5 E Lesson Plan

Teacher: Chris Herald, STEM Project Coordinator, USD 383 Class: 90 minutes

LESSON TITLE: Lift the Load with Levers

QUESTION: The Greek philosopher Archimedes said, "Give me a lever long enough, and a place to stand and I can move the world." What did he mean by this?

LESSON OBJECTIVES:

- Make a lever.
- Learn how to use the sensor & Lab Quest to collect data
- Measure the amount of force needed to lift up a book when applying a force at different positions on the lever.

KCCR STANDARDS MATH: 6.NS.2 Fluently divide multi-digit numbers using the standard algorithm. **6.NS.3** Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. **7.RP.2** Recognize and represent proportional relationships between quantities.

KCCR STANDARDS SCIENCE: 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.3-**5ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

SEP: Analyzing Data; Obtaining, evaluating & communicating information; Constructing Explanations; Designing Solutions

CCC: Cause and Effect; Scale, Proportion and Quantity; Structure and Function

MATERIALS: for each group- Lab Quest and force sensor (or Newton spring scale), marker to use as a fulcrum, meter stick, tape, loop of string and heavy book (12cm thick)

ENGAGE: Share a  photo of the Maya-Toltec Pyramid to start a discussion how early engineers used simple machines to transport heavy stones. Ask students to name the 6 simple machines and give examples of levers. https://en.wikipedia.org/wiki/Chichen_Itza

EXPLORE: Students follow the lab sheet to investigate forces and levers as they move the fulcrum to different places on the meter stick. Ask students questions about the set up and parts of a lever as they work. Is there any kind of pattern?

EXPLAIN: Have students discuss their answers to questions listed on the lab sheet in small groups and present their information (slide show, drawing, etc.). How does the force required to lift the load change when the fulcrum is moved? How do engineers use simple machines? Introduce mechanical advantage.

ELABORATE: Students could use the formula *Work = [Force Applied] x [Distance the Object Moved]* to calculate the work as they design a different set up OR Check out the simulation at http://phet.colorado.edu/en/simulation/balancing-act which allows students to play with objects on a teeter totter to learn about balance. They can test what they learned by trying the Balance Challenge game.

EVALUATION: Have students write their thoughts about the focus question on an "exit" pass or compare the use of simple machines in ancient times compared to the present. Show Eureka! Episode 12 - The Lever https://www.youtube.com/watch?v=I-1LI2tWtNg

Vocabulary or topics discussed

Science = levers, simple machine, friction, fulcrum, resistance arm, effort arm, forces, work

Technology = Tools, materials, and skills are used to make things and carry out tasks; sensors

Engineering = inventions, machines, designing

Mathematics = visualize data, recognize patterns, proportions

This activity was modified from the lab book Middle School Science with Vernier copyright Vernier Software & Technology http://www.vernier.com and https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_simple/cub_simple_lesson03.xml

Levers

1st Class Levers

scissors, screwdrivers, crow bar, pliers, seesaw, pruners, hammer pulling a nail

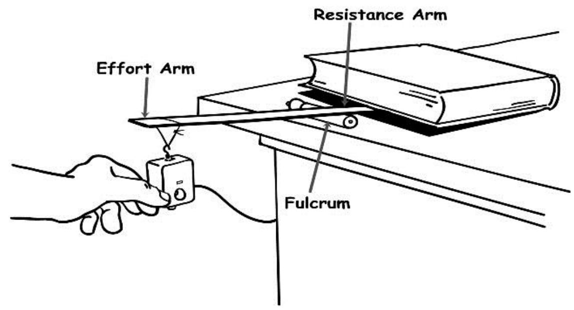
2nd Class Levers

Wheel barrow, doors, paper cutters, stamp pad lid, some nutcrackers

3rd Class Levers

shovel, fishing pole, arm, bat, oar, jaw, rake, broom, hammer hitting nail

Lift the Load!



In this activity, you will

- Make a lever.
- Measure the amount of force needed to lift up a book when applying a force at different positions on the lever.

