Science Experiments for Primary Schools – A Guide for Teachers

Table of Contents

Table of Contents

Table of Contents

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Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

Published October 1992 by

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Abteilung 411 – Education and Science Division
P.O. Box 51 80
D–6236 Eschborn
Federal Republic of Germany
Phone: (06196) 79–0 Telex: 41 523–0 gtz d Fax: (06196) 79–1115

Evaluation of curricula and project documents and compilation of the collection:

Renate Voßwinkel

Professional inputs:

Physics
Prof. Dr. Dieter Nachtigall, University of Dortmund

Biology
Dr. Gernot Strey, University of Göttingen

Illustrations
Dorsi Germann

Please let us know whether this collection lives up to its goal of providing practical assistance and as many ideas as possible in terms of materials, methods and experiments. We would be interested to hear from you which interests were awakened and what understanding pupils developed as a result of the individual experiments.

We would like to thank all those who contributed information, critical comments and ideas and, above all, the authors whose professional inputs have made this collection possible.

Hubert Hartmann
GTZ, Education and Science Division

1. BOTANY

1.1. THE EXPANSION IN VOLUME OF SWELLING SEEDS

Main Goal:

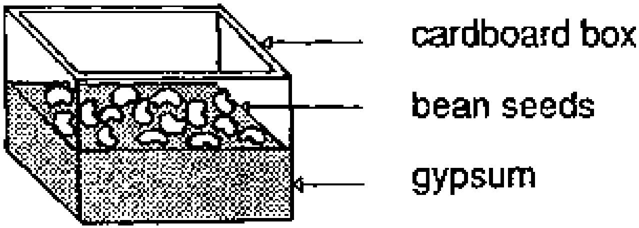
> **This experiment illustrates in an impressive way how seeds expand in volume as they steep.**

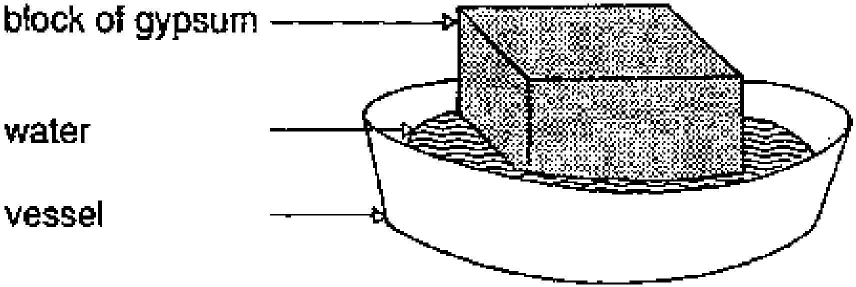
Information:

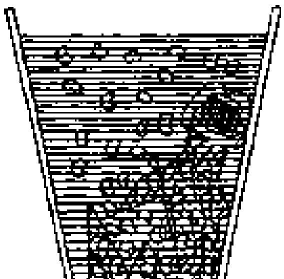
> Seeds have a great osmotic pressure, which is responsible for water absorption during the steeping process. (Osmosis is the diffusion of fluids and gases through a membrane or porous partition.)

Materials and Apparatus:

b. The small cardboard box is half filled with plaster of Paris. 15 seeds are placed in this and then the box is immediately completely filled with the plaster of Paris. The gypsum is left to firm completely and then the whole block is placed in water. Instead of a cardboard box you can use any other container, e.g. a plastic yoghurt tub.







This experiment illustrates that seed leaves (cotyledons) play an important role in the early development of seedlings.

Information:

The two seed leaves of beans (or peas) contain a certain amount of reserve substances. These nourish the seedling until it is able to absorb mineral salts from the soil through its fully developed roots and carbon dioxide from the air through their leaves.

Materials and Apparatus:

a. 9 seeds capable of germinating (peas) 9 seedlings of the same size 2 pieces of wire gauze or 9 test tubes or flint–pebbles to hold the plants (the size should be such that the seedlings do not fall through the mesh) 1 dish (measuring about 13 cm by 5 cm, and about 7 – 10 cm in height) distilled water (Available in every garage. If distilles water cannot be bought or produced, rain water or tap water may be used).

Procedure:

a. Put the beans on the wire gauze. Make sure that they are moistened regularly. Let them germinate. Watch the water. If it becomes grey change it, because there are fungi in the water which may start to destroy the experiment.

b. When the seedlings are about 1 cm hight, both seed leaves are taken from each of three seedlings and one seed leaf from three others. The roots must be kept below the surface of the water. The last three remain unchanged. The experiment is analysed after about a week.

The seed leaves nourish the seedlings until they are capable of absorbing mineral salts through their roots.

Importance in Nature:

The nutrients the seed leaves use when germinating are the same as those we use when we eat beans, peas or other seeds. The reserve substances stored for the seeds themselves give us the feeling that we are full.

1.3. SEEDS DO NOT GERMINATE IN FRUITS

Main Goal:

This experiment illustrates the existence of materials which inhibit the germination of seeds in fruits.

Information:

In order to germinate, seeds need water as well as air. In most kinds of fruits, seeds do not germinate. One reason, besides the lack of air, is that there are substances in the fruits which prevent germination.

Materials and Apparatus:

different kinds of fruit (e.g. oranges, apples, melons, tomatoes)
40 cress seedlings
4 round filters, or absorbent paper, or cotton wool
5 round dishes, about 10 cm in diameter (e.g. lids of jam jars)

Observation:

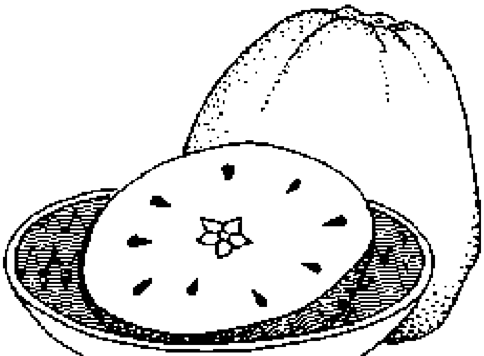
Although the seeds in all the dishes receive air and water, germination takes place only in those dishes in which they were placed directly on moistened paper. (One or two germinated seeds on the fruit slices do not distort the result. Experiments in biology do not necessarily succeed completely.)

Analysis:

Fruits contain substances which inhibit the germination process. These prevent the germination of seeds. The seeds can only start germination and growing once the fruits are rotten.

Importance in Nature:

Fruit seeds are spread by birds, which are attracted by the coloured fruits. The birds eat them, and drop the seeds with their droppings. The seeds then germinate and grow where they land.



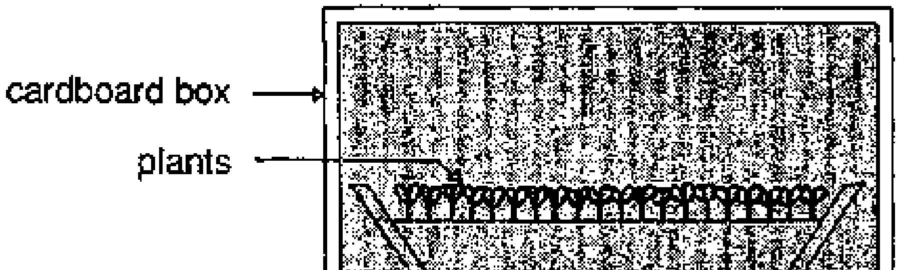
energy necessary for the vital functions of the plant is liberated.)

Materials and Apparatus:

cress plants (about 30)
2 flat receptacles filled with soil (e.g. cut–off tins or plastic mugs)
water
1 cardboard box

Procedure:

Cress plants are grown in the two receptacles in moist soil until they are approximately 1 cm high. A cardboard box is placed over one of the receptacles (see diagram). The soil is kept moist. (Other plant types may also be used.)



Besides water and the mineral salts which are found in the soil and carbon dioxide from the air, plants need light to grow.

1.5. PLANTS GROW TOWARDS THE LIGHT

Main Goal:

This experiment demonstrates that plant shoots usually grow towards the light.

Information:

As a rule, shoots grow towards the light. Light is indispensable for photosynthesis of plants.

Materials and Apparatus:

about 20 cress seedlings in soil (mustard seedlings or other kinds of plants can also be used)

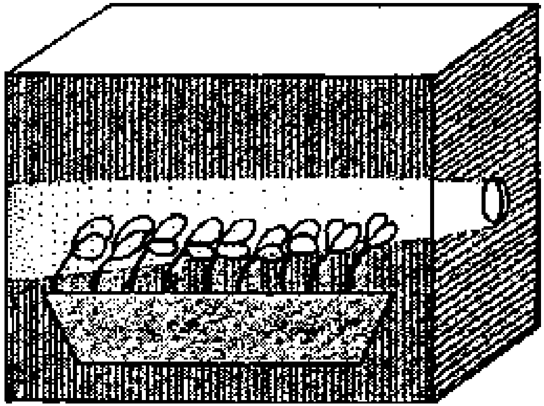
cardboard box

a pair of scissors or a knife

Procedure:

A hole measuring some 2 cm^2 is cut in one side of the cardboard box. The hole should be cut at the height of the cress seedlings. This cardboard box is placed over the seedlings. The experiment should be placed beside a window with the hole facing the window.

After a few days it is observed that the axes of the seedlings bend towards the light source.



Analysis:

This bending towards the rays of light is known as **“phototropism”.**

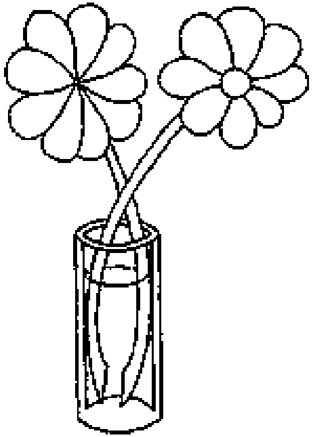
Importance in Nature:

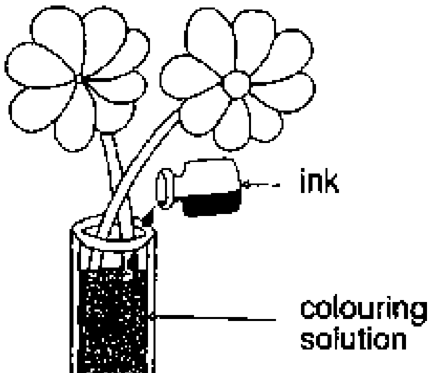
Phototropism helps the plant to get as much light as possible for a maximum photosynthesis. But in nature this involves certain problems: maximum photosynthesis means a maximum of transpiration. High rates of light deminish the growth in length, which can become a problem in competition with other plants. Everywhere in nature we thus see an optimal compromise.

1.6. PLANTS TRANSPORT WATER

Some flower stalks are cut obliquely under water and placed in the dish with the colouring solution. The stalks must be cut under water to prevent the appearence of an embolus of air in the lower part of the stalk. That would prevent the coloured water rising in the stalk.

This experiment takes between 30 and 60 minutes, sometimes half a day, depending on the kinds of plant used.





Importance in Nature:

The water has to got somewhere. Otherwise the plant would be fully saturated, no more water could rise and there would be no more intake of nutrients from the soil. Here once again we se optimal compromise.

The next experiment looks in more detail at water loss.

1.7. THE WATER EVAPORATION OF PLANTS

Main Goal:

This experiment illustrates that plants release water via their leaves.

Information:

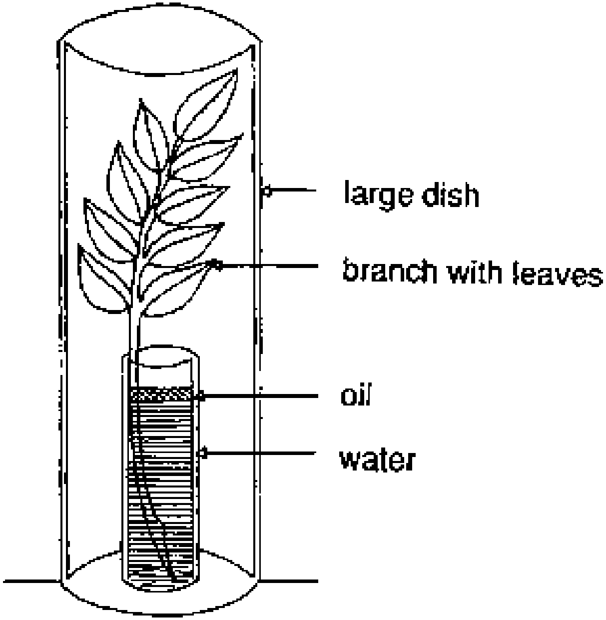
Roots absorb water, which is conducted by the vascular tissue to all parts of the plant. The water evaporates via the leaves, so that a constant flow of water is guaranteed.

Materials and Apparatus:

1 thin (young) branch of a deciduous tree

water

oil (plant oil as used for cooking will be best. Do not use motoroil at all. It will damage the leaves by releasing poisonous gases).



Observation:

Moisture condenses after some time on the inside of the larger glass. The condensed water will firstly form a layer on the wall of the glass and will later flow together to form drops of water.

The water can be identified with dried white copper sulfate, which turns blue.
(see experiment: THE COMBUSTION PRODUCTS OF A FLAME.)

Practical Meaning:

There are different devices which prevent a plant drying out.

The plant protects itself by:

- thick leaves covered with a layer of wax;
- thick shoots with a tissue that can store water;
- bark formation;
- closing the stomata in the leaves in certain circumstances;
- growing dry hair on the lower surface of the leaves.

1.8. THE IMPORTANCE OF MINERAL SALTS

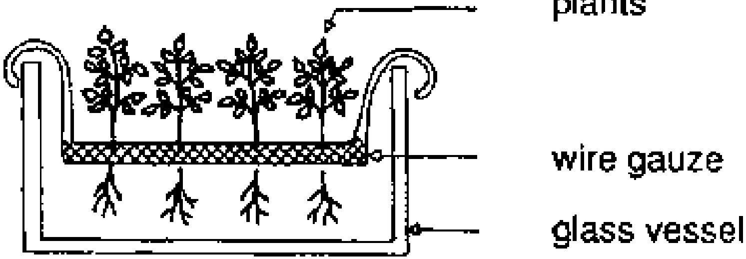
Main Goal:

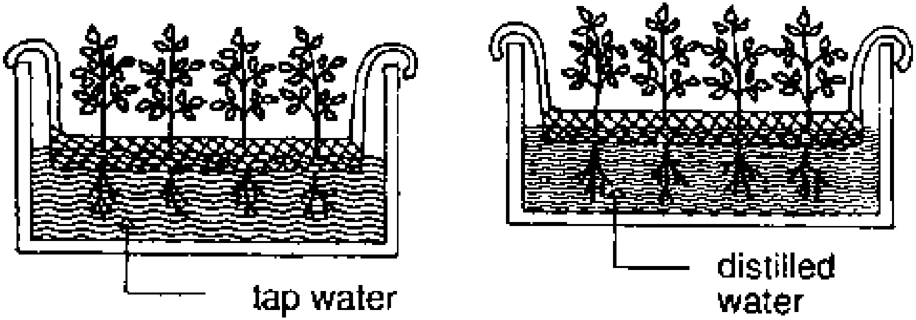
This experiment shows that plants cannot live without mineral salts.

Information:

The seedlings obtain proteins, fats, carbohydrates, the nutrients necessary for their growth from the seed leaves.

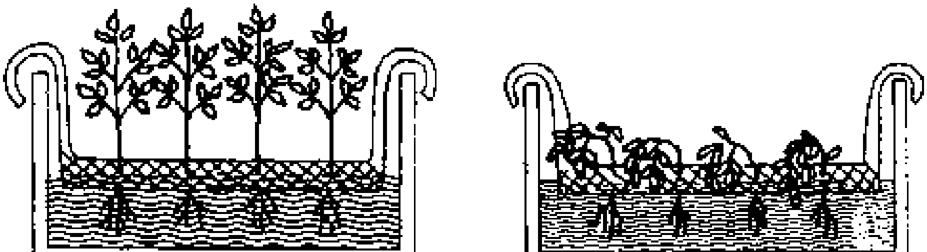
To retain their vital functions, plants synthesize the nutrients in various metabolic processes. In order to do this, mineral salts and water are indispensable.





Observation:

After a few days it can be observed that the plants in the distilled water develop poorly.



funnel with a short or shortenes neck (see figures)

rubber stopper

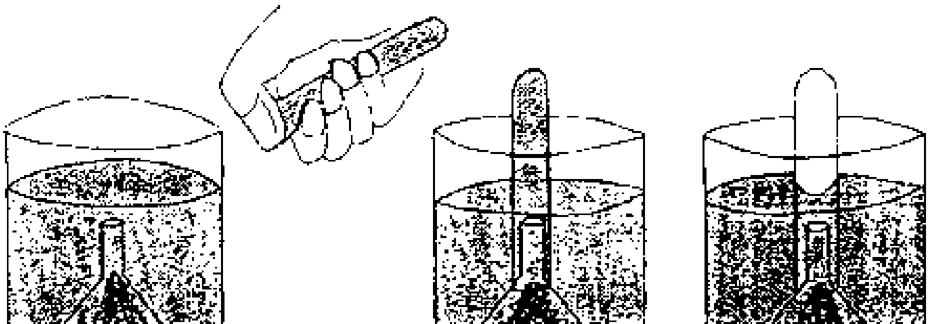
a wood chip

matches

Procedure:

Bind about 15 stems of waterweed together with a piece of thin wire or a thread. Place them in a vessel which is filled with water almost up to the rim. The cut parts of the waterweed must point upwards. Put the funnel over the waterweed. Make sure that the top of the funnel neck is under water. (See figure) Then fill the test tube up to the rim with water. Seal it with your thumb. Turn it over and place it, still sealed with your thumb, into the water in the vessel. Place the tube over the funnel neck without pulling the tube out of the water. This is the only way, of placing the tube over the funnel neck, while retaining the water in the tube. – When the tube is nearly full of gas produced by the waterweed, take a glowing wood chip, remove the testtube from the funnel neck, turn it up and place the glowing wood chip into the tube.

Observe what happens.



1.10. STARCH FORMATION IN LEAVES

Main Goal:

This experiment serves to identify a product resulting from photosynthesis, namely starch.

Information:

Starch is one of the most important reserve substances of green plants. It is found as assimilation starch in the chloroplasts of green leaves.

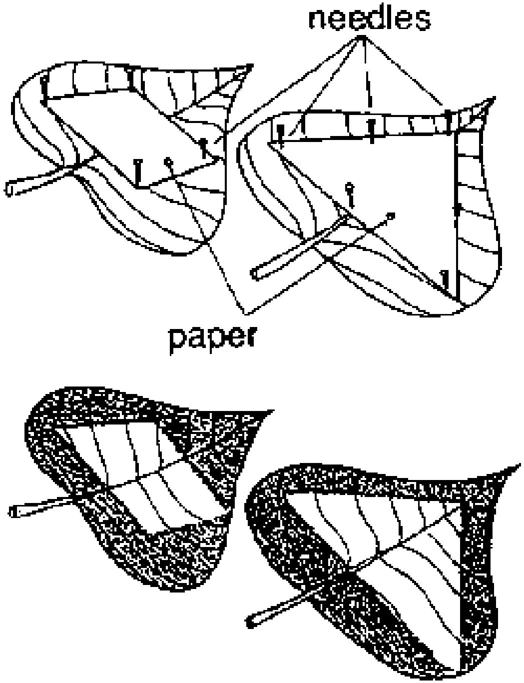
Materials and Apparatus:

a. plants with relatively large leaves
paper
pair of scissors
needles

b. 3 dishes
water
alcohol (96%)
iodine solution
(iodine–potassium iodide solution 1%)

Procedure:

a. As shown in the diagram below, the leaves are covered with patterns. The plant stays like this for one day and one night. The experiment to detect starch can be carried out after the plant has been sunlit for at least three hours the next morning.



Analysis:

Iodine colours starch bluish brown or deep dark brown.

For the starch formation, chlorophyll and light are indispensable.

Addition:

Starch is the typical vegetable reserve carbohydrate, e.g. of grain,

waterweed (other plants have to be tested)
one watch to count minutes

Procedure:

Fill the vessel up to one cm below the rim with tap water. Place a piece of waterweed into the water. Wait one minute. Watch and count the bubbles rising from the stem for exactly one minute. The bubbles are best if they large and discharged at a rate of not more than about ten a minute. Then change the water and place the waterweed into the boiled cooled water. Observe whether the plant continues to produce gas bubbles. After a few minutes pour some soda water into the vessel. Wait a minute and observe the plant. If it starts producing gas again, wait two minutes and then count the bubbles once more for exactly one minute. Compare the results obtained.

Observation:

In the first case you will note a few bubbles, in the second case there will be no bubbles, and in the third case you will see more bubbles of gas than in the first case.

Analysis:

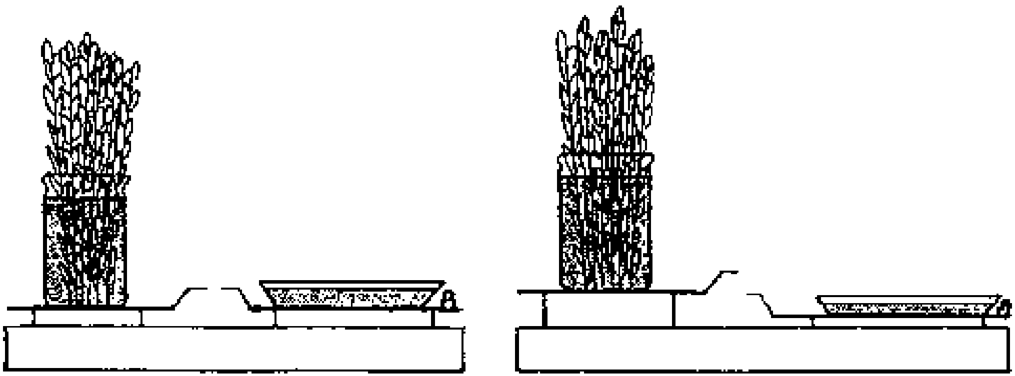
Tap water contains a little carbon dioxid, enough for the waterweed to produce sugar and then a surplus of oxygen. In boiled water there is no carbon dioxide and the plant cannot act. The plant is not dead, however as we can see from the fact that it produces a lot of bubbles after adding soda water, which contains a large quantity of carbon dioxide.

Importance in Nature:

Procedure:

Put the bunch of twigs into the beaker and fill it up with water. Fill the dish with water too. Put them on the scales so that they balance.

Leave the experiment for about 30 minutes. Then compare the levels of the plantforms.



Observation:

The platform with the twigs in the beaker will go up, the other one naturally down.

Analysis:

More water has evaporated through the leaves of the bunch of twigs than via the surface of the water in the dish.

Importance in Nature

Put the cotton wool in one of the dishes and place five pea seeds on it. The other five seeds are placed in the other dish. Fill the first dish with water so that the seeds are just covered. Keep only the cotton wool wet after the seeds have soaked up the water.

Fill the second one up to the rim and keep the water at this level.

Watch the dishes and change water if it becomes grey.

Than there are funghy which will start to destroy the experiment.

Observation:

After 24 hours the seeds are swollen.

After another 24 hours the pea seeds on the cotton wool have germinated, while the seeds under water have not germinated or not to any great extent.

Analysis:

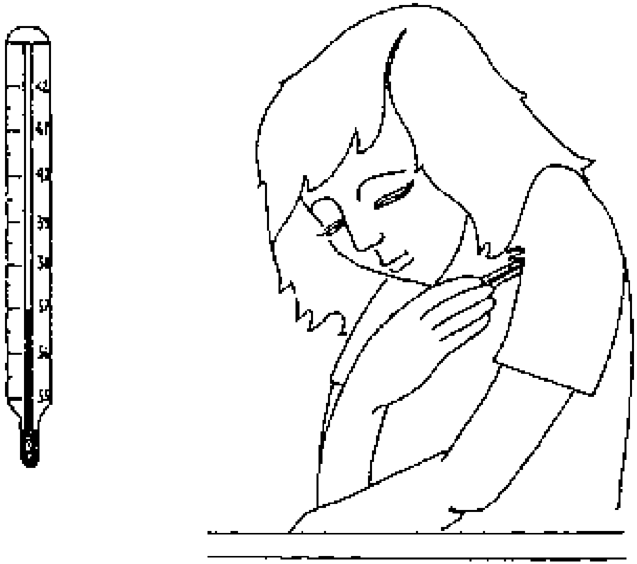
Though there is some oxygen soluted in tap water it is not enough to let seeds germinate. Plants can use their nutrients stored in the seed leaves only if there is enough oxygen available to decompose the starch into sugar.

Addition:

Now you know why the earth has to be loose and wet, when you sow seeds in the garden.

2. HUMAN BIOLOGY

Wait about one or two minutes and note what happens.



Observation:

a. The thermometer indicates about 37° C.

b. The thermometer ascends for two to five degrees, depending on the surrounding temperature.

Analysis:

The average body temperature of a human being is 37° C.
The body emits heat to a colder surrounding, e.g., the air

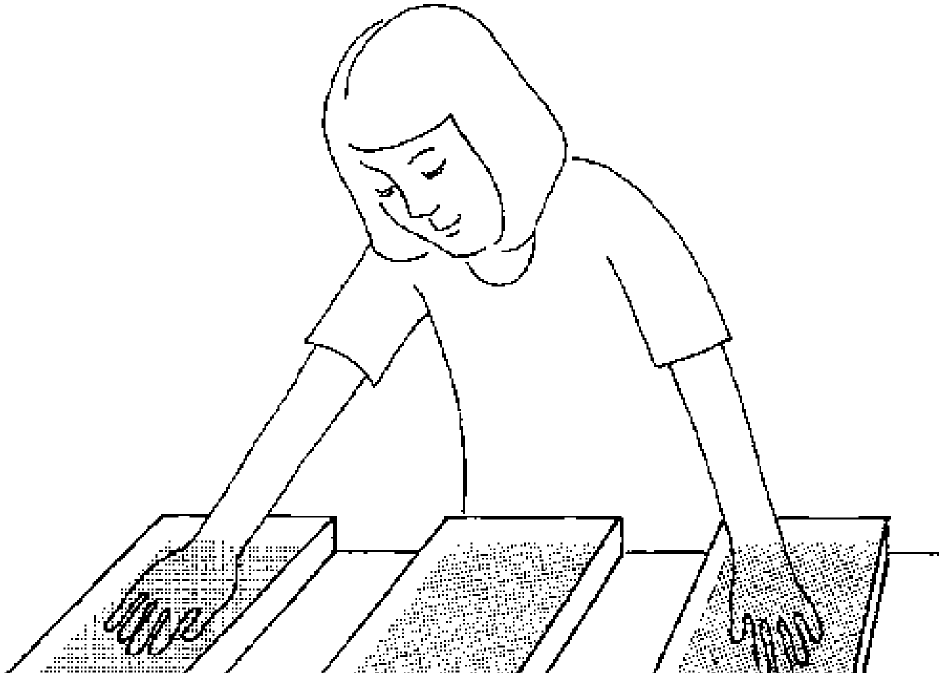
three litres of water one each at a temperature of 5° C, 20° C and 40° C 3 flat dishes

Procedure:

One litre of water is cooled down, in a refrigerator, with ice or by placing it outside at night.

Another litre is heated to about 40° C, and the last litre to about 20° C.

The experiment is set up as shown in the diagram below.



Non–heated rooms such as a cellar, are perceived to be cool in summer and warm in winter, although the temperature is higher in summer than in winter.

2.3. THE TASTE BUDS ON THE TONGUE

Main Goal:

This experiment shows that the tongue is divided into various areas which perceive different kinds of tastes.

Information:

On the surface of the tongue are taste bud areas which are capable of distinguishing between sweet, sour, salty and bitter. These areas can be easily located.

Materials and Apparatus:

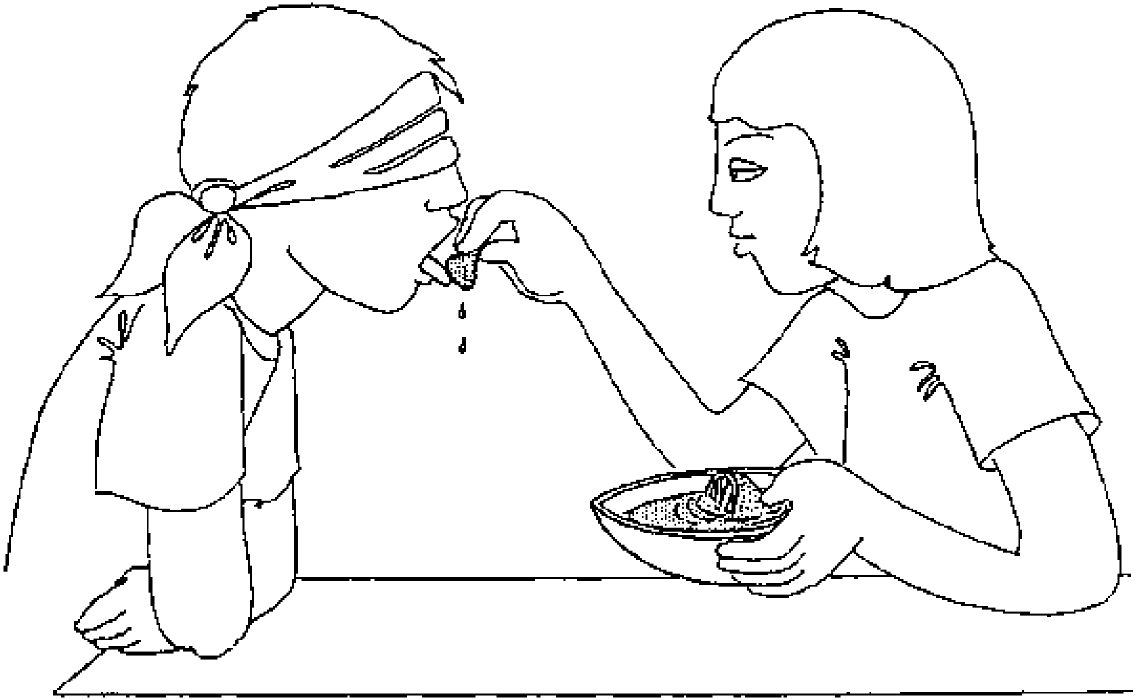
sugar

sodium chloride – household salt

1 lemon

magnesium sulphate or one bitter grapefruit

4 cotton buds or wooden spatula
4 flat glass receptacles



The solutions are placed on his/her tongue with the cotton buds. The test person states on which part of the tongue he tastes the solutions. The test person must rinse out his/her mouth with water between tests.

Observation:

Sweet tastes are perceived on the tip of the tongue.

The front edges of the tongue perceive salty substances.

Addition:

The knowledge of the places where you perceive the four different tastes is of no use at first, for you will seldom taste only one of the four tastes, when you eat anything. But if you think about your taste of **a** meal, you can imagine what happens in your mind with all the single tastes, componed in a very tasteful meal: Your tongue distinguish only four different tastes, in your mind find hundreds of different tastes, all composed by only the four, plus the taste “hot”.

2.4. THE SENSATION OF TASTE AND SMELL

Main Goal:

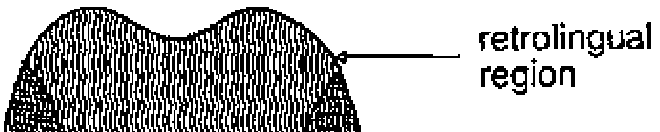
This experiment demonstrates the interaction of the senses of smell and taste.

Information:

Four different areas of taste are located on the tongue:

sweet, salty, sour, bitter.

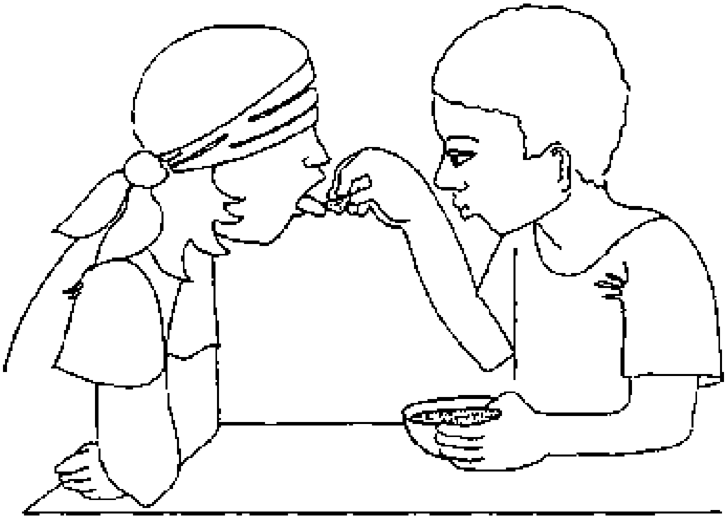
However, feelings of taste are created by an interaction of the sense of taste with the sense of smell. The latter is located on the mucous membrane of the nose. Besides this, the sensation of taste is affected by the sensations of warmth, cold, pain and touch.



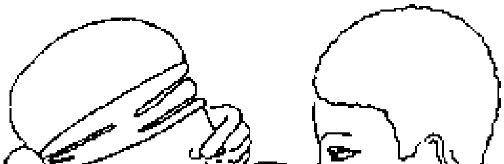
The fruit and vegetables are grated and placed on the dishes.

One test person is blindfolded.

Using the spoons, the grated apple, potato and onion are put onto the tongue of the test person one after the other. After each test the test person rinses his/her mouth with water. The test person identifies the taste.



The second test is performed in the same way, but this time the test person holds his/her nose.



2.5. STARCH BREAKDOWN IN THE MOUTH

Main Goal:

This experiment illustrates that starch breakdown starts in the mouth.

Information:

In the mouth, food is chewed into small pieces and moistened with saliva. The saliva is formed in the salivary glands, two sublingual, two lower jaw, and two parotid glands.

Saliva consists of mucus and the enzyme “ptyalin”. This enzyme causes the catabolism of starch into maltose. This catabolism continues in the stomach until the enzyme is made ineffective by hydrochloric acid, which is found in the stomach.

Materials:

a few cubes of bread
a few tubes
iodine–potassium iodide solution 1%

Procedure:

Put one cube of bread into a tube. Then drop so much of your saliva into the tube that the cube of bread becomes wet through. Drop about three drops of the iodine solution onto the cube. It turns dark blue. Keep the tube warm by closing your hand around the tube. Look periodically at the colour in the tube.

2.6. THE CINEMA EFFECT

Main Goal:

An expressive demonstration of the imperfections of the human eye.

Information:

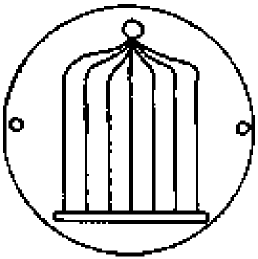
The human eye does not register individual stimuli which hit the retina within less than an eighteenth of a second. One uniform impression is created.

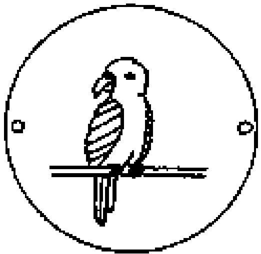
Materials and Apparatus:

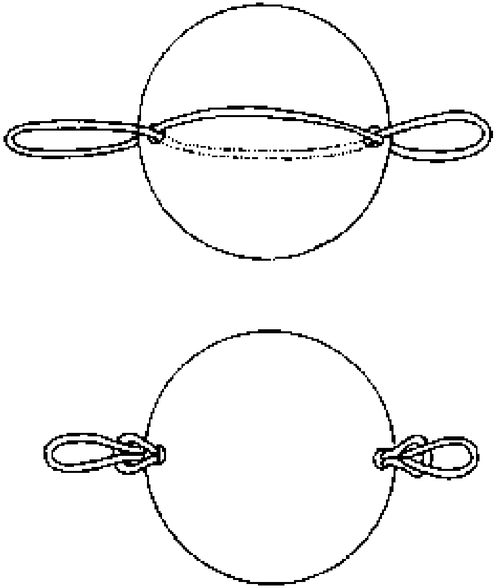
one cardboard disk, about 5 cm in diameter
a piece of string
coloured pencils

Procedure:

On one side of the cardboard disk a bird is painted and on the other side an upside–down cage.



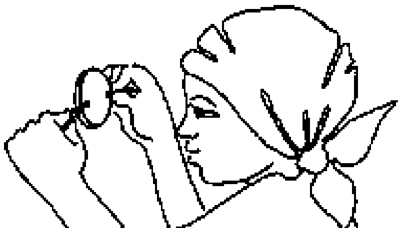




fastening of the strings

Observation:

Initially, the disk turns so quickly that the bird seems to be sitting in the cage.



Nerve fibers conduct stimuli to the optic nerve and then to the visual centre of the cerebral cortex.

Where the optic nerve emerges, there are no rods and cones, so that an image cannot be created. This spot is called the “blind spot”.

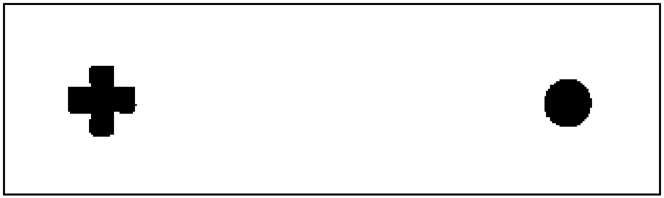
The brain completes the missing part of the image from its surrounding. Thus there is no “hole” in the field of vision.

Materials and Apparatus:

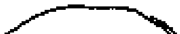
light cardboard, measuring about 10 cm × 3 cm
scissors
coloured pencil

Procedure:

The cardboard is prepared as shown in the following diagram. (Other symbols can also be used.)



The cardboard is held at arm’s length in front of the right eye, and the left eye shut. The right eye focusses on the cross, and then the cardboard is slowly moved towards the eye.



2.8. A MODEL DEMONSTRATING THE FLEXIBILITY OF THE SPINE

Main Goal:

This experiment illustrates the flexibility and the stability of the spine.

Information:

The spine of a human being is shaped like a double “S”. The spine of a baby or an ape is shaped like a single “S”.

Materials and Apparatus:

2 solid pieces of wire about 50 cm long

a wooden board measuring about 10 cm × 20 cm different weights weighing about 50 – 200 g or other objects which can be hung at the top of the spine models.

Procedure:

As shown in the drawing below, the two wires are fastened onto the board and bent. Make sure that the curves are exactly at the same points as shown in the figure. Bend the two spine models so that the top is exactly above the fixing point of the lower part of the spine models. (This is indispensible for the success of the experiment.)

The single S–shaped spine sags to a greater extent than the double S–shaped spine.

Consequences

The double S–shaped spine of adolescents and adults is more stable than the single S–shaped spine of babies and apes.

Practical Meaning:

The spine of an adult can be subjected to great pressure.

Because it is more flexible, it absorbs vibrations resulting from walking upright. This protects the brain against the usually occuring vibrations.

In many countries, loads, e.g. water jugs, are carried on the head, because this makes the transport easier.

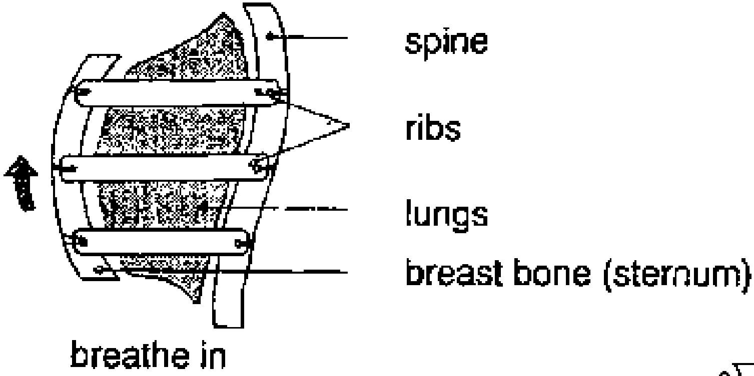
2.9. COSTAL RESPIRATION

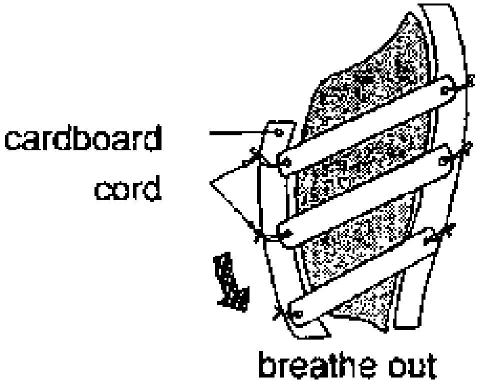
Main Goal:

This experiment illustrates costal respiration.

