in this case a lever system

- A diagram uses a system of symbols and conventions to communicate information about lever designs.
Investigation Two
Part Three: Real-World Levers

- We will need:
  - Student Sheet no. 12 called “Levers at Work”
  - 1 broom
  - 1 nutcracker
  - 1 scissors
  - 1 bottle opener
  - 1 pliers
  - 1 tweezers
  - 1 hammer
  - Half meter sticks
  - Loads with rubber bands
  - Masking tape
  - 3 lever diagrams and 3 lever pictures (on bulletin board)
Real-World Levers

- Levers are all around us in the world – every toolbox, kitchen drawer, toys, appliances, cars, and machines.

- Let’s review each of the three types of levers......
Levers at Work

- We have a number of tools here to investigate. Each one uses one or more levers to give its user some kind of advantage
  - Investigate each tool
  - Analyze it to kind the levers
  - Diagram it on the levers at work student sheet
  - Write the lever’s class on the sheet in the space provided
Levers at Work

- Let’s try one together:
  - What class of lever is the screwdriver when it is used to pry the lid off a can? (Class 1)
  - When you are trying to lift the lid off a can of putty or paint, there is no metal cube to be lifted. Where is the load, and what direction is the load acting?
    - Load can be either a mass that you lift or a resistance that you need to overcome. Here the resistance is the load.
  - Identify the load, fulcrum, effort, and class.
  - Diagram the lever
Investigate!!!!
Report the Results

- Each team report on one of the tools, identifying its class and diagramming the lever on the board.
Wrapping Up Part 3

- Vocab
- New Concepts – Part Three
  - Many common tools use levers: scissors, pliers, bottle openers, hammers, wheelbarrows, and brooms, to name a few.
  - Effort is reduced as the load moves closer to the fulcrum
- Let’s read Science Stories: Class-3 Levers!!
Investigation Three
Part Four: Lever Pictures

- We will need:
Investigation Three

Pulleys
Part One: One-Pulley Systems

- Inquiry Questions:
  - How much effort is needed to lift a load in a one-pulley system?
  - Is it always the same?
If you were on a construction site and needed to lift a steel grinder to the fifth floor of a building, you would need the world’s biggest lever. Not very practical! Levers do provide advantage, but they aren’t appropriate for certain jobs. It would make more sense to use a pulley.
We will need....
Free Exploration with One Pulley

- Find out if you can use a pulley
- Can a pulley be used to lift a load?
Scientific Method

- Let’s organize this experiment based on the scientific method.
- What is the order of the scientific method?
- What is the independent variable of this experiment?
- What is the dependent variable?
- What is the control variable?
- What is the testable question?
- Can we form a hypothesis statement?
Name the Pulley

- Pulley: a wheel with a grooved rim in which a rope can run to change the direction of the pull (force) that lifts the load
- Fixed pulley: has a wheel that is attached/secured to something above the pulley (meter stick in this case)
- Movable pulley: has a wheel that is attached to the load
Mechanical advantage: reduces the effort (force) needed to lift a load or overcome a resistance; it results from using a simple machine.

Directional advantage: is a change in direction that results from passing a rope through a pulley
Inquiry Answered

- Can a pulley be used to lift a load?
  - A single pulley can be set up as a fixed pulley or a movable pulley to lift a load.

- Do single-pulley systems provide advantage?
  - Single-fixed pulleys change the direction of effort. (directional advantage)
  - Single-movable pulleys reduce the effort needed to lift the load. (mechanical advantage)
Part one continued....

- Pulley Diagrams Student Sheet
- Spring Scales
  - Zero the scales at the beginning of every session
  - Always use the spring scales right side up
  - Add 0.5 N to scale readings only when pulling down
<table>
<thead>
<tr>
<th>Pulley System</th>
<th>Load (N)</th>
<th>Direction of Pull (Draw arrow)</th>
<th>Scale reading (N)</th>
<th>Effort (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-fixed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-movable</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Let’s Review the One-Pulley Systems…

- How are fixed and movable pulleys the same?
- What kind of advantage is provided by each pulley system?
- In what ways are pulleys and levers the same?
Part Two:
Two-Pulley Systems
The Two-Pulley Challenge

- Is there any advantage to using two pulleys at the same time?
- Let’s break into our science groups and give it a try!
- I might give you a hint in a few minutes.........
Keep the Wheels Turning

- Pulley Diagrams Student Sheet again
- Let’s diagram the pulleys using red dot stickers
Is there any advantage to using two pulleys at the same time?
- Two pulleys can provide greater mechanical advantage than one when lifting loads.

What is a simple machine?
- Simple machines provide mechanical or other advantage.
What type of pulley did he use?
- Single movable

How do you know?

What would the pulley look like?

How much easier do you think this made the work of lifting the load?
- It took half as much effort as the weight of the load

How do you know?
Levers and Pulleys Unit
Review
Unit Review

- Utilize all of your notes in your portfolio
- Go over content questions and answers from each investigation
- Utilize previous quizzes from the unit
- What is the purpose of a lever?
- Be able to diagram different levers
- Be able to identify different levers
- What is the purpose of a pulley system?
- Be able to diagram different pulley systems
- What do simple machines offer the user?
- Be sure to review the study guide that was handed out on Friday