*LabQuest engineer	* recorder
* Force Sensor operator	

PROCEDURE

<u>Part I</u> Lever with Fulcrum at <u>20 cm</u>

1. Put the book at the 5 cm mark so that just the edge of the book rests on the meter stick and the rest of the book is on the table. Place a pencil at 20 cm. This is the fulcrum, leaving the longer end sticking out over the edge of the table.
    a. Slide the loop of **string** up the meter stick from the end overhanging the table until it reaches the <u>30 cm</u> mark.
    b. Hook the Force Sensor on the loop of string, as shown above.

2. **<u>Read</u>** the following steps to learn about the different parts of the lever you have built.
    a. The side of the lever where the book is placed is called the **resistance arm**. For the lever you have built, the resistance arm is 20 cm.
    b. The side of the lever where the push or pull happens is called the **effort arm**. To find the length of the effort arm, find the difference between where the Force Sensor is attached and the pencil is the **fulcrum (pivot point)**. Since the loop of string is holding the Force Sensor at 30 cm and the fulcrum is at 20 cm, the length of the effort arm is 10 cm.
    c. **Draw** a lever on your paper with the 3 parts labeled.

3. Collect data by doing the following:
    a. Hook the sensor on the string. Press the green arrow on the Lab Quest found at the bottom left side.
    b. Holding the screw of the Force Sensor, **slowly** pull down until the lever is horizontal.
    c. Click stop, and touch the screen at the highest point on the line. Record the force shown on the right hand side into Table 1.
    d. Be sure the person pulling the Force Sensor down notices how it **feels to pull down** and writes this observation on the Observations Sheet. The string should be at 30 cm.

4. Collect more data. Press File, then choose NEW. Discard your data.
    a. Make sure the book is still at 5 cm.
    b. Move the string out to the **40 cm** mark.
    c. Click stop, and touch the screen at the highest point on the line. Record the force shown on the right hand side into Table 1.
    d. Record your observations about how much effort it took to pull the lever down.

5. Repeat Step 4, moving the string and force sensor **10 cm** each time, until you reach the 70 cm mark. Each time you move the string, record your observations and the force.

Part II Lever with Fulcrum at 30 cm

6. Move the meter stick so the pencil or **fulcrum** is at the **30 cm** point. In this position, the resistance arm is 30 cm. Keep the book in the same position as before. Move the Force Sensor to 40 cm.

7. Collect data.
    a. Press the green arrow found at the bottom left side.
    b. Holding the Force Sensor, **slowly** pull down until the lever is horizontal.
    c. Click stop, and touch the screen at the highest point on the line. Record the force listed on the right hand side into Table 2.
    d. Move the string and Force Sensor to the **50 cm** mark.

8. Repeat Step 7, moving the string 10 cm each time, until you reach the 80 cm mark. Each time you move the string, write down the force.

ANALYZE YOUR DATA

1. What did you notice about how hard you had to pull as the effort arm became longer and longer?

2. How did your prediction match what happened when the resistance arm moved from the 20 cm mark to 30 cm?

3. Do you think it would be possible to make a lever that would allow you to be able to pick up a car? Describe the effort arm and resistance arm you might need to do it.

Good job!!

LabQuest Engineer __________________ Recorder _______________ Force Sensor Operator ______________

Observations Sheet: Fulcrum at 20 cm
10 cm effort arm
20 cm effort arm
30 cm effort arm
40 cm effort arm
50 cm effort arm

Key Question

How will having a longer resistance arm affect how hard you must pull to pick up the book?

If the resistance arm is longer than the force will be _____________________________

(same, increase or decrease).

Table 1 Fulcrum at 20 cm

Position of Force Sensor	Effort arm length	Applied force
30 cm	10 cm	N
40 cm	20 cm	N
50 cm	30 cm	N
60 cm	40 cm	N
70 cm	50 cm	N

Table 2 Fulcrum at 30 cm

Position of Force Sensor	Effort arm length	Applied force
40 cm	10 cm	N
50 cm	20 cm	N
60 cm	30 cm	N
70 cm	40 cm	N
80 cm	50 cm	N

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