Information:

When you breathe in, the volume of your chest increases. The muscles between the ribs contract, lifting the ribs, with them the breast bone (sternum) and therefore the complete chest (thorax).





Observation:

If the breast bone is lifted, the chest widens. In reality the lungs expand.

respiratory movement.

2.10. IDENTIFICATION OF CARBON DIOXIDE IN EXHALED AIR

Main Goal:

This experiment illustrates that exhaled air contains carbon dioxide.

Information:

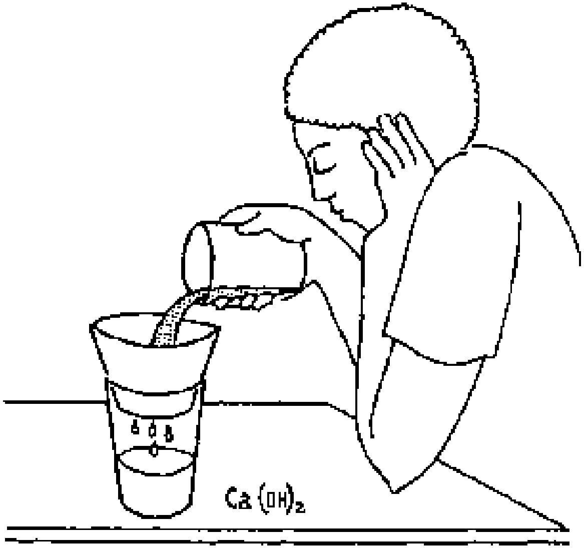
The constituents of food are catabolized into carbon dioxide, water and urea. Carbon dioxide is exhaled. The carbon dioxide proportion of inhaled air is about 0.03% and the oxygen proportion about 20% volume. The carbon dioxide proportion of exhaled air is approximately 4.5% and the oxygen proportion 15.5% volume.

A solution of limewater ($Ca\ (OH)_2$ in water) or a solution of ($Ba(OH)_2$ in water), baryta water, is used as a carbon dioxide indicator.

Materials and Apparatus:

calcium hydroxide or lime or calcium oxide (CaO)
barium hydroxide (made from barium oxide)
water
glass beaker
a glass pipe, a straw or a hollow bamboo cane
filters or clean paper from a cement sack

Procedure:



Exhaled air is blown into limewater through the glass pipe.

Observation:

The limewater (baryta water) becomes cloudy.
A white substance is precipitated.

Analysis:

Exhaled air contains so much carbon dioxide that it reacts with calcium hydroxide to form white, hardly soluble calcium carbonate. In the reaction with barium hydroxide, white, hardly soluble barium carbonate is precipitated.

Practical Importance:

The main task of the perspiratory glands in the skin is to regulate the body temperature. Besides water, sweat contains other products, predominantly sodium chloride – or household salt. This is why perspiration has a salty taste.

Materials and Apparatus:

a. distilled water – available at any garage

2% silver nitrate solution ($AgNO_3$), which can be purchased from a chemist
large beaker holding 1 – 2 litres

b. magnesia sticks, which can be obtained from

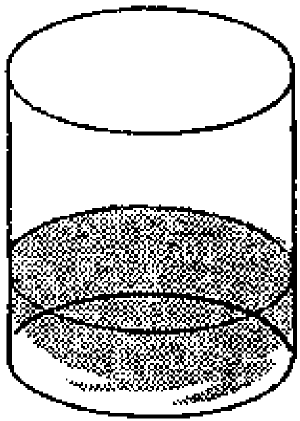
a *chemist*
1 candle

Procedure:

a. The glass dish is filled with distilled water.

A test person places one hand into the water and holds it there for about 10–20 minutes.

Then a few drops of silver nitrate solution are added to the distilled water.



Analysis:

a. The chloride ions together with silver nitrate form white silver chloride.

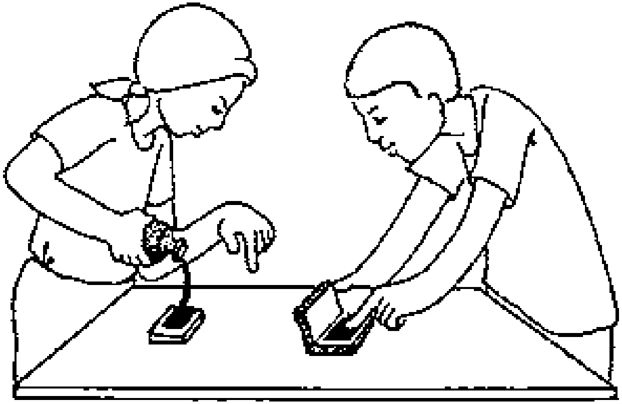
$$Ag^{+} + Cl^{-} ? AgCl?$$

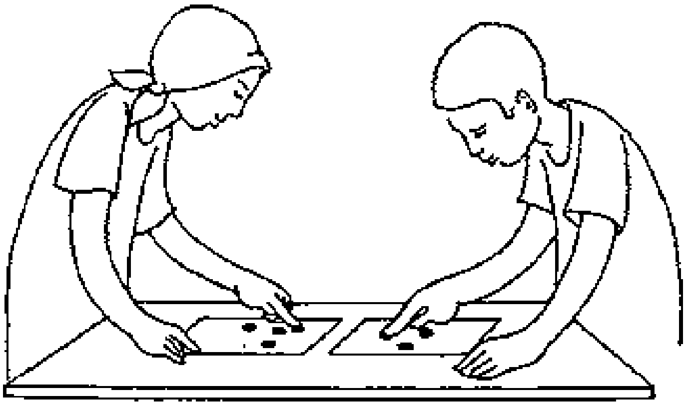
b. The yellow colouring of the flame indicates the presence of sodium.

Practical Meaning: The skin releases warmth by evaporating water on the skin and with that a remarkable account of sodium chloride. The loss of water is as problematic as the loss of sodium chloride. Loosing too much water can cause circulatory problems.

In countries where it is always hot, it is important that the body receive sufficient sodium chloride, otherwise the high loss of sodium chloride in perspiration can lead to circulatory disturbances as well.

In the last centurie British miners became ill, suffering from too little sodium chloride after





Observation:

2.13. DISTINGUISHING SEVERAL MATERIALS BY TOUCHING THEM WITH THE FINGER TIPS

Main Goal:

This experiment demonstrates that your finger tips can be used successfully to identify different surfaces.

Information:

see analysis

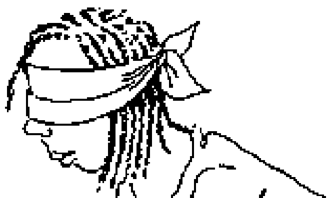
Materials and Apparatus:

You will require several objects with different surfaces such as a stone, a brick, pieces of bark from different trees, pieces of rough and smoothed wood, different textiles etc.

a scarf or shawl to blindfold a person.

Procedure:

One student is blindfolded and is given three objects to touch and retain the feeling. Then the scarf is removed. The student is allowed to test all objects and he/she must then determine which she/he touched while blindfolded.



The differences in the results stem from the different experience in identifying things by touching.

2.14. TESTING PULSE FREQUENCY UNDER DIFFERENT CONDITIONS

Main Goal:

This experiment demonstrates that the rate of the pulse depends on the work done immediately prior to measuring.

Information:

see analysis

Materials and Apparatus:

one watch to measure minutes

Procedure:

Look for your pulse on your wrist using the thumb of your other hand. You will find it one thumb length away from the back rim of the hand above the sinews of the inner side of your arm.

You will probably need a little while to find it and feel it well.

One person, perhaps your teacher, says, observing the watch: “go” and you start counting the pulse beats. When he says: “stop” (after exactly one minute) you note the number of pulse

Observation:

In the second case you will count a higher number of pulse beats than in the first. You may also be breathing faster especially if you are unaccustomed to sport and physical exercise.

Analysis:

Your body registers the work you do, in this case the knee bends.

It is able to regulate the pulse frequency in order to provide the muscles with enough blood for them to receive sufficient oxygen. That is also why you breath faster.

2.15. DETERMINING THE DIRECTION FROM WHICH A NOISE COMES

Main Goal:

This experiment demonstrates that with both ears you can better determine the direction from which a noise comes than with only one ear.

Information:

see analysis

Materials and Apparatus:

a scarf or shawl to blindfold a person

Observation:

With both ears the blindfolded student will probably achieve about 9 right answers out of ten.

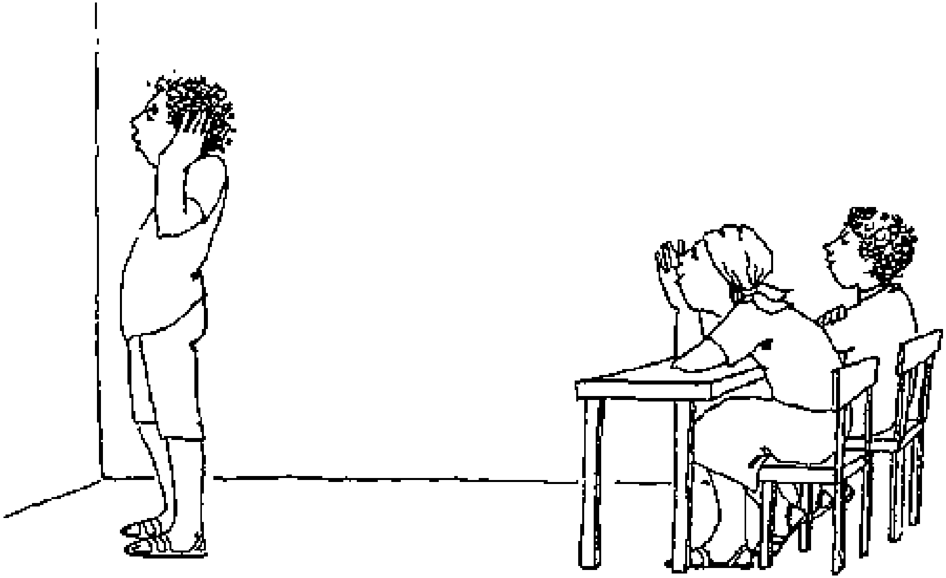
When holding a hand over one ear though the student might achieve a score of only some five or six correct answers, or less.

Analysis:

Our ears are very sensitive. They can distinguish the time lapse which occurs if a noise does not come from immediately infront or behind us.

When one listens with only one ear this time lapse can no longer be heard and it

The 'listening' student should then cover one ear, and the experiment should be repeated another ten times.



Observation:

In most cases it is not necessary to use both ears to understand whispered numbers.

Where a student does have difficulty he or she may have a hearing impediment.

Analysis:

Both ears are usually equal sensitive. Thus one ear is sufficient to identify whispered

The blue zones of the flame contain candle gas, that is not burning.

The temperature of the yellow zone is higher than that of the blue zone.

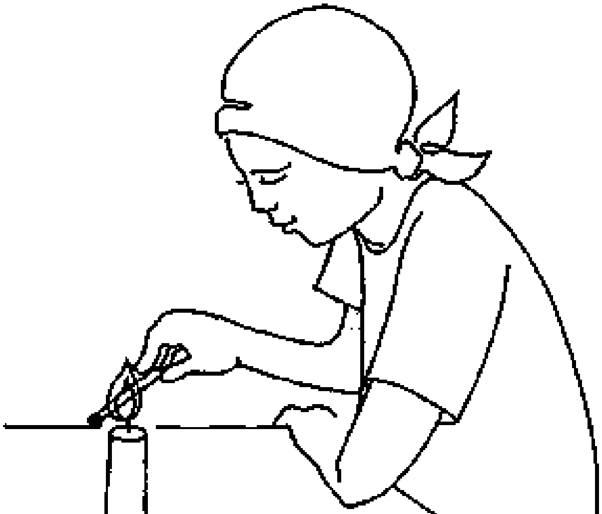
Materials and Apparatus:

matches, magnesia sticks
a candle

Procedure:

a. One match is passed through the flame of the candle (see diagram).

b. The same experiment is carried out with a magnesia stick.



Analysis:

The dark burnt parts of the match and the glowing parts of the magnesia stick demonstrate that the temperature in the yellow zone is higher than that in the blue zone. The combustion of the candle gas takes place in the yellow zone, as it is only here at the outer part of the flame, that enough oxygen is available and can mix with the candle gas.

Practical Meaning:

With this candle flame experiment the basic characteristics of a common laboratory burner or any other open fire can be demonstrated.

In open fires, a good oxygen supply is required to achieve complete combustion.

3.2. THE CANDLE FLAME AND ITS DAUGHTER FLAME

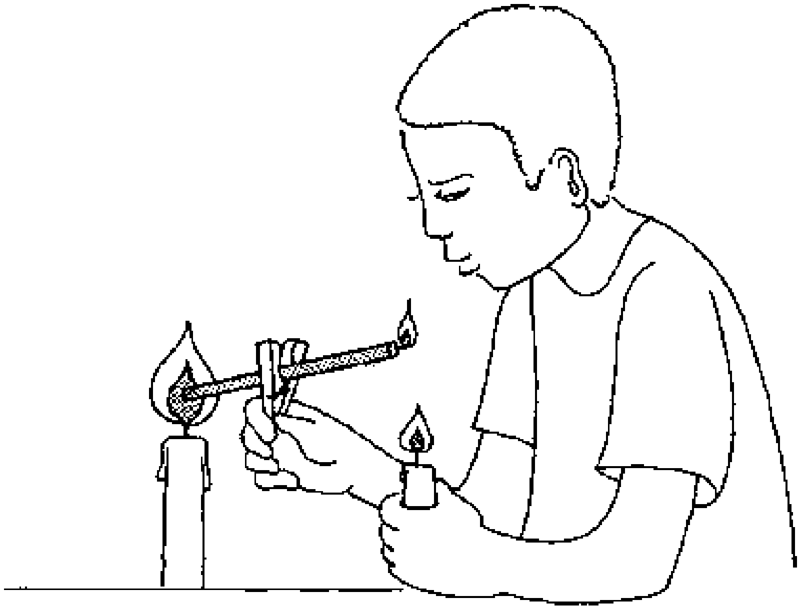
Main Goal:

This experiment demonstrates that the blue zone of the flame contains unburnt candle gas.

Information:

(see experiment: THE COMBUSTION ZONES OF THE CANDLE FLAME)

Materials and Apparatus:



Observation:

This gas can be ignited with a lit candle.

Analysis:

Unburnt candle gas can be found in the blue zone of the flame.

When the candle gas from the blue zone reaches the outer zone, it burns, when atmospheric oxygen and candle gas mix in the right proportion.

candle
glass vessel
limewater
white copper sulfate (dried blue copper sulfate)

Procedure:

a. The bottom of a glass vessel is held over a burning candle.

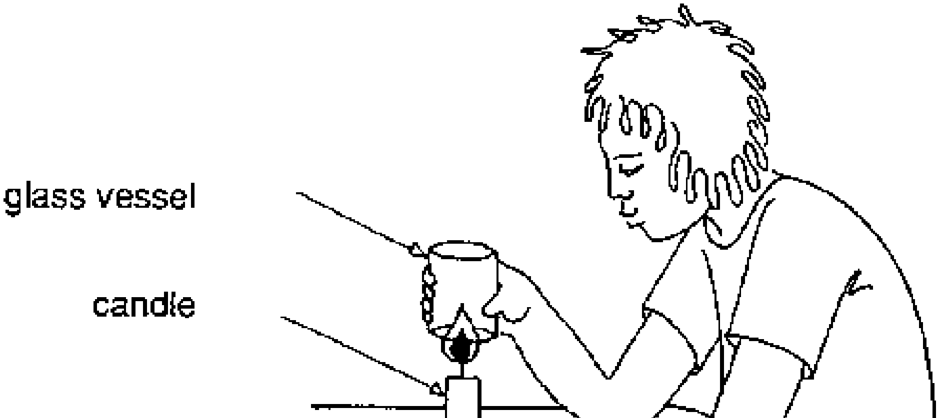
b. A cold glass vessel is held upside down over **a** burning candle.

The water which is produced can be identified with finely pulverized copper sulfate.

c. A glass vessel is held over a burning candle.

It is then rinsed with limewater to identify the carbon dioxide produced.

(As carbon dioxide is heavier than air, a great amount of it escapes from the glass dish.)



Practical Use:

All organic substances contain carbon and hydrogen.
These elements can always be identified using the above methods.

3.4. THE DETERMINATION OF OXYGEN CONCENTRATION IN THE AIR

Main Goal:

This experiment demonstrates that part of the air is used during combustion.

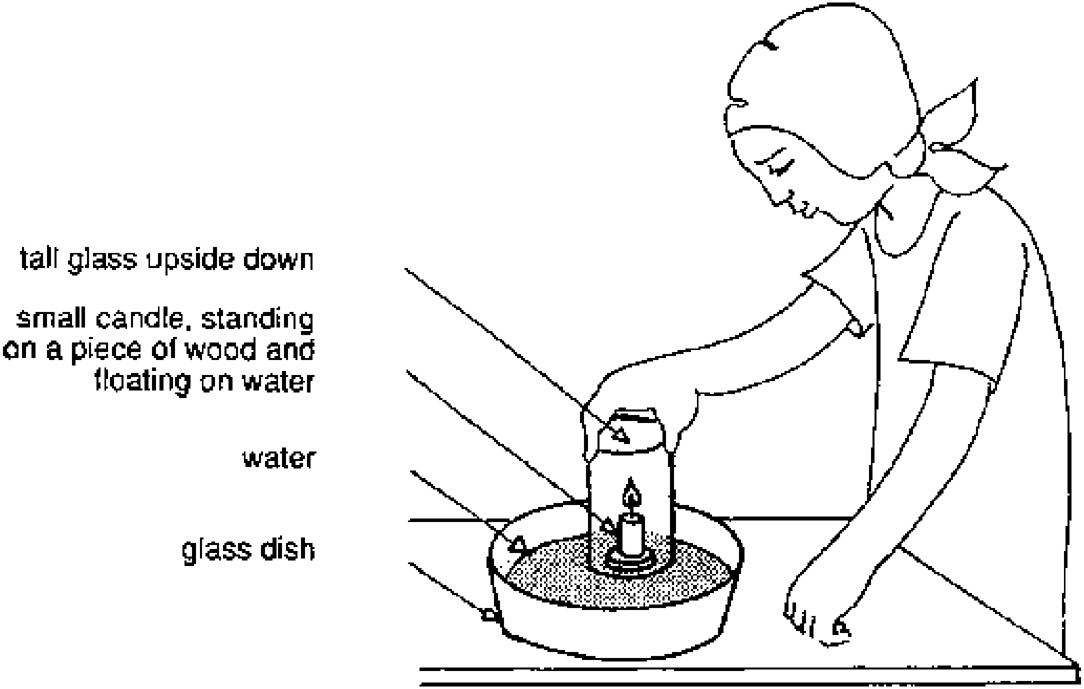
Information:

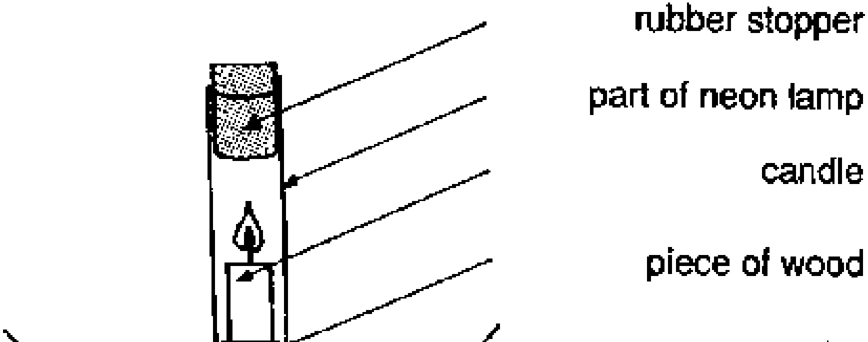
The investigation of air compounds shows that air consists of about 20 parts by volume oxygen and about 78 parts by volume nitrogen. The amount of other gases can be ignored for the purposes of the two following experiments. (These other gases are carbon dioxide and inert gases.)

Materials and Apparatus:

part of a neon lamp (about 30 cm) or a tall glass
small candle – should be light enough to float in water
rubber stopper
large glass dish
a clamp stand if available (if not, the glass can be held as shown below)

Procedure:


tall glass upside down
small candle, standing on a piece of wood and floating on water
water
glass dish


rubber stopper
part of neon lamp
candle
piece of wood

During combustion, the candle uses about one fifth of the air volume. This part of the air is called oxygen.

Practical Meaning:

Plants are the sole producers of oxygen on Earth.

They guarantee the constant oxygen content of the air. Any massive disturbance to the plant world would automatically seriously perturb the lives of man and animals. Human beings and animals need atmospheric oxygen to breathe. During the process of metabolism, carbon dioxide is produced in their bodies. With the help of solar energy, plants produce oxygen and carbohydrates from carbon dioxide and water (CO_2 and H_2O).

3.5. NITROGEN EXTINGUISHES A CANDLE FLAME

Main Goal:

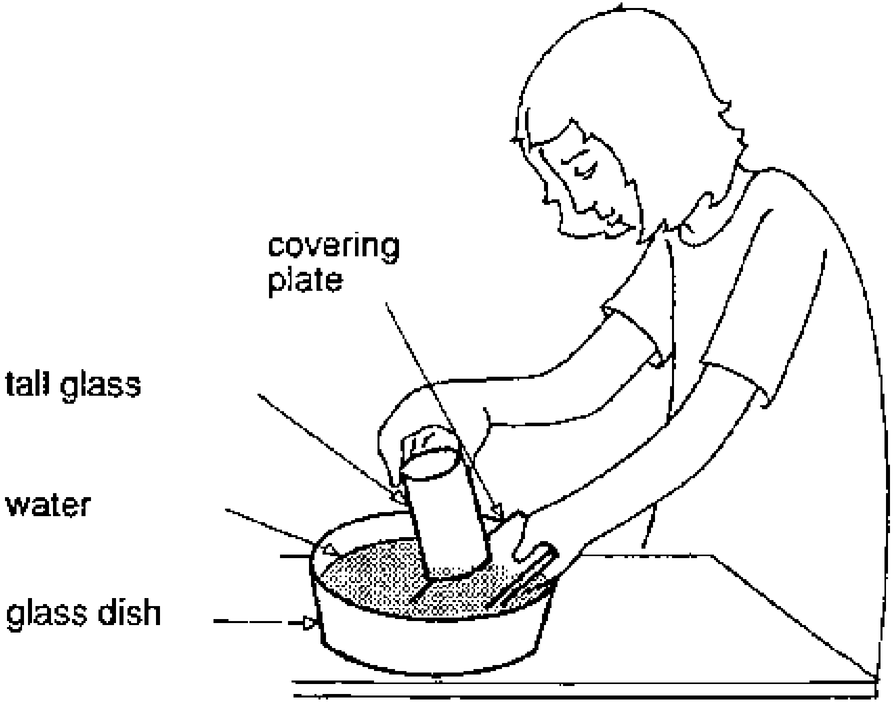
This experiment demonstrates that a candle, or any other kind of flame, does not burn in nitrogen.

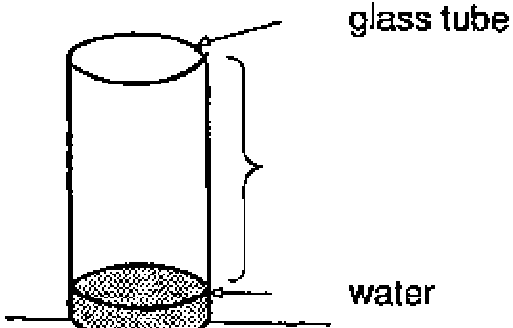
Information:

(see experiment: DETERMINATION OF OXYGEN CONCENTRATION IN THE AIR)

Materials and Apparatus:

part of a neon lamp (about 30 cm) or a tall glass
small candle – should be light enough to float in water


covering plate
tall glass
water
glass dish


glass tube
water

Air consists of about 78% parts by volume nitrogen. (Oxygen supports combustion. Other gases, e.g. nitrogen, carbon dioxide, inert gases do not support combustion.)

3.6. ATMOSPHERIC OXYGEN SUPPORTS COMBUSTION

Main Goal:

This experiment illustrates that combustion can only take place if there is a constant supply of oxygen.

Information:

Without oxygen, combustion cannot take place.

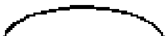
The oxygen necessary for combustion is present in the air. If a burning candle is placed in a small closed volume, it burns until the available oxygen is nearly used up.

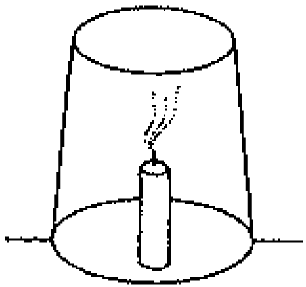
Materials and Apparatus:

candle
glass vessel
cover plate

Procedure:

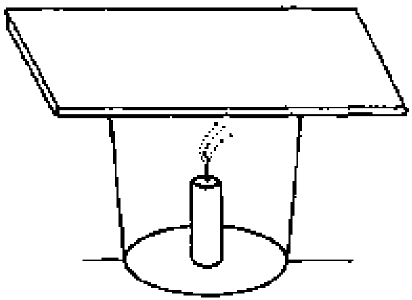
a. A glass vessel is placed upside down over a burning candle (see diagram).





Observation:

a. During the course of the experiment, the flame gradually becomes smaller until it is finally extinguished.



b. The candle is not extinguished until the vessel is completely covered.

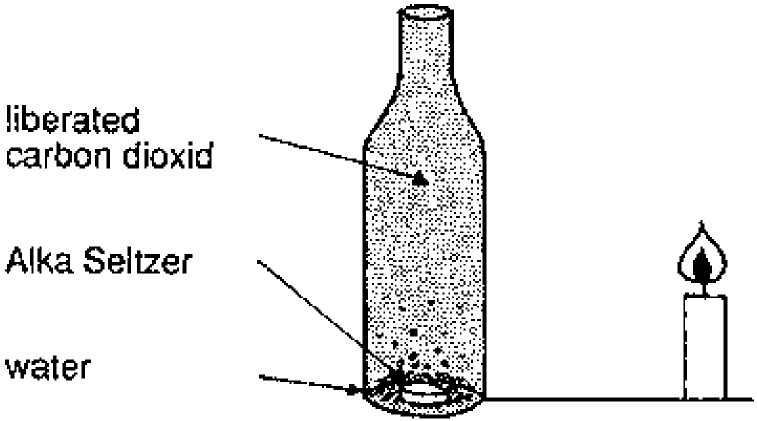
Analysis:

A candle can only burn if there is a constant supply of oxygen.

candle
glass dish or bottle
Alka Seltzer (1/2 or 1 tablet)

Procedure:

One Alka Seltzer tablet is mixed with a few drops of water in a glass dish.



The carbon dioxide liberated is poured over a burning candle.
(A burning candle can also be dipped into the dish.)

The air contains 0.03 per cent carbon dioxide by volume. If there is more than 5 per cent of this gas in the air, respiration is impeded. Exhaled air contains about 4 per cent carbon dioxide by volume.

Carbon dioxide does not conduct electricity and does not leave any kind of residue. For this reason it is used instead of water as a fire extinguisher in chemical and nuclear plants.

3.8. THE FORMATION OF CRYSTALS

Main Goal:

This experiment demonstrates the formation of crystals, and proves that dissolved substances are present in solutions, even if they cannot be seen.

Information:

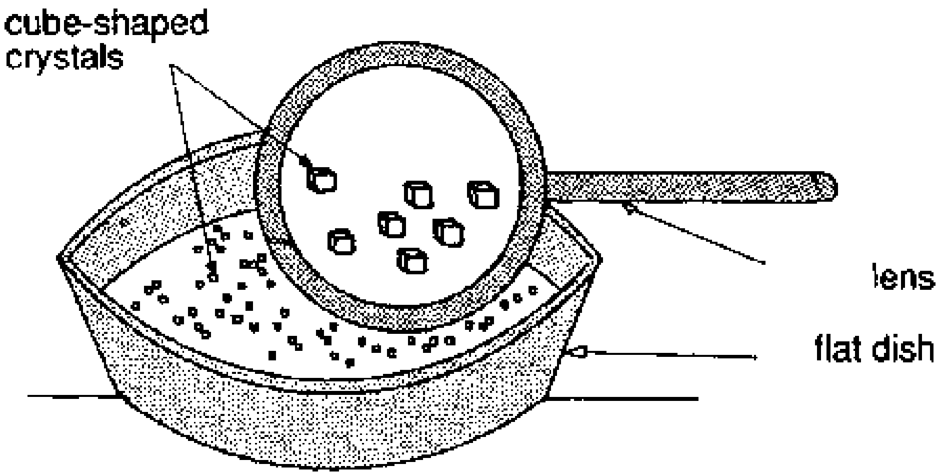
Salts form crystals. The longer it takes for water to evaporate from a salt solution, the more even the crystals become.

Every salt has a typical crystalline form.

On the basis of this experiment, some further terms can be explained:

solvent
dissolved substance
soluble/insoluble
water–soluble
precipitation

The water takes several hours or even a day to evaporate.



Observation:

The water evaporates.
Cube–shaped crystals form.

Analysis:

Sodium chloride forms cube–shaped crystals.

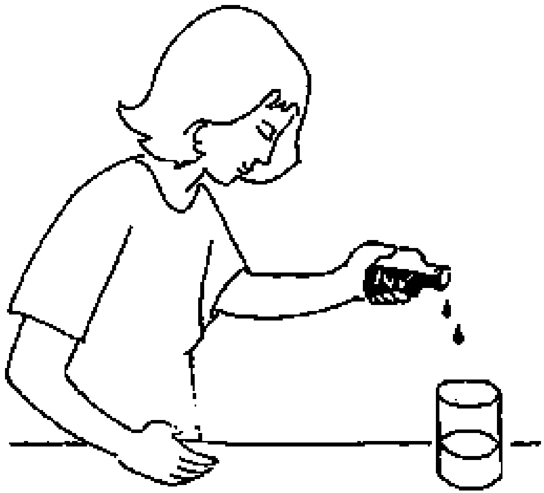
Addition:

Various substances can be identified from their crystaline form.

salt water – sodium chloride dissolved in water
drinking water
2 glass dishes, glass stick
ink or other colours

Procedure:

2 – 3 drops of ink are added to the salt water, which is then carefully added to the drinking water. This is best done by means of a glass stick along which the salt water runs down.



3.10. SEPARATION OF SOLID MIXTURES

Main Goal:

The experiment illustrates that solid mixtures can be separated using their physical properties.

Information:

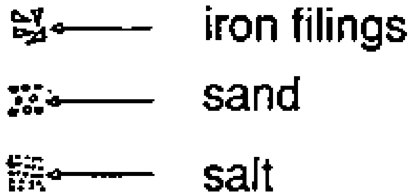
In contrast to a compound, the single substances of a solid mixture exist independently in an unaltered form. Their individual physical properties are preserved. Using these known properties, the single substances can be separated from each other.

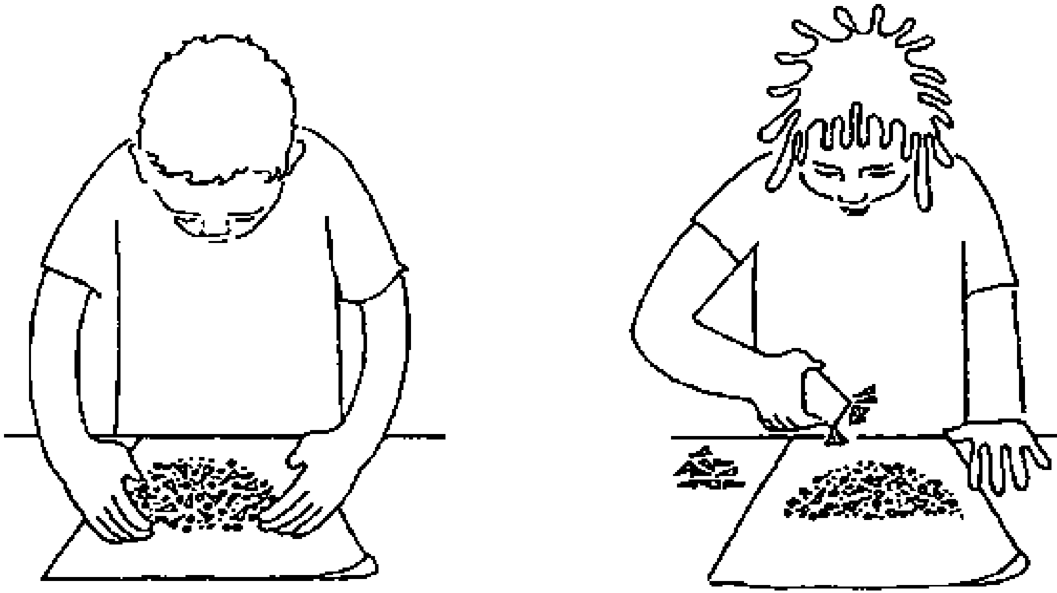
Materials and Apparatus:

salt (sodium chloride)
sand iron filings (cutted iron wool)
magnet
filter papers
filter
glass dish
burner, candle
tripod
paper
water
wooden stick, spoon

Procedure:

Salt, sand and iron cuttings are mixed up on a sheet of paper.





(1)

(2) The salt–sand mixture is added to 30 ml of water, stirred well, and filtered. The filtration residue is rinsed 2 – 3 times with water. Then it is dried in the air.

(3) Using the burner, the filtrate (salt solution) is slowly evaporated until it is dry.

After the water evaporates, the salt is left as residue. In a solid mixture, the properties of each substance are preserved.

Analysis:

By means of a magnet, iron is separated from other kind of metals and other substances, e.g. in junkyards.

There are several other methods for obtaining salt. One is by evaporation of sea water and another, the washing out of salty soil.

3.11. THE CORROSION OF IRON

Main Goal:

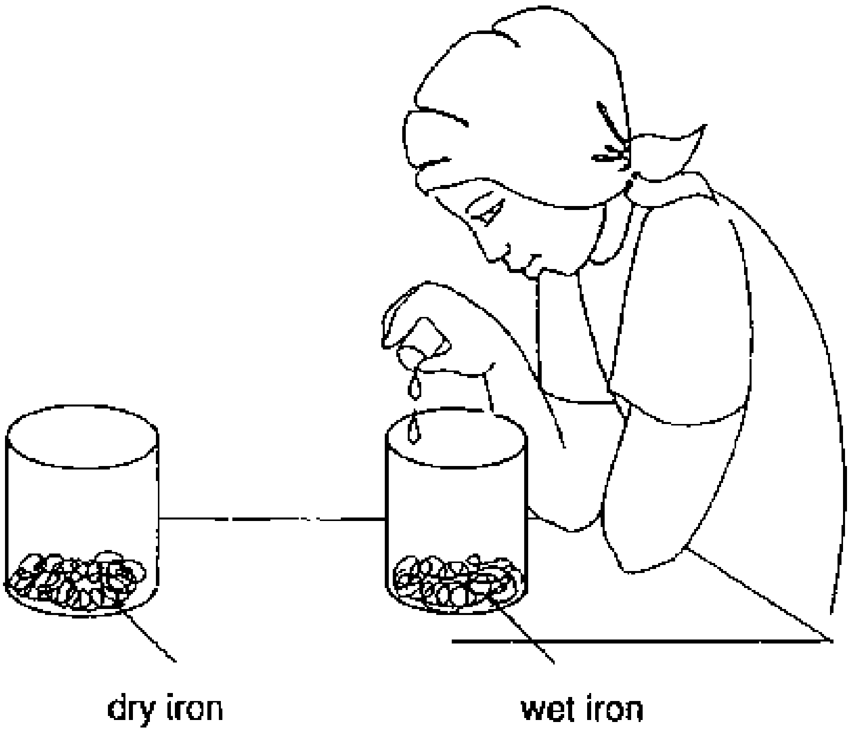
This experiment demonstrates that moistened iron corrodes faster (corrodere – Latin: to gnaw away), than dry iron.

Information:

When the air is humid, iron reacts with oxygen to form rust.

Materials and Apparatus:

iron wool, iron filings
2 glass vessels
water



The experiment takes some days.

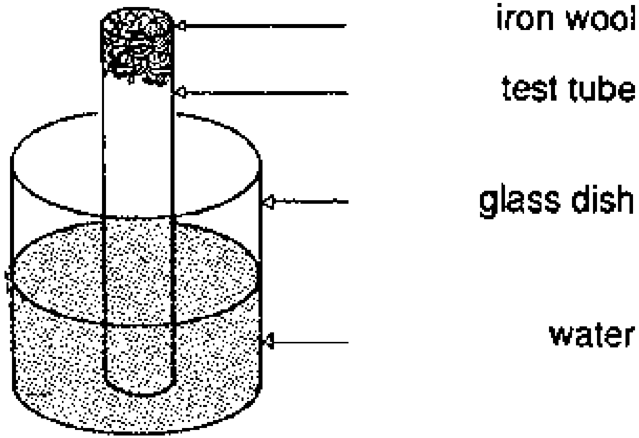
Observation:

The moistened iron wool has turned a brown colour. It has become brittle.

Analysis:

It can be concluded that rust has been formed.
Moist iron rusts faster than dry iron.

Leave some space between the open end of the test tube and the bottom of the glass dish.



b) Do the same experiment in parallel with salt water in place of water.

3.13. TINS ARE PROTECTED AGAINST RUST

Main Goal:

The experiment shows that tins are protected against corrosion.

Information:

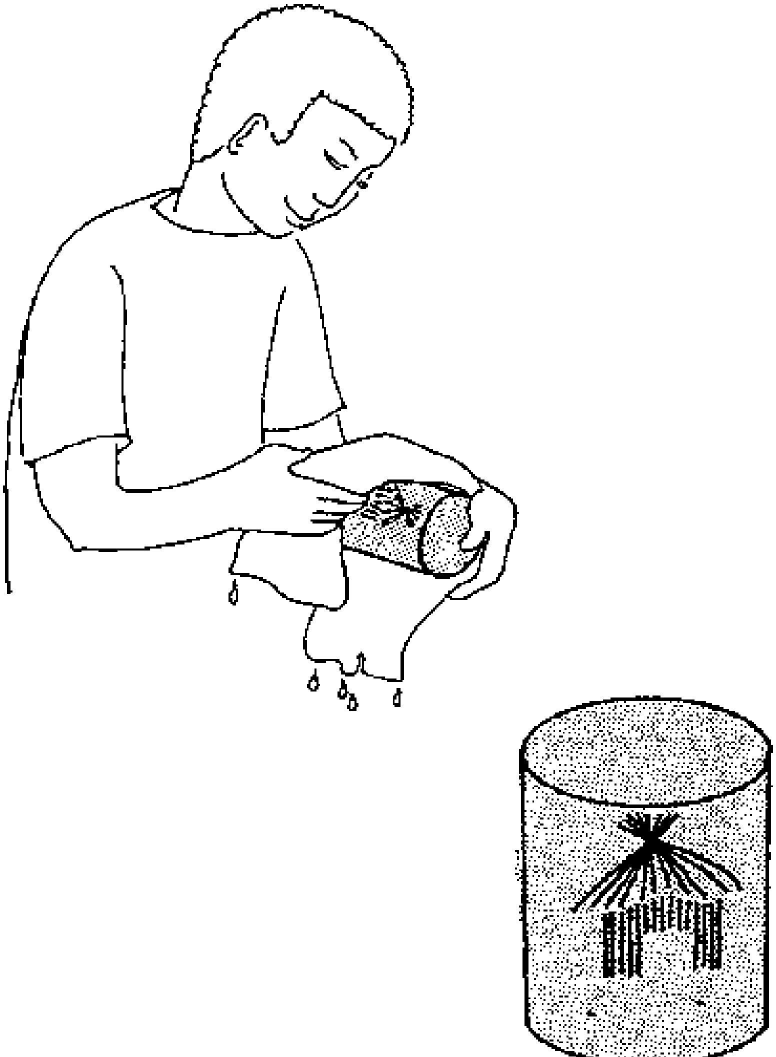
Tins consist of tinned sheet iron.
This is iron which is plated with tin.

Materials and Apparatus:

2 tins
1 nail
2 rags
water

Procedure:

A pattern is scratched with the nail into one of the tins.

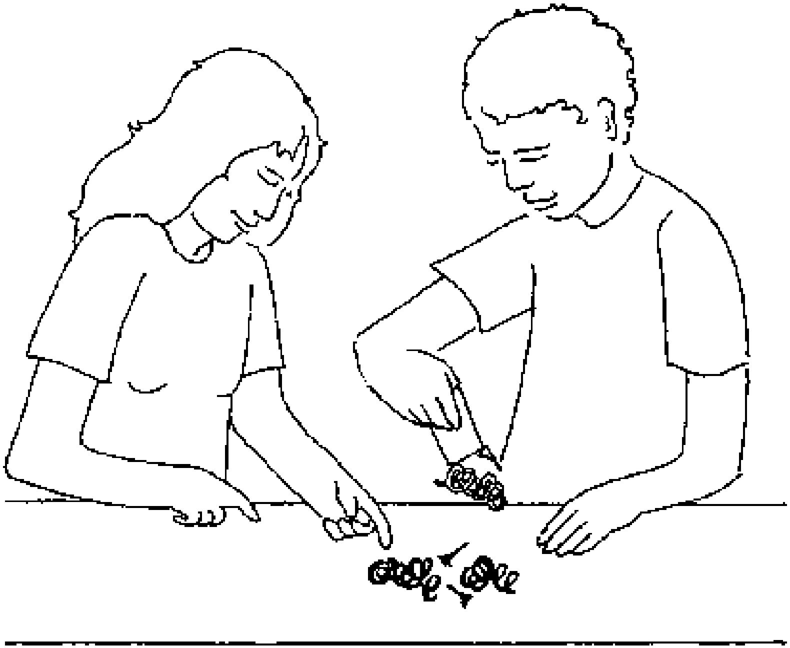


rust
iron wool
magnet

Procedure:

a. The physical properties of iron are examined, such as flexibility, magnetism and colour.

b. Rust is examined for the same physical properties.



the negative pole (cathode).

Sodium ions are collected also at the cathode where sodium appears as metal.

An additional product is sodium hydroxide solution.

(Warning: A detonating mixture of chlorine and hydrogen may be formed. **Chlorine is toxic!)**

Materials and Apparatus:

household salt (sodium chloride) (5–10 g)

2 copper wires about 15 cm long, insulated apart from the last 3 cm at each ends of the wires, which shall be knocked flat.

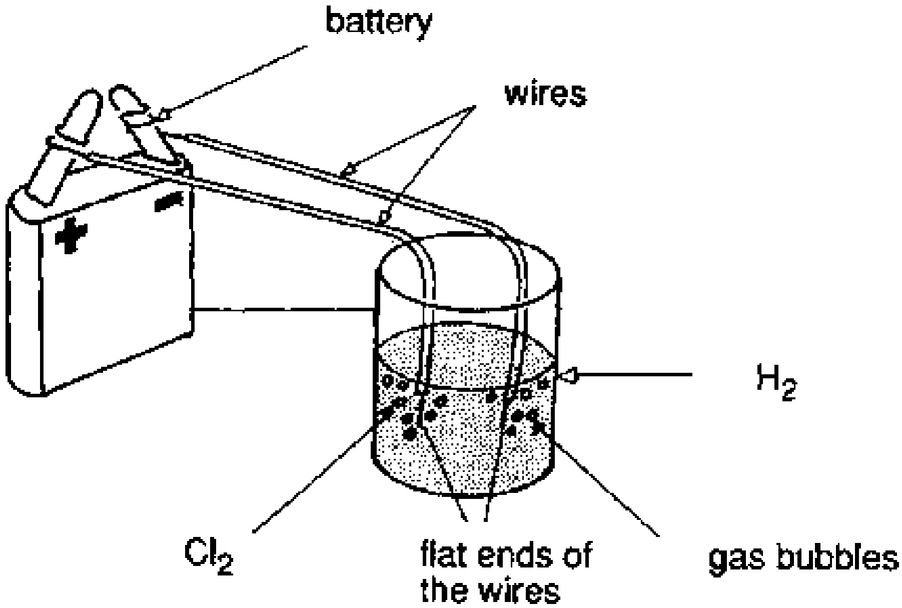
glass vessel

battery, about 4.5 V

(indicator, e.g. litmus, see experiment: VEGETABLE INDICATOR – ANTHOCYANE)

Procedure:

The household salt is dissolved in water.



Observation:

Gas bubbles rise at the two poles.

There is a smell of chlorine.

(Near the cathode, the litmus turns blue after a while. Near the anode it is bleached.)

Analysis:

Chlorine gas is released at the positive pole (anode).

Information:

With a constant voltage of 4,5 V, delivered by a battery, water can be decomposed into hydrogen and oxygen. The effect is more impressive when two batteries in series are used.

Materials and Apparatus

1 glass vessel (beaker), filled with water,

copper or iron electrodes

insulated wire

2 batteries, serially connected, the two electrodes, covered by test tubes, about 1.5 cm separated

sulphuric acid

wood chip

candle, matches

wooden board (ca. 10 × 20 cm)

Procedure:

The following apparatus is set up.

A few drops of sulphuric acid are added to the water. (This increases conductivity.)

c. Before the left test tube is taken out of the water in the same manner as the right one, a wood chip is lighted. The glowing wood chip is dipped into the test tube.

Observation:

a. Gas bubbles are formed at both poles.

They displace the water from the test tubes.

b. An explosion is heard and perhaps of blue flame may be seen.

c. The glowing wood chip lights up in the test tube.

Analysis:

The two test tubes fill with gas.

The gas in test tube (A) is called "hydrogen".
Hydrogen burns with a blue flame.

The gas in test tube (B) is called "oxygen".
Oxygen supports combustion.

Water consists of the element hydrogen and oxygen.

to b.) The explosion, which is not dangerous on such a small scale, is the so-called "oxyhydrogen gas reaction".

Hydrogen and oxygen react to form water.

$$2\ H_2 + O_2 ?\ 2\ H_2O$$

1 coke can, or metal tea caddy
1 nail
1 hammer
1 pair of sheet–iron shears
1 piece of adhesive tape
1 flask of compressed hydrogen matches

Procedure:

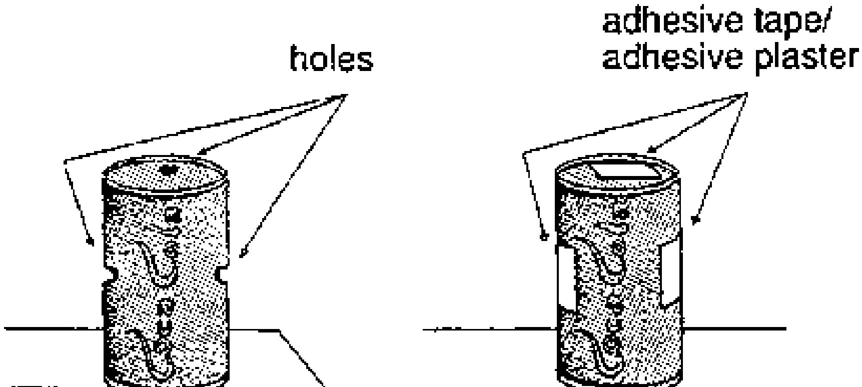
The top of the coke can is cut off, using the sheet–iron shears.

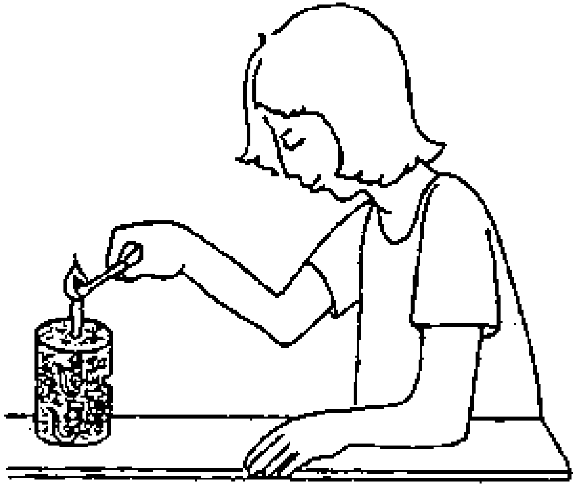
As shown in the following diagram, 2 small holes are cut in the can.

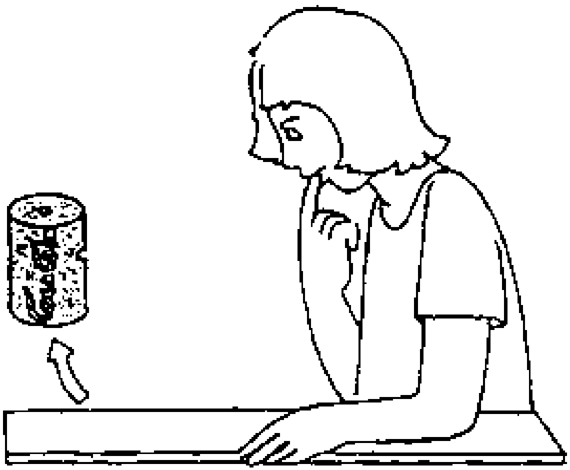
These two holes are covered with adhesive tape or adhesive plaster.

As shown in the diagram, the can is filled with hydrogen, taken from the flask, for one minute. It is placed on the table.

The flask with compressed hydrogen is sealed and placed several metres away from the can.







With a welding torch, this combustion is not dangerous.

3.18. VEGETABLE INDICATOR – ANTHOCYAN

Main Goal:

The pupils learn to distinguish between an acid and an alkali with the help of an indicator.

Information:

The word “indicator” is derived from the Latin “indicare”: meaning to show. Indicators change colour according to the medium with which they are in contact.

Anthocyans are vegetable colourings, which form salts with acids and alkalies. The salt formation with an acid gives a red colour and the salt formation with an alkali a blue colour.

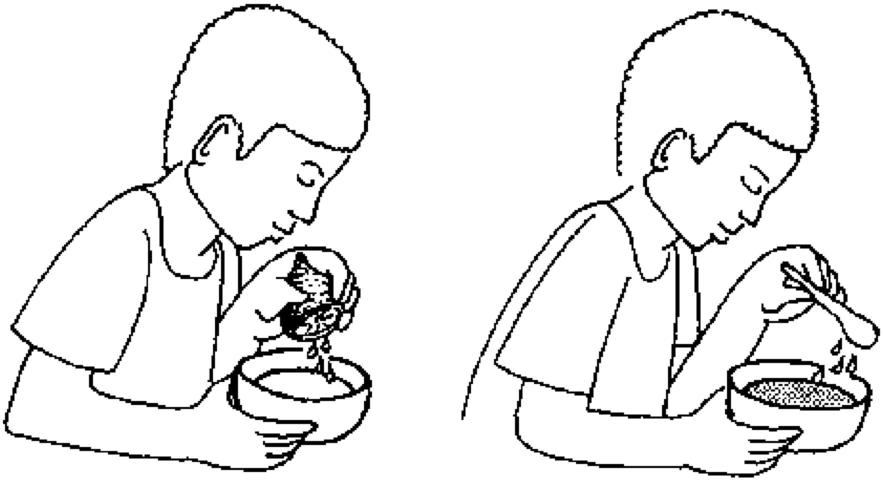
Anthrocyans can be produced from red cabbage or red corn.

Materials and Apparatus:

red cabbage juice (litmus)

a. lemon juice

acetic acid
a selection of other acids (HCl, H_2SO_4, etc.)



Observation:

The colour of the indicator is red–violet in the acidic range (a.), whereas it is green–yellow in the alkaline range (b.).

Analysis:

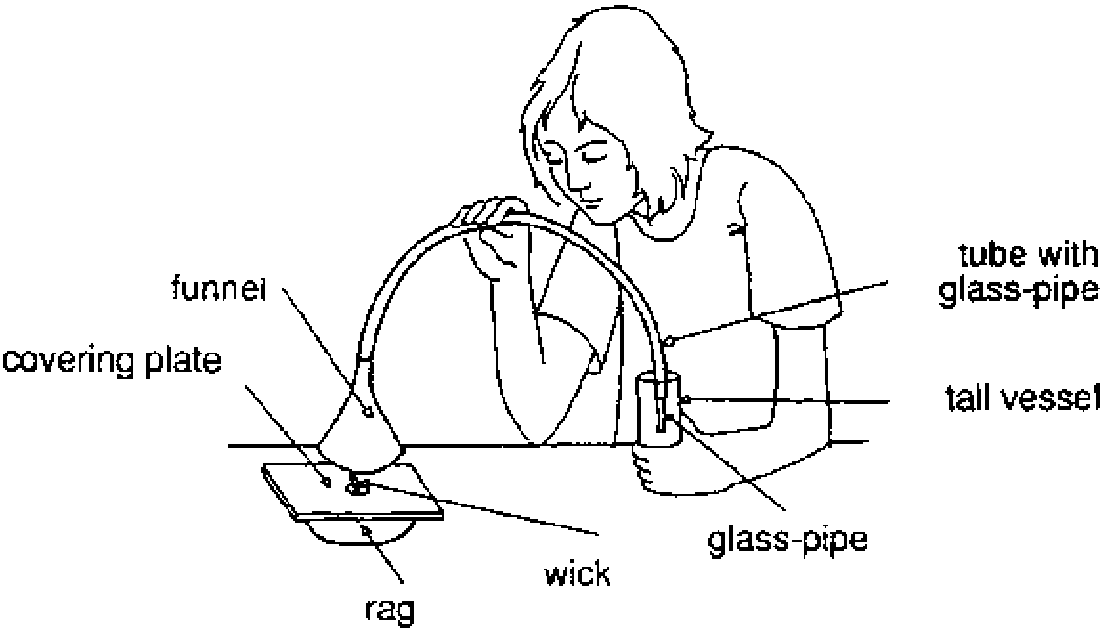
With the help of indicators, acids and alkalies can be identified.

3.19. ACID AIR – ACID RAIN

Main Goal:

The apparatus is set up as shown in the following diagram.

The water contains 2 – 3 drops of the indicator. The glass and the funnel can be supported with one hand.



Observation:

Gas bubbles can be observed in the water. The indicator changes colour. The colour change indicates the presence of an acid.

Note: A non–metal oxide and water form an acid.

Practical Meaning:

Sulphur dioxide is one of the components of “acid air”.

When combinated with water, it forms one essential part of “acid rain”.

Sulphur dioxide as well as sulphurous acid demage animate and the inanimate nature. Trees become sick.

It is assumed that what is called “forest die–back” in some industrialized countries might have its origin in acid rain.

(see botany: THE DESTRUCTIVE INFLUENCE OF ACID AIR AND ACID RAIN)

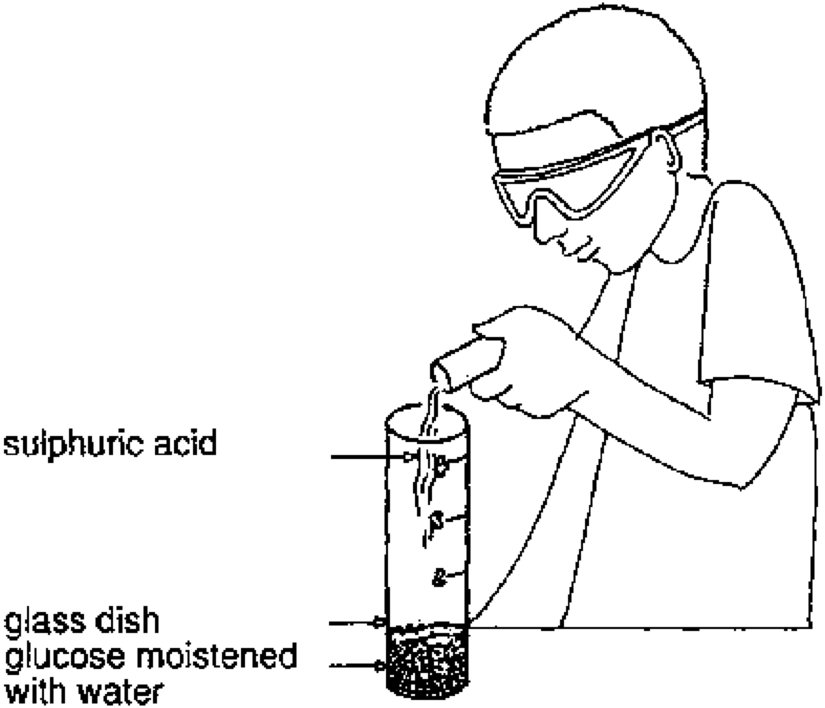
4. ORGANIC CHEMISTRY

4.1. SUGAR CONTAINS CARBON

Main Goal:

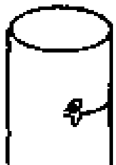
Qualitative ultimate analysis.

All matter is made out of atoms, tiny particles that cannot be decomposed anymore by chemical methods. Most matter of our environment, and also our body, is made of compounds the building blocks of which are atoms. There are many different sorts of



Observation:

A very voluminous black substance is formed.



4.2. PROTEINS CONTAIN NITROGEN

Main Goal:

Qualitative ultimate analysis.

Information:

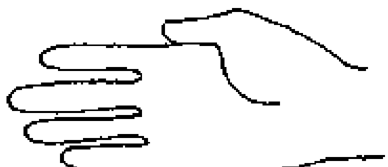
Proteins are organic compounds containing, among other elements, nitrogen, in particular the so called amino group – NH_2. Proteins are essential parts of animals' food, and also indispensable for mens' nutrition. Within the scope of ultimate analysis, nitrogen can be indirectly identified. When proteins are heated, ammonium gas is formed.

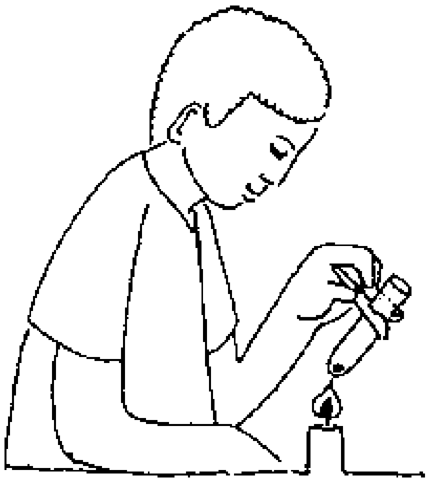
Materials and Apparatus:

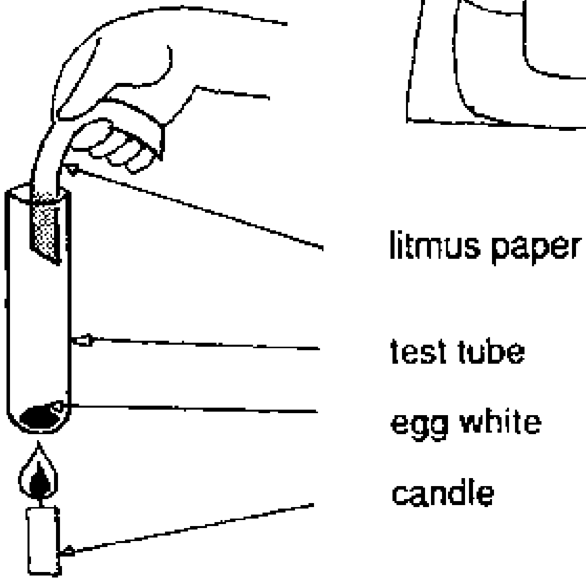
hard–boiled egg, chicken protein
moistened litmus paper
test tube or fire–resistant glass dish
test tube holder
burner or candle

Procedure:

About 1 – 2 cm^3 of hard boiled egg white is placed into a test tube.







The egg white is heated, and after a few minutes the moistened litmus paper is held in the vapour released.

Observation:

Proteins are made up of amino acids. There are two kinds of amino acids which have sulphur in their functional group – cysteine and methionine.

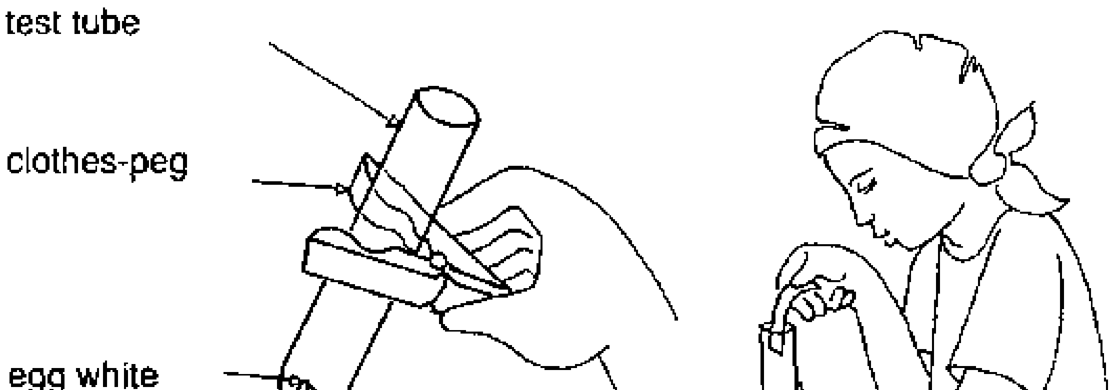
When protein, e.g. chicken protein, is heated, hydrogen sulphide is formed. Sulphur can then be indirectly identified within the scope of ultimate analysis.

Materials and Apparatus:

hard–boiled egg, chicken protein
moistened lead acetate film
test tube or glass dish
test tube holder
burner

Procedure:

About 1 – 2 cm^3 of hard–boiled egg white is placed into a test tube. The egg white is heated, and after a few minutes the moistened lead acetate paper is held in the vapour released



Analysis:

When protein is heated, carbon is left as black residue.

Chicken protein contains sulphur. When heated, hydrogen sulfide gas is set free. Hydrogen sulfide in combination with lead acetate forms black lead sulfide.

4.4. IDENTIFICATION OF STARCH IN FOOD

Main Goal:

Starch is identified with iodine potassium iodide solution.

Information:

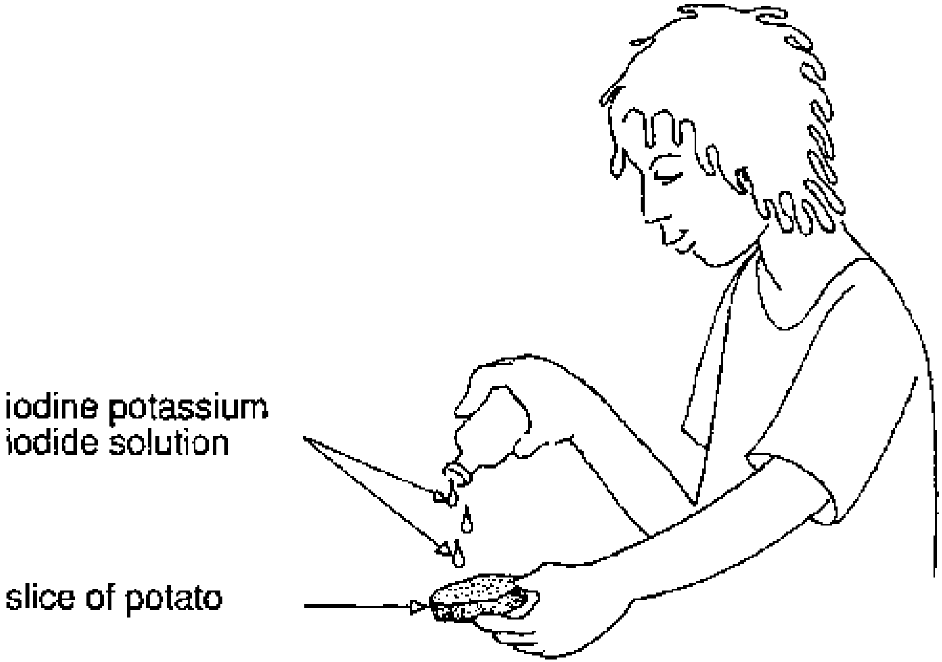
Starch is a polysaccharide and belongs to the class of carbohydrates.

Starch is a vegetable reserve substance, found in grain, potatoes, etc.

Materials and Apparatus:

a. about 0.5 g iodine

1 g of potassium iodide
100 ml distilled water
200 ml brown glass dish which can be tightly closed



Observation:

The bread and the slice of potato turn a dark blue colour.

Analysis:

The blue colour indicates starch.

Addition:

250 ml glass vessel which can be closed with a rubber stopper

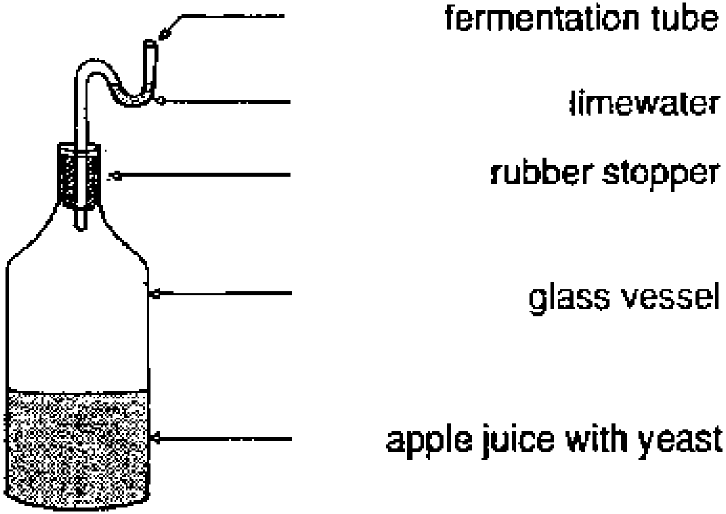
a pierced rubber stopper with a fermentation tube

limewater (CaO is dissolved in water and filtered)

Procedure:

About 100 ml freshly pressed apple juice is poured into a glass vessel. Then 10 – 20 g yeast is added and the vessel is closed with a rubber stopper. The fermentation tube is filled with limewater (see diagram).

If the fermentation does not start immediately the glass vessel should be warmed in a water bath.



Analysis:

The gas formed is carbon dioxide.

Carbon dioxide and calcium hydroxide form white calcium carbonate.

$$CO_2 + Ca(OH)_2 ? CaCO_3 + H_2O$$

Addition:

Fermentation vessels are closed with fermentation tubes which usually contain water. One reason for this is to create an anaerobic medium.

In an anaerobic medium more alcohol is produced than in an aerobic one.

Practical Use:

In industry, ethanol is produced in large quantities by alcoholic fermentation.

5. PHASE TRANSITION

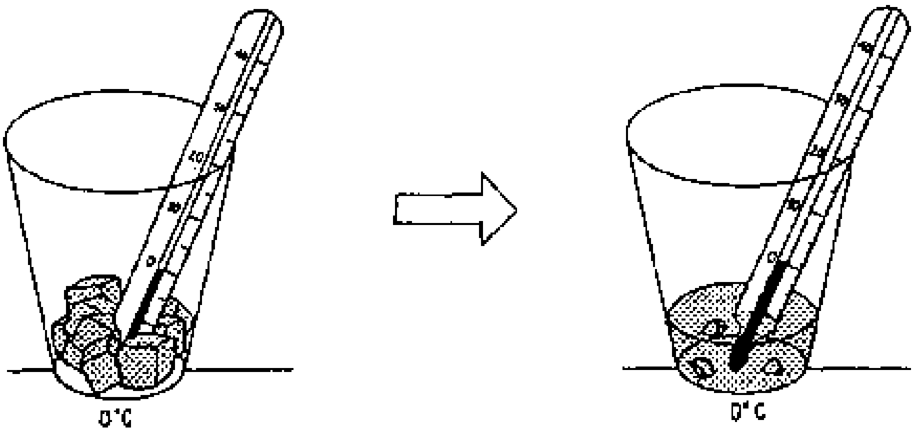
5.1. MELTING AND SOLIDIFICATION

Main Goal:

This experiment demonstrates the processes of melting and solidification taking water

a. A little water is poured into a dish and this is then placed in the refrigerator.

b. Some ice is placed in a glass dish, and the temperature is measured as the ice melts (see drawing).



Observation:

a. After some time the water freezes.
b. As long as the ice melts, the temperature remains at 0°C.

Analysis:

The transition from the liquid phase into the solid phase at a particular temperature (point of solidification) is called "solidification".

The transition from a solid phase into a liquid phase at a given temperature (melting point) is called "melting".

5.2. EVAPORATION AND CONDENSATION

Main Goal:

This experiment illustrates evaporation (boiling) and condensation taking water as an example.

Information:

The boiling point and the condensation point of a pure substance are identical.

These two phase transitions are highly dependent on air pressure.

Condensation comes from the Latin “condensare” meaning to thicken.

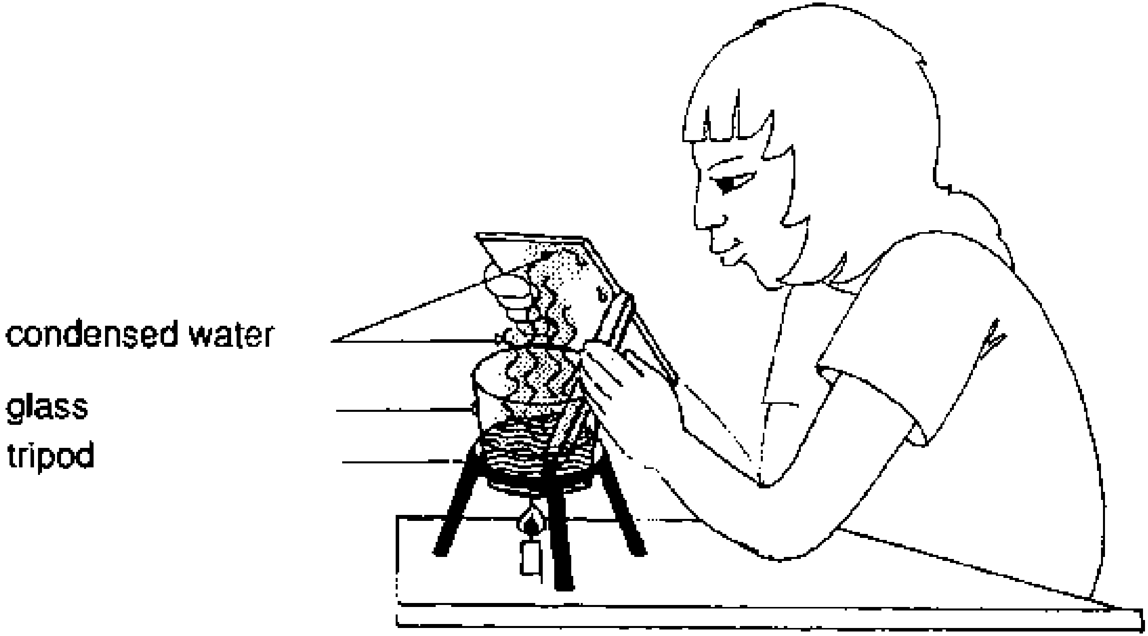
Materials and Apparatus:

water
glass or a pot
glass vessel
tripod
burner
thermometer

Procedure:

a. The apparatus is set up as shown in the diagram below.

The water is heated.



Observation:

a. The water boils at about 100° C (at normal air pressure).
b. Moisture condenses on the second glass vessel.

Analysis:

a. The transition of a liquid to a gas at a certain temperature (the boiling point) is called "evaporation" or "volatilization".

Sublimation is the direct transition of a solid body into a gaseous substance. The reverse process is called resublimation.

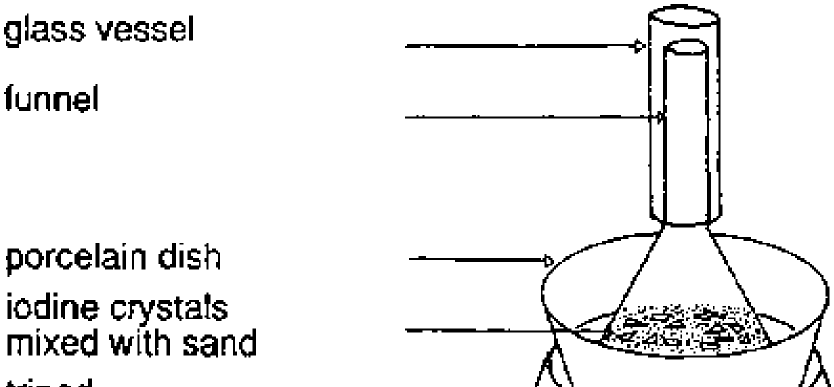
Materials and Apparatus:

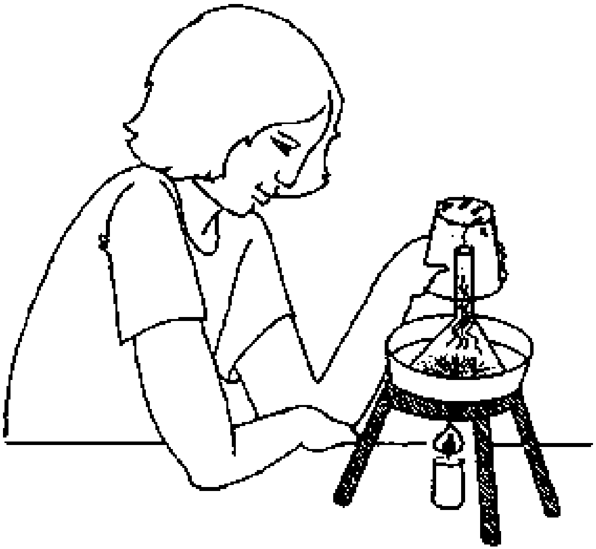
iodine – some crystals
sand – 2 or 3 teaspoons
porcelain or clay dish
funnel or a cut–off bottle neck
glass vessel – must be cooled in a freezer prior to the experiment
burner or candle
tripod

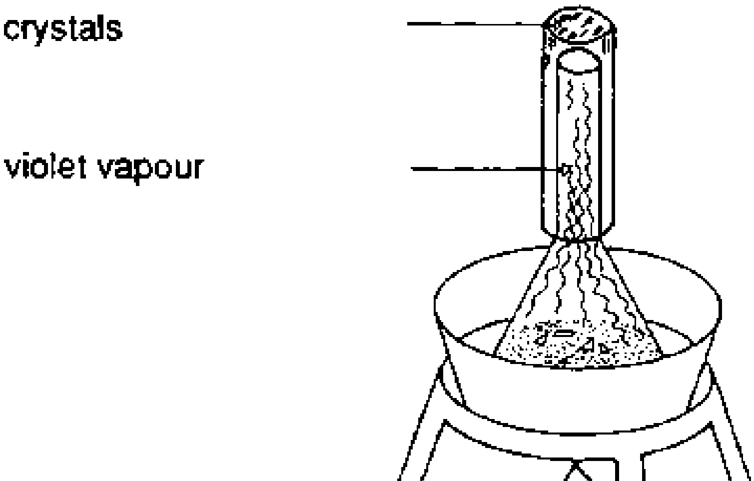
Procedure:

The iodine crystals are mixed with the sand in the porcelain dish.

The apparatus is set up as shown in the diagram below and heated slowly.






crystals
violet vapour

Information:

Even below the boiling point water can become a gas. This process is called evaporation. The pace of water evaporation is dependent on the factors temperature and vapor saturation of the air (among others). Generally air contains water vapor. The concentration of water vapor i.e. the number of grams of water per cubic meter of air, depends on the temperature of the air. If air of a certain temperature contains the maximum possible amount of water vapor we call this air ‘saturated’. The higher the temperature of the air the more water vapor can it contain.

The following experiments illustrate these two interdependent factors.

Materials and Apparatus:

a. 2 dishes of about the same size

1 glass vessel

b. 2 rags of about the same size

(about 15 cm × 15 cm)
water

Procedure:

a. The two dishes are half filled with water. A glass vessel is placed over one of the dishes. The experiment is observed for several days.

evaporated.

b. The rag in the sun dries more quickly than that in the shade.

Analysis:

The ambient air takes in the gaseous water particles to a certain degree until the air becomes ‘saturated’. This is why the water from the dish with the cover (experiment a.) evaporates only partially. Water evaporates more rapidly in warm air than in cold air.

An additional air movement, e.g. caused by wind, moves away the air surrounding the wet rags which is saturated with water vapour.

The “dry” air is moved along and the whole process starts again. Thus, the pace of evaporation is increased.

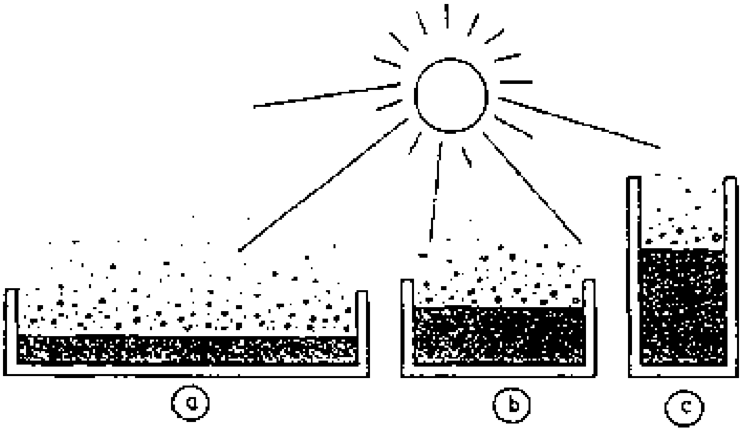
Practical Use:

A technical way of using water evaporation is the process of refining salt (basically sodium chloride) from sea water in warm countries. The sea water is lead into huge basins. The water evaporates, according to the water circulation, with the help of the sun and the wind.

The salts crystallize out and can then be refined (see experiment: CRYSTAL FORMATION).

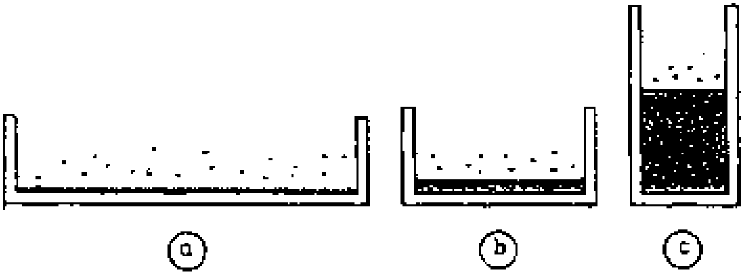
Further thought:

The cloth covering canteens are moistened when we want to keep the liquid inside cool.
Why?



Observation:

The water in the tin pan (a) evaporates faster than that in glass vessel (b). Slowest evaporation takes place in glass vessel (c).



Analysis:

The speed of water evaporation is dependant on the size of the surface. The bigger it

The volume expansion of solidified water can be demonstrated impressively by the volume increase undergone by water when it freezes.

This phenomenon, which is a contradiction of accepted, normal laws is called the “density anomaly”. The word anomaly comes from the Greek and Latin word “anomalus” meaning: against the law.

Materials and Apparatus:

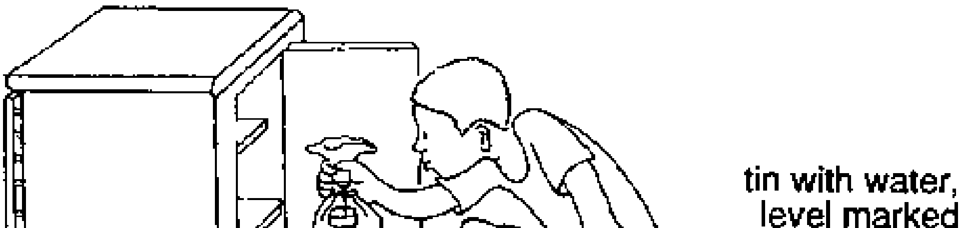
a bottle or jar with a screw cap
water which has been boiled and then cooled
freezer
plastic bag, paper
an empty tin

Procedure:

The jar is filled up to the rim with boiled water and the screw cap is tightly closed. Then it is placed in a plastic bag.

The tin is also filled up to 3/4 of its height. The water level is marked.

Both, the bag with the jar and the tin are placed in the freezer for one or two days.



Water expands when it solidifies.

Practical Meaning:

Underground water which freezes causes erosion (from the Latin word “erodere”, meaning to graw off) in the mountains and streets.

Further thought:

When water solidifies, it not only enlarges its volume but also releases heat into the freezer.

What does the freezer do with this heat?

5.7. ICE FLOATS ON TOP OF WATER

Main Goal:

This experiment demonstrates that ice is less dense that water.

Information:

At room temperature, the density of water is approximately 1 g/cm^3 and that of ice about 0.9 g/cm^3.

Materials and Apparatus:

ice cubes (if a refrigerater is not available in your school, go to the next bar and ask for some

Observation:

The ice floats on the water.

Analysis:

We observe that water expands when it solidifies. This means that 1 cm^3 ice weights less than 1 cm^3 liquid water. The bigger volume of ice has the same mass as the water that becomes ice. Therefore, the density, i.e. the mass (in g) per volume (in cm^3) of ice is smaller than that one of liquid water.

Further thought:

What happens to the water level in the pan (see drawing) when the ice melts?

5.8. ICE MELTS WHEN THE PRESSURE INCREASES

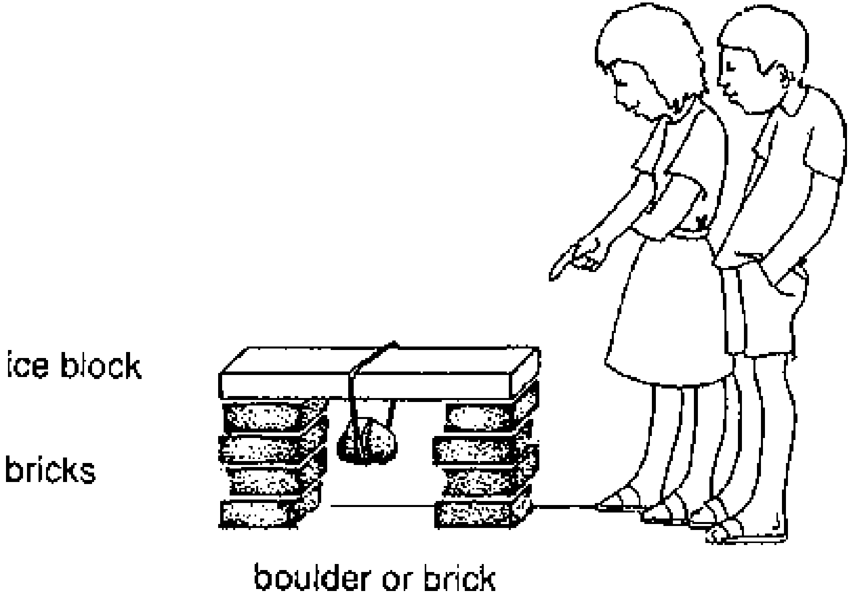
Main Goal:

This experiment demonstrates that ice melts where locally the pressure is increased.

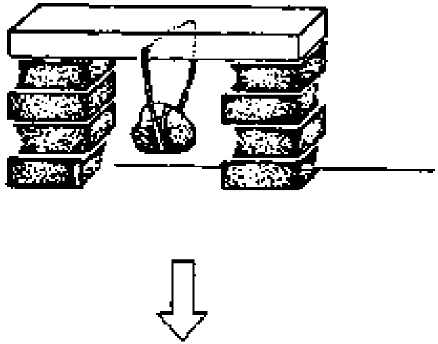
Information:

The freezing point, or rather melting point, slides toward lower temperatures as pressure is increased. This is true of water and of the elements mercury and bismuth. Thus, under high pressure ice melts already at – 5° C or even lower temperatures.

a)



b)



Further thought:

Look at the ice block in drawing c).

It is not quite correct. The wire when pulled though the ice will leave a trace! Why?

6. WARMTH AND COLD

6.1. METALS EXPAND WHEN HEATED

Main Goal:

This experiment demonstrates the expansion of metals when heated.

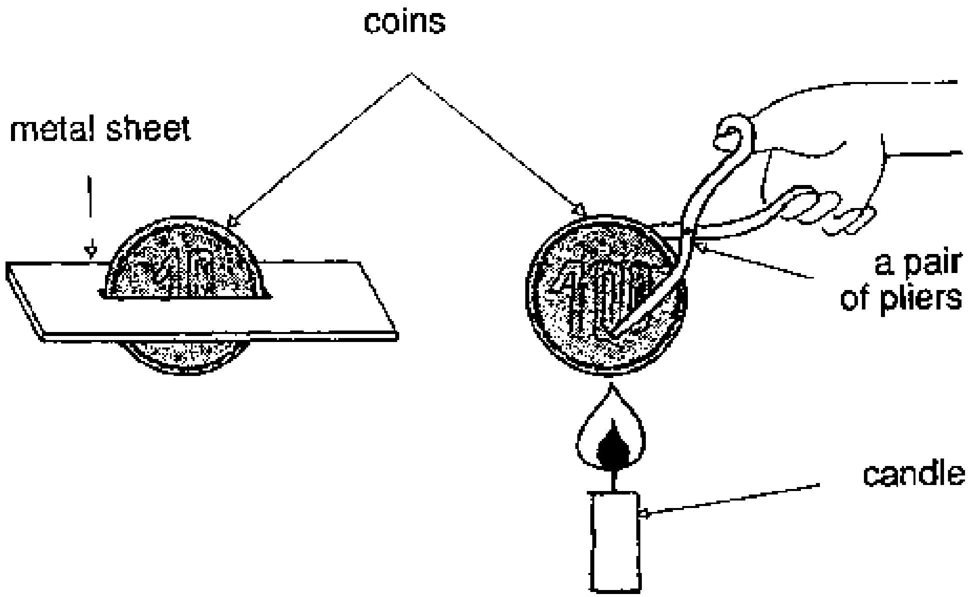
Information:

Some important properties of metals are malleability, thermal conductivity, expansion when heated and electrical conductivity.

The expansion of metal under the influence of heat is very important. The effect is in particular conspicious for long, tin rods and pipes, which are at high temperatures significantly longer than at low temperatures.

Solid materials do not expand as much as liquids or gases.

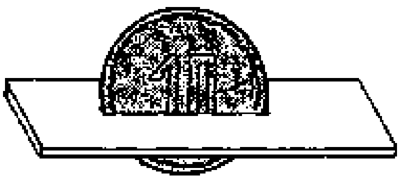
Materials and Apparatus:



Observation:

The heated coin no longer fits through the opening as before. It jams.

After the coin has cooled down, it fits through the opening again.



Futher thought:

Mercury, under normal conditions, is a liquid. It expands also when heated. The same happens to glass, even if it is not a metal. Many thermometres are made of glass and mercury. Which material expands more with increasing temperature?

6.2. THE THERMAL CONDUCTIVITY OF DIFFERENT KINDS OF MATERIALS

Main Goal:

This experiment shows the good and poor conductivity of various kinds of materials.

Information:

All kinds of substances conduct heat. The degree of heat conductivity is dependent on the material. If the transport of heat takes place in testing substances, it is said to be heat conduction (in contrast to heat streaming due to differences in density).

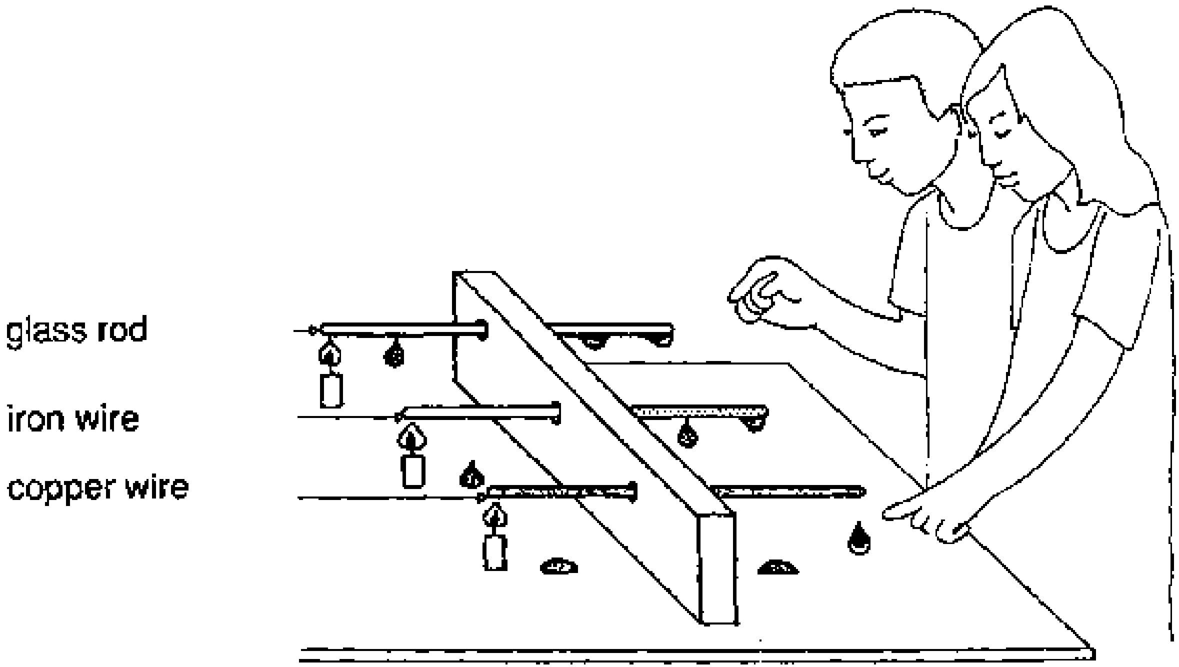
Materials and Apparatus:

about 20 cm of copper wire, iron wire and glass rod, each one of the same length and with the same diameter

a wooden rack

wood auger

wax



Observation:

First the little wax ball at the end of the copper wire melts and then the one on the iron wire. The one at the end of the glass rod does not drop off.

Analysis:

Heat needs time to go through. The faster the better the conductivity. Glass is a poor heat conductor. Copper is a better one than iron. The heat conductivity is dependant

6.3. THE THERMAL CONDUCTIVITY OF WATER

Main Goal:

This experiment demonstrates the thermal conductivity of water.

Information:

see experiment: THE THERMAL CONDUCTIVITY OF DIFFERENT KINDS OF MATERIALS.

Materials and Apparatus:

glass tube
cold water
burner or candle

Procedure:

The water is heated in the upper part of the glass tube.

Further thought:

How can you make this experiment even more dramatic? Think about the usage of ice!

6.4. THE HEAT "STREAMING"

Main Goal:

The experiment demonstrates that the density of water decreases when it is heated.

(The density anomaly of water – highest density at 4° C – is not taken into account.)

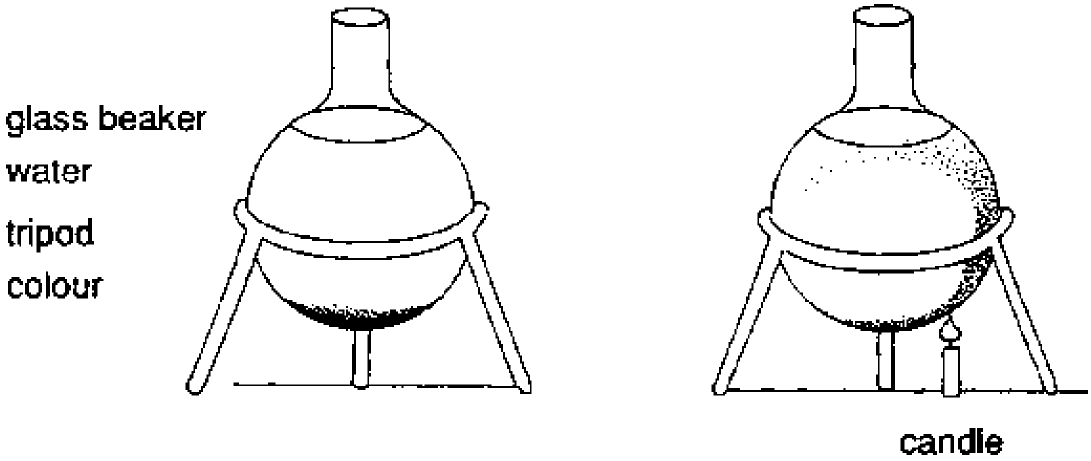
Information:

When water is heated, it expands and its density decreases. It becomes lighter (i.e. 1 cm^3 of hot water is lighter than 1 cm^3 of cold water). If heated at the bottom of a beaker the hot water moves upwards. At the surface it cools down. Its density increases and the water sinks. These processes cause a "heat streaming" in water.

"Heat streaming", (unaided convection, Latin: convehere to bring along), occurs when the density differences are caused by different temperatures.

Materials and Apparatus:

water, ink
sawdust, straw, glass pipe, bamboo pipe
tripod or a similar frame
candle



Observation:

The coloured water ascend at the side of the beaker which is heated. At the opposite side the water sinks back to the bottom. After a while it curculates.

Analysis:

The warmed up water ascends and carries the colour with it. The density of heated water is less than that of cold water, which sinks back to the bottom. This "heat streaming" can be observed as long as the water is heated in the way shown.

Practical Use:

This phenomenon is used in warm water heating. In the basement, cold water is warmed up. Warm water ascends into the heating system, cools down and arrives at the boiler over a *thermometer*

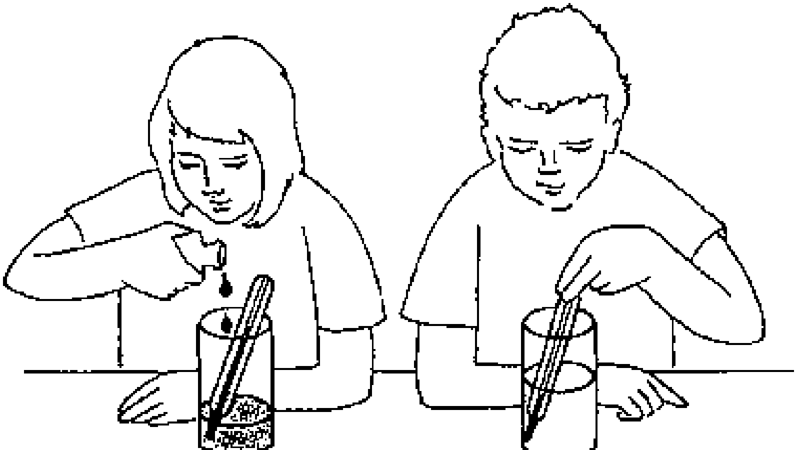
b. water heated to about 50° C

ink
cold water of about 10° C
2 glass dishes
thermometer

Procedure:

a. The warm water is coloured with 1 – 2 drops of ink and then carefully added to the cold water.

b. The cold water is coloured with 1 – 2 drops of ink and then carefully added to the warm water.



Analysis:

Warm water has a density lower than that of cold water. However this is only true for water above 4° C. Below this temperature, the density of water decreases again. Thus, water of 4° C is 'heaviest'. It has the highest density.

Practical Meaning:

This characteristic of water is important in countries in which the water freezes in winter. On the floors of frozen lakes, the water temperature is 4° C. Therefore, fish and other aquatic animals can survive in the deeper layers of these waters.

Further thought:

Suppose that water is used in a thermometer instead of mercury. Suppose further that it is 4° C. Then temperature changes. The thermometer indicates this change. Is this indication unequivocal?

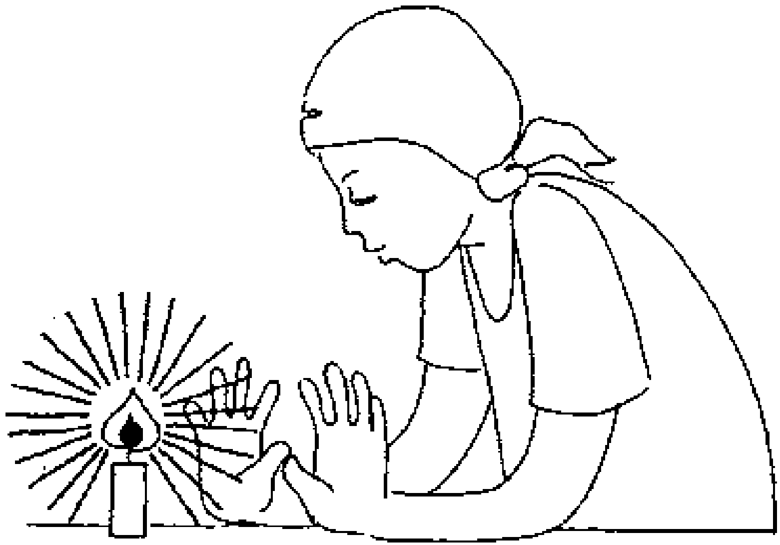
6.6. HEAT RADIATION

Main Goal:

This experiment illustrates heat transmission by means of heat radiation.

Information:

"Heat radiation" is the name given to a process of transmission of energy, which is not linked with any specific Kind of substance. Sun rays reach earth through space which is void of air.



Observation:

A warming sensation is felt on the palms of the hand.

Analysis:

The energy transport hardly takes via heat conduction as air is a poor thermal conductor.

It cannot take place on the basis of heat streaming because warm air rises. The heat transmission in this case is called "heat radiation". Heat radiation is not linked with any specific kind of substance. It needs no medium.

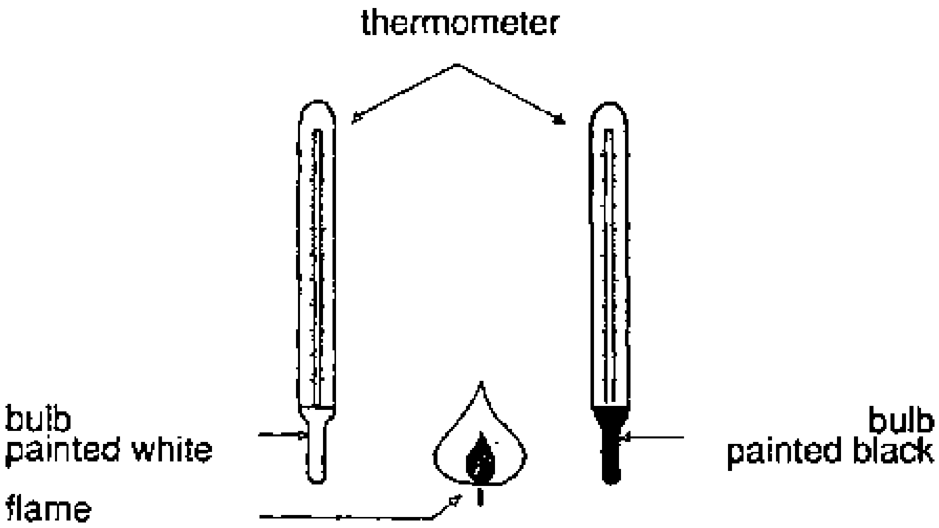
Some investigations have shown that rough surfaces absorb more heat radiation than smooth ones.

Materials and Apparatus:

2 thermometers
soot or black paint
white paint candle, a gas burner or similar source of heat

Procedure:

The mercury or coloured alcohol–filled bulb at the bottom of one thermometer is painted black with soot or paint. That of the other thermometer is painted white.



Light materials reflect the heat radiation better than dark materials.

Practical Use:

Refrigerators, freezers and refrigerator vans almost all have white, smooth surfaces so that heat radiation which hits them is well reflected.

In southern countries houses are painted white.

The people in these countries often wear light coloured clothes.

Sun collectors, for instance black tubes through which water flows, are black.

Further thought:

In countries where there is snow you can lay samples of light and dark cloth on the snow.

What can be observed?

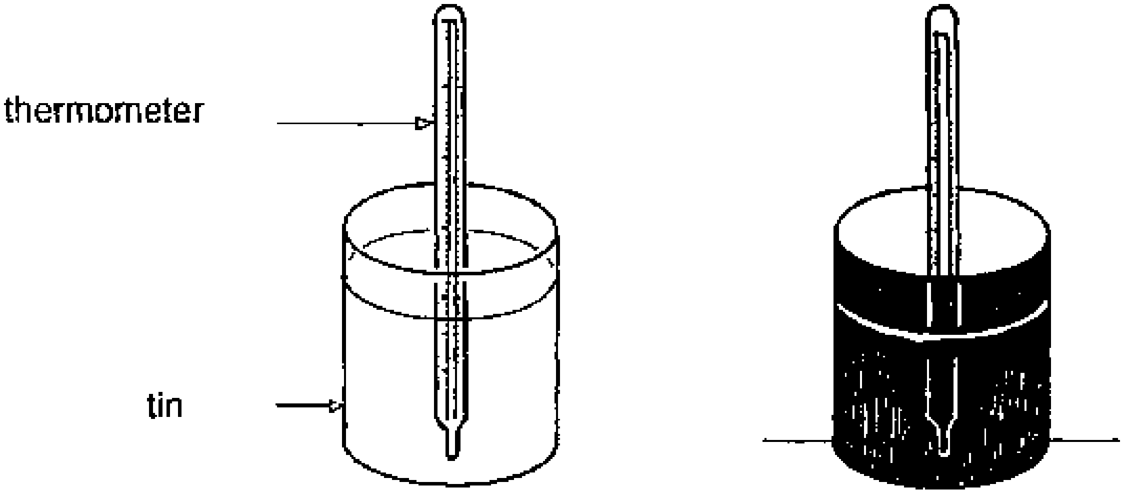
6.8. DARK MATERIALS COOL DOWN FASTER THAN LIGHT ONES

Main Goal:

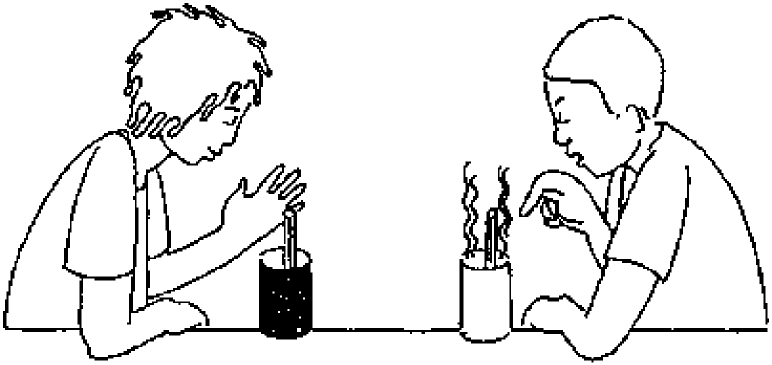
This experiment demonstrates that dark materials cool down faster than light ones.

Information:

Dark materials emit (from the Latin “emittere”: to send out) heat faster than light ones.



The two tins are filled with boiling water. The temperatures are taken regularly at intervals of 30 seconds or 1 minute. It might be useful to note the temperatures recorded.



Observation:

Further thought:

Suppose at a restaurant you get coffee before you are ready to drink it. But you want is hottest when you are ready. When do you add the cream? Right away or when you are ready?

6.9. HEATING WITHOUT A FLAME

Main Goal:

The experiment illustrates the warming up of substances by mechanical work.

Information:

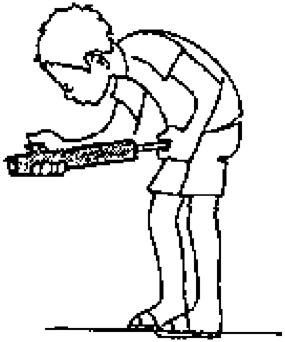
In contrast to heating bodies by heat radiation, conduction or streaming solids, liquids and gases can also be heated if they are mechanically worked on.

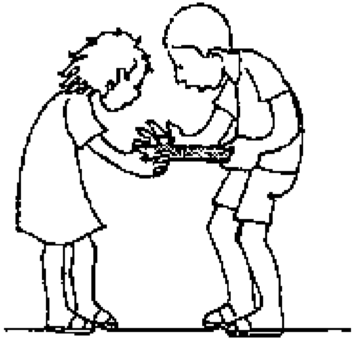
Work done in that way that friction force is applied on a body, increases the movement of the atoms the body is made off. This increase of (invisible) microscopic motion appears microscopically as an increase of temperature.

Materials and Apparatus:

a. blackboard or a table
b. air pump

Procedure:





Observation:

a. The blackboard and the fingers become warm.
b. The cylinder is warm – this is also true of the air in the cylinder.

Analysis:

In both cases, mechanical work is done, which increases the movement of the atoms. In the first case this increase is transmitted by friction and in the second case by a pressure increase as well as by friction.

Practical Meaning:

When a spaceship enters the earth's atmosphere, its cover becomes very hot. The spaceship dives into the air, which presses it together. The strong increase of temperature results from the friction of the air with the spaceship. Friction increases the thermal energy.

If a bucket on a rope is let down into a well quickly, the warming up of the hands can be

Materials and Apparatus:

a. dry glass

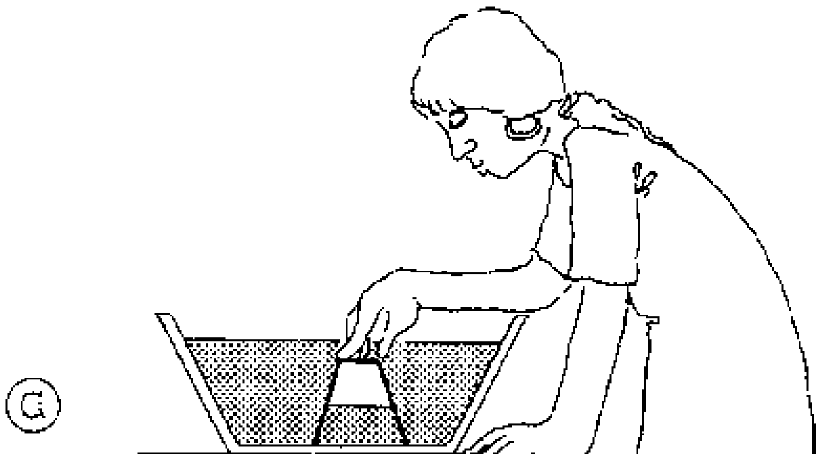
basin filled with water

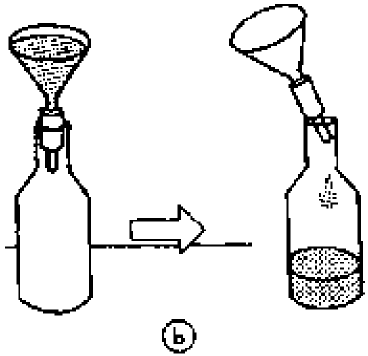
b. funnel

pierced cork or rubber stopper
bottle
water

Procedure:

a. As shown in the diagram below, an empty glass is dipped into water, upside down.





Analysis:

The glass and the bottle both contain air. This space can only be filled with water if the air is compressed or when it can escape. Air occupies space. Thus it is a body.

Futher thought:

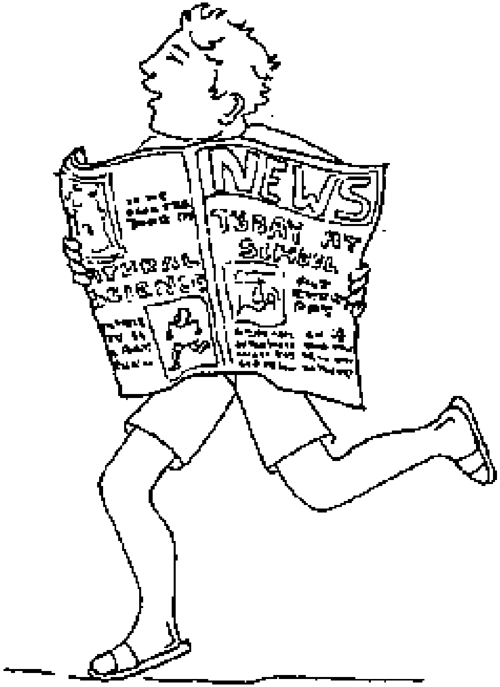
Why does a balloon, filled with air, not rise?

7.2. WE FIND OUT ABOUT AIR RESISTANCE

Main Goal:

During this experiment the pupils feel air resistance.

Information:



Observation:

The newspaper is pushed against the body. When it is pushed away from the body, the resistance can be felt.

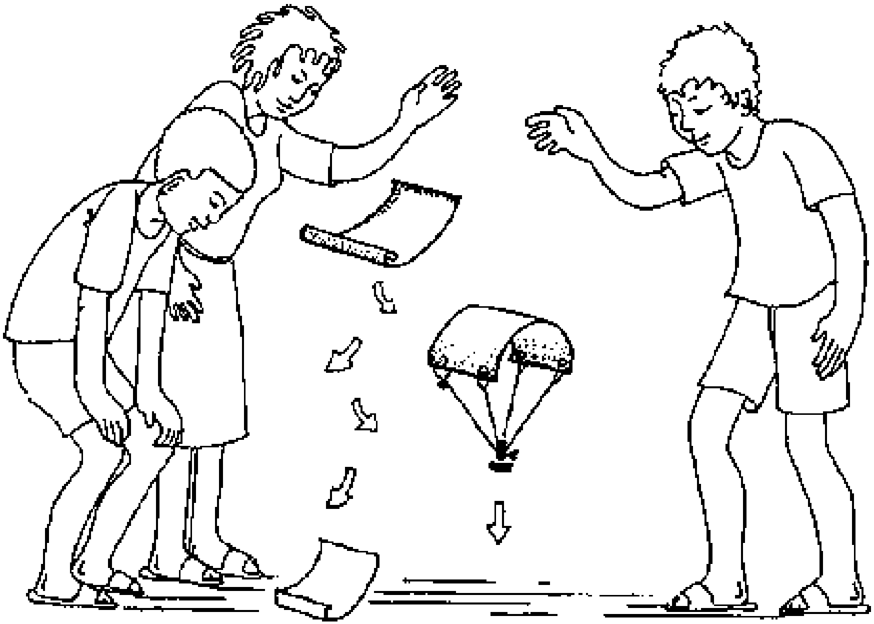
Analysis:

The resistance is caused by your moving against the air. Air consists of gases, which can be visualized as invisible bodies. All bodies offer resistance against their

Procedure:

a) From a height of about 1.5 m, a student lets a sheet of paper fall as demonstrated in the following diagram. The time it needs to reach the floor is measured with the stopwatch.

In further experiments, the sheet of paper is gradually folded up until in the final experiment a ball is formed.



b) Drop the cardboards simultaneously from the same height so that one fells with one edge in front, the other one with a flat side in front.

Which one hits the ground first?

screw.

Further thought:

A stone dropped from the top of a tower becomes faster when it falls. A parachutist falls toward the earth with constant speed.

Why this difference?

7.4. THE DIFFUSION OF GASES

Main Goal:

This experiment illustrates the diffusion of gases.

Information:

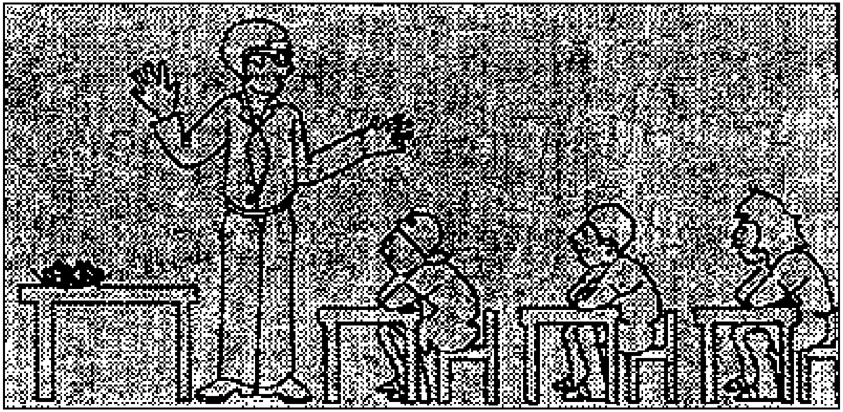
Gas particles diffuse into even space, no matter how large it is.

Materials and Apparatus:

perfumed substance perhaps a spraycan or an atomizer with mosquito spray, perfume, or a strongly smelling flower or fruit)

vessel

Procedure:



Observation:

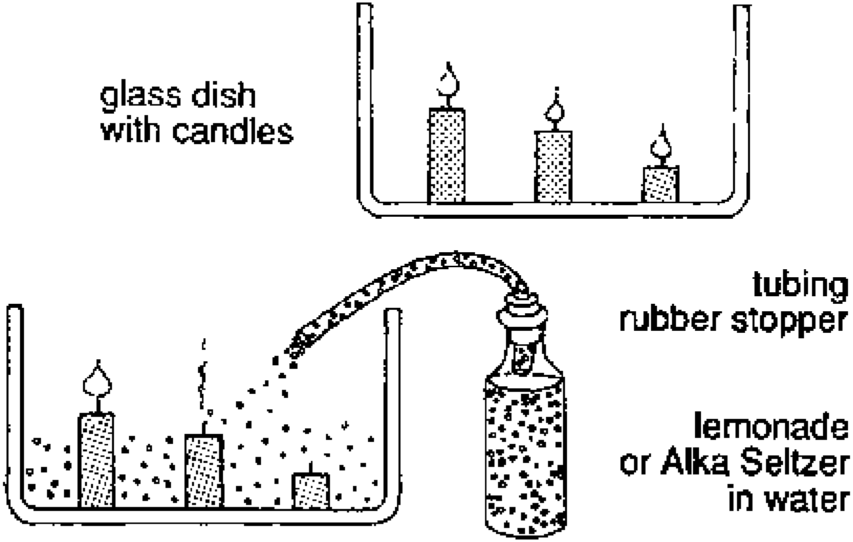
After a short time the smell can be detected by pupils sitting near the teacher's desk. A little later also pupils in the following rows of seats smell successively the perfume.

Analysis:

Gases diffuse into each space. This unaided distribution of particles is called diffusion. We cannot see the perfume moving through the classroom. It is said that all bodies, also perfume, is made out of atoms. Therefore, atoms must be very very small.

Further thought:

What changes when you heat the perfume?



Carbon dioxide from lemonade or Alka Seltzer is conducted through the tubing just to the top of the glass dish.

Observation:

The candles are extinguished one by one because the carbon dioxide sinks down. It is havier than air. (A burning match is extinguished when dipped into the carbon dioxide atmosphere.)

Analysis:

The carbon dioxide is heavier than air and sinks down and concentrates at the bottom of the dish. The more carbon dioxide is produced, the more air is displaced.

Air is a body and exerts pressure. The average air pressure is 1 bar. This pressure equals water pressure at a depth of 10 m under the water's surface.

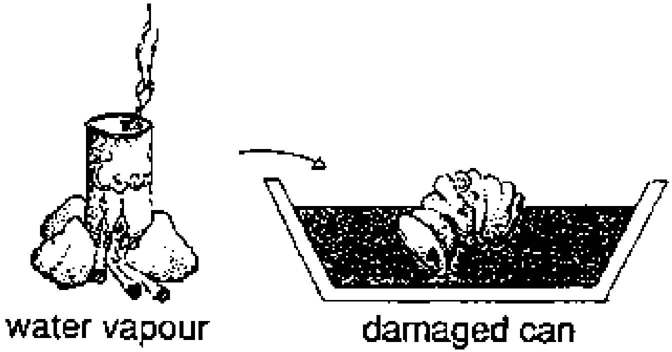
With increasing height, e.g. in the mountains, the air pressure decreases.

Materials and Apparatus:

glass, paper, water
empty cola can
heater
bowl with cold water

Procedure:

a) Fill a little water into the empty cola can (four tea spoons are enough). Heat that water so that it boils. Let it boil for a minute. Then dip it –upside down – into the cold water in the bowl. Observe the dramatic effect.



b) The glass is filled up to the rim with water. Then it is covered with the paper, which is

The external air pressure is greater than the pressure exerted by the water in the glass.

Practical Use:

To secure the water supply, pressure and suction pumps can be used.

By means of suction pumps, water can theoretically be sucked up to a height of 10 m. However, in practice it can only be sucked up to **a** height of 8 m, due to the fact that valves are not entirely leaktight.

As there are pipes linked to the pressure pumps, the water is conveyed 10 m high.

Both pumps operate on the principle that, on raising the piston, low pressure is generated. The air pressure then forces the groundwater into the pump. Repeated pumping movements result in the filling of the pump with water, which flows out through a discharge pipe in the case of a suction pump. In a pressure pump the water is forced into a carrying pipe. Valves, which only open under the pressure of the water in the pump, prevent the water flowing back down the vertical pipe.

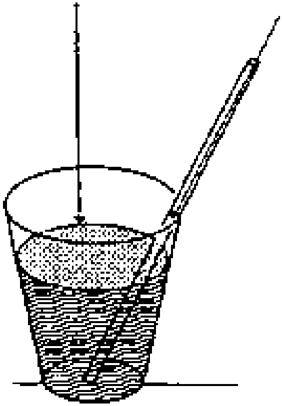
Further thought:

Make a small hole near the bottom of an open tin can. Fill it with water. It will spurt from the hole. Cover the top of the can firmly with the palm of your hand. What happens? Why?

7.7. HOW A DRINKING STRAW WORKS

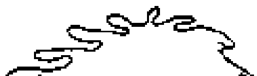
Main Goal:

This experiment demonstrates the practical use of air pressure.



Observation:

see diagram



(see also experiment: THE PHENOMENON OF AIR PRESSURE)

Strictly speaking, one does not suck the water up the straw. One instead reduce pressure in the straw and allow the pressure of the atmosphere to press the water up into the straw.

Further thought:

On the moon there is no air atmosphere.
Could one drink water this way on the moon?

7.8. THE DANCING COIN

Main Goal:

To demonstrate that gases are bodies which expand when heated.

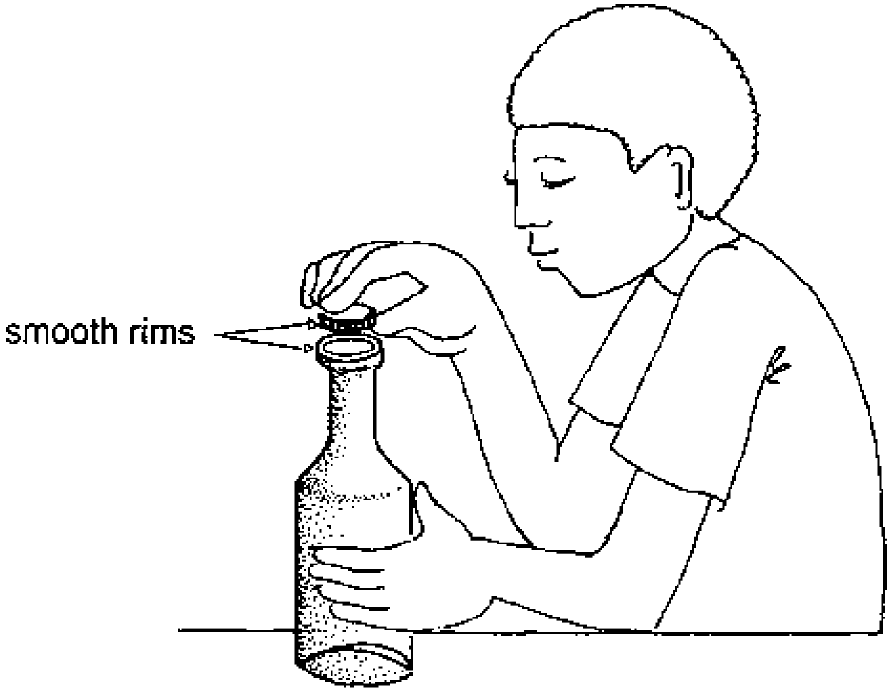
Information:

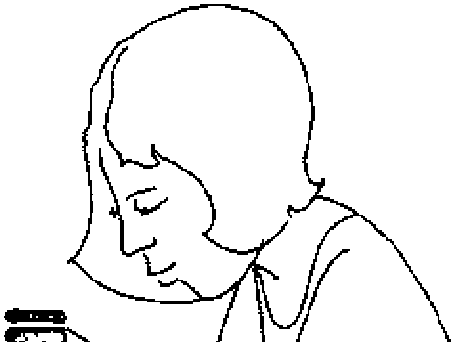
Air expands when heated.

Materials and Apparatus:

a bottle – the glass should be very thin
a coin which covers the opening of the bottle.

Procedure:


smooth rims



All gases expand when heated. Gas tanks have to be protected against the sun, otherwise they eventually would not be able to withstand the excessive pressure of the expanding gas. Fizzy beverages must be chilled to prevent the escape of the carbon dioxide.

Further thought:

When heat is transferred to the air, also glass explands. Then the volume of the bottle must increase. Doesn't this just compensate the air expansion? Obviously not. What kind of conclusion can you draw?

7.9. THE BALLOON IN THE BOTTLE

Main Goal:

To demonstrate air pressure, excessive pressure, and vacuum.

Information:

Warmed air enclosed in a certain volume, expands. The pressure increases and some air escapes.
When cooled down and no air from outside is allowed to enter the volume, low pressure is generated inside that volume.

Materials and Apparatus:

1 bottle
1 balloon

see diagram

Analysis:

Due to the burning of the paper, the air in the bottle is warmed and some of it escapes. The balloon closes the bottle opening. As the air inside the bottle cools down, less air is now present in the bottle and lower pressure than outside is created. The air pressure outside of the bottle presses the ballon into the bottle neck.

Further thought:

gas–meter measure the volume of gas you are using.

Who would gain by having gas warmed up before it passes the meter, you or the gas company?

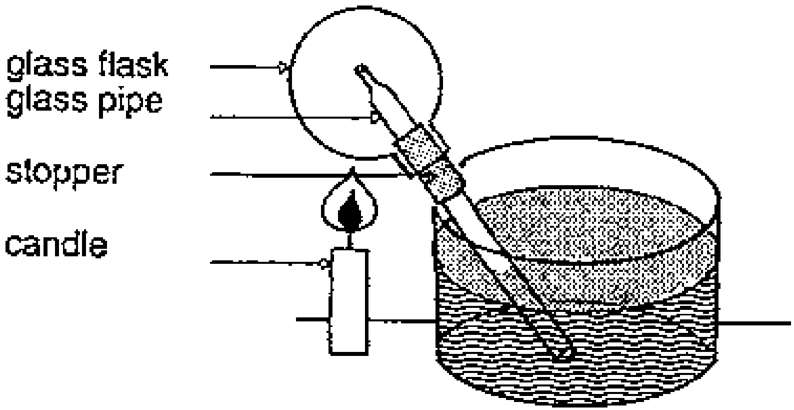
7.10. THE FOUNTAIN EXPERIMENT

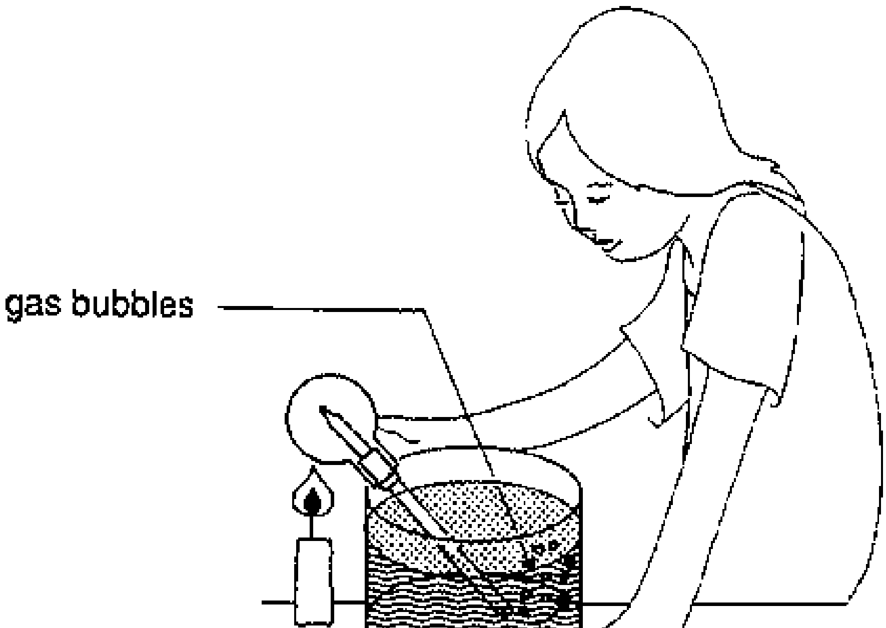
Main Goal:

The experiment essentially demonstrates:

– gases are bodies
– gases expand and contract
– the existence of air pressure

Information:


glass flask
glass pipe
stopper
candle


gas bubbles

When the glass flask is heated, the air expands greatly and part of it escapes. When the burner is removed, the remaining air in the flask cools down. It's now less air inside which needs under normal temperature less space. The gas contracts, and the outer air pressure presses water into the flask until the pressure inside is equal to the pressure outside.

Practical Use:

Bicycle and car tyres can burst if they are over inflated and then exposed to the sun.

Further thought:

Why do the gas bubbles rise?

7.11. THE PHENOMENON OF AIR FLOW

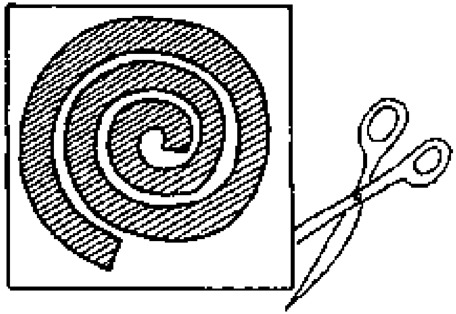
Main Goal:

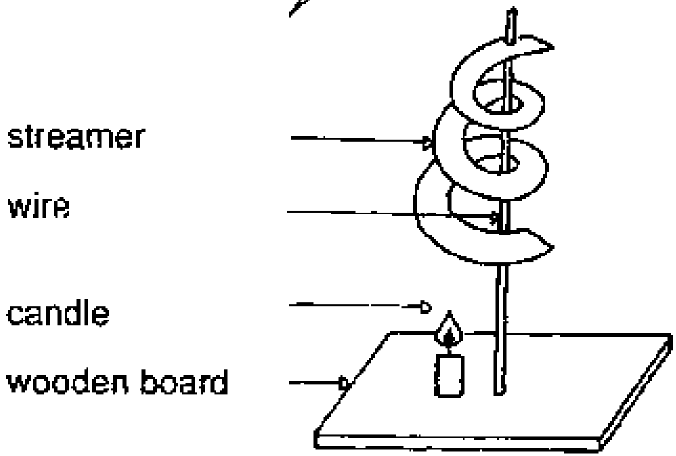
This experiment illustrates air flow.

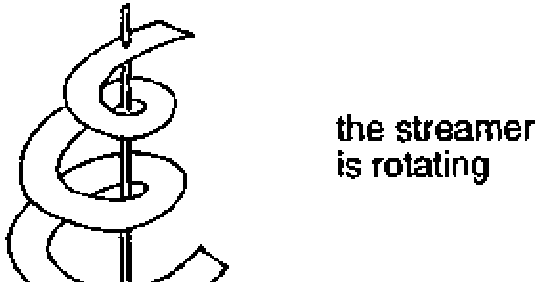
Information:

Warm air ascends in a room, so that the lowest temperature is always found at floor level. Heated air expands. Its density is less than that of cold air, and it therefore ascends into the upper layers. Cold air flows in from the surrounding, is also heated, expands and ascends.

Materials and Apparatus:




streamer
wire
candle
wooden board


the streamer
is rotating

When a house burns, the air is heated strongly, and ascends. Cold air containing oxygen flows in very quickly. This effect causes a strong wind. Open doors and windows support this process, which supports the fire.

Further thought:

How can it happen that birds in the air gain height without moving their wings?

7.12. THE AERODYNAMIC PARADOX

Main Goal:

This experiment demonstrates that low pressure is generated by streaming air.

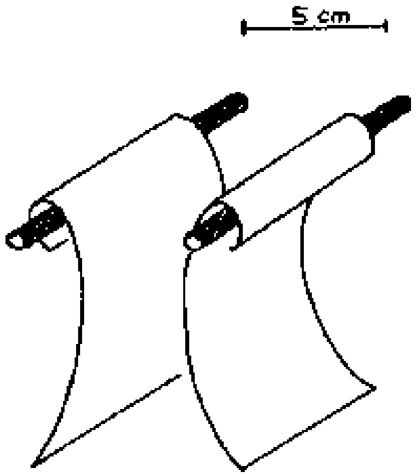
Information:

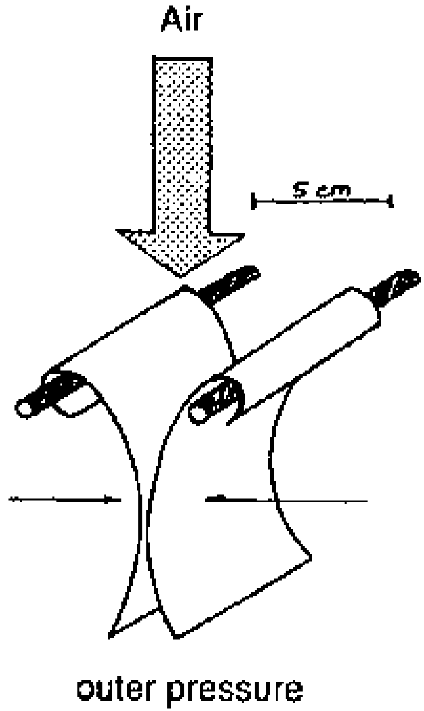
The aerodynamic paradox it applies also to liquids, where it is called hydrodynamic paradox. It states that, the higher the pace of streaming, the lower the pressure. Consequently, if the pace of streaming increases due to a decrease of the sectional area of a pipe, the pressure within this area decreases.

Materials and Apparatus

2 sheets of paper
2 wooden rods

Procedure:





Observation:

Against our intuition the two sheets are drawn towards each other and not apart!

Analysis:

The blown air streams between the two sheets with high pace. An area of low pressure is generated.

If the pressure exerted on a closed gas volume is decreased, the volume increases. This means that gas always occupies the whole volume available. Moreover, it tends to expand and to enlarge its volume permanently.

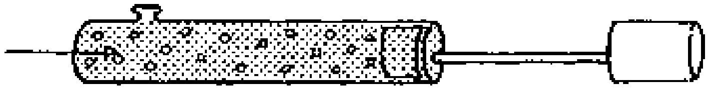
The English physisist Boyle (1627 – 1691) and the French physisist Mariotte (1620 – 1684) discovered this association, which is the basis of a law linking the pressure and volume of gases.

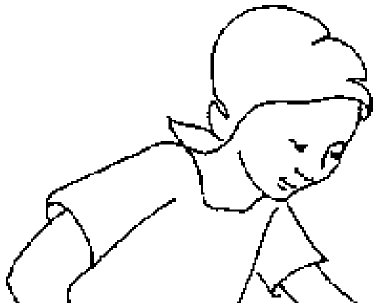
The law states that the product of pressure and volume is constant. It is valid only at constant temperatures.

The pressure of gases can be demonstrated with the help of the model of particles: gas particles are in constant motion, and when they collide with an obstacle, they exert pressure.

Materials:

air pump





Air can be pressed together. The further the piston is pressed into the cylinder, the greater the force required, the greater the pressure of the enclosed air.

The further the piston is pressed into the cylinder, the more quickly it jumps back out when released.

(The air pump and the enclosed air warm up. See experiment: WARMING UP WITHOUT A FLAME)

Therefore, Boyle's Law is not an accurate description of this effect.

Analysis:

If a given gas volume is decreased, its pressure is increased.

If a given gas volume is increased, its pressure is decreased.

Further thought:

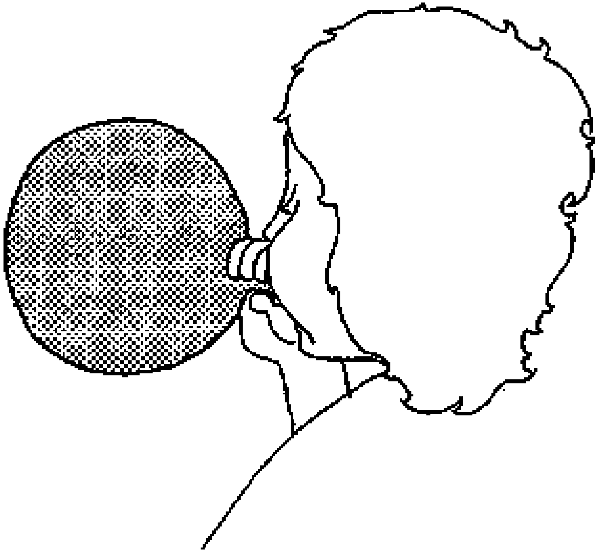
Boyle's Law can be written in shorthand notation as a formula

$$p_1 \times V_1 = p_2 \times V_2 = \text{const.}$$
(p = pressure, V = volume

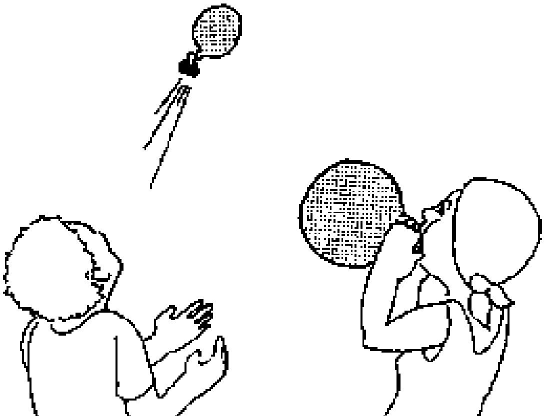
There are other laws in physics that have the same structure, e.g. the Law of Lever. Compare!

7.14. MOVING FORWARD BY REPULSION

Main Goal:



Its opening is first held closed, and then the balloon is released.



Jets and rockets move forward due to this principle of repulsion. They are driven forward by combustion gases escaping rapidly.

Further thought:

What happens to a boat when you jump out of it?

8. WATER

8.1. MODEL OF A WATER–PIPELINE

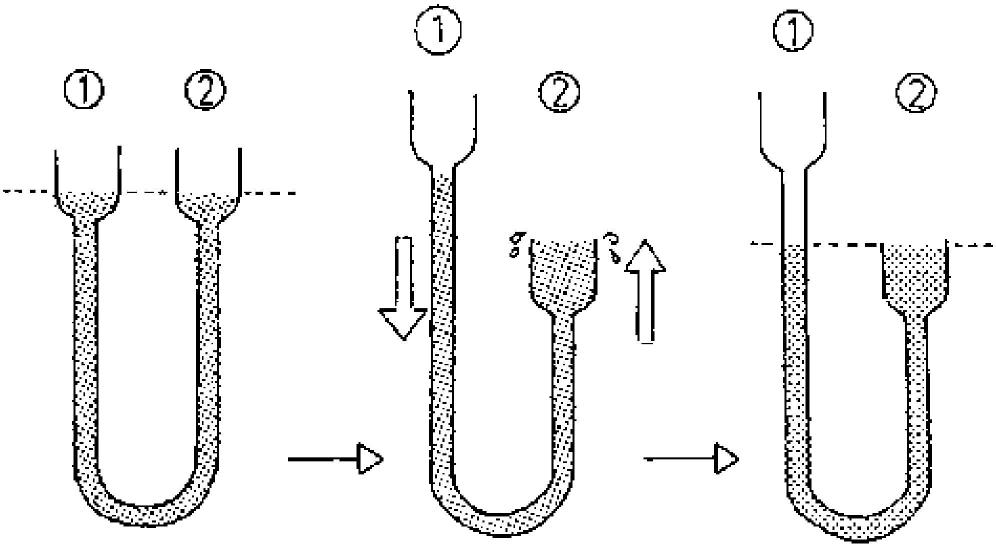
Main Goal:

The same air pressure acting on the surfaces of a liquid in joint vessels which are opened at the tops causes them to lie at the same level, (exceptions are very narrow vessels because of capillarity.) This principle is applied in water–pipes in technology. (Ground water is pumped into a water–storage tank such as a water–tower. The storage tank must be higher than the taps.)

Materials and Apparatus:

funnels or bottles from which the bottoms are cut off
(use caution!) or glass–pipes tubing
2 nails
hammer
rope
water

The bottles (or the funnels) are alternately lifted and lowered. In the beginning, the two water surfaces lie at the same level.



Observation:

If bottle 1 is lifted, the water level in bottle 2 is suddenly lower than that one in bottle 1 and then the water rises into the bottle 2 until the two water columns are equally high.

Analysis:

In joint vessels, water tends to stand at the same level. Thus water can be taken from taps which are placed lower than the water–storage tank. If the bottle 1 is lifted up high enough, water will spout out of the top of bottle 2.

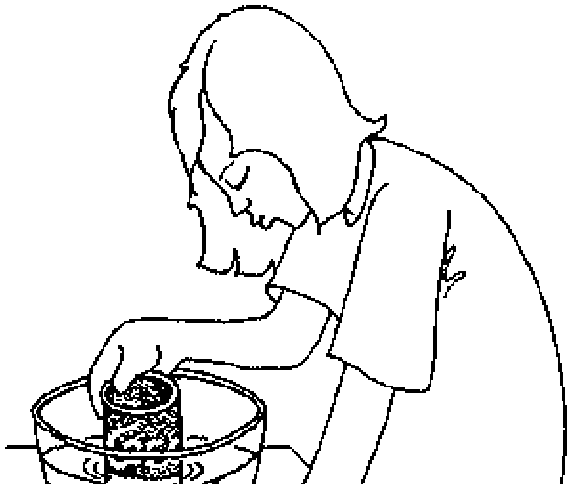
In order to obtain drinking–water, a well can be dug into the aqueous layers of the soil. The ground water soaks into the well up to the level of the ground water surface and can be taken from the well with a bucket.

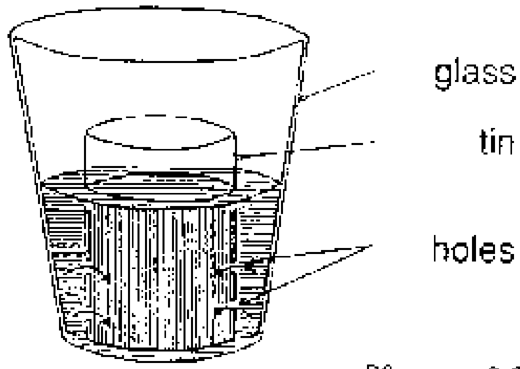
Materials and Apparatus:

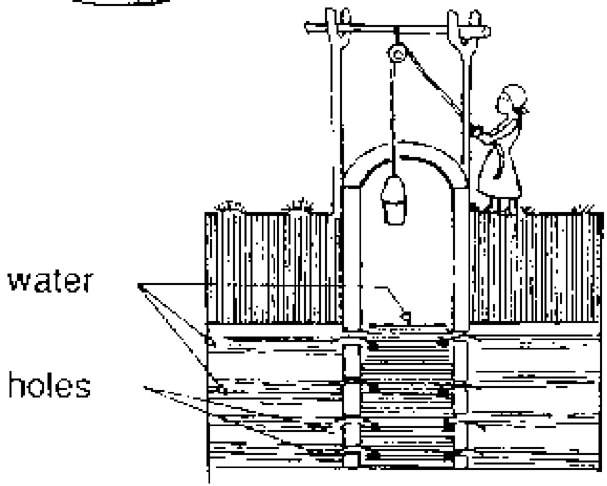
tin (cola tin) with the top removed
nail
hammer
glass vessel or a bucket with water
tin–opener or pair of plate–shears

Procedure:

Two to three holes are made with the nail and the hammer in the tin walls.







Observation:

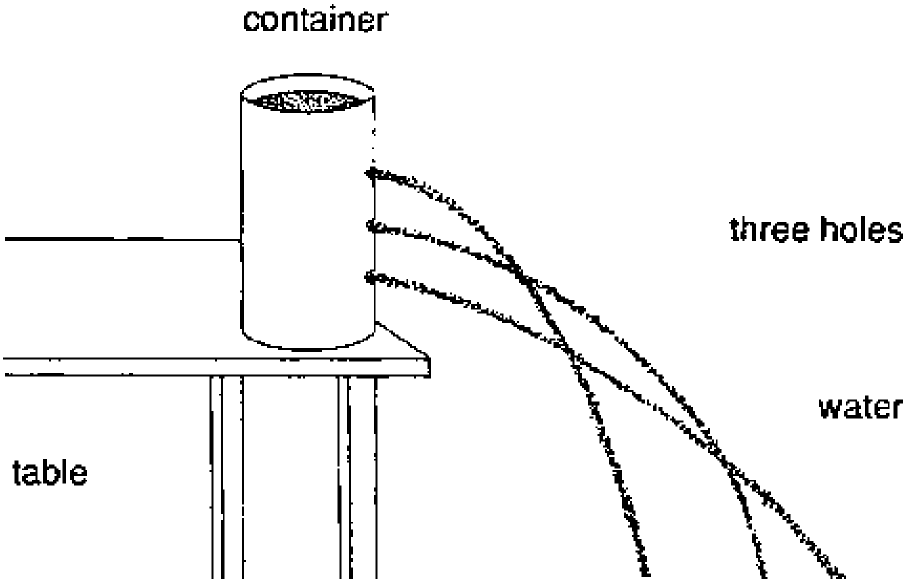
The water soaks into the tin through the holes. The water level inside and outside of the tin adjustes itself after a short time.

Materials and Apparatus

container made of sheet metal (tin or cola tin)
– should be very high and open at the top –
nail
hammer
water
plate–shears or tin–opener

Procedure:

3 holes are made at different heights in the metal container. Afterwards it is filled with water.



The pressure is exercised onto the sides as well as onto the bottom of the tin. It increases with the height of the water–column, because it's the weight of the water column above the level of the hole that determines the pressure. The more weight, the more pressure.

Practical Use:

When roller dams are built, the walls are reinforced towards the ground, in order to make them withstand the water pressure which increases with the height of the water–column.

Further thought:

Is there any difference concerning the water pressure acting against the bottom of the dam in the drawing, when you have a small volume of water held back or a very big one? The depth shall be the same in both cases.

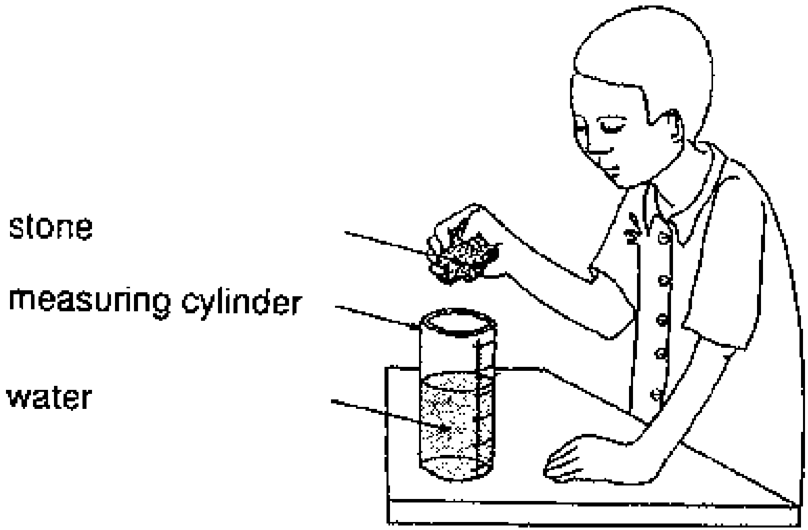
8.4. VOLUME DETERMINATION OF A STONE

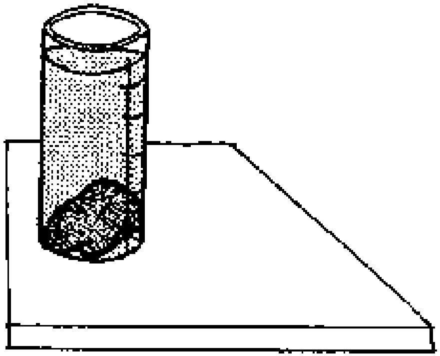
Main Goal:

This experiment demonstrates how to determine the volume of an uneven solid body on the basis of its liquid displacement. (it is necessary that the body is dipped completely into water.)

Information:

If a stone is placed into water, it displaces as much liquid as corresponds to its volume. (This is also true for other kinds of liquids, such as alcohol, oil and also for all gases.)





Then the stone is placed into the measuring cylinder.

Observation:

The stone sinks to the bottom, and the water level rises.

Information:

At the surfaces of liquids are cohesive forces (Latin: attractive), whose forces are directed inward.

These forces tend to pull the surface molecules inward, which means, to reduce the size of the surface.

This special cohesion between like molecules is called “surface tension”.

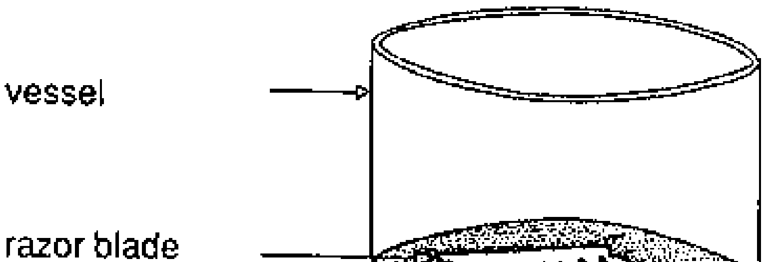
Materials and Apparatus:

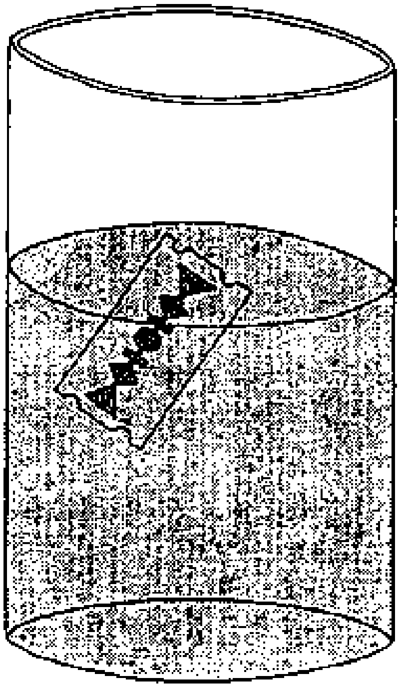
vessel
razor blade (greased needle, paper clip)
water

Procedure:

a. One vessel is filled half way with water.

The razor blade is placed flat onto the water surface.





Observation:

a. The razor blade floats on top of the water.
b. The razor blade sinks.

Analysis:

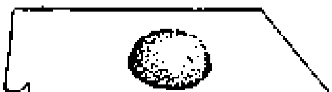
The water surface can be imagined as one connected water skin. It is temporarily destroyed when the razor blade sinks in.

water

Procedure:

With the help of a pipette, several small portions of water are dropped onto waxed paper.

waxed paper



(see further experiments with detergents)

Further thought:

What additional effect makes bigger drops more tear–shaped?

8.7. THE PHENOMENON OF SURFACE TENSION

Main Goal:

These experiments use a soap solution to illustrate the surface tension.

Information:

(see experiment: A RAZOR BLADE FLOATS **ON** TOP OF WATER)

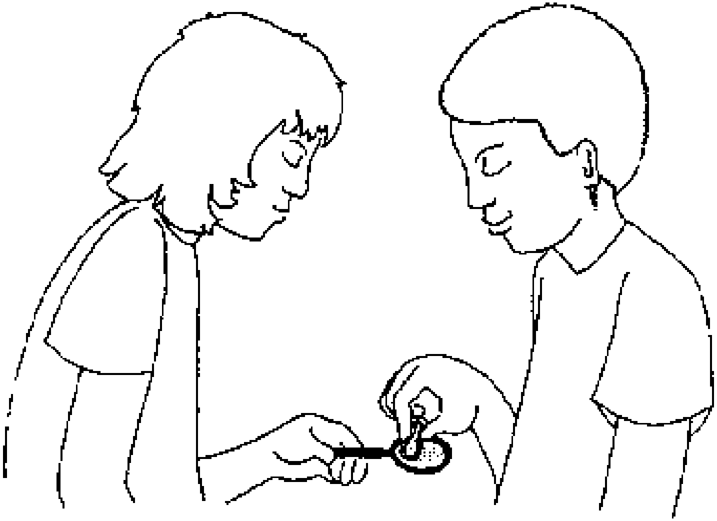
Materials and Apparatus:

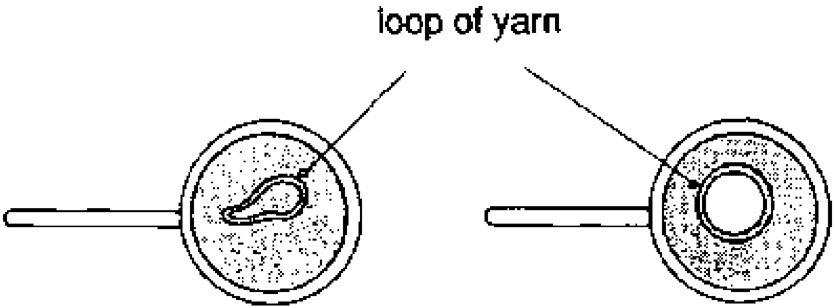
concentrated soap–solution

a. clay pipe or a peashooter

b. a ring of wire

a loop of thin yarn
needle





Observation:

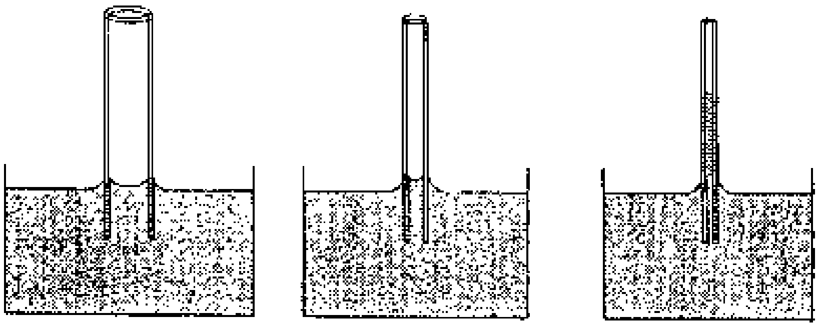
a. The soap–bubbles slowly become smaller.
b. The loop of yarn is drawn apart.

Information:

Very thin tubes are called capillary tubes (capillary –Latin: hair–like). In these, water climbs up. The thinner the tube, the higher the water climbs. The cause is the surface tension (see further experiments on surface tension).

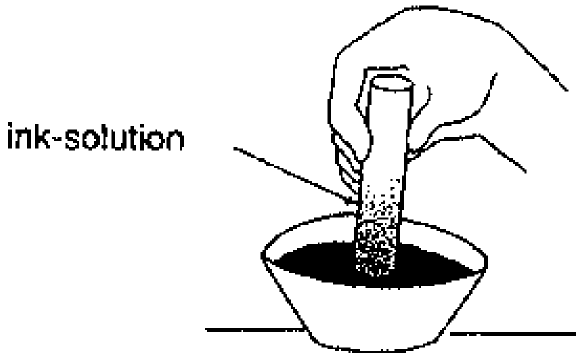
Water molecules are attracted to glass or other substances more than to each other. This effect is called adhesion. When a glass tube is dipped into water, the adhesion between glass and water causes a thin film of water to be drawn up over the surface of the tube. Surface tension causes this film to contract. The film on the inner surface continues to contract, raising water with it until the adhesive force is ballanced by the weight of the water lifted (see drawings).

capiilarity



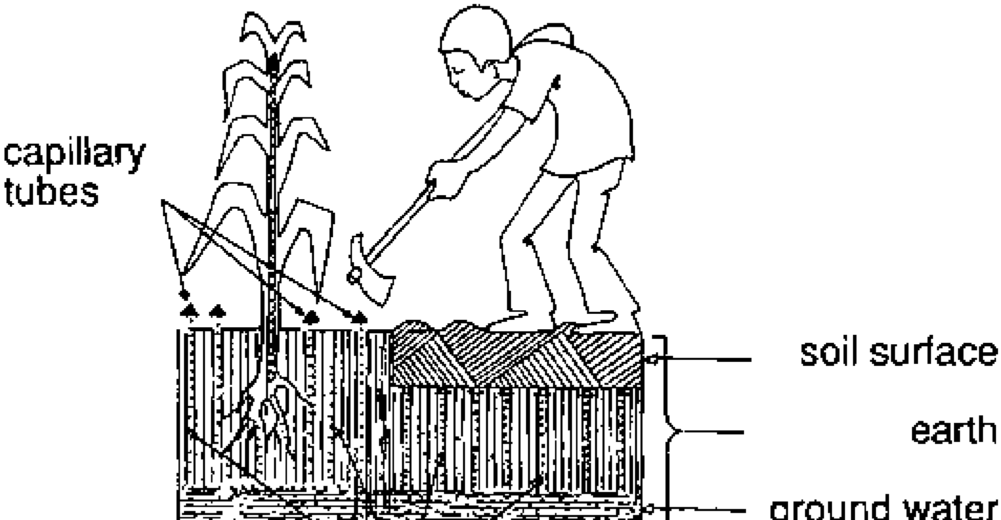
Materials:

piece of white chalk
ink or coloured water
(transparent tubes of different diameter)



Observation:

The ink climbs up the piece of chalk.



8.9. DETERGENTS FACILITATE THE ABILITY OF PERFUSION

Main Goal:

These experiments illustrate the effects of water and a detergent solution on fabric cloth.

Information:

Soaps and detergents reduce the surface tension of water.

The process of perfusion, which is the absorbtion of a detergent solution (soap solution) by the fabric cloth, is facilitated.

Materials and Apparatus:

detergent solution (soap solution)
(1 g detergent in 100 ml of water)
water
2 wool threads
2 small rags
2 vessels

Procedure:

One vessel is half filled with water; the second is half filled with a detergent–solution.

A wool thread and a small rag are placed into each vessel.

Analysis:

Compared to a detergent–solution, pure water soaks more slowly into similar fabric cloths.

Practical Use:

Soaps and modern detergents are used for the cleansing of laundry.

(see experiment: THE EFFECT OF DETERGENTS ON DIRT)

Further thought:

If soap reduces surface tension of water, why do we blow soap bubbles instead of water bubbles?

8.10. THE EFFECTS OF DETERGENTS ON DIRT

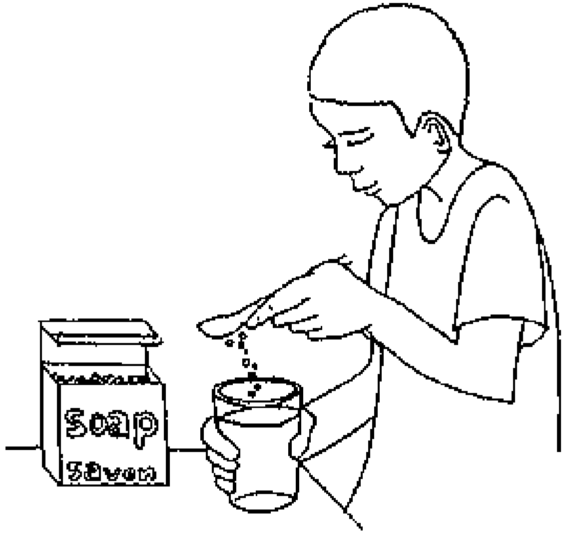
Main Goal:

This experiment illustrates that dirt is distributed in very small particles in a detergent solution.

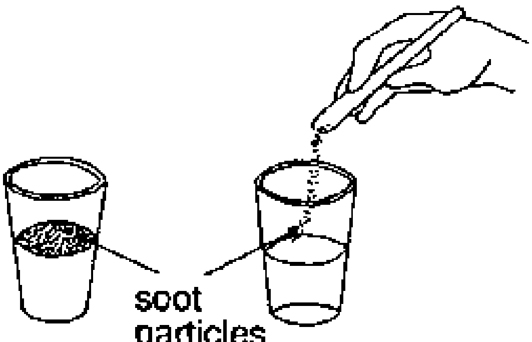
Information:

The basic components of dirt are grease, soot, and proteins. Detergent molecules distribute soot and grease particles, in the washing solution so that they can be washed away.

Some soot (about one spatula tip) is added to each dish, vigorously shaken and then filtered.



b. One glass dish is half filled with water, a second is half filled with detergent solution. About 0.5 ml oil is added to each dish, and then the dishes are vigorously shaken.



(emulsion: a mixture of two liquids; suspension: a misture of a liquid and one solid, which can not solve in the liquid)

Practical Use:

Soaps and detergents are used to remove dirt from clothes, dishes, and the human body.

Further thought:

We say that some liquids “wet” a surface, whereas other don’t do this. What’s the difference? Where is it coming from?

9. MECHANICS

9.1. GEAR MECHANISM – A TRANSMISSION

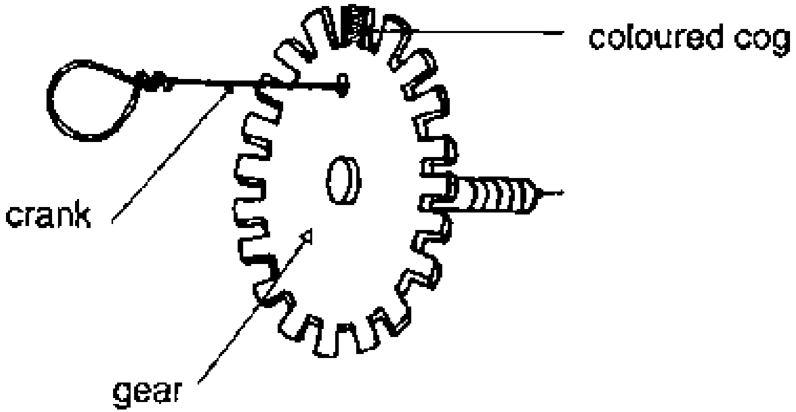
TO SPEED UP

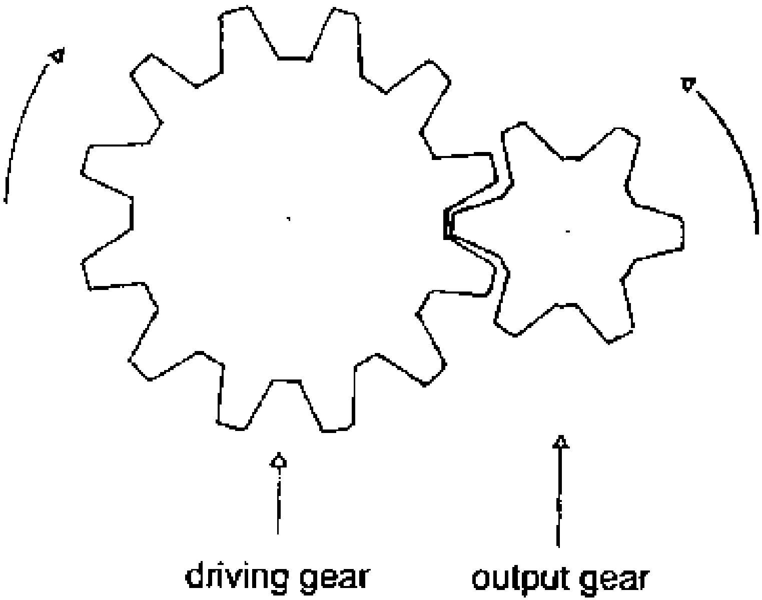
Main Goal:

The pupils become familiar with an important element of machines – the gear transmission.

Information:

In technology, cogwheels serve to transmit rotary motions.


coloured cog
crank
gear


driving gear
output gear

9.2. GEAR MECHANISM – A TRANSMISSION TO SLOW DOWN

Main Goal:

By means of this experiment the pupils experience an important element of machines – the gear transmission.

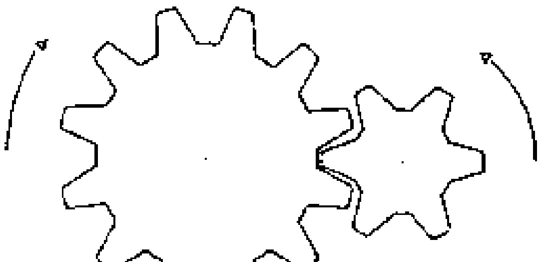
This experiment demonstrates a transmission in order to slow down.

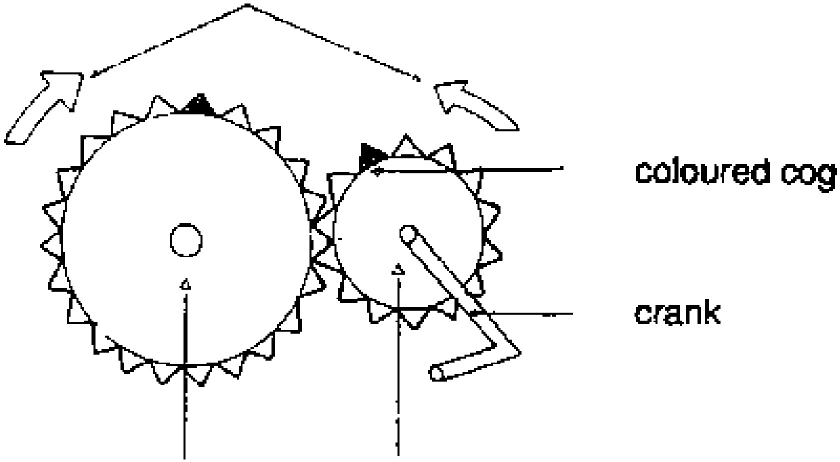
Materials and Apparatus:

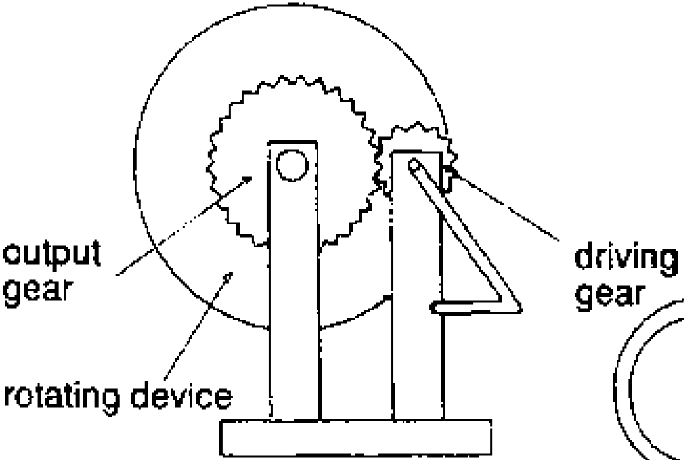
corrugated board
screws
knife or pair of scissors
wire
coloured pencil

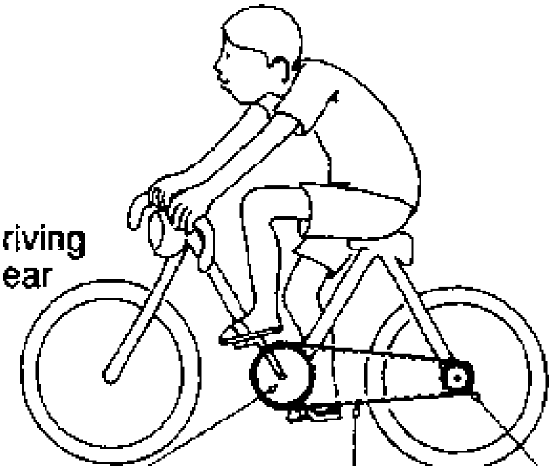
Procedure:

see "GEAR MECHANISM – TRANSMISSION TO SPEED UP"




opposite directions
coloured cog
crank
output gear
driving gear


output
gear
rotating device
driving
gear



9.3. A SEESAW – A TWO–ARMED LEVER

Main Goal:

Pupils learn that a seesaw is a two–armed lever and flat in case of equilibrium. There is a special relationship between the length of a levers and the weights resting on them. For older pupils this experiment provides a mathematical basis to approach the law of the lever.

Information:

In physics, a lever is a bar, which can turn about one point (axis). This point is called the fulcrum. The fulcrum of a two–armed lever lies between the two attacking forces (see drawing 1). If a lever is in balance, the effects on left and right are equal. These effects are the product of the attacking force and the lever bar (distance between attacking force and the fulcrum). In drawing 1 the attacking forces F_1 and F_2 are the weights of the paper clips.

The law of lever says:

$$F_1 \times L_1 = F_2 \times L_2$$

If F_1 is considered the force that is to balance the load at the right hand side (F_2), then we have

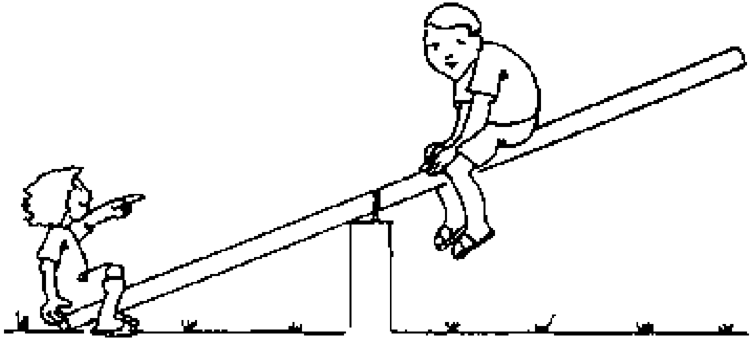
force × force arm (left hand side) = load × load arm (right hand side)

Materials and Apparatus:

styrofoam (or soft wood)
thin iron nails

(This corresponds to the children on a seesaw.)

It is the pupils' task to balance the lever.



Observation:

The lever is balanced if the same number of paper clips is placed on each arm of the lever at the same distance from the fulcrum or, if different weights are fixed, the heavier weight must be closer to the fulcrum in order to balance the lever.

Analysis:

When the lever is balanced, the product of force and force arm equals the product of weight and weight arm.

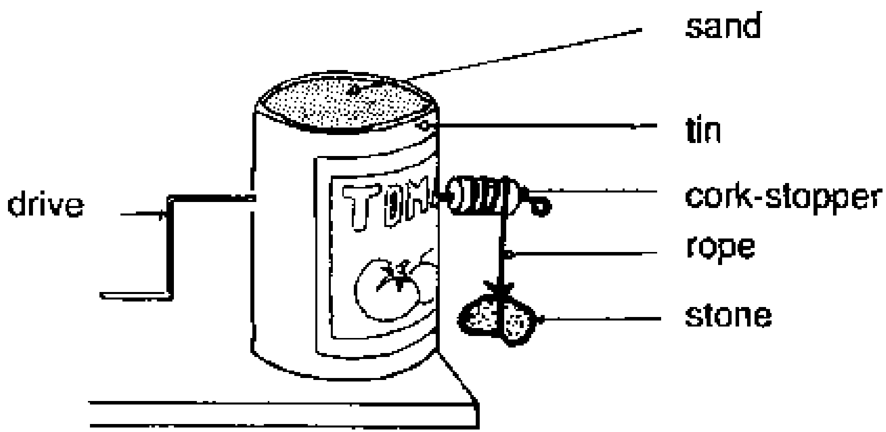
That's to say: the product F × L of the left hand side must be equal to the product F × L of the right hand side.

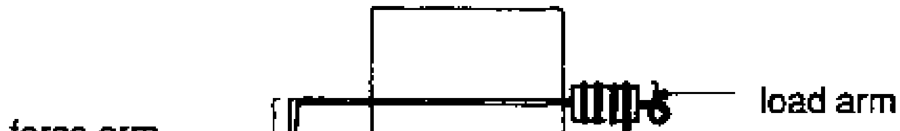
Materials and Apparatus:

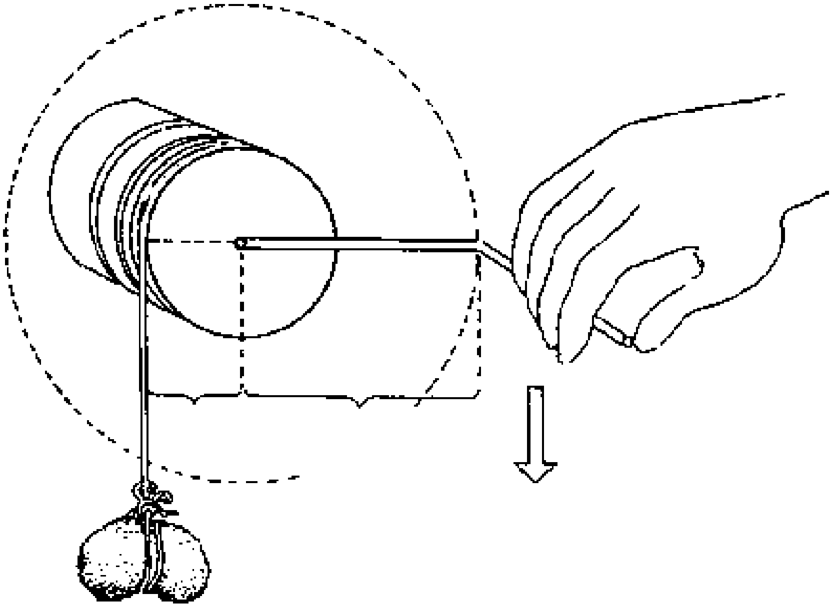
stone as the load
rope
tin (with 2 holes) filled with sand, (see diagram)
pierced cork–stopper
stable wire

Procedure:

The experiment is set up as shown in the diagram below. The stone is lifted once with the help of the cable winch, and another time without it.







Analysis:

The winch presents a two–armed lever. When a load is lifted, force is saved, because the force arm is longer than the load arm. Thus the required force is smaller than the load (weight of the stone).

Practical Use:

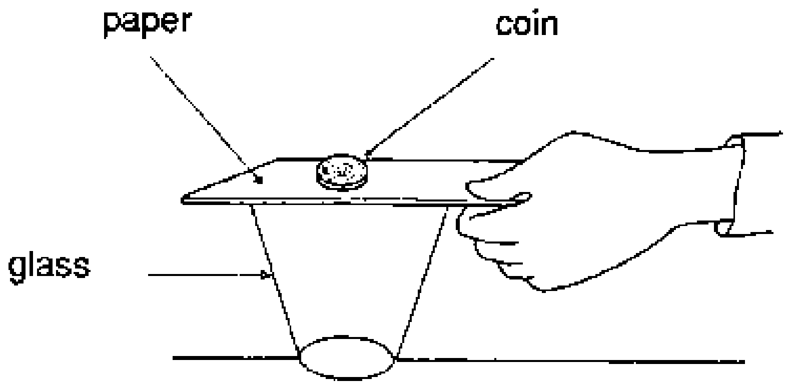
Uses for winches: water cranes, pit–head frames, lifting device at wheels, etc.

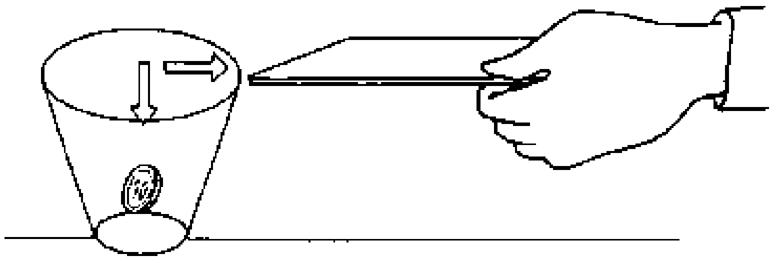
glass, tin etc. with smooth rims
coin
firm paper (cardboard)

Procedure:

The experiment is prepared as shown in the diagram below.

The paper is pulled away horizontally as quickly as possible.





When one pulls slowly, the coin joins the movement of the paper. Why?

9.6. FRICTION

Main Goal:

These experiments demonstrate the principles of adhesive friction, sliding friction and rolling friction.

Information:

1. Friction is the result of mutual contact of irregularities in the surface of sliding objects. Three types of friction are distinguishable:

With **adhesive friction,** the force of friction is strongest. It decreases from **sliding friction** to **rolling friction.**

The strength of the frictional force depends on the surfaces of the bodies which rub against each other and on the weight of the upper body.

2. Adhesive friction causes two bodies to stick together.

Sliding friction counteracts the act of gliding.

Rolling friction is created when one body unrolls over another one.

The force of friction can be measured with a dynamometer.

Materials and Apparatus:

b. The bristels of the upper brush are twisted to the left and those of the lower brush are twisted to the right side.

c. The marbles roll further on the smooth ground than on the rough ground.

Analysis:

Observation (a) is called adhesive friction.

The irregularities or unevenesses of the two surfaces grip one another.

Observation (b) is called 'gliding friction'.

The unevenesses of the two bodies grip each other less strongly than with the adhesive friction.

Observation (c) is called 'rolling friction'.

Here, the unevenesses can grip each other to an even lesser extent than in sliding friction.

The strength of the respective frictional force basically depends on the surfaces of the two bodies, which is made clear in experiment c.

Practical Use:

For reduction of frictional forces, very smooth surfaces are used in technology. In addition, lubricants, e.g. oil and graphite, are used. Frictional forces should be minimized at those machine parts which move. However, often frictional forces are necessary. Tires need a certain depth of tread patterns, so that the car does not skid on a wet road.

The lever principle is:

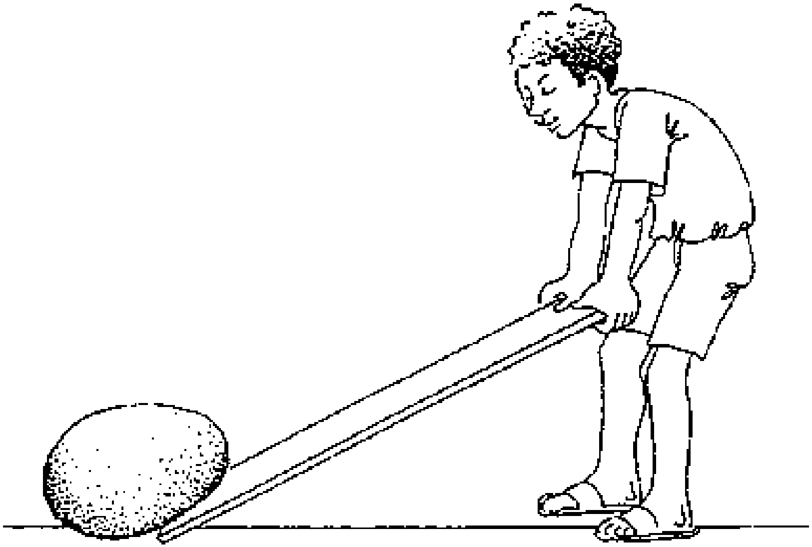
force × force arm = load × load arm

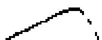
Materials and Apparatus:

one heavy stone or a heavy object as load
one stable wood lath or iron rod

Procedure:

The stone is lifted with the wooden lath as shown in fig. a).





If the lever is in a state of balance, the product of load (weight of the stone) and load arm equals the product of force and force arm.

(A dynanometer is needed to check this principle. It measures the force held against the load.)

Practical Use:

Examples for one–armed levers include:
a wheel–barrow and a nutcracker.

Further thought:

If we are rowing a boat, do we apply the law of levers?

10. ELECTRICITY

10.0. THE SCIENCE OF ELECTRICITY

Before we look in detail at the following experiments, here are some suggestions relating to the necessary materials and apparatus.

As the equipment used is always very similar, it is practical to build up one basic board and to put together basic equipment.

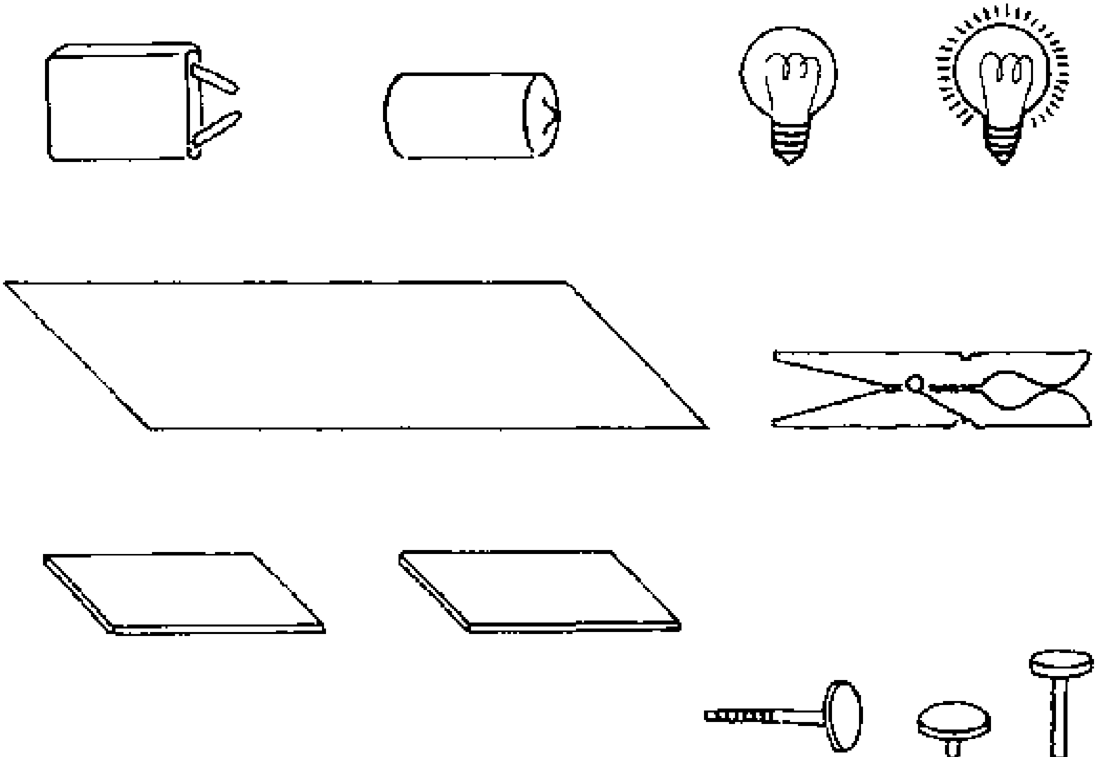
N. B.

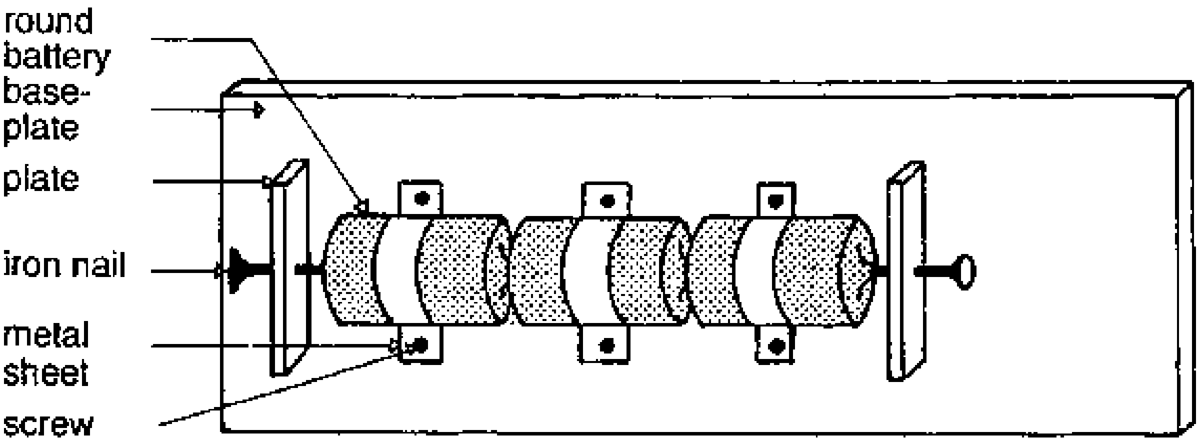
wire	:	single core, length as required
clothes peg	:	made of wood or plastic

drawing–pin, paper clips, different kinds of iron nail,

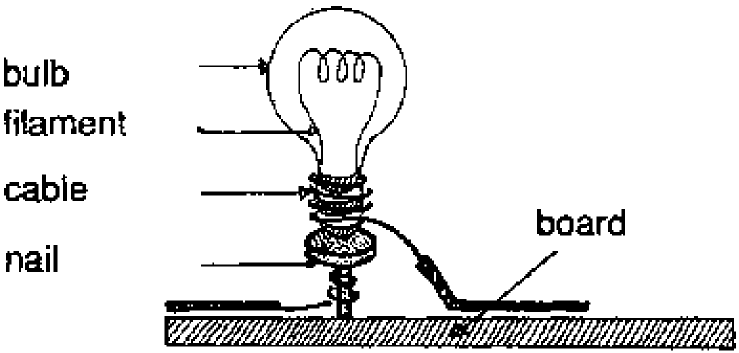
screws rubber bands (broad)

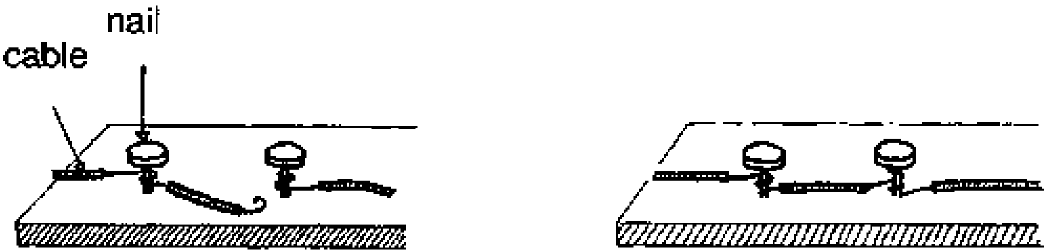
knife, pair of scissors, hammer, screw–driver, pair of pliers.





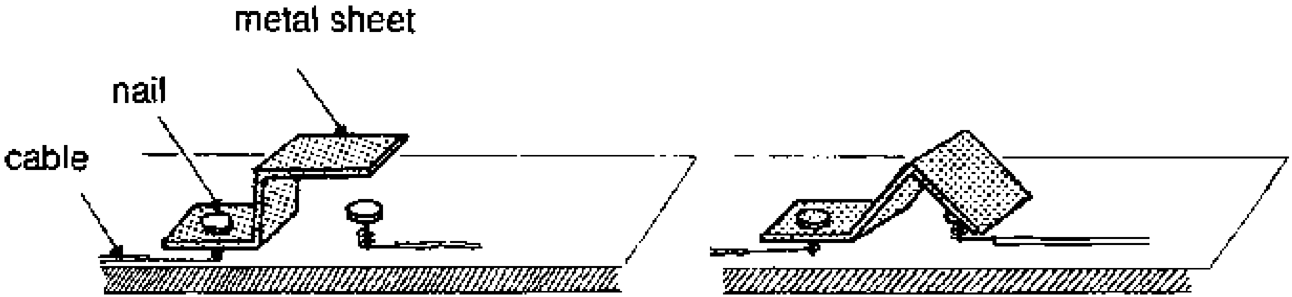
c) Suggestions for the sockets





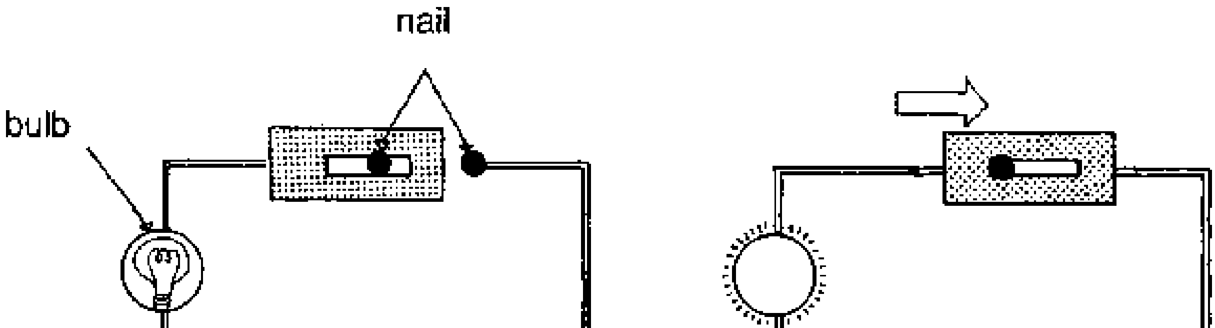
simple switch: off

simple switch: on



press-switch: off

on



or repulsion – may be illustrated.

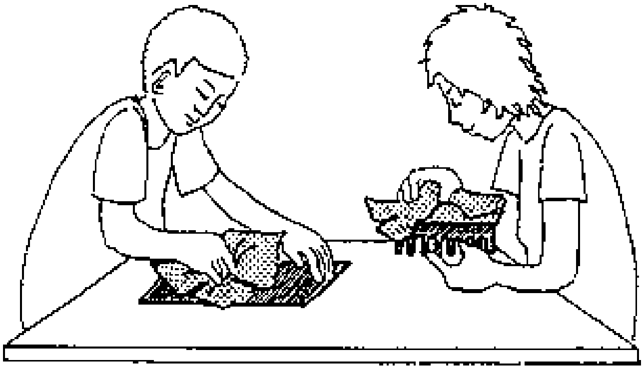
The experiments can be performed best in very dry air.

Materials and Apparatus:

2 pieces of plastic sheeting, plastic bags, wool cloth
plastic comb, ball–point pen...
woollen cloth
jet or water from a water–pipe or a tin
2 balloons

Procedure:

a. The sheeting or bags are rubbed vigorously with a woolen cloth and then brought close together.



b. One piece of sheeting or bag is charged by rubbing vigorously. A finger is then held very close to it.

d. You feel a repelling force.

Analysis:

a. The sheeting/bags carry the same type of charge and repel each other.

b. Friction of non–conductors produce high voltage electricity. It breaks down immediately when a spark leaps and is not dangerous.

c. The plastic comb and the jet of water have the opposite electric charges and attract each other.

d. The same type of charge on the balloons cause them to repel each other.

Further thought:

You can put a charged balloon on a wall. It sticks to it. What is the reason?

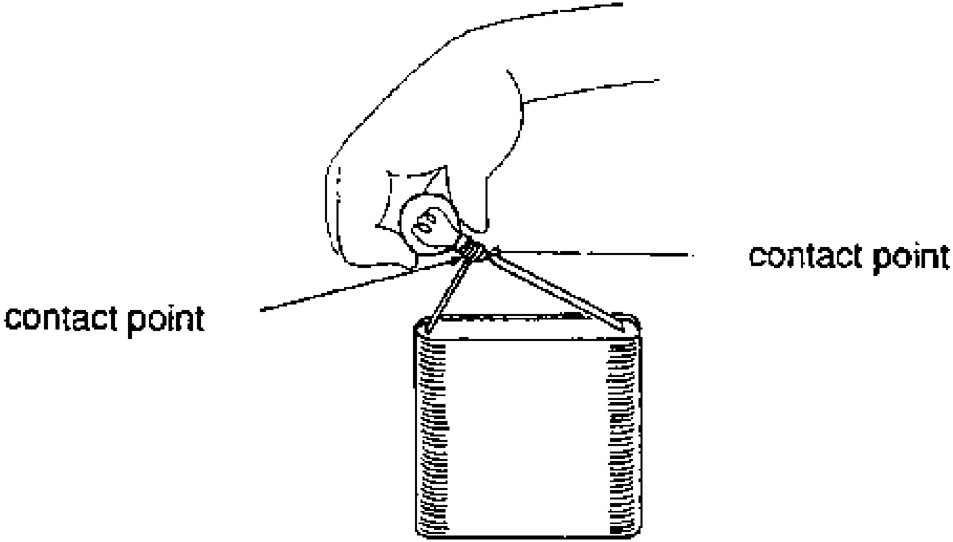
10.2. A SIMPLE CIRCUIT

Main Goal:

This experiment teaches pupils how a simple circuit is built and how it works.

Information:

When electric charge moves in **a** circuit, it does work. The rate at which this work is done is called power. Electric power (in watts W) is equal to the product of current (in amperes A) and



Observation:

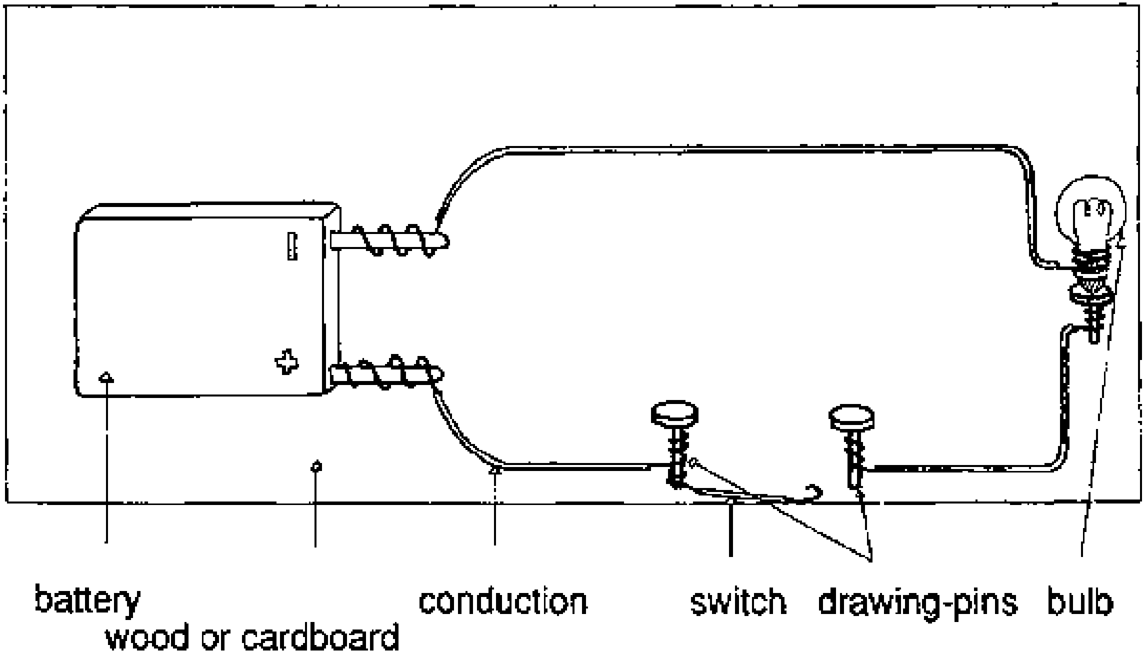
The lamp lights up if each of the two contact points are connected with one of the poles.

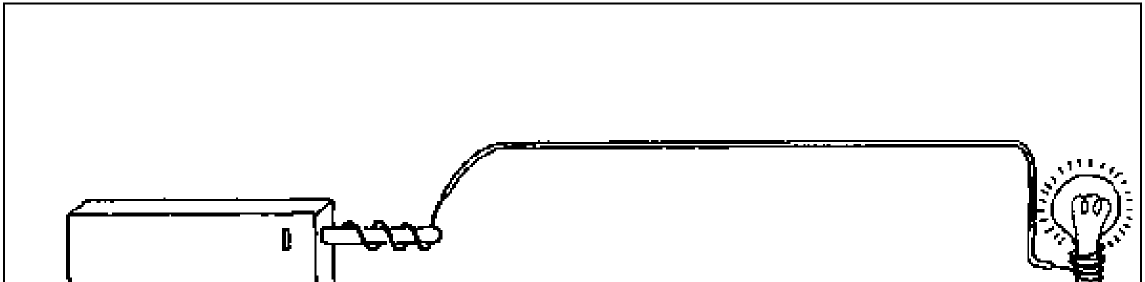
Analysis:

A simple circuit consists of a battery, that provides the voltage, and of a power consumer, in this case a small light bulb. Electric current only flows if the circuit is closed. When the small bulb lights up, the circuit is closed.

Practical Use:

A circuit is set up as shown in the following diagram. The circuit is closed or interrupted with the switch.





Further thought:

Is there any voltage in the circuit even when the switch is off?
Is any current possible without voltage?

10.4. CONDUCTOR AND NON–CONDUCTOR

Main Goal:

The pupils learn about the classification of materials as good conductors, not so good conductors, and non–conductors.

Information:

Metals conduct an electric current very good. Non–metals may be moderate conductors (like ordinary water or wet wood) or bad or very bad conductors (like glass, hard rubber or quartz).

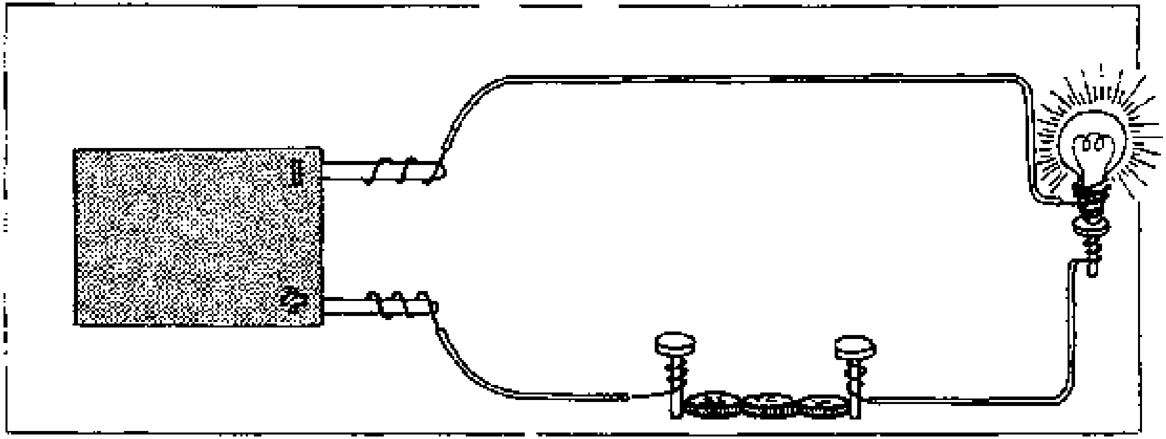
The conductivity is dependant on free electrons.

The flow of current can be equated with the flow of electrons.

(The word “electricity” comes from the Greek word “elektrum” meaning amber. Static electricity was first discovered with amber.)

Materials and Apparatus:

see suggestions – “SCIENCE OF ELECTRICITY”.
See the following chart and select a few materials to test.



Observation:	material	conducts current	does not conduct current	conducts a little
	wood		–	
	glass		–	
	yarn		–	
	rubber		–	
	paper		–	
	plastic		–	
	coal	+		

10.5. SERIES CONNECTION

Main Goal:

This example teaches younger pupils the principles of a series connection, in which several consumers are connected up one after the other. The observations are not analysed in detail. Older pupils learn Ohm’s law and the meaning of partial resistors.

Information:

Electric power consumers are ‘consumers’ because they convert electric power into heat power or light power. The property that enables ‘consumers’ to such conversion is called electric resistance. Circuit elements with appreciable resistance are called resistors. Bulbs are such resistors.

If several bulbs – resistors – are connected in series, they scarcely shine if at all.

This is due to the fact that the strength of the current, which is equally large at each partial resistor, drops. To calculate the current, Ohm’s law is used.

Materials and Apparatus:

see suggestion “SCIENCE OF ELECTRICITY”

Procedure:

The circuit is set up as shown in the following diagram.

a. One, then two, then three small bulbs, etc., are connected in series.

Observation:

a. The bulbs shine less brightly after every additional connection, until they finally do not shine at all.

b. If one bulb is unscrewed, all bulbs go out.

Analysis:

a. The strength of the current sinks gradually, so that it is finally not strong enough to make the bulbs light up.

b. The circuit is interrupted if one bulb is unscrewed.

This means: the bigger the resistance, the smaller the current.

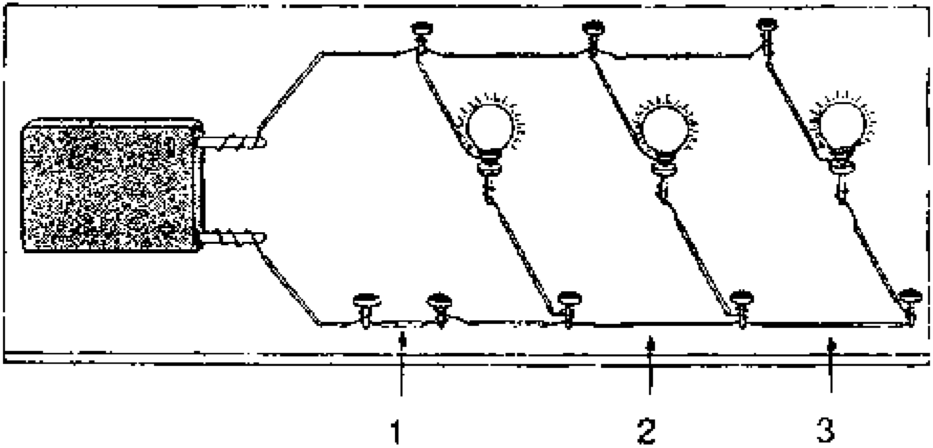
Practical Use:

see “Main Goal”

Further thought:

But what will happen in case the current is not strong enough anymore to make the bulbs light up, when we take a battery that delivers higher voltage?

10.6. PARALLEL CONNECTION



Observation:

a. The small bulbs light up with equal intensity.

b. If one bulb is unscrewed, the others still burn.

Analysis:

Every parallel connection forms an independent circuit. The current through each bulb is only dependant on the output of the battery (i.e. the voltage) and the resistance of the bulb.

Practical Use:

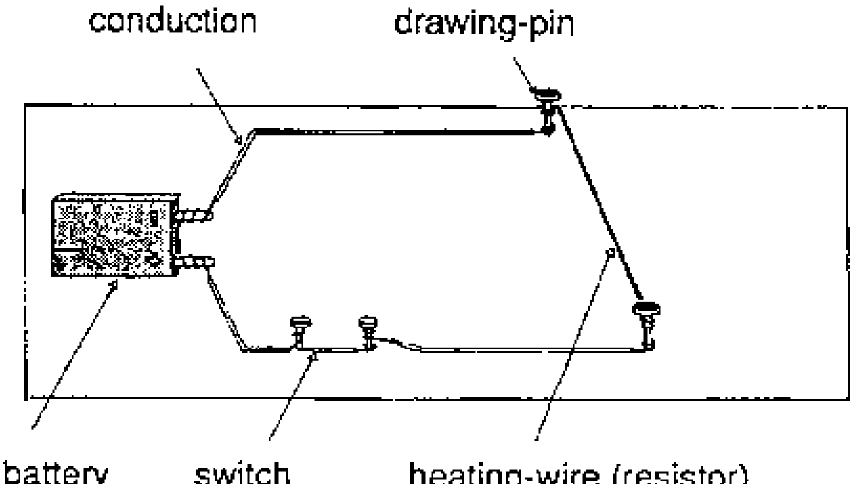
In all households, outlets and switches are connected in parallel circuits. The electricity meter or less. In heating instruments a special resistance wire – “constantan wire” – is used. It does not fuse at high temperatures and has a high resistance, which is hardly dependant on temperature.

Materials and Apparatus:

See suggestions – “SCIENCE OF ELECTRICITY”
resistance wire (constantan wire)
2 iron nails
15 V battery (or several batteries connected in series)
styrofoam (wood)

Procedure:

A circuit is set up as shown in the following diagram.



Electrical current produces heat in resistors or power consumers.

Practical Use:

In the household, a lot of electrical appliances are used which produce heat, e.g.:

electric heater
hot–plate
immersion heater

Further thought:

Sometimes you hear someone say that the electric current in a circuit is used up. Is it really the current, i.e. the flow of electrons, that's 'used up', or what?

10.8. THE PRINCIPLE OF AN ELECTROMAGNET

Main Goal:

The experiment demonstrates the magnetic effect of an electrical current.

Information:

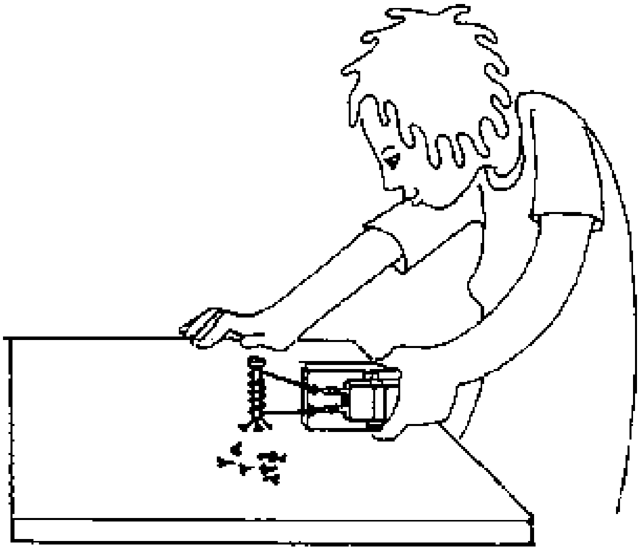
A current–carrying coil has the same effect as a permanent magnet. If a non–magnetic iron core is placed in the centre of the coil, it too becomes a magnet. The magnetism is intensified by increasing the number of times the coil is wound round the core.

– Try to attract the lighter pieces of iron with the iron nail.

– The pieces of iron can be attracted with the current–carrying coil.

– The big iron core (nail) is placed in the coil.

– The number of times the coil is wound round the nail is increased or decreased.



Observation:

– The non–magnetic iron nail does not attract the iron pieces.

– The current–carrying coil attracts the lighter pieces.

10.9. THE PRINCIPLE OF A BIMETALLIC STRIP

Main Goal:

The experiment demonstrates the behaviour of a bimetallic strip when heated.

Information:

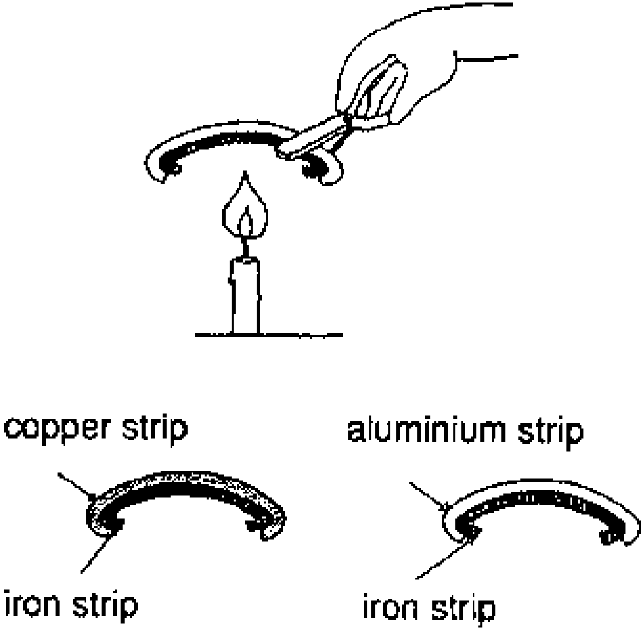
Bimetals consist – as the name suggests – of two strips of different metals, which are either rivetted or soldered together. When heated, a bimetallic strip bends due to the different expansion properties of the different metals.

Materials and Apparatus:

1 copper and 1 iron strip and 1 aluminium strip and
1 iron strip (of the same strength)
hammer
pair of pliers
alcohol burner, gas burner or a candle

Procedure:

Two metallic strips are joined by twisting their ends as shown below.



The bimetallic strip is held in a flame.

Observation:

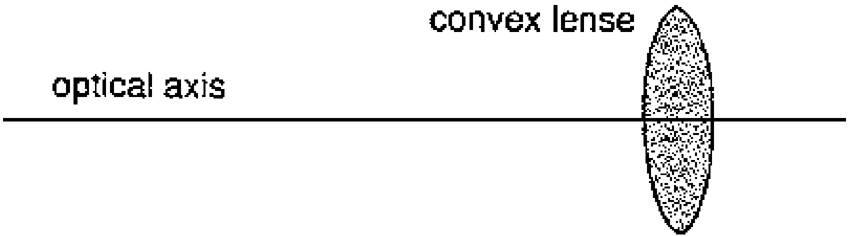
The bimetallic strip bends when heated.

Analysis:

The copper and the aluminium strip expand more than the iron strip.

Practical Use:

Convex lenses are thicker in the middle than at the edges. Rays which are parallel to the optical axis, are refracted by a convex lens in such a way that they focus again behind the lens at the focal point. However, the marginal rays are refracted more than those rays which are closer to the optical axis.

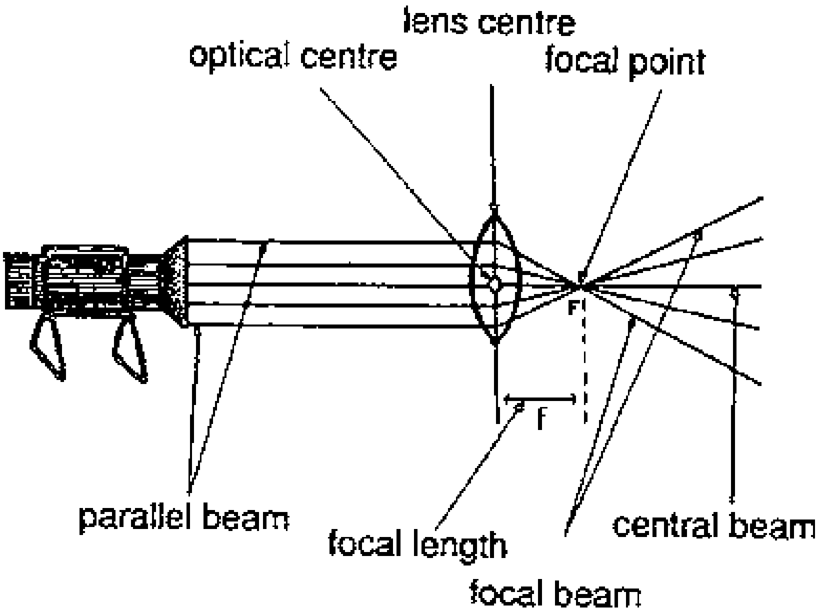


Materials and Apparatus:

magnifying glass –
(one spectacle–lens for long–sighted people)
flashlight (maybe a candle)
rack made of wire for the flashlight

Procedure:

The apparatus is set up as shown in the diagram below.
The room is darkened and the path of the rays observed.
This is possible when cigarette smoke is blown into the beam.



Observation:

The light of the flashlight is focused on one point behind the lens. When parallel light comes in from the right side, there can also a focal point be observed at the left side of the lense.

Analysis:

Lenses, which focus parallel light on one point are called condensing lenses or convex lenses.

The point is called the focal point.

With a convex lens the sun's rays can be collected at the focal point (see experiment: A CONVEX LENS).

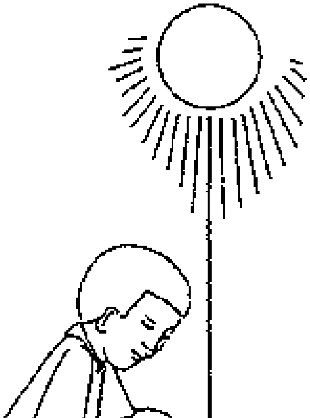
If a sheet of paper or the head of a match is held at the focal point, these materials ignite after a short while when the lens is placed perpendicular to the incoming sunlight. This is due to the fact that the energy carried by the sunlight is concentrated at the focal point.

Materials and Apparatus:

magnifying glass (one strong convex lens)
paper (match)

Procedure:

Sunlight is collected with a convex lens.
A sheet of paper or a match is placed at the focal point.
The spot of light should be as small as possible.



11.3. MAGNIFYING GLASS – VIRTUAL IMAGE OF A CONVEX LENS

Main Goal:

This experiment demonstrates a virtual image of a convex lens.

Information:

If an object is placed at the focal point or between the lens and the focal point, a real image cannot be perceived. If one looks through the lens at the candle however one can perceive a larger non–inverted image. (The eye must be at a greater distance from the lense than of its focal length.)

The image is called a virtual image and is only perceived with the eyes. It cannot be projected on the screen. The virtual image is formed when the eye follows the incoming rays backwards to the seeming point of intersection.

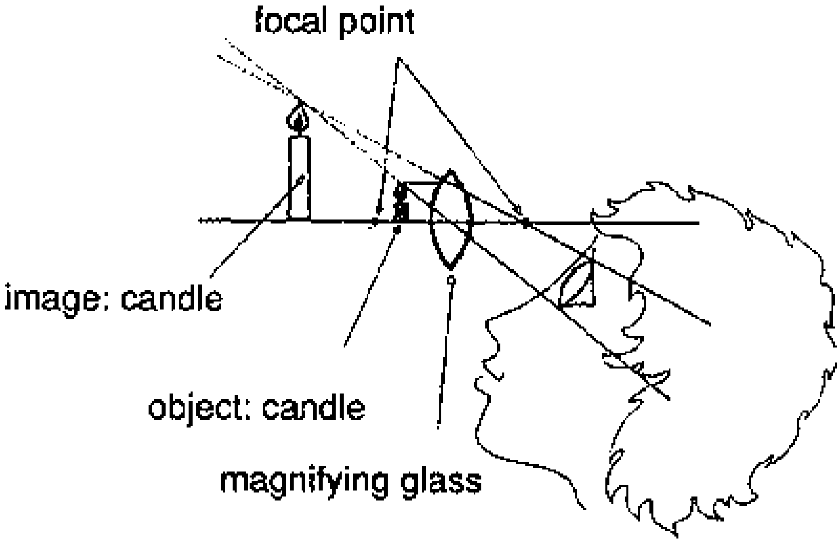
Materials and Apparatus:

magnifying glass –
(one spectacle–lens for long–sighted people)
candle or other objects such as flowers

Procedure:

The burning candle is placed close to the lens. The candle is observed through the lens.

image: candle object: candle



Observation:

Looking through the lens at the candle, non–inverted magnified image can be seen.

Analysis:

This image cannot be projected onto a screen. It is just the eye which perceives this imaginary or "virtual" image.

Practical Use:

A convex lens is needed by people who are longsighted.

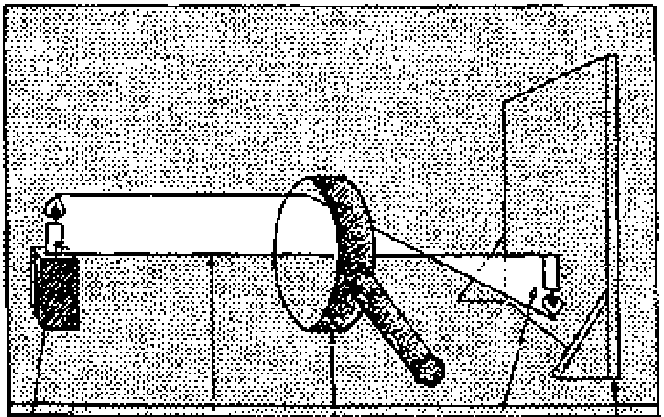
If the distance between the object and the lens is equal to twice the focal length, the image is the same size as the object. The distance from the image to the lens also equals twice the focal length.

Materials and Apparatus:

magnifying glass –
(one spectacle–lens for long–sighted people)
screen made of cardboard, candle,
rack made of wire or wooden rack for the magnifying glass, measuring rod.

Procedure:

The apparatus is set up as demonstrated in the diagram below. The candle is placed at one side of the lens. The screen is placed in such a way at the other side that a sharp image is obtained. When the candle is moved gradually towards the lens, the screen is moved correspondingly away from the lens.



Upside–down images are created.

The closer the candle is to the convex lens, the further away the image. At a certain distance (twice the focal length) from the lens, the object is the same size as the real image.

If the candle is placed close to the lens, no image is formed at all.

Analysis:

When the height of the object is equal to the height of the image, the distance from the candle to the lens is equal to the distance from the image to the lens and both on exactly double the focal length.

If the candle is placed at the focal point or between focal point and lens, no image can be projected.

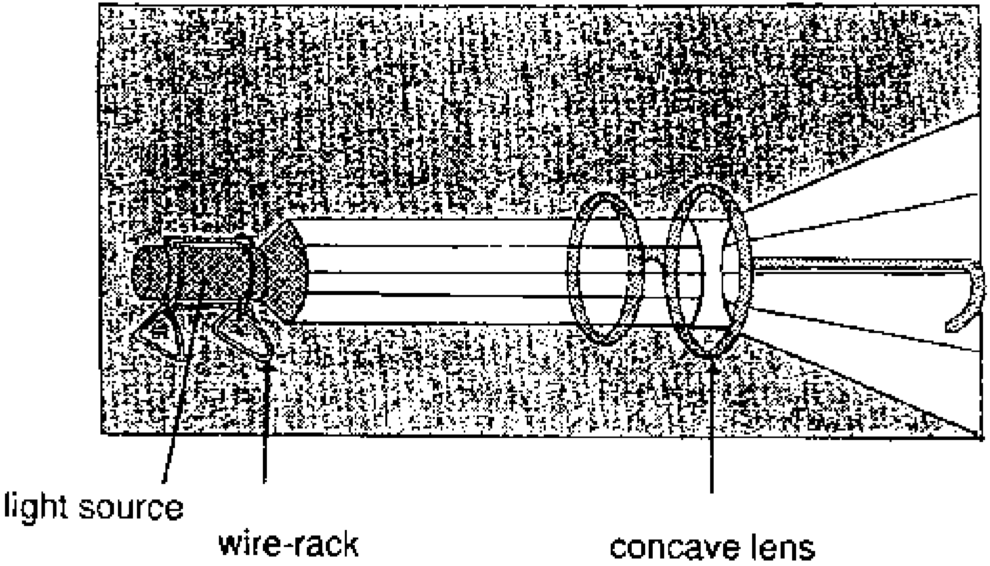
Further thought:

When we want to get a magnified image of the object on the screen in which distance from the lens must the object be placed?

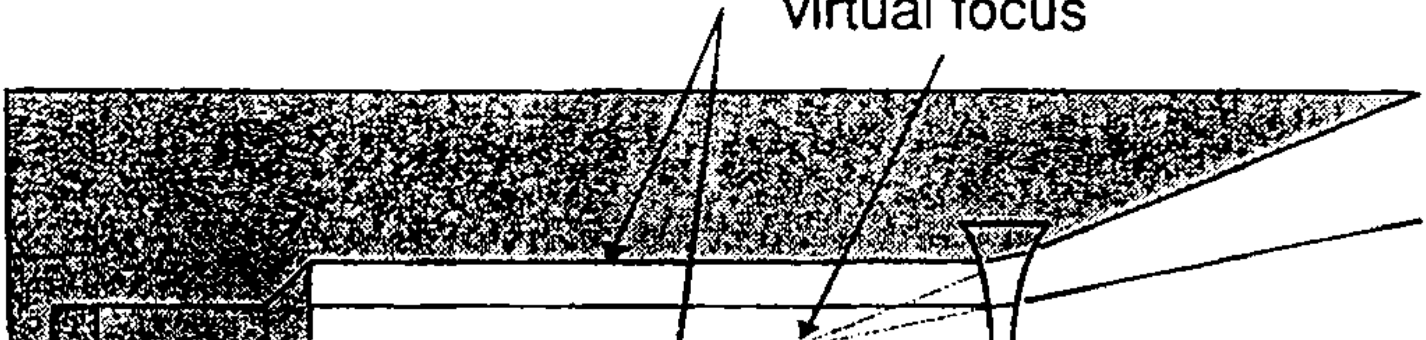
11.5. THE CONCAVE LENS

Main Goal:

Through this experiment, the course of the rays of a concave lense – diverging lens – can be observed.



parallel beam



A concave lens is used in glasses for short–sighted people, in cameras, telescopes, etc.

Further thought:

If light traveled at the same speed in different media, would glass lenses still alter the direction of rays?

11.6. VIRTUAL IMAGE OF A CONCAVE LENS

Main Goal:

This experiment demonstrates the virtual image of a concave lens.

Information:

Looking through a diverging lens towards an object, one can see a virtual, upright image. The image is always smaller than the object.

The course of rays followed by the eye is shown in a diagram.

Materials and Apparatus:

candle
concave lens –
(one spectacle–glass for short–sighted people)

Procedure:

Analysis:

The image can only be observed with the eye or with a camera. It cannot be projected on a screen. For this reason it is called a “virtual image”.

Practical Use:

The concave lens is needed by people who are shortsighted.
The eyeball of the short−sighted eye is lengthened.
The incoming rays focus in front of the retina.
The lens corrects the defect.

Further thought:

There are lenses that are at one side convex and at the other side concave. How do they refract the light?

11.7. PINHOLE CAMERA

Main Goal:

Using a pinhole camera, the origin of optical images is demonstrated.

Information:

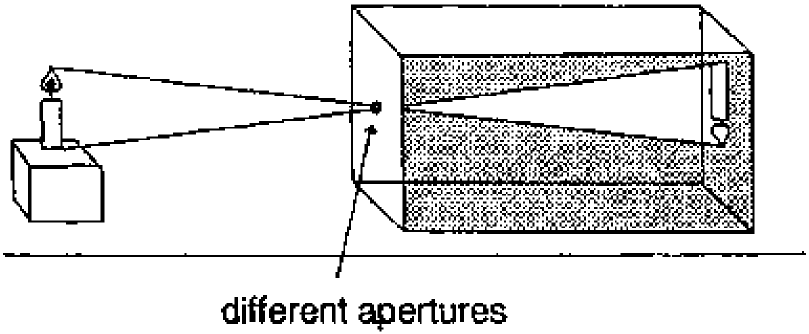
A pinhole camera creates upside−down, back−to−front images.

Two more holes with smaller diameter (2 or 1 mm) are cut into two other pieces of cardboard. The three card–board pieces with holes are called pinhole apertures.

a. A burning candle is placed before the 4 mm aperture side at a distance of about 20 cm.

The room is darkened.

b. The image is observed. Then the 2 mm aperture is put over the 4 mm aperture. Again the image is observed. Finally the 1 mm aperture is used. The candle is moved away from and toward the apertures.



Observation:

a. The image is always turned upside–down.

b. The image becomes smaller as the candle is moved away from the diaphragm opening and bigger as it is moved in the other direction.

c. The image created by a larger aperture is of higher light intensity but more blurred than that

GLOSSARY

ACCELERATION	:	Rate at which velocity changes with time. The change in velocity may be in magnitude (speeding up or slowing down) or in direction or both.
AMINO ACID	:	Chemical compounds in which a hydrogen atom in the alkyl group attached to the COOH (carbonyl) group of an organic acid is replaced by an NH_2 group. Their common chemical formula is: $R\text{–}CH(NH_2)\text{–}COOH$.
ANODE	:	anodos – Greek: the way upwards It is the electrode which is connected to the positive pole of a voltage source. (Gives off positive ions and towards which negative ions move)
ASSIMILATION	:	ad – Latin: to similis – Latin: similar Synthesis of organic compounds of indigested and digested nutrient materials, e.g. at the photosynthesis.
ATOM	:	atomos – Greek: an atom, invisible The smallest particle of an element, which does not admit a further division on the basis of chemical processes.

CELLULOSE	:	The chief substance composing the cell walls or woody part of plants, a carbohydrate of unknown molecular structure but having the composition represented by the empirical formula $(C_6H_{10}O_6)_x$. (polysaccharides).
CINETIC ENERGY	:	Energy of motion of a body. Is proportional to the mass of the body and to the square of its speed.
CONDENSATION	:	Change of state from vapor to liquid.
CONDUCTOR	:	Any material through which electric charges easily flow when subject to an applied voltage.
CONES	:	Cells which perceive light. About 120 millions are found in the retina. They are responsible for the ability to see in the night, as they work at very low light intensities.
CONSERVATION OF ENERGY	:	Experience shows that energy cannot be destroyed. The total amount of energy never changes. But it may be transformed from one form into another one.
CONSTANTAN WIRE	:	A special kind of wire which has the same resistance does not expand when heated. It is an alloy made of 60% copper and 40% nickel.

		= m/v (g/cm^3 or kg/m^3) The density of solid and liquid matters is dependant on temperature and that of gaseous matters is dependant on temperature and pressure.
DIFFUSION	:	diffundere – Latin: to diffuse The gradual permeation or spreading out, e.g. of a substance through a liquid (ink through water) or of a gas or of ions.
DIVERGING LENSE	:	A lens that is thinner in the middle than at the edges, causing light rays passing through it to diverge.
ELECTROLYSIS	:	lysis – Greek: a loosening, decomposition The decomposition into ions of a chemical compound by the action of an electric current passing through the solution.
EMBRYO	:	embryon – Greek: seedling The rudimentary plant which is usually contained in seeds.
EMIT	:	emittere – Latin: to send out
ENERGY	:	A state of a body or a system of bodies that – among other characteristics – enables the body or the system to do work.

FREEZING	:	Change of state from the liquid to the solid form.
FRICTION	:	A force that arises to oppose the motion or attempted motion of a body pass another with which it is in contact.
INDICATOR	:	indicare – Latin: to show A substance used to indicate by change in colour the acidity or alkalinity of a solution.
INERTIA	:	The sluggishness or apparent resistance a body offers to changes in its state of motion.
INSULATOR	:	Any material through which charge resist flow when subject to an applied voltage.
ION	:	ionos – Greek: to move Electrically charged atoms or molecules, formed by the loss or gain of one or more electrons.
MAGNET	:	An iron–bearing matter which possesses the property of attracting iron.
MAGNETISM	:	The property or quality or condition of a magnetic field.

		concentration on both sides of the membrane.
OSMOTIC PRESSURE	:	The pressure caused by osmosis.
PARTICLE	:	Any body that is projected by some force and continues in motion by virtue of its own inertia.
PHLOEM	:	phloios – Greek: inner bark Bast–tissue; the soft bast of vascular bundles, consisting of sieve–tube tissue. Its purpose is to transport proteins and minerals.
PHOTOSYNTHESIS	:	phos – Greek/Latin: light synthesis – Greek: putting together Carbon assimilation, requiring the presence of chloroplasts and light, and consisting in synthesis of carbohydrates from carbon dioxide and water.
PHOTOTROPISM	:	phos – Greek/Latin: light tropein – Greek: to change A bending towards light.
POLYSACCHARIDE	:	polys – Greek: many saccharum – Latin: sugar

radiation, into voliant energy.

REFLECT	:	reflectare – Latin: to mirror
RODS	:	Cells which perceive light. About 6 milliosn are found in the retina of vertebrate animals. They serve to perceive light and the exact recognition of details.
SPEED	:	Distance traveled per time.
SPROUT	:	Usually the above ground part of a plant with the leaves, the buds, genital organs (e.g. blossoms).
STARCH	:	A polysaccharide which is insoluble in water. It consists of the two components amylose and amylopectin.
SURFACE TENSION	:	Tendency of the surface of a liquid to contract in area and thus behave similar a stretched rubber membrane.

SURFACE TENSION : Tendency of the surface of a liquid to contract in area and thus behave similar a stretched rubber membrane.

The government–owned GTZ operates in the field of Technical Cooperation. Some 4,500 German experts are working together with partners from some 100 countries in Africa, Asia and Latin America in projects covering practically every sector of agriculture, forestry, economic development, social services and institutional and physical infrastructure. – The GTZ is commissioned to do this work by the Government of the Federal Republic of Germany and by other national and international organizations.

GTZ activities encompass:

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– advisory services to other agencies implementing development projects

– the recruitment, selection, briefing and assignment of expert personnel and assuring their welfare and technical backstopping during their period of assignment

– provision of materials and equipment for projects, planning work, selection, purchasing and shipment to the developing countries

– management of all financial obligations to the partner country.

Source Book for Teaching, Learning and Enjoying Physics

Table of Contents

Source Book for Teaching, Learning and Enjoying Physics

SOURCE BOOK

IDEAS FOR TEACHING PHYSICS TO BEGINNERS WITH LOCALLY AVAILABLE MATERIALS

IDEAS FOR TEACHING, LEARNING AND ASSESSMENT BY DOING

MZUMBE BOOK PROJECT
P.O. Box 19 MZUMBE,
MOROGORO • TANZANIA

This source book is the result of a workshop held at Morogoro Secondary School (Tanzania) from July 15th to 26th 1991. The workshop was organised by the Ministry of Education and Culture in cooperation with the Goethe–Institüt (German Cultural Institute).

Workshop Administrative Coordinator:

Ignatius Sarikoki, Ministry of Education and Culture, Tanzania

Workshop Technical Coordinator:

Hans Schmidt, Darmstadt, Germany

Editing Coordinators:

– German Didacta Association, Frankfurt, Germany (Deutscher Didacta Verband, e.V.)
– Merck Ltd., Darmstadt, Germany.

Type set by B.B. Sallim, Mrs. A. Mihigo

Graphic design by R. Kanyawana, C. Mdachi, P. Ndunguru

Darkroom technique: M. E. Mwano, Miss. E. Mwombeki

Production Supervisor: C. Mazunda

ISBN 9987 552 11 0

Printed and Bound by

Mzumbe Book Project
P.O. Box 19 Mzumbe
Morogoro – Tanzania

List of Participants:

Alinanuswe W.P. Mwakabanje
Loleza Secondary School

Daudi Mbungu
Tambaza Secondary School

Busanji Wilson Faustine
Kilakala Secondary School

Samwel N.J. Mwakasonda
Tabora Boys Secondary School

Mrs M. Muyenge
Mzumbe Secondary School

George Emmanuel
Morogoro Secondary School

Detlef Pietz
Iyego Secondary School, Murang'a, Kenya

Jones M. Waryoba
Institute of Curriculum Development, Tanzania

J.M. Sekulu
Kleruu Teachers Training College

Dr. Manfred Spohr
Dar es Salaam Teachers Training College

A.S. Mrutu
Ministry of Education

D.D. Ben Enjiku
Institute of Teacher Education – Uganda

Ignatius Tabaro–Sinaruhamagaye
National Curriculum Development Centre – Uganda

Foreword

fun for him. Most of the experiments described in this book can be performed in a very short time and without long sessions of preparation.

The described experiments are not only for school purposes, but also for other people interested in this subject.

It is my sincere hope that this book will contribute to the building up of a broad line of people in our country who are interested in learning more about Physics.

LET US ENJOY PHYSICS BY DOING
L.K. MSAKI
Acting Commissioner for Education

Preface

This source book is addressed to people who are concerned with teaching Science at the Junior Secondary School level. This includes Teachers, Teacher Training College Tutors and University Lecturers. Nevertheless, the book can be useful to Science Club Masters and Students who want to experiment on their own. The main audience are the teachers and tutors who work in inadequate teaching and learning conditions trying to encourage students to develop capabilities to master and use science in their daily life.

This source book contains therefore experiments and activities which can be performed in any classroom and in a very short time with a few low or even no cost materials. Moreover, these practicals do not require a long preparation time.

Such easy to carry out experiments for and through beginners have a long standing tradition in the history of teaching science. They are called *handy experiments* because they can be performed "by hands" only without any difficulties.

You will find in this source book ideas and suggestions which are not normally found in textbooks. We assume that the teachers know most of the traditional experiments which are found in the usual textbooks. Therefore

How to Use This Book

This source book may be used in connection with the series of textbooks called "Enjoy Physics", volume I and II, produced by the same publishers, the MZUMBE BOOK PROJECT. These books have been written with great emphasis on the use of materials which can easily be obtained from our environment. However, this source book may be also used without these textbooks.

Many students think that Physics is a very tough subject and they actually fear it. If you as a Physics teacher use the approach suggested in this source book, you can be quite sure that your students will lose their fear. They will become interested and creative in Physics. They will like and even enjoy your Physics lessons. This way they will be able to develop those talents which are needed for real development to take place.

Being a Physics teacher, this book will help you to master the simple techniques described in order to be able to make simple apparatus, models and other teaching aids. After this you may want to transfer the skills to your pupils so that they may help you in making the required items.

The experiments described in this book are simple and can be carried out even in the absence of a Physics laboratory. The Physics kit described in the appendix is meant to be self–contained. However, first you may select only a few experiments from each section. Therefore, we have listed the materials needed for each single experiment in the appendix. Of course, each kit needs all the *materials* listed on p.111 and these were omitted in the list of materials of the various experiments (see p.112).

Perhaps your students might become interested to prepare the materials for further experiments described in this source book. Thus, after some time you might be able to carry out most of the experiments suggested.

For heating purposes an improved, sootless kerosene burner has been developed which any "fundi", who makes normal "vibatari", is able to produce, see p. 109.

Being a Student, this book may also help you in the designing and carrying out of physics projects. If you produce your own Physics kit, this will provide you with a kind of minilab at home.

Using it, you can train yourself on the practical and investigating aspects of Physics. Therefore, you will enjoy Physics and develop your talents in this subject. This way, Physics may contribute to self–substained

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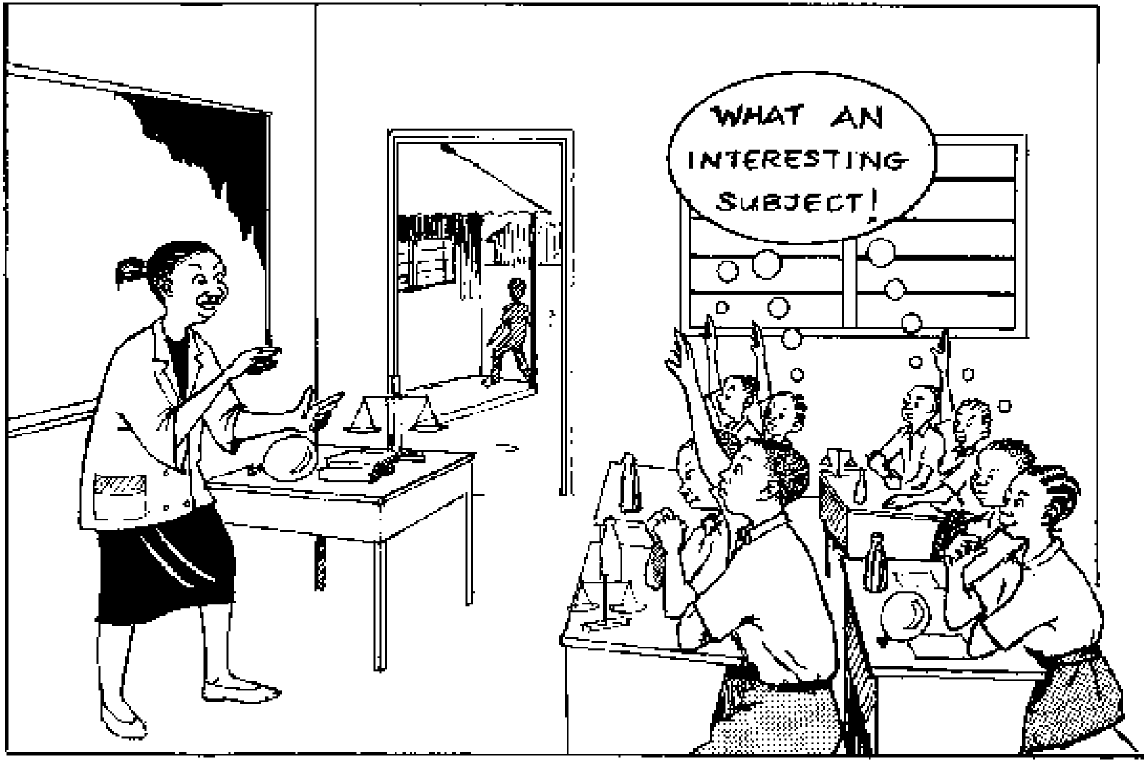
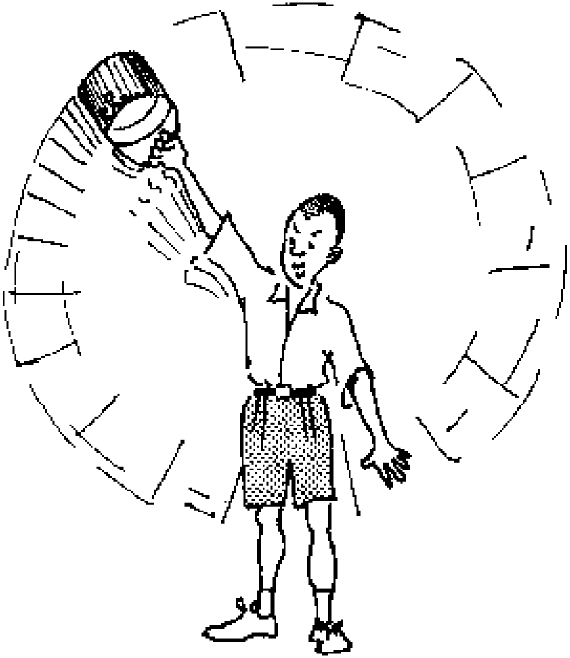




A bucket of water is sufficient to start investigating the effect of centripetal forces. Fill the bucket with various quantities of water and you will learn even more by doing. Increase the number of revolutions of the bucket.

Physics must not be a boring, tough subject, just good for exams and to be understood by a few "experts" (nly. Physics should not happen in books only. It is everywhere where things are. The teaching of science without experiments is just like a ngoma without dancers.

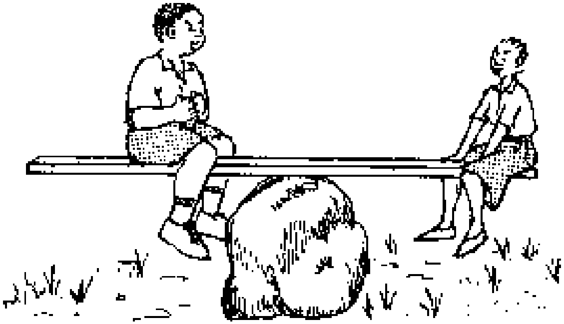
Pupils learn more and better by doing. Stimulate them to investigate their environment through easy to carry out experiments. Ask the pupils to make a list of physical phenomena which can be observed in their environment. Let the pupils enjoy physics. This sourcebook shows how this can be achieved.

1.2 Laboratory Techniques

indispensable.

Therefore physics as a subject has to introduce even beginners to the principles of measuring and data collection. "I have no measuring instruments in my school," you may say. Really? Let the students enjoy physics starting with measurements which are easy to carry out and the construction of measuring instruments. For a lot of hints see chapter 2.

1.3 Basic Mechanics



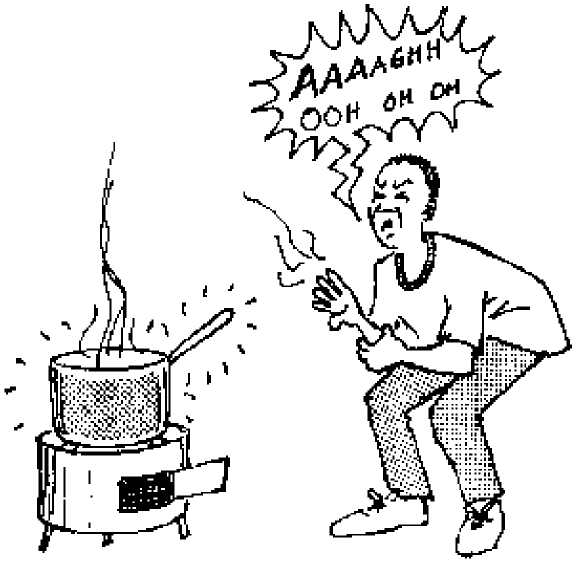
Have you observed children balancing a plank like a seesaw? They know how a big and a small child can balance although they are of different weight.

Usually they do not know what a fulcrum, a load distance and a moment of force is. However, such basic mechanics dominate an essential part of our daily life. We encounter motion, friction, inertia, work and power almost every day. We also learn in a practical way about density, pressure of fluids or gases. Work, energy, power and other physical phenomena look very abstract in books but happen every day. Also the movement of earth, moon and the planets which determines the lengths of our days, months and years, has to do with basic mechanics such as motion, mass attraction and centripetal forces.

Ask the students to discuss where such basic mechanics phenomena can be observed. Discussing only? No! There are plenty of meaningful experiments. For these, see chapter 3.

Discuss with the students from which evidence we can conclude the existence of particles and ask them to write an essay about this. You may think, there are no experiments possible about states of matter, diffusion, molecular forces and other properties of matter? Failed! For details see chapter 4.

1.5 Thermal Physics



Would you ever touch the handle of a hot pan? Not me. Would you put margarine just aside of the pot? Not me. Would you hold your hand right above the hot water? Not me. This is because, we know a lot about thermal physics by daily experience. But we do not always relate this knowledge with what we learn at school about heat conduction, heat radiation or heat convection as is the case in the examples mentioned above.

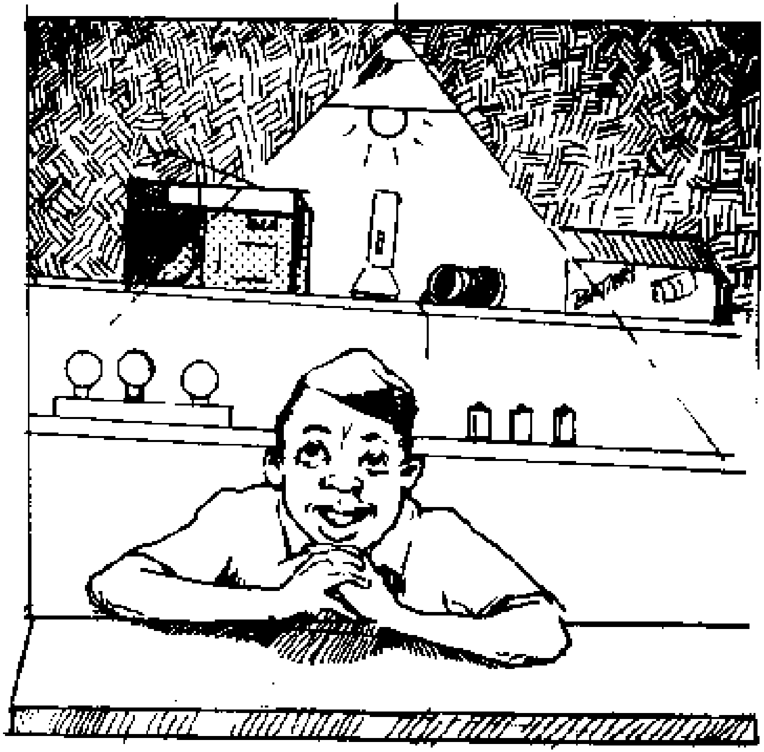
Thermal physics has also to do with thermal energy and the measurement of temperatures, with calorimetry, change of states, expansion, etc. Ask the students to talk about everyday thermal phenomena and to write about these. Why should we teach this topic by talk and chalk only, if there are illustrative experiments which

However, children know how to construct a good string telephone. Two tin cans are needed, also a string which is tied with a knot in a hole at each can. The string should be stretched and not be slack. It should not be heavy. All this is everyday knowledge about the transport of sound waves.

