7th Grade: MAKING WORK EASIER

(Friction and Levers)

Rational of this unit

Without realizing it, pupils are experiencing friction in their normal lives. They know that moving a heavy box on a surface with friction requires a strong force. However, while they have experienced that you can move a heavy object without a strong force if you lower friction, this has not quite developed into a total understanding of what friction is.

In this unit, first the pupils will realize through experience in experiments that a force is acting to hinder movement when trying to slide an object on a surface. The aim is then for them to understand that frictional force exists and how that force works. Here we will make them aware that friction exists based on the difference in the force needed when moving a big box over an uneven surface and a smooth surface. We then hope to deepen understanding of the work of friction while comparing resistance on the two surfaces.

Next we shall learn about levers. Many everyday tools and machines make use of levers. We can deepen perspectives on how force works by aiming to understand that the lever functions as the basis of how our tools and machines work.

The pupils will realize through trying out experiments that the ability to tilt a lever is related to the length of the lever arm from the fulcrum and the magnitude of the force, eventually bringing this back to real-life settings. Next, we will make adjustments like shortening the distance between the fulcrum and the load and lengthening the distance between the fulcrum and the effort in order to allow the lever to make a small force do larger work. Through these experiments we hope for pupils to objectively grasp the function of levers and discover problems and their solutions. This will allow them to understand the structure of everyday tools and hopefully lead to them being able to use these everyday tools more effectively.

Objectives: what pupils are expected to achieve in this unit

- To understand that when moving an object along the ground, frictional force is at work.
- To understand by feeling for themselves through experiment and working that frictional force gets bigger and smaller depending on the weight of the object and condition of the surface.
- To notice that the work of friction is put to use in various tools and understand how they use frictional force.
- To understand that in a lever there is a fulcrum, effort and load, and that depending on the distances between these three points, or alternatively the configuration of these three points, applying force of the same magnitude will work differently.
- To understand by feeling for themselves through experimentation that ability to tilt a lever is related to distance from the fulcrum and the magnitude of the force applied, and the rule that using a lever allows you to do bigger things with a smaller force.
- To notice that the function of levers is put to use in various tools and understand how they use this force.

Interrelation of contents of each grade

** The order below is as shown in the syllabus.*

Grade	What to teach (Making Work Easier)
1st Grade	• Making wheels • Using wheels
2nd Grade	• Making differently shaped wheels • The best shape for wheels • Rollers (pencils, corn stalks, corncobs, sticks)
3rd Grade	–
4th Grade	• Safe use of simple tools (hammers, saws, jembes, pangas, knives, bottle openers) • Maintenance of simple tools (cleaning after use, sharpening of cutting tools, oiling, proper use, and proper storage methods)
5th Grade	• How to balance on a see-saw • Making a simple beam balance and balancing different materials on it to compare their masses.
6th Grade	• Motion (Moving objects, stopping moving objects) • Force (meaning of force, units of force (N))
7th Grade (This unit)	• Meaning of friction • Advantages and disadvantages of the work of friction • Ways to increase and decrease friction • Positioning of a lever's fulcrum, load and effort (claw hammers, crowbars, hand-pushed wheelbarrows and plows)
8th Grade	• Inclined slopes (ladders, stair case landings, spiralling roads climbing hills) • One fixed pulley (Items using one pulley, such as on a flagpole)

Before starting this unit

Current learning status of the pupils

7th grade pupils have much experience with feeling friction even in their normal lives. However, while they have experienced that you can move a heavy object without a strong force by lowering friction, they do not think about or understand the mechanics behind this phenomenon.

Also, while they do not yet understand the mechanics of a lever or the fulcrum, effort and load, they use tools that make use of levers in their daily lives including scissors, spades, bottle openers, and wheelbarrows, and have unknowingly experienced how they make work easier and smoother.

Preparatory Notes

- With both friction and lever experiments, pupils should be able to sufficiently experience things one by one. Prepare enough tools using frictional force and sandbags to act as weights for several groups to use at once.
- For friction experiments, you should prepare heavy and light objects as well as set up smooth and unsmooth surfaces so the pupils can compare the different experiences.
- If one is only moving a weighted object like when digging up a rock buried in the dirt then there will be no problem, but in order to make pupils better experience the magnitude of the force applied we will be actually lifting the weights off the ground. In such cases, try to use hemp bags of sand or dirt as weights, avoiding use of stones or concrete in case someone drops the weight on their foot.

Objectives to be achieved by competency

Interest, motivation, and attitude

1. Taking an interest in and participating in experiments examining how friction and levers work, and willingly trying to investigate any points of question.
2. Taking an interest in everyday tools that use friction and levers and actively seeking examples that make practical use of friction and levers.

Scientific thinking and communication activities

1. Ability to perceive based of experiments that frictional force changes depending on the weight of an object or condition of the surface.
2. Ability to explain the functions of friction while relating it to weight of the object and condition of the surface.

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3. Ability to substitute magnitude of force with weight in their thinking and perceive this fact based on experiments showing that the weight of a weight doesn't change when hung in different positions.
4. Ability to notice that the ability of a weight to tilt a lever arm changes based on its distance from the fulcrum and discover the rules for how to do larger work with a smaller force.
5. Ability to explain how everyday tools that make use of the work of levers do so and how they are arranged using the terms fulcrum, effort and load.

Knowledge, understanding, and skills in observation and experimentation

1. Ability to understand that when moving an object along the ground, frictional force is at work.
2. Ability to understand that frictional force gets bigger or smaller depending on the weight of the object and condition of the surface.
3. Ability to show examples of everyday tools that use the mechanics of friction.
4. Ability to understand the function of a stick when used as a lever, and the three points of the lever (fulcrum, load and effort).
5. Ability to understand that even with the same magnitude of force applied, the ability to tilt the arm of a lever becomes greater the further the force is from the fulcrum.
6. Ability to understand that even with the same magnitude of force applied, tilting the lever arm becomes easier when the distance between the fulcrum and load is decreased.
7. Ability to show examples around them of tools that use the work of levers.

Ideas behind the structuring the unit

First, the unit starts off with a lesson on friction, having the pupils actually move some heavy objects on the ground so they can experience it for themselves. Upon confirming the existence of friction, we expand on this by examining through experiments the relation of the weight of objects and condition of the surface to friction.

Next, we make the pupils realize that there are plenty of tools making practical use of the work of friction and use this to help them understand the uses of frictional force.

The lesson on levers leads off with hands-on activities with everyday tools. After clarifying the concepts behind the lever, we substitute weight for force and expand on things by further clarifying using an experimental-use lever.

In the process of trial and error using the experimental-use lever, the pupils can approach the functions of levers as a means to make discoveries so they can make practical use of tools in their daily lives.

Unit teaching plan

(13 periods + 1 period for the Final Unit Evaluation Test)

* The numeric value in parentheses represents the corresponding period (e.g. 1) means the first period).

* *(Evaluation: Knowledge and Skills 1), (Evaluation: Interest 1)*, etc. indicate the points at which teachers can check whether the pupils have attained the goals specified in the section *Objectives based on the viewpoint*.

Sub-Unit	Description
1. What is Friction? (2 periods)	1) Move a small box along a desk surface and investigate the existence of friction and how it works. *(Evaluation: Interest 1)* 2) Examine the function of friction on a rough surface. (*Evaluation: Knowledge and Skills 1)*
2. Examining the State of an Object's Surface (1 period)	3) Observe the object's surface and record the findings in the worksheet. *(Evaluation: Thinking and Representation 1)*
3. Advantages and Disadvantages of Frictional Force (2 periods)	4) Look for the advantages of frictional force and enter them in the worksheet. • Search for advantages of frictional force from everyday life such as walking, matches, blackboards and chalk, rubbers, and brakes. *(Evaluation: Interest 2, Thinking and Representation 2, Knowledge and Skills 2, Knowledge and Skills 3)* 5) Look for the disadvantages of frictional force and enter them in the worksheet. • Search for disadvantages of frictional force from everyday life such as how bicycle tyres and collars get worn out. *(Evaluation: Thinking and Representation 2, Knowledge and Skills 2 and Skills 3)*
4. How to Increase and Decrease Friction (2 periods)	6) Confirm by experiment how to decrease frictional force and record in the worksheet. *(Evaluation: Thinking and Representation 2, Knowledge and Skills 3)* 7) Confirm by experiment how to increase frictional force and record in the worksheet. *(Evaluation: Thinking and Representation 2, Knowledge and Skills 3)*
Intermediate Review (No time allotted)	Give the "1st to 4th **Sub-Unit Review Test**." (Homework can be given depending on the progress of the class.)
5. Levers Using a Stick (2 periods)	8) Become able to look at things and think of how to make work easier based on where you hold or push things through activities like pulling nails with a claw hammer and lifting sandbags with sticks. *(Evaluation: Interest 1)* 9) Know that a lever has three points called the fulcrum, effort and load through experiments using a stick as a lever, and be able to explain how the effort and load should move in order to move a heavy object. *(Evaluation: Knowledge and Skills 4)*
6. Examining the Tilt of Lever Arms (2 periods)	10-11) Examine how the ability of weights to tilt lever arms changes depending on the position the weights are hung from and record the results in your worksheet. *(Evaluation: Thinking and Representation 3 and 4,Knowledge and Skills 5 and 6)*
7. Tools Using Levers (2 periods)	12-13) Search for everyday tools that use levers and locate the fulcrum, effort and load. Know that there are not only levers in which the fulcrum is between the effort and load, but also those where the fulcrum is at one end as well. *(Evaluation: Interest 2, Thinking and Representation 5, Knowledge and Skills 7)*
Intermediate Review (No time allotted)	Give the "5th to 7th **Sub-Unit Review Test**. (Homework can be given depending on the progress of the class.)
Final End Review (2 periods)	14) Teachers gives the "**Final Unit Evaluation Test**."

Lesson Plan

5. Levers Using a Stick (2 Periods: 8th – 9th period)

Goals of this sub-unit

- Become able to look at things and think of how to make work easier based on where you hold or push things through activities like pulling nails with a claw hammer and lifting sandbags with sticks.
- Know that a lever has three points called the fulcrum, effort and load through experiments using a stick as a lever, and be able to explain how the effort and load should move in order to move a heavy object.

Material Preparations

- Claw hammer (if possible, multiple hammers so that everyone can try)
- Stick made of bamboo or some other sturdy wood (wood that will not bend too much, about 2-3m long)
- Bags made of hemp or another sturdy material (put 10kg of sand or dirt in it and tie it off with a rope, then make it easy to put on a stick by using the rope as a ring), sand or dirt (10kg)
- Wooden blocks for fulcrums and platforms to support them
- Worksheet

Period 8: Claw Hammers and Levers Using a Stick

	Learning flow and activity	Teaching Hints and Advice
Introduction 10 minutes	• Have you ever used tools that use a stick that can do large amounts of work using a small amount of force?	• Have pupils record the results in their worksheet. *(Refer to pg. 193 regarding worksheet)* • There are plenty of tools that use levers, but here we will use a claw hammer as an example and reach a common understanding of what a lever refers to while the pupils experience it for themselves. • Do not have pupils try to pull nails right from the start, but rather have a pupil who has used one before tell how and when a claw hammer is used. *(Evaluation: Interest 1)* Taking an interest in and participating in experiments examining how levers work, and willingly trying to investigate any points of question.
Questions	How should you use a claw hammer to make work easier? What about lifting a sandbag with a stick?	
Experiment 15 minutes	• Try actually pulling a nail with a claw hammer. → It is easier to pull the nail grasping the end of the hammer than it is grasping it in the middle. • Try lifting sandbags with a stick in the school yard. → First, try to pick up the sandbag with your hands. → Next try to pick it up grasping the middle of the stick. → Then try to pick up it up grasping the end of the stick.	• Let the pupils discover the place on the hammer easiest to pull the nails by themselves through trial and error. • If there are pupils who are taking notice of the distance between the fulcrum and load in their grip positioning on the stick, make them try various positions and check further. * Letting go of the stick suddenly when lifting sandbags or letting go when people are near the sandbags is dangerous. Make sure to sufficiently warn the pupils.
Presentation 10 minutes	• Summarize in your worksheet what worked best in using the claw hammer and stick, then present the results in class.	• Have the pupils write down the results in their worksheet. • After they have summarized things, have them each make their reports in a presentation format.

Period 9: The Fulcrum, Effort and Load

	Learning flow and activity	Teaching Hints and Advice
Introduction 10 minutes	• What is a ***lever***? → Know what a fulcrum, effort and load are.	• Write down examples from the last class about the claw hammer and stick that lifted sandbags on the blackboard, explaining the fulcrum, effort and load in each example.
Questions	How should you use a lever to lift a heavy object easily? Explain using the terms ***fulcrum, effort*** and ***load***.	
Review Additional Experiment 20 minutes	• While looking at the worksheet from the last class, confirm that when we changed the position of our grip on the hammer we were changing the position of the ***effort***. → The ***fulcrum*** and ***load*** are the same. → When lifting the sandbags, moving not only the ***load*** but also moving the ***effort*** changed the amount of resistance.	• Between the components of ***fulcrum, effort*** and ***load***, always make pupils aware of which have the same conditions and which have different conditions. → Explain the idea of condition control. → Make one component the variable and have them be aware that leaving the remaining two in the same condition makes them easy to compare. *(Evaluation: Knowledge and Skills 4)* Ability to understand the function of a stick when used as a lever, and the three points of the lever (fulcrum, load and effort).
Presentation 5 minutes	• Present what you have learned from the results. → It makes things easier when the ***effort*** and ***fulcrum*** are farther apart, but easier when the ***load*** and ***fulcrum*** are closer together.	

Lesson Plan

6. Examining the Tilt of Lever Arms (2 Periods: 10th – 11th period)

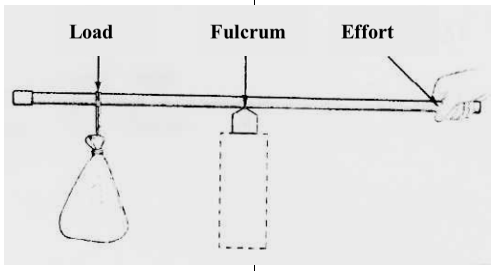
Goals of this sub-unit

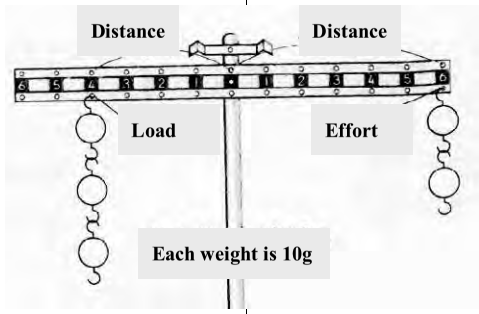
- Ability to substitute magnitude of force with weight in their thinking and perceive this fact based on experiments showing that the weight of a weight does not change when hung in different positions.
- Ability to notice that the ability of a weight to tilt a lever arm changes based on its distance from the fulcrum and discover the rules for how to do larger work with a smaller force.
- Ability to understand that even with the same magnitude of force applied, the work done leaning on a lever becomes greater the further the force is from the fulcrum.
- Ability to understand that even with the same magnitude of force applied, tilting the lever arm becomes easier when the distance between the fulcrum and load is decreased.

Material Preparations

- Stick made of bamboo or some other sturdy wood (wood that will not bend too much, about 1m long)
- Bags made of hemp or another sturdy material (put 1kg of sand or dirt in it and tie it off with a rope, then make it easy to put on a stick by using the rope as a ring), sand or dirt (1kg)
- Wooden blocks for fulcrums and platforms to support them
- Experimental-use lever
- 30cm ruler, paper clips, string, a few weights

Periods 10-11: The Tilt of Lever Arms

	Learning flow and activity	Teaching Hints and Advice
Introduction 10 minutes	• How does weight (resistance) change when you change the position you hang the weight from? → The weight gets lighter the closer it is to the fulcrum. → The weight gets heavier the further it is from the fulcrum. 	• Prepare a lever as shown in the figure below and urge the pupils to pay attention while they are confirming the results. → Let pupils express their feedback freely.

Questions	How does the ability of weights to tilt lever arms change depending on the position the weights are hung from?	
Experiment 40 minutes	• Hang some weights from a lever, and through experimentation confirm the left to right balance while changing the number and position of the weights.  → If you change the lengths of the left and right arms, you also have to change the number of weights. → It appears as if there is some kind of rule in place.	• Prepare an experimental-use lever as shown in the figure below and have the pupils look for the rule through trial and error. → Give them advice to think of the rule that can be deduced from the experimental data. *(Evaluation: Thinking and Representation 3)* Ability to substitute magnitude of force with weight in their thinking and perceive this fact based on experiments showing that the weight of a weight does not change when hung in different positions. *(Evaluation: Thinking and Representation 4)* Ability to notice that the ability of a weight to tilt a lever arm changes based on its distance from the fulcrum and discover the rules for how to do larger work with a smaller force.
Presentation 20 minutes	• Summarize in your worksheets how the ability of weights to tilt lever arms is decided by the position the weights are hung from and number of weights and present your findings.	• Have pupils write down the results in their worksheet. • After they have summarized things, have them each make their reports in a presentation format. *(Evaluation: Knowledge and Skills 5)* Ability to understand that even with the same magnitude of force applied, the work done leaning on a lever becomes greater the further the force is from the fulcrum. *(Evaluation: Knowledge and Skills 6)* Ability to understand that even with the same magnitude of force applied, tilting the lever arm becomes easier when the distance between the fulcrum and load is decreased.

Lesson Plan

7. Tools Using Levers (2 Periods: 12th – 13th period)

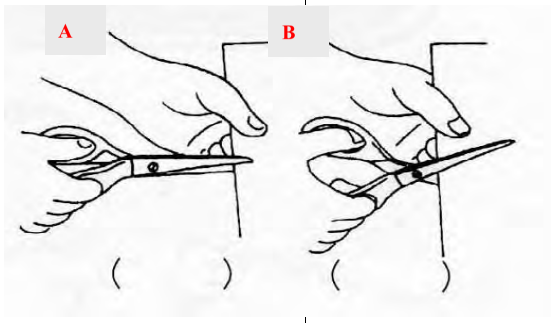
Goals of this sub-unit

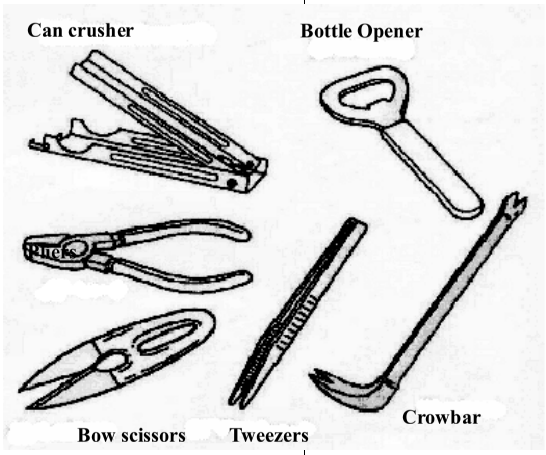
- Taking an interest in everyday tools that use levers and actively seeking examples that make practical use of levers.
- Ability to explain how everyday tools that make use of the work of levers do so and how they are arranged using the terms fulcrum, effort and load.
- Ability to show examples around them of tools that use the work of levers.

Material Preparations

- Everyday tools using levers (bottle opener, scissors, can crusher, pliers, tweezers, crowbar, stapler, etc.)

Periods 12-13: Tools Using Levers

	Learning flow and activity	Teaching Hints and Advice
Introduction 10 minutes	• Using scissors, where should the load be in order to get a larger action out of a smaller force?  → **B** in the figure can cut with less force applied.	• Scissors are an everyday tool that uses a lever. Have the pupils use scissors to confirm the rules of levers. *(Evaluation: Interest 2)* Taking an interest in everyday tools that use friction and levers and actively seeking examples that make practical use of friction and levers.
Questions	Look for the rules of levers using everyday tools.	

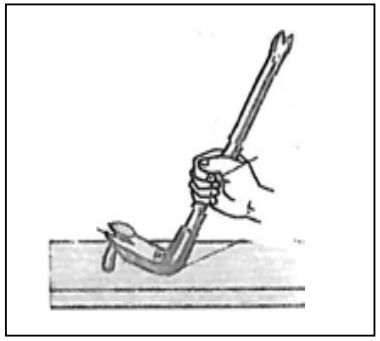
Experiment 40 minutes	• Search for everyday tools that use levers and locate the fulcrum, effort and load. → All tools have a fulcrum, effort and load.  	• Let the pupils discover the fulcrum, effort and load by themselves through trial and error.
	• Know that there are not only levers in which the fulcrum is between the effort and load, but also those where the fulcrum is at one end as well. → Bottle openers and tweezers have the fulcrum in a different position. → The position of the fulcrum, effort and load are different for different tools.	• Have them check where the fulcrum, effort and load are on the tools one by one and record the positions on learning cards. *(Evaluation: Thinking and Representation 5)* Ability to explain how everyday tools that make use of the work of levers do so and how they are arranged using the terms fulcrum, effort and load.
Presentation 20 minutes	• Summarize the positions of the fulcrum, effort and load of the tools you examined on your worksheets and present the findings.	• Have pupils write down the results in their worksheet. • After they have summarized things, have them each make their reports in a presentation format. *(Evaluation: Knowledge and Skills 7)* Ability to show examples around them of tools that use the work of levers.

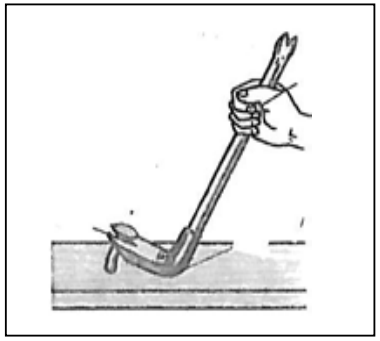
[Worksheet] ---------- *to be used in 8th period

How Should You Use a Claw Hammer or Stick to Make Work Easier?

Date: **Class:** **Name:**

For a claw hammer





What is the resistance like gripping at the bottom? ( )

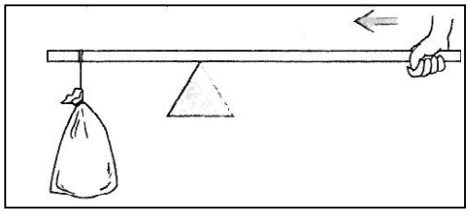
What is the resistance like gripping at the top? ( )

Lifting sandbags with a stick

What is the resistance like gripping close to and far from the wooden block?

(Close:)

(Far:)



What is the resistance like when there is a shorter distance between the sandbag and the block? What about when it's longer?

(Shorter distance:)

(Longer distance:)

When was it easiest to work using the stick?

( )

** Keep this worksheet for the next class.*

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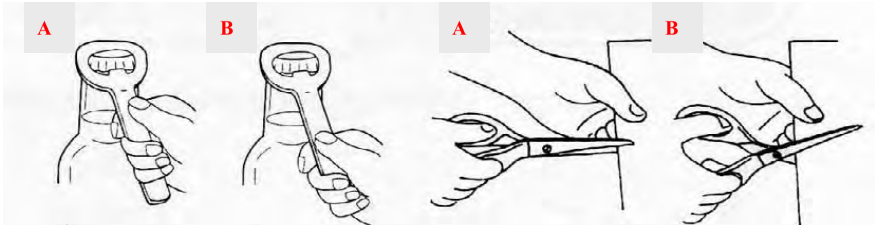
5th and 7th Sub-Unit Review Test

* given after end of 13th period

Class: Name:

1. In the following figures, which of the two works efficiently with little force? Answer for both **case 1)** and **case 2)** below.

1) bottle opener *2) scissors*



1) (B) **2) (B)**

2. Enter the appropriate words in the blanks below.

1) With a lever, the further you put the (**effort**) from the fulcrum, and the closer you put the (**load**) to the effort、the bigger the force applied by the hand or foot at the (**effort**) becomes.

2) The variables that show how far a lever's arm will tilt are the (**distance**) from the fulcrum and the magnitude of force applied.

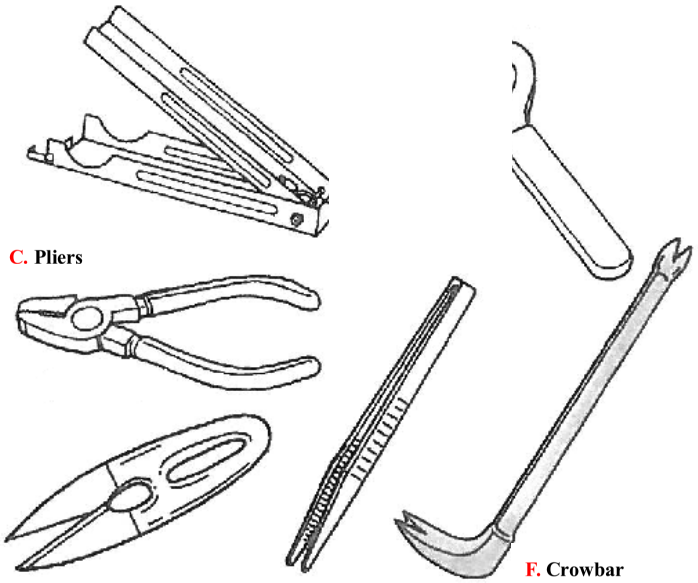
3. What type of lever do the following tools use? Answer the question by putting the letters of the appropriate tools in **blanks 1 – 3**.

1) Load Fulcrum Effort (C, F)

2) Fulcrum Load Effort (A, B)

3) Load Effort Fulcrum (D, E)

A. Can Crusher **B.** Bottle Opener



C. Pliers **D.** Bow Scissors **E.** Tweezers **F.** Crowbar

Final Unit Evaluation Test

* Given at end of unit

Class: Name:

1. In the figure below, which figure, **a or b**, can move the box with a lighter force? Give your reason with the answer.

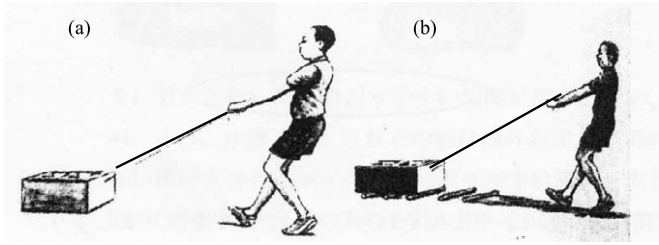


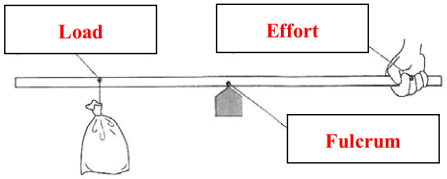
Figure that will move the box will a lighter force: (b)

Reason: (By using round sticks, the friction between the boxes and the ground is lowered)

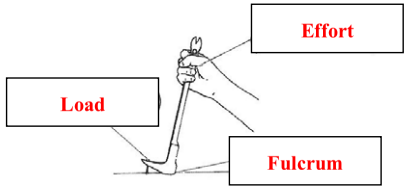
2. Answer the questions looking at the figure below.

1) In the blank boxes below, write in whether the part pointed to is the **fulcrum, effort**, or **load.**

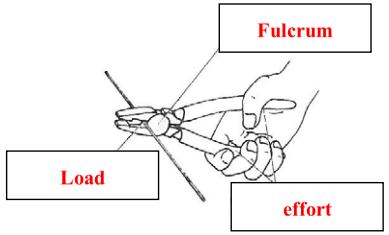
A.



B.



C.

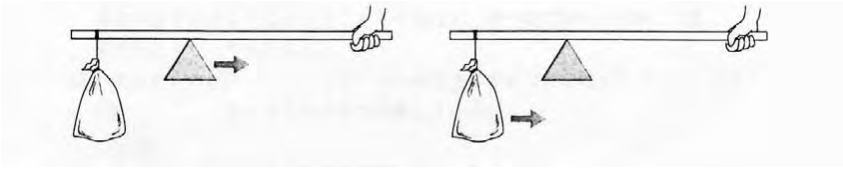


2) Of the following tools, which has the effort between the fulcrum and the load? Answer using the tools given below.

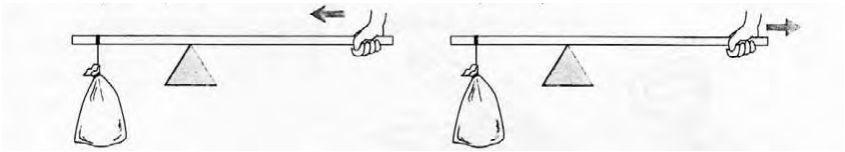
tweezers, bottle opener, pliers, hammer claw, scissors (**Tweezers**)

3. Which of the following levers will become easier to lift when the **fulcrum, effort** or **load** is moved in the direction of the arrow indicated? Answer using **A – D**.

A. **B.**



C. **D.**



(**B, D**)

4. Enter the appropriate words in the blanks below.

1) If you use a long stick properly, you can lift or move (**heavy objects**) with ease. In this case, the stick would be called a (**lever**).

2) In a lever, the (**effort**) is where the force is applied, the (**load**) is where the force works on, and the (**fulcrum**) is where the lever is held up or supported.

3) When moving objects using a lever, the longer the distance from the fulcrum to the (**effort**) is compared to the distance from the fulcrum to the (**load**), the easier you can move heavy objects.

Student Questionnaires

1. What kinds of studying have you done in the past for the above test problems?

0.	None at all	This was done 10% of the time for all problems.
1.	No	This was done 30% of the time for all problems.
2.	Average	This was done 50% of the time for all problems.
3.	Yes	This was done 70% of the time for all problems.
4.	Absolutely yes	This was done over 90% of the time for all problems.

Answering Questions using Pictures and Diagrams in the Textbook or Illustrations Drawn on the Blackboard

1. The Students answered the questions by walking up to the board and drawing diagrams or writing words.

   0. 1. 2. 3. 4.

2. The teacher asked and answered the questions by drawing diagrams or writing words on the board.

   0. 1. 2. 3. 4.

3. Questions were answered using pictures and diagrams in the textbook.

   0. 1. 2. 3. 4.

Experiments

1. Did the students conduct any experiments or observations?

   0. 1. 2. 3. 4.

2. The teacher conducted the experiments.

   0. 1. 2. 3. 4.

3. The students conducted the experiments by following the teacher's instructions.

   0. 1. 2. 3. 4.

Discussion and Thinking

4. We talked with friends in the class and thought about the problems.

   0. 1. 2. 3. 4.

5. We thought about the problems carefully with friends and stated our ideas logically.

   0. 1. 2. 3. 4.

6. We thought about the problems carefully when coming up with a hypothesis and after the experiment.

0. 1. 2. 3. 4.

Understanding Ideas

7. I was able to understand new ideas.

0. 1. 2. 3. 4.

8. I was able to see new viewpoint of looking at and thinking about science.

0. 1. 2. 3. 4.

9. I was able to grasp the principles hidden beneath the facts.

0. 1. 2. 3. 4.

Application of Knowledge

10. I was able to apply the new knowledge that I learned in school in my daily life.

0. 1. 2. 3. 4.

11. The teacher has explained that the new knowledge things the students are learning in school are connected with actual life.

0. 1. 2. 3. 4.

12. I was able to learn that the new principles and viewpoints toward science can be applied to a variety of different phenomena.

0. 1. 2. 3. 4.

Pursuing Knowledge through Problem Solving

13. We were first given a problem and then were to solve that problem.

0. 1. 2. 3. 4.

14. We made predictions, put then to the test, formulate scientific explanations, and put them to practical use.

0. 1. 2. 3. 4.

15. The students were asked to verify through the experiment that they had created a hypothesis as well as a plan for the observation.

0. 1. 2. 3. 4.

2. When you learned each unit for the above test problems, did you become interested in the material?

0.	None at all	This was true 10% of the time for all problems.
1.	No	This was true 30% of the time for all problems.
2.	Average	This was true 50% of the time for all problems.
3.	Yes	This was true 70% of the time for all problems.
4.	Absolutely yes	This was true over 90% of the time for all problems.

Interest and Motivation

1. I was very interested in science lessons.

0. 1. 2. 3. 4.

2. I became more motivated to learn.

0. 1. 2. 3. 4.

3. I was interested in what we were learning from start to finish.

0. 1. 2. 3. 4.

Concentration and Involvement

4. I was actively engaged in learning the topic.

0. 1. 2. 3. 4.

5. I enjoyed learning the topic so much I lost track of time.

0. 1. 2. 3. 4.

6. I was very focused on learning topic material but at the same time, I was also very excited and enjoyed myself.

0. 1. 2. 3. 4.

Cooperation and Collaboration

7. I enjoyed the learning process while collaborating with friends.

0. 1. 2. 3. 4.

8. I was able to learn through cooperation and mutual support with my friends.

0. 1. 2. 3. 4.

9. I shared my experiments and ideas with my friends and we all had a fun time learning together.

0. 1. 2. 3. 4.

Level of Earnestness and Enjoyment during Experiments

10. The experiments were very enjoyable.

0. 1. 2. 3. 4.

11. Since experiments need five senses, I carefully moved my hands and eyes when collecting the data.

0. 1. 2. 3. 4.

12. During the experiments, I recorded my observations accurately and carefully.

0. 1. 2. 3. 4.

Spirit of Inquiry

13. I began to have more an inquiring mind toward new discoveries.

0. 1. 2. 3. 4.

14. I became very excited and curious about challenging the unknown.

0. 1. 2. 3. 4.

15. I made a strong effort to learn what is known by trying to find examples, drawing illustrations, and through discussions and experiments.

0. 1. 2. 3. 4.

Logic and Objectivity

16. I attempted to find plenty of evidence and facts to check whether my hypothesis held true.

0. 1. 2. 3. 4.

17. I was able to confirm that the principles and concepts were true by applying them to actual life.

0. 1. 2. 3. 4.

18. The explanations were very convincing and easy to understand for the entire class. I was very satisfied with the interpretations which were logical and accorded with the truth.

0. 1. 2. 3. 4.

Appendix

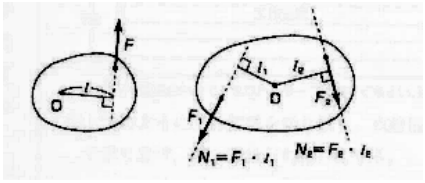
Levers and Moment of Force

Stick-like objects used in a lever are known as rigid bodies in physics, which ideally refers to an object which does not change in shape whatsoever when a force is applied to it. When a force acts upon a rigid body, its movement will force a translation or the lever's rotation around a central point.

One of these rotational motions is generally given using **moment of force**, or rotational capacity.

Moment of force is proportional to the magnitude of force **F** acting upon the object and the length **l** (called the arm length) perpendicular to the line of action of force from rotational axis **O**. When this load is shown in terms of N, the moment of force around axis **O** is shown with the following equation:

$N = F \times l$



When two forces are acting on one object to keep it from rotating, then the moments of force $\mathbf{N_1}$ and $\mathbf{N_2}$ around **O** are equal, as shown in the right-hand figure on the left. That is to say, the moment of rotation to the left (counter-clockwise) and the moment of rotation to the right (clockwise) are balancing each other.

When two or more forces are acting upon an object and it is not rotating, the sum total of the moments of force is 0, with clockwise moments shown as positive and counter-clockwise moments shown as negative.

$\mathbf{N} = N_1 + N_2 + N_3 + \ldots\ldots = 0$

When a stick is being used as a lever, there are forces acting upon the stick's fulcrum, effort and load. When the lever is balanced, the moments of force are in the following relationship.

(force applied to the load) x *a* = *(force applied to the effort)* x *b*

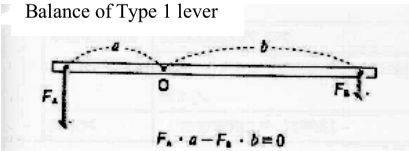
Here, *(force applied to the load)* x *a* on the left of the equation and *(force applied to the effort)* x *b* on the right hand side are moments which are acting to try to rotate the stick around the fulcrum, and *a* and *b* are the lengths of the respective arms of the lever. These moments are using the fulcrum as a rotational axis and the moment of force upon the fulcrum is 0, thus they can be disregarded.

When the lever is balanced, adding up the moments of force at the fulcrum and effort will work out to a sum force of 0 even when the load is chosen as the axis of rotation. This is shown specifically by the following equation.

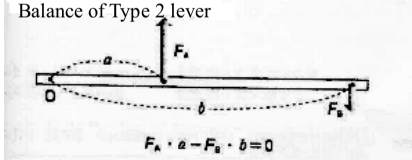
(force applied to the fulcrum) x *a* – *(force applied to the effort)* x (a + b) = 0

Figures and equations for moment around the fulcrum of the three different types of levers are as shown below.

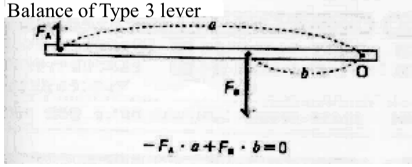
Balance of Type 1 lever



Balance of Type 2 lever



Balance of Type 3 lever



When using a lever, the force applied to the effort is slightly larger than that needed to balance the lever, breaking the balance of moments. This in turn makes the stick rotate in the direction of the force applied.

Appendix

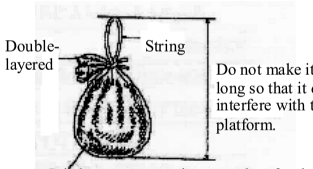
Material Preparations for Experiments with Levers Using Sticks

- **Stick**

For sticks, as long as it can lift the weight of 10kg of sandbags then a sturdy bamboo stick can be used. However, as there is a chance that the children may lay their weight onto both sides of the stick, it is better to prepare something stronger such as a steel laundry pole. An old mop handle is also a possibility, but these can sometimes break in the direction of the wood grain, so preliminary testing is needed. You will have no problems with strength if using a steel pipe as you would find in a construction site, but as the pipe itself is heavy you will need to take care in handling it.

- **Weights**

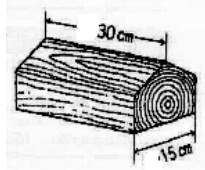
You should make and prepare sandbags. If using polystyrene bags, double or triple-layering will ensure that they will not spill in the course of the experiment. To make them easy to hang on a stick, make a secure ring with some string. Making 10kg of weight will be easy to handle.



It is best to use a polystyrene bag for the inner layer and a sturdy bag for the outer layer. (use a hemp bag, grain bag, or sandbag.

- **Fulcrum**

All of the weight of the lever will be put on the fulcrum, so prepare a sturdy object that can sufficiently withstand such weight. Don't simply use a bottle, can or square block, but rather try to make a use-specific post. Also, fulcrums which fastens to some sort of bar are very dangerous as children will be hanging from them and they can slide.



Fabricate a post

- **Fulcrum Supporting Platform**

The full weight of the lever will also be put upon the support, and thus something sufficiently sturdy should be prepared. A wooden chair with a flat seat will be suitable.

Appendix

Examples of assessment questions which is used in Kenyan text books

What is the meaning of friction?
Name three effects of friction.
List four advantages of friction.
List three disadvantages of friction.
Name four ways of reducing friction.

(Oxford; Science in Action 7　P.102)

Oiling and greasing reduces friction by
A. reducing the area of contact between moving parts.
B. reducing the amount of heat produced.
C. replacing worn out parts of the machine.
D. reducing sliding speed of moving parts.

Friction can be increased by
A. using friction resistant materials.
B. making the surfaces rougher.
C. heating the moving parts.
D. using ball bearings.

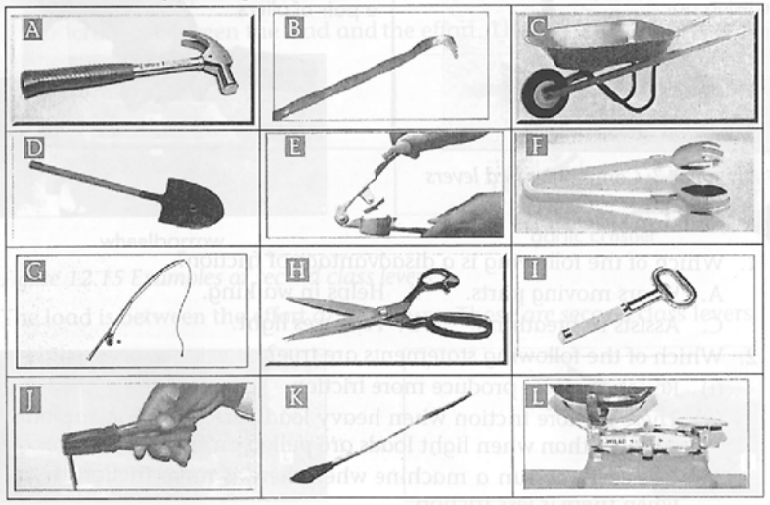
(Oxford; Science in Action 7　P.102)

Which of the following is a disadvantage of friction?
A. Wears moving parts.　B. Helps in walking.
C. Assists in breathing.　D. Produces light.

Which of the following statements are true?
(i) Rough surfaces produce more friction.
(ii) There is more friction when heavy loads are pulled on smooth surfaces than when light loads are pulled on smooth surfaces.
(iii) It is easier to run a machine when there is more friction than when there is less friction.
(iv) Friction produces heat and wears out surfaces.
A. Only (i), (ii), and (iv).　B. Only (i) and (iv).
C. Only (i) and (ii).　D. Only (i), (iii) and (iv).

(Oxford; Science in Action 7　P.101)

10. Below are different types of levers. For each lever, state the class to which they belong.



(Oxford; Science in Action 7　P.102)

The diagram below represents a crowbar in use.

Which letter represents the position of the fulcrum?

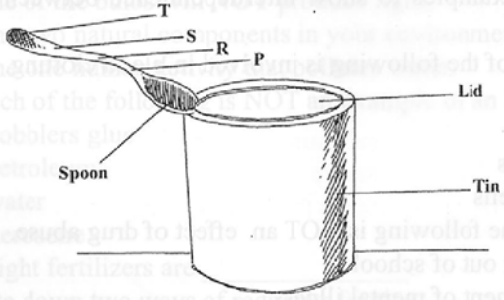
A. P C. R
B. Q D. S

(Longhorn, Understanding Science, Pupil's Book 7 P.84)

Which one of the following lever has the effort between load and fulcrum.

A. Wheelbarrow B. Spade C. Clawhammer D. Crowbar

Omolo wants to open the tin below.



To open the tin easily the best position for the effort would be

A. P B. R C. S D. T

(The Jomo Kenyatta Foundation, Foundation Science Pupils' Book 7, P. 129)