THE PRINCIPLE OF LEVERS

TOPIC:

Levers

SCIENTIST:

Archimedes c.287–212 BC

INTRODUCTION:

Archimedes, one of the foremost mathematicians and inventors of the ancient world, was a pioneer in the study of mechanics. Among his studies was an investigation of the principle of the lever, a type of simple machine. A simple example of a lever, and the one used in this experiment, is a see-saw. A plank (the lever) is balanced on a pivot or fulcrum. A person (the load) sits on one end; a second person (the effort) sits on the other end of the lever and raises the first person into the air. Archimedes showed how a lever could be used to lift a heavy load with relatively little effort. He also showed that the effort required to lift a load increased the nearer to the fulcrum it was applied, and that it decreased the further from the fulcrum it was applied. To lift a heavy load, therefore, the fulcrum should be close to that load and the effort should be applied to the lever as far away from the fulcrum as possible. Archimedes hailed this principle when he said, "Give me a place to stand and I will move the earth." Archimedes also predicted that the load multiplied by the distance of the load from the fulcrum was equal to the effort multiplied by the distance of the effort from the fulcrum, and he proved his prediction by testing it.

TIME NEEDED:

30 minutes

MATERIALS:

- meter ruler
- metric ruler (30 cm)
- 10 identical small coins (*e.g.*, dimes or pennies)
- piece of cardboard 18 cm x 5 cm
- X-acto® knife
- transparent tape
- felt-tip marker
- calculator

Original Materials:

It is not known precisely what materials Archimedes used, although it is likely they would have been everyday objects like those you are using here.

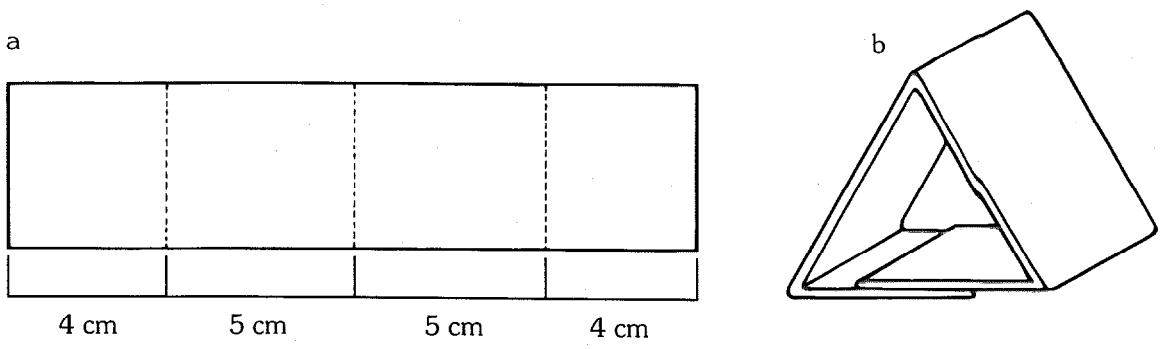
Safety Precautions

Please read and copy the safety precautions at the beginning of this book. Be careful when cutting with the knife.

PROCEDURE:

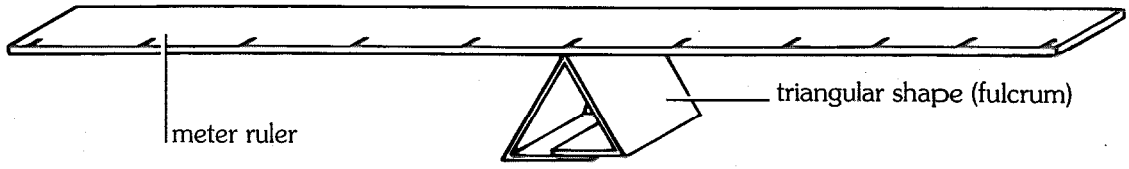
1. On the piece of cardboard, measure and mark out four sections of the dimensions shown in figure 1a.
2. Gently score along these lines by holding the ruler along the line and cutting partway through the cardboard using the knife. Fold the cardboard into a triangular shape as shown in figure 1b. Use tape to hold the shape together.

Figure 1



3. Place the triangular shape on a table so that it can act as a fulcrum (see figure 2). Find the midpoint of the meter ruler by carefully balancing it on the fulcrum. Mark the midpoint with the marker.

Figure 2



4. Place the meter ruler on the fulcrum so that it balances. Put one coin (the load) at the 40-cm mark. Note what happens.
5. Now position a second coin (the effort) on the other side of the fulcrum to balance the first coin. Note the distance from the end of the ruler of the position where you have to place the coin (the effort) in order to lift the load and achieve balance.
6. Put two coins (the load) at the 40-cm mark. Predict where you would have to position *one* coin on the other side of the fulcrum in order to achieve balance. (Archimedes' prediction was that load x distance of the load from the fulcrum = effort x distance of the effort from the fulcrum.) Place the single coin at the predicted position on the meter ruler and record what happens. If balance is not achieved, move the coin until the ruler balances, and make a note of the position.
7. Repeat step 6 using loads of 3, 4, 5, 6, 7, and finally 8 coins. Use more than one coin on the "effort" side if necessary. Note the position of coins on the "effort" side and the number of coins used.
8. Experiment with different numbers of coins at different positions on the "load" and "effort" sides of the meter ruler, attempting to achieve a balanced ruler as before. Record, in each case, the positions of the coins and the number of coins at each position.

ANALYSIS:

1. In step 5, where did you have to place the coin in order to balance the meter ruler? Can you explain this?
2. Write an account of what you recorded in steps 6 to 8. Do your results confirm Archimedes' prediction or not?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES