The Balance:

An example of a 1st Class lever.

OBJECTIVES

Students will:

1. Identify the fulcrum, resistance and effort on a balance.
2. Determine the lever class of a balance.
3. Through manipulation, investigate how the closeness of the resistance to the fulcrum affects the effort needed to achieve a state of balance.

MATERIALS

Each group of 2 students will need:

- 1 K'NEX Levers and Pulleys Building Set with Building Instructions booklet
- 10 washers or small paper clips
- Dot stickers or pieces of masking tape
- A small object such as a binder clip, an eraser, or a piece of chalk
- Student Journals
- Ruler
- Gram weights (optional)

NOTE: The Principle of Levers (See Key Concepts, Page 3-4.) During the activities in this unit, your students will be moving washers/coins/pulleys until the lever is balanced. You may be aware of math manipulatives that use this concept to help students balance math equations.

PROCEDURE

Introduction

- Discuss with the class how, when they play on a seesaw with a friend, the beam is sometimes completely level. What is another way of describing this state?

  Students should respond that the seesaw is balanced.

- Ask them why they think this state of balance occurs.

  Students will answer that both people weigh the same amount. Some may realize from their inquiries with the K'NEX seesaw, that it could also be related to the distances that they are each sitting from the fulcrum.

- Discuss with the students how a balance can help you weigh things like apples or candy. Extend this idea to discuss how a balance can also help you compare the weights of two different objects. To make the balance work, place the object to be weighed on one side of the balance and some standard units such as gram weights on the opposite side. When the objects on either side weigh the same, the balance will be perfectly horizontal.

- Balances can also be used to make it easier to carry a heavy load. Students should look at the photo on Page 4 of the K'NEX Building Instructions booklet. Ask them why it might be easier to carry a load in this way.

Students should be helped to understand that the large load is split into two equal parts so that the weight of the load is evenly distributed and balanced across the man's shoulders.

- Ask the students to draw a picture of something that is balanced or describe in their journals a situation where a balance is used.

- Explain that they will build a model of a balance to continue their investigation into levers. A balance is another example of a lever and they will investigate to which class of lever it belongs. They will also observe what happens when they move the positions of the load and the effort on the lever.

Building Activity

- Organize the class into teams of 2 (maximum 3) students and distribute 1 K'NEX Levers and Pulleys Building Set to EACH group.
- Invite the students to build the **BALANCE** model (Pages 4-5 of the Building Instructions booklet.) We recommend that one student build Steps 1-2 and the other, Steps 3-7. The parts should then be assembled, as shown, to form the completed balance.
- Discuss with the students the similarities between the K'NEX Balance model and the Seesaw model investigated in the previous lesson.

Inquiry Activity: How do we balance a balance?

- Ask the students to use stickers or tape to identify and label the parts of the balance.

F - Fulcrum **L** - Load **E** - Effort

- Ask the students to which class of lever the balance belongs and why. They should write their answer, together with a drawing of the labeled balance, in their journals.
- Use the following script to help the students discover how to balance the balance.

Steps

1. (a) Remove the gray trays (gray pulley wheels) from the model. Push the red and orange hangers to the end of the balance arms. Once the two arms are stationary, observe and describe, using the correct vocabulary, what the model is doing.

The balance will not move because the forces acting on either arm are equal.

   (b) What happens when one end of the model is given a small push/has a force applied? Explain your observations.

When a force is applied to one side, the balance moves because the forces acting on it are unequal. The movement of the balance arm will be in the same direction as the applied force.

(c) Discuss with the students how this activity demonstrates that an object will remain stationary, or at rest, until a force acts on it.

2. (a) Replace the hanging trays (gray pulleys) so that there are **two** (2) pulleys on one side and **one** (1) pulley on the other. Push both of the hanging trays (gray pulleys) to the end of the balance arms.

(b) What happens to the balance? Why does this happen?

Students should notice that the tray with two gray pulleys goes down while the other side goes up. This is because the two pulleys on one side are heavier than the one pulley on the other side. They should be helped to understand that this is the result of unbalanced forces in action.

3. Ask the students what they have to do to balance the forces in the model.

Students may either add or remove a gray pulley to one or other side in order to equalize the weights on both sides. The students should be encouraged to discuss their observations in terms of balanced and unbalanced forces.

4. Ask the students to go back to their unbalanced model with 2 pulleys on one side and 1 pulley on the other. Ask them to find a different way to balance the model without adding or removing pulleys. Offer the following suggestions if necessary:

(a) Slide the hanging trays, one at a time, closer to the center.

(b) What happens?

(c) Why does this happen?

*Students should notice that the balance arms become level when they move the tray with two pulleys **closer to the center** while leaving the other tray at the end. This is because the load is closer to the fulcrum so it requires less effort to balance it.*

Remind the students that in their previous activity with the seesaw they discovered that a small amount of effort applied a long distance from the fulcrum can lift a heavier load closer to the fulcrum.

5. Distribute a table template for the students to record their results from the next set of activities (Steps 6-8.) Remind them that they should also make drawings of their models.

Effort Arm		Load/Resistance Arm	
Number of washers/paperclips (weight)	Distance from fulcrum	Object	Distance from fulcrum

6. (a) Change the balance so that there is one pulley on each hanging tray. Make sure each tray is the same distance from the fulcrum. Measure that distance and record it in the table.

   (b) Place a small object on the load tray. Use washers or small paper clips as the weights on the other tray. Add washers or paper clips to the effort tray until the balance is level.

   Students can put the blue rod through the washers or paper clips so that they do not fall off the tray.

   (c) Count how many washers/paperclips it takes to balance the balance. Record your result in the table.

7. (a) Move the **load** closer to the fulcrum. Balance the load by changing the amount of the effort force (weight). Record the measurements in the table.

   (b) What do you notice about the length of the effort arm and the length of the resistance (load) arm?

   (c) Did you add or remove weight? Why?

   (d) Repeat this, moving the load and balancing it again. Record the measurements in the table.

   (e) Make a drawing of the balance in your journals to show the positions of the fulcrum, effort and load and the directions in which the forces are acting.

   *Students will need to **remove weight** to balance the load since it requires **less effort** when the load is close to the fulcrum and the effort arm is longer than the resistance arm.*

8. (a) Move the **effort** closer to the fulcrum. Balance the load by changing the amount of the effort force. Record the measurements in the table.

   (b) What do you notice about the length of the effort arm and the length of the resistance (load) arm?

   (c) Did you add or remove weight? Why?

   (d) Repeat this, moving the effort and balancing the load again. Record the measurements in the table.

   (e) Make a sketch of the balance in your journals to show the positions of the fulcrum, effort and load and the directions in which the forces are acting.

   *Students will need to **add weight** to balance the load since it requires **more effort force** when it is applied close to the fulcrum and the effort arm is shorter than the resistance arm.*

Applying The Idea

- Discuss the results of the experiments with the whole class. Their investigation involved balancing the forces acting on the model and demonstrated that when balanced, the forces on one side must equal the forces on the opposite side.

- Ask the students to record in their journals the processes they used to balance the system. They should understand that two factors are involved in balancing the lever:
    1. The weight (force) of the load and the effort.
    2. The distances of the effort and the load from the fulcrum.

- Challenge the students to establish a general rule for balancing a lever and write it in their journals. They should understand from their inquiries that the **closer the load is to the fulcrum the less effort is needed to move it.** Encourage them to include a reference to the lengths of the effort arm and resistance arm. (See 7b and 8b above.)

Extending The Idea

1. Use gram weights and a ruler to determine the mathematical relationship involved in balancing the lever. Balance the lever with gram weights on both hanging trays. Use the ruler to measure the distances of the load and the effort from the fulcrum when the lever is balanced.

   The Principle of Levers states that for a lever to be balanced:

   Effort x its distance from the fulcrum = Resistance (load) x its distance from the fulcrum

   or

   E x EA = R x RA

   Where: **E** = Effort force; **R** = Resistance
   EA = Length of Effort Arm; **RA** = Length of Resistance Arm

   NOTE: In order to simplify the activity, ignore the units.

2. Students could be set the task of applying the Principle of Levers to find the weight of an unknown object using only one 10g weight.

JOURNAL CHECK:

- ✔ Explanation of how to balance the balance.
- ✔ Labeled diagram of the balance identifying fulcrum, effort, load and the directions in which the forces are acting.
- ✔ Completed table with results of their balance experiments.
- ✔ General rule for balancing a lever.

NOTE: You may want to present the activity on a pair of scissors next (see Page 35.) A pair of scissors serves as an example of two connected 1st Class levers.

NOTES: