Science Unit: ***Energy and Motion in Man and Machine***

Lesson # 2: ***Simple Machines – Levers, Fulcrums and Pulleys***

Summary: Students explored the concept of **fulcrums**, **levers** and **work ratio** by building a simple lever using paint sticks. They also explored the difference between fixed and moveable **pulleys** by building their own using bobbins and ribbons.

School Year:	2014/15
Developed for:	Beaconsfield Elementary School, Vancouver School District
Developed by:	Sheila Thornton (scientist); Susan Worthington and Angela Ward (teachers)
Grade level:	Presented to grade 5/6/7
Duration of lesson:	1 hour and 30 minutes

Objectives

1. Understand how machines provide an advantage when doing work
2. Examine the six simple machines
3. Explore the mechanical advantage of levers, fulcrums and pulleys

Background Information

Machines help us to transfer energy more efficiently. A **simple machine** is a mechanical device that changes the direction or magnitude of a force. In general, they can be defined as the simplest mechanisms that use mechanical advantage to increase the magnitude of force. Renaissance scientists defined six classical simple machines as follows:

Simple machines can be regarded as the elementary "building blocks" of which all more complicated machines are composed. For example, wheels, levers, and pulleys are all used in the mechanism of a bicycle.

Vocabulary

Lever	A typical lever consists of a solid board or rod that can pivot about a point or **fulcrum**. A force or **effort** is applied, resulting in moving or applying force to a **load**. The distance from the applied force or effort force to the fulcrum is called the **effort arm** and the distance from the load to the fulcrum is called the **load arm**.
Fulcrum	The support about which a lever pivots.
Pulley	A pulley is a wheel with two raised edges so that a rope or a string will run along the wheel without coming off. It's often also called a block and tackle. Because there are no wheels in nature, there are also no pulleys.
Mechanical advantage	The advantage gained by the use of a mechanism in transmitting force.
Work ratio	The amount of effort or work done by a system per unit put into the system

Materials

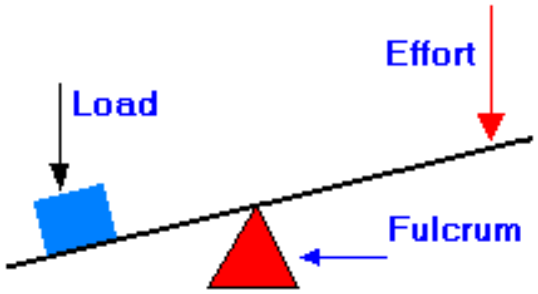
- Levers (paint stir sticks work well)
- Bobbins
- Packing/duct tape
- Single hole punch
- Wedges (any triangular material will do – cut hemlock corner trim)
- Ribbon (width of bobbin or smaller)
- Small cups or buckets
- Paper clips
- Washers – variety of sizes
- Embroidery thread
- String
- Marbles

In the Classroom

Introductory Discussion

Levers and Fulcrums

1. First Class Lever - a long pole or a rod put under an object to lift it. A fulcrum is an object used to brace under the long tool, giving the long pole something to push down against. The closer the fulcrum is to the object being lifted, the higher the person can lift the object. The longer the lever, the higher the object can be lifted.



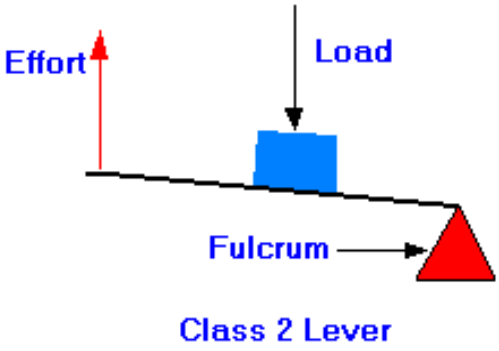
Class 1 Lever

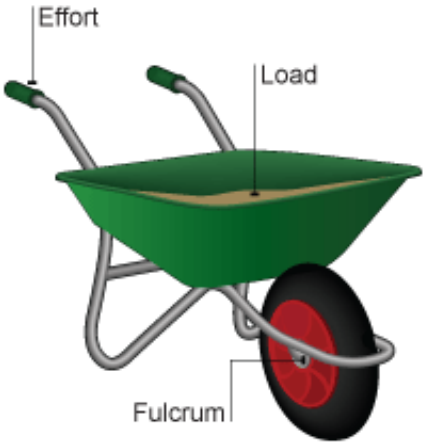
Discuss the see-saw dilemma:

Question: How do you see-saw safely with a smaller child?

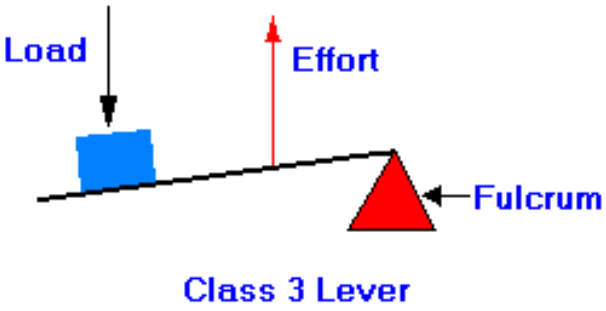
Answer: Larger child moves closer to the center of the see-saw.

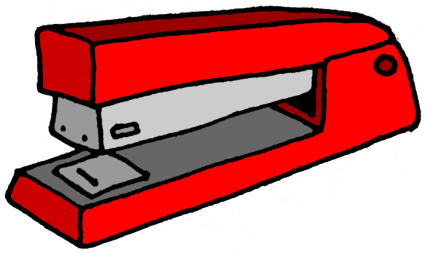
Class 2 Lever





Class 3 Lever





Science Activities

Activity 1: Mechanical Advantages of Fulcrums and Levers

Purpose of Activity: To explore the concept of fulcrums, levers and work ratios.

Observation: Using a Class 1 lever, explore the level of effort required to lift 5 washers will be **less or more** if the effort arm is shorter than the load arm.

Methods and Instructions:

1. Have the students set up a "see saw" with the levers and fulcrums. They can begin by practicing reaching equilibrium by balancing an equal number of washers on the load arm and the effort arm.

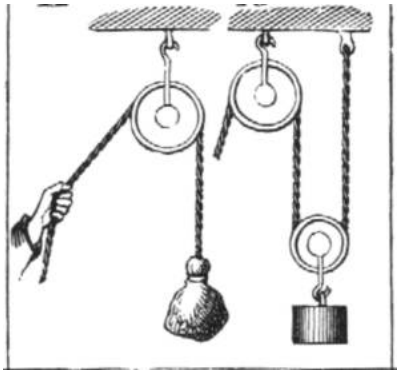
2. Then instruct the students to remove the washers from one side (the effort arm), and using one finger, press down on the effort arm. Note the level of effort required.

3. Reposition the fulcrum such that the effort arm is **shorter** than the load arm, and ask them to repeat the exercise.

4. For the third trial, have the students move the fulcrum away from themselves (the effort arm is **longer** than the load arm), and repeat the exercise. Which fulcrum position provides the greatest mechanical advantage? This will demonstrate the mechanical advantage of using a fulcrum and lever.

5. Once the students have understood the effect of the fulcrum position on the effort or work required to lift the washers, ask them to quantify the most efficient **work ratio, i.e.:**
    - With the fulcrum in the optimal position, how many washers does it take to lift 5 washers?
    - Does optimal placement of the fulcrum result in a 5:1 ratio? 5:2?
    - This will demonstrate the magnitude of the mechanical advantage provided by the fulcrum and lever.

Activity 2: Mechanical Advantage of Pulleys



Methods and Instructions:

1. Explain the difference between fixed and moveable pulleys:

   With a *fixed pulley* (pulley on the left of the image above), the pulley is attached to a hook and doesn't move. A fixed pulley doesn't give you any mechanical advantage, but it changes the direction of the force. For instance, you can pull down in order to lift something up.

   With a movable pulley (pulley on right of image above), you do have a mechanical advantage: you can pull with less force for a longer distance to get the same work done. This lets you lift things that would be too heavy for you without a pulley.

2. Have the students make small “buckets” by punching holes in the side of the plastic cups and tying a loop of embroidery thread through each hole to make a handle.

3. To create fixed pulleys, tie a piece of embroidery thread through the bobbin and tape the thread to the edge of the desk. The bobbin will then hang down and act as a fixed pulley.

4. Tie one end of the ribbon to the handle of the cup and thread the other end through the pulley. Add weight to the cup using marbles or washers, and have the students assess the effort required to lift the cup using the fixed pulley.

5. Add a second moveable pulley onto the ribbon. Unfold a paperclip and thread it through the pulley to create a hook. Hang the cup from the pulley and assess the effort required to lift it.

   Note: This activity was challenging for students - set aside extra time for the moveable pulley.

6. Encourage students to explore the concept by tying a cup to the “effort” end of the ribbon, and quantifying the effort required to lift the other cup:

   - Using a fixed pulley, how many washers does it take to lift a cup that contains 5 washers?
   - How many does it take to using a moveable pulley?