But teaching about waves does not mean only sound waves. We already have mentioned electromagnetic waves. Water waves we notice in a water puddle as well as in a cup of tea.

Produce waves in physics not only by talking. Meaningful and simple experiments are possible on many themes of this topic. No time? Hand experiments are always brief, illustrative and can be carried out with everyday things. Get ideas by reading chapter 6.

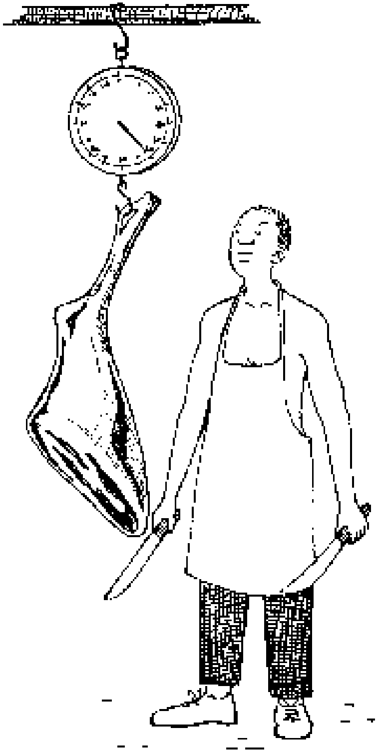
1.7 Geometrical Optics



Effects of electricity can be observed nowadays nearly everywhere. A light bulb lights the room, a radio enchants our ears and a torch helps to find our way in the darkness and last but not least we do owe a cool soft drink to a refrigerator. The understanding on how electric apparatus work is essential nowadays.

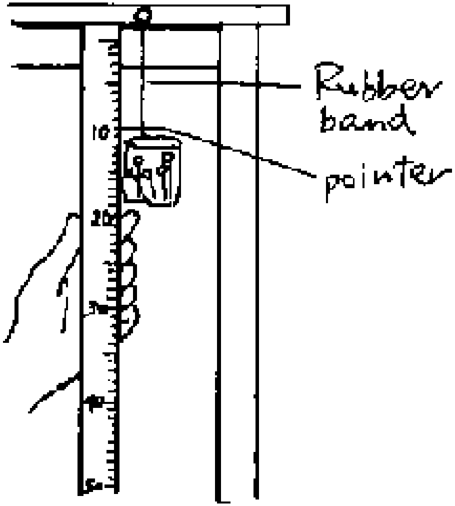
But electricity does not only mean a current flows in a circuit. It means also static electricity or a lightning during a thunderstorm. The topic electricity is closely related to magnetism. Without magnets electric motors would not work. Loudspeakers work with magnets and even a simple bicycle dynamo has one. In harbours you can see how "attractive" magnets can be to lift heavy loads. Do you think that the teaching of electricity by doing is difficult, needs a lot of equipment and is even dangerous? Brief and attention attracting experiments

2. Laboratory Techniques



2.1 Collection of Data

Man's progress is due, in large part, to his ability to measure and hence collect data with greater and greater precision. Young pupils should learn, generally, about how to obtain data by carrying out simple experiments.



Number of nails	Extention in mm
1	
2	
3	
4	
5	
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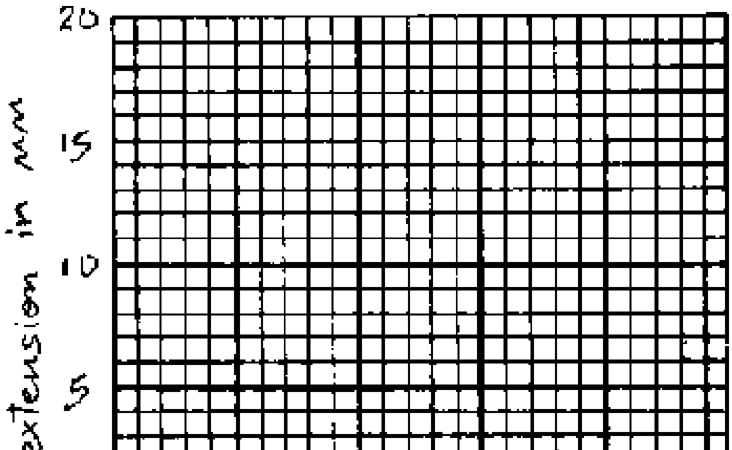
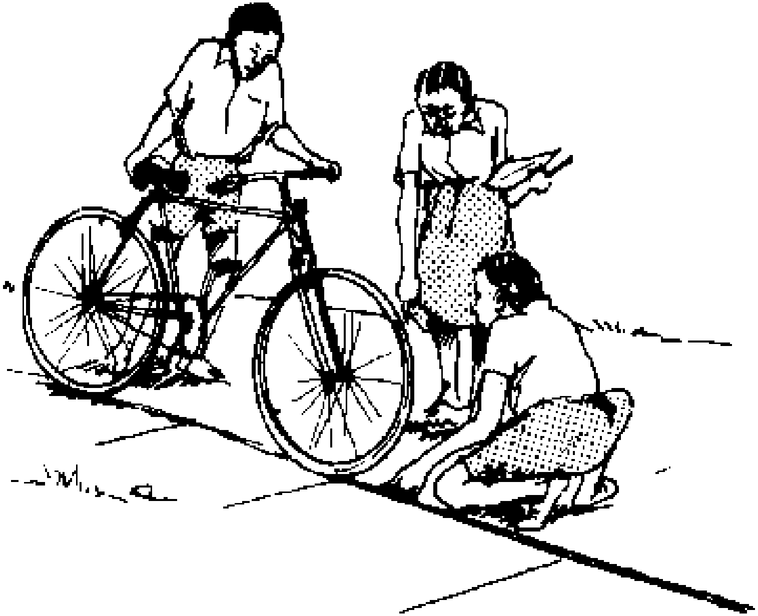
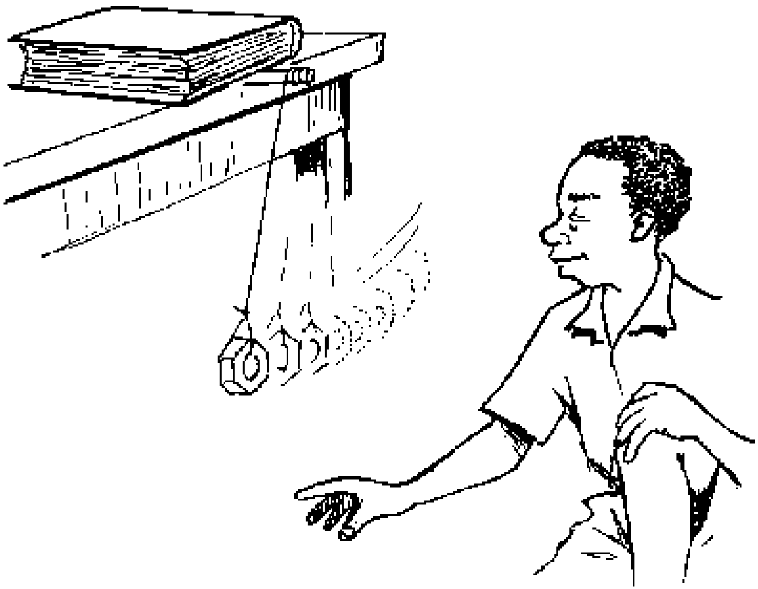
16	





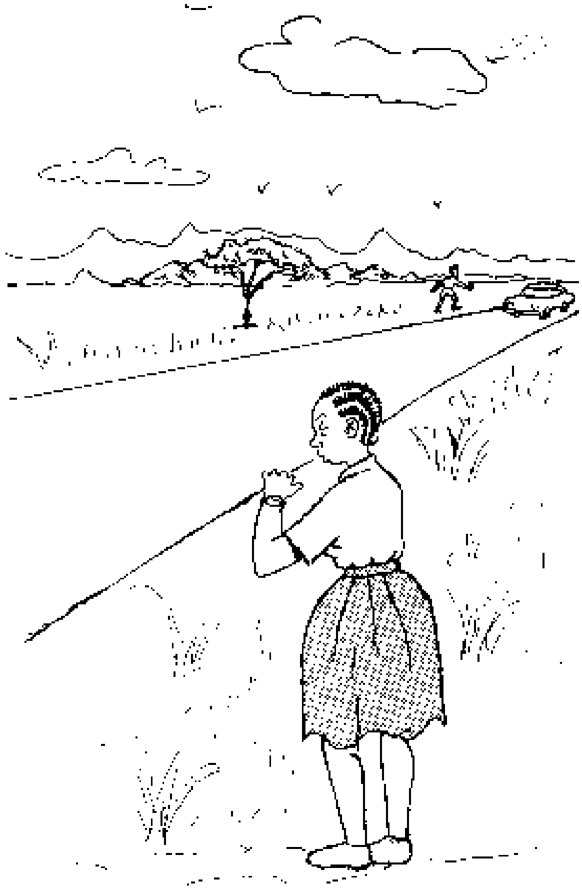
TURNS	DISTANCE

Make a mark on the tyre of a bicycle or a car at a point just next to the surface of the pavement. Turn the tyre to move straight forward along the pavement and measure and record the length of one turn. This is the distance covered when the mark is about to make contact with the pavement again. Let the pupils repeat the



LENGTH OF PENDULUM	SWINGS		
	5 CM	10 CM	15 CM
50 cm			
75 cm			
100 CM			

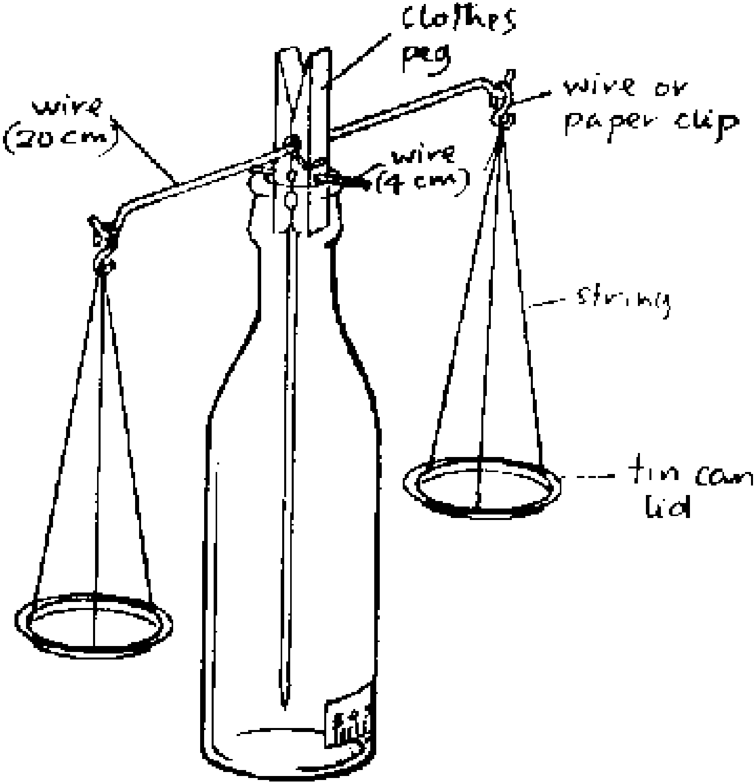
Fix a thin thread somewhat off the edge of a table and hang e.g. a nut at a distance of 50 cm on it. You have made a pendulum. Hold the (nut) pendulum and pull it to one side, so that it is horizontally displaced by 5 cm. Start counting the number of oscillations (back and forth) that take place in one minute. Record your result as shown. Repeat the experiment by horizontally displacing the nut by 10 cm and 15 cm consecutively. Try to find out the length of a pendulum which happens to oscillate just 60 times in one minute.



Mark a distance of 100 metres along a nearby road or playground. Note the time taken for a car, a bicycle or a sprinter to cover the distance as follows. One pupil waves down his hand as either the car, bicycle or sprinter crosses the 0 metres mark. Another pupil with a watch, starts timing at the same time. A third pupil at the 100 metre mark waves down his hand as the moving object crosses the 100 metre mark and at this instant the

A balance for teaching moments and equilibrium can be made from a ruler or a thin wooden bar. A balance for introducing equilibrium consists of a wire with a loop for hanging in the centre and with two hooks at the ends.

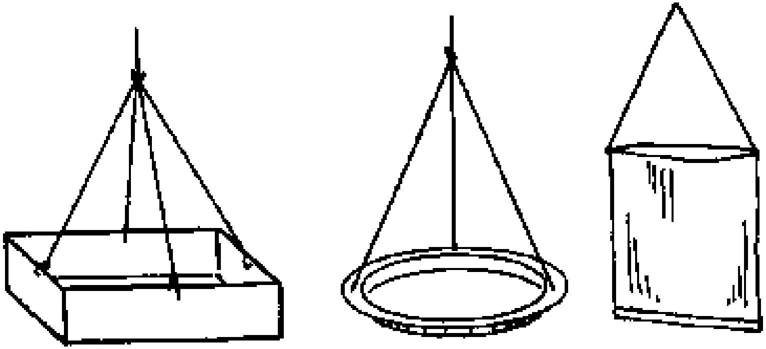
2.1.6 Sensitive Laboratory Balance



Drill a hole through a clothes peg below the spring for a wire or nail to pass through. Fix a wire right in the spring as a balance beam, and another one in the mouth of the peg as a pointer. (The shorter the pointer, the

(b) Where there are no standard weights, use syringes or measuring cylinders to fill plastic bags with equal amounts of water. Use the fact that 1 cm^3 of water has a mass of 1 gram.

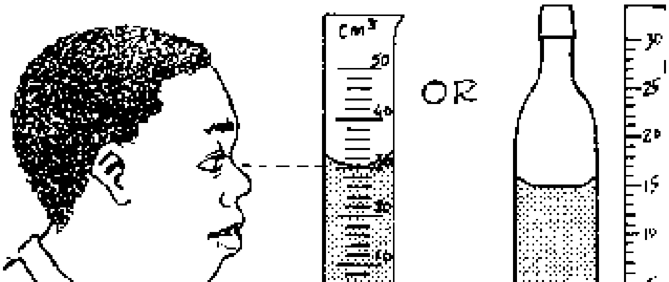
2.1.8 Weighing Pans

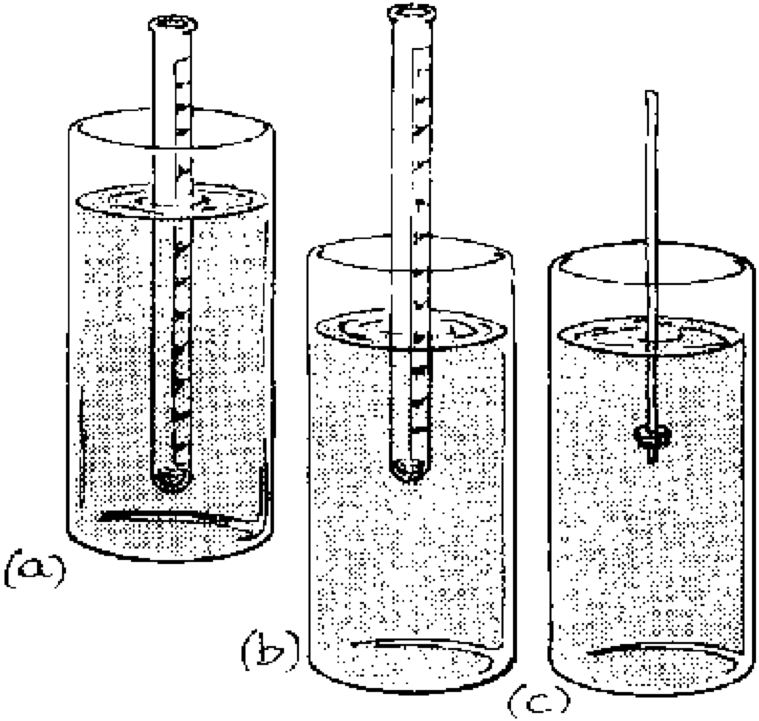


(a) (b) (c)

Weighing pans can be made from match boxes (a), plastic lids (b), or even small plastic bags (c) as used for wrapping ground nuts.

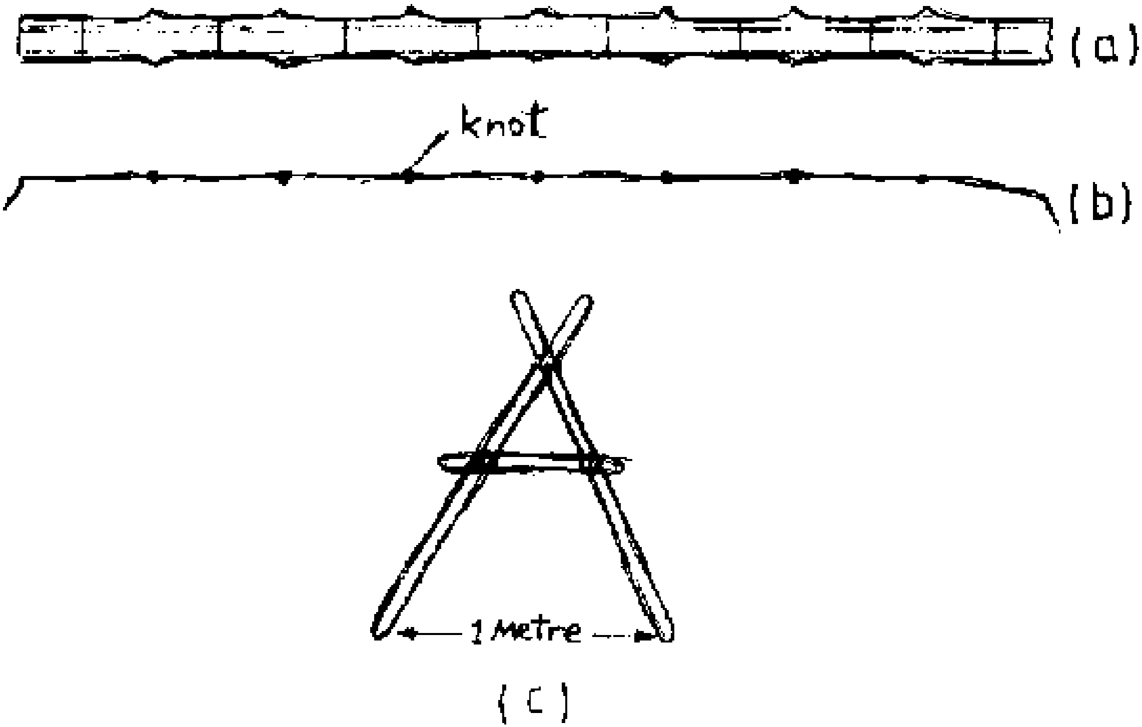
2.1.9 Measuring Liquids





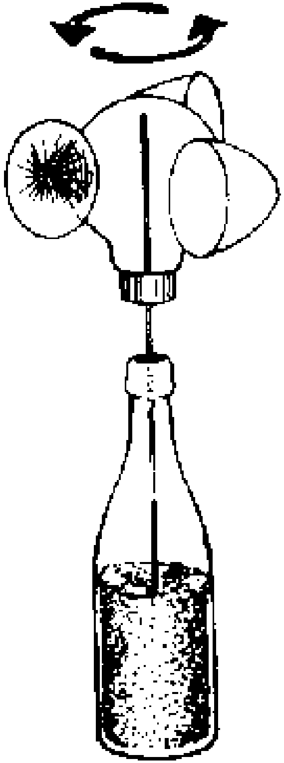
Fill a test tube with sand to keep it upright in water (b). Place a paper scale inside or fix a nut or a stone at one end of a wooden stick. Make regular marks (scale) along the wooden stick (a). Dip the tube or wooden stick in water (b), oil (a), (or kerosene, ethanol, etc.) and record in each case the extent to which the device sinks.

2.1.11 Measuring Irregular Bodies



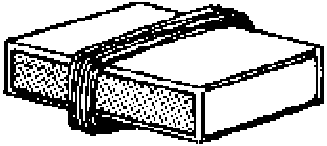
Measuring devices can be made from wooden sticks (a,c) or from strings by making knots at definite intervals (b). The sticks can be arranged closely together in succession to measure distances on uneven ground.

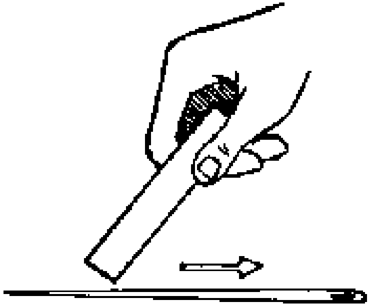
2.1.13 Wind Direction

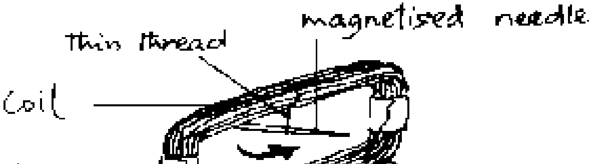


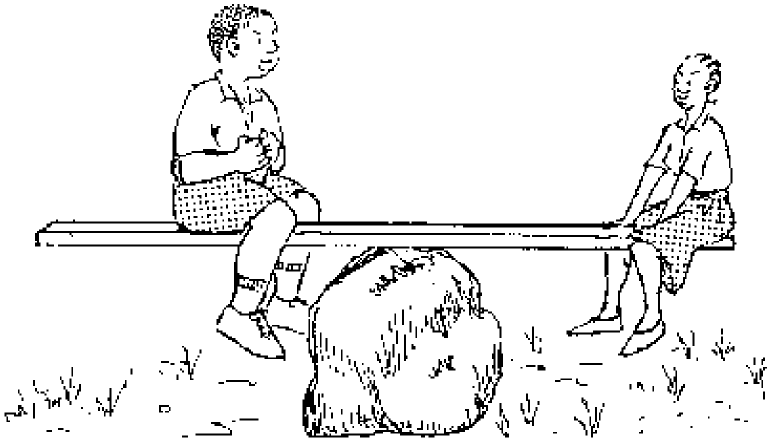
Fold 3 cones from round paper disks (preferably from cement bags or other resistant paper). One cone should be painted outside in a different colour for a better counting of the number of revolutions. Glue the cones to the bulb. Insert a piece of stiff wire which can be dipped in a sand filled bottle as a support (see experiment 2.1.13).

2.1.15 A Simple Current Indicator






magnetised needle
thin thread
Coil



3.1 Rectilinear Motion

This section introduces the uniform and the accelerated rectilinear motions, i.e. those having constant velocity and constant acceleration.

Definitions:

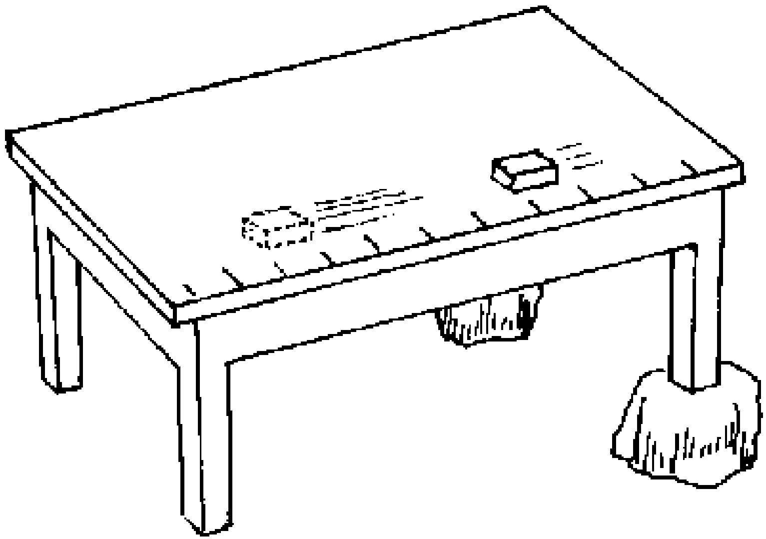
Displacement = distance measured along a straight line
Velocity = displacement ÷ time taken
Acceleration = change in velocity ÷ time taken

Uniform and accelerated motions play an important role in the movement of cars, buses, trains, ships and aeroplanes.

3.1.1 Uniform Motion

A: Where does this motion occur in daily life? – For example, a bus, a train or a boat going at constant speed on a straight line path.

3.1.2 Accelerated Motion

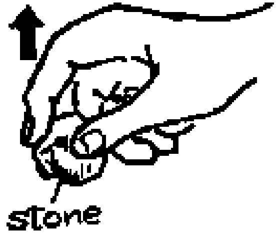


P: Tilt the smooth table or plank more than in experiment 3.1.1.

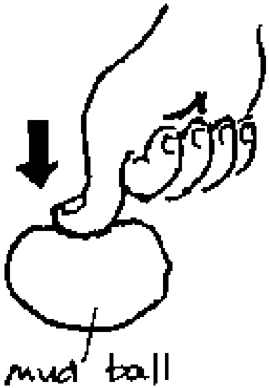
Q: How is the time which the matchbox needs to cover the distance between two marks? Is this time getting shorter when the box moves down?

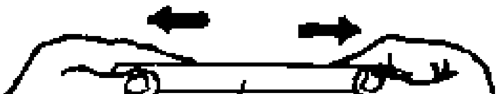
E: If so, this is an *accelerated* motion. Its velocity changes as the box moves down. Its velocity *increases.* Thus, it is an accelerated rectilinear motion.

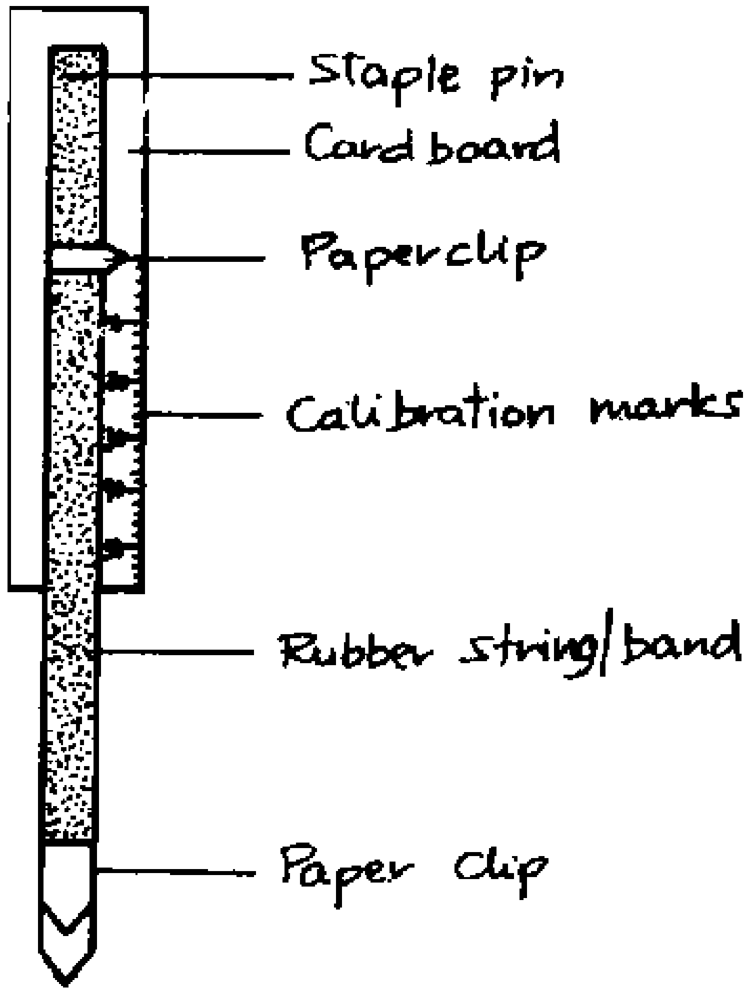
A: Where do such motions occur in daily life? – For example, a stone falling down; a bus accelerating after the stop; a bus breaking before a stop.


stone

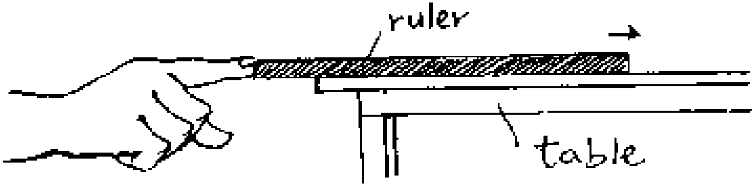

stone

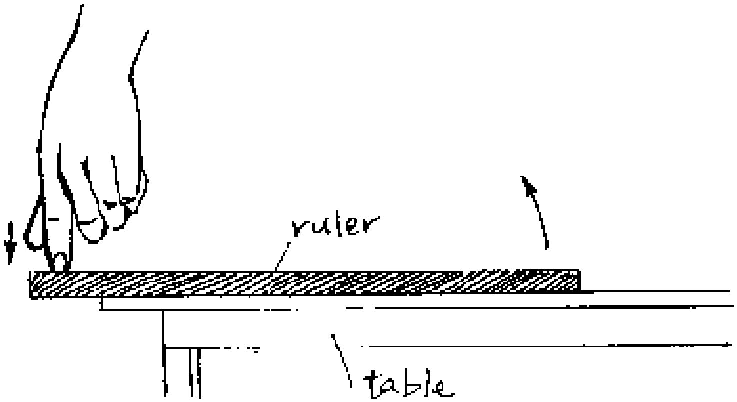

mud ball





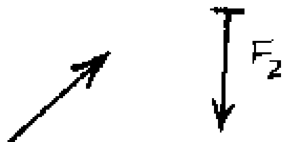
Forces are measured with a Newton balance.

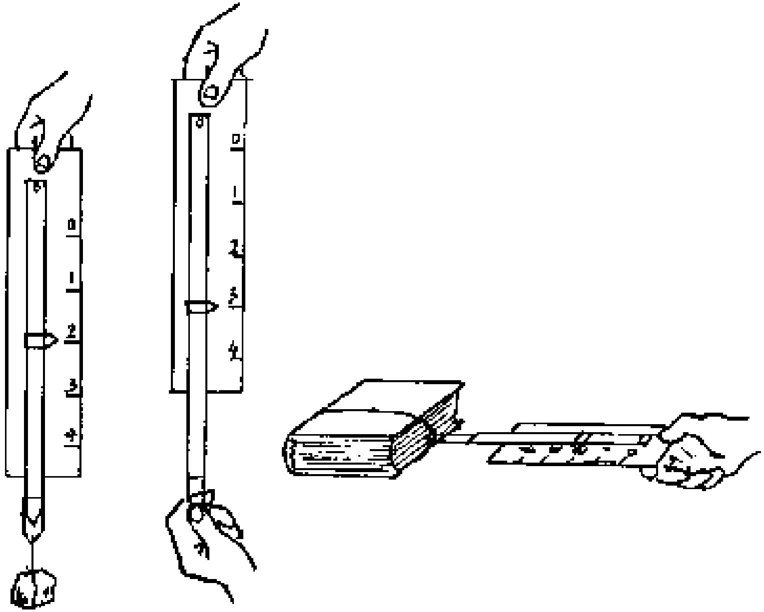




P: Show that the direction of a force is important for the effect of a force by applying a force on a stick in various directions, see the figure.

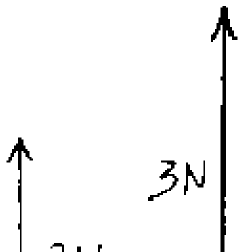
3.2.4 Forces as Vectors



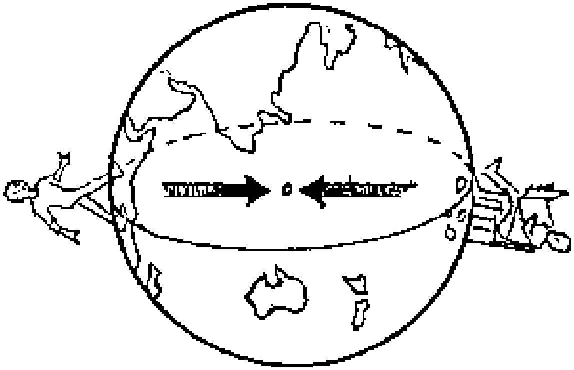


P: Using your Newton balance measure various forces like the force needed to lift different stones, the force needed to pull a book sliding over your desk, the force to stretch a spring, etc.

3.2.6 Drawing Forces



3.3.1 Weight as the Pull of the Earth



P: Hold a stone at the level of a table plate and release it.

Q: What do you observe?

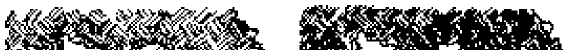
O: It will fall down to the floor.

E: It changes its velocity, i.e. a *force* must act on it. This force is the pull of the earth on the stone. This pull is always directed to the centre of the earth. Thus, the weight has magnitude and direction. It is a *vector.*

Hence, as the figure shows, the weight of people in different regions of the world has different directions. However, it is *always directed to the centre of the earth.*

The *magnitude* of the weight of the same body is *not* everywhere the same. The further away from the centre of the earth the body will be, the less its weight will become.

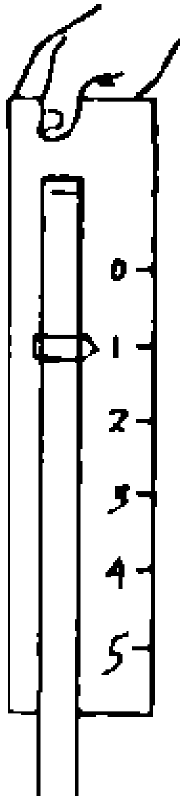
3.3.2 Mass as the Quantity of Matter



E: The greater the mass of a body, the more it resists to any change in its velocity. We say, the greater the mass of a body, the greater its *inertia.*

The quantity of matter of the same body, and hence its mass, is everywhere (e.g. on the earth, on the moon, etc) the same. Mass has no direction, thus it is a *scalar.*

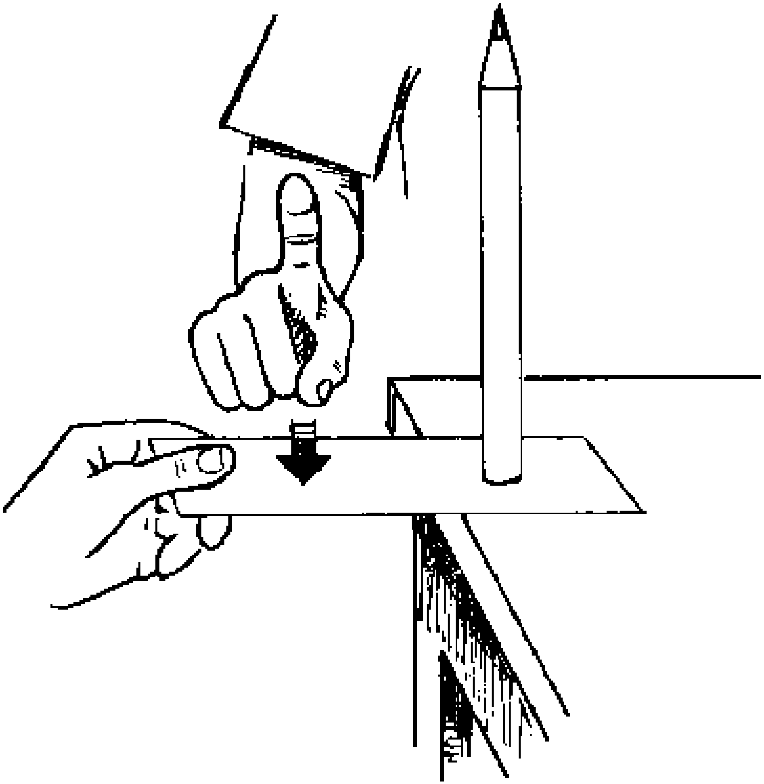
3.3.3 Weight is Measured by the Newton (Spring) Balance



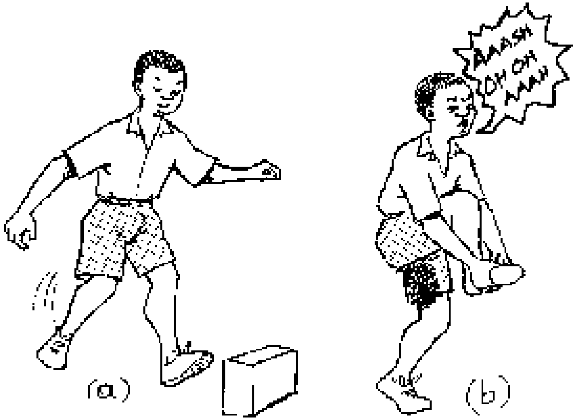
The mass of a body is measured by the beam balance.

P: Take a beam balance and a set of weighing pieces (see p. 10) and measure the mass of a pencil, a book, etc. in grams (g).

3.3.5 The Surprising Pencil



P: Stand a pencil upright on a strip of paper near the edge of a table. At once hit the strip with your finger so

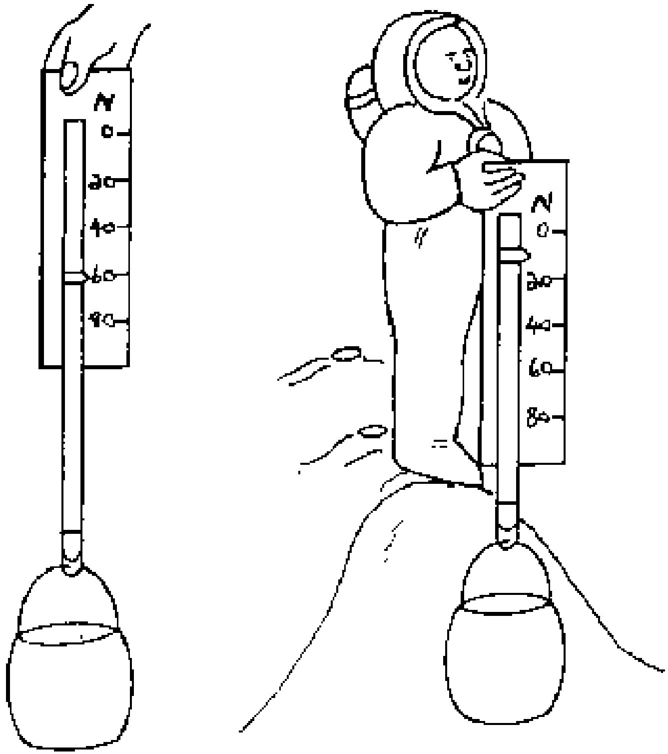


P: Ask students to draw the figure on a display chart.

Q: Why does the student feel great pain after he kicked the brick? Would the same happen, if he kicked the same brick on the moon?

E: He feels pain because the brick has a greater mass, and hence a greater inertia than a football. The same would happen at the moon, because the mass, and hence the inertia of the brick, is the same on the moon.

3.3.8 Car Crash



(a) On the earth (b) On the moon

P: Make a display chart of the figure.

Q: Why is the weight of the same bucket of sand less on the moon than on the earth?

E: The weight of a body depends on the place where the body is. It is *not* everywhere the same.

3.3.10 The Mass Stays the Same

Moment of a force = force x perpendicular distance from the pivot

In equilibrium: total clockwise moment = total anti–clockwise moment

The *centre of gravity* (centre of mass) *is the point in which the total weight of the body seems to act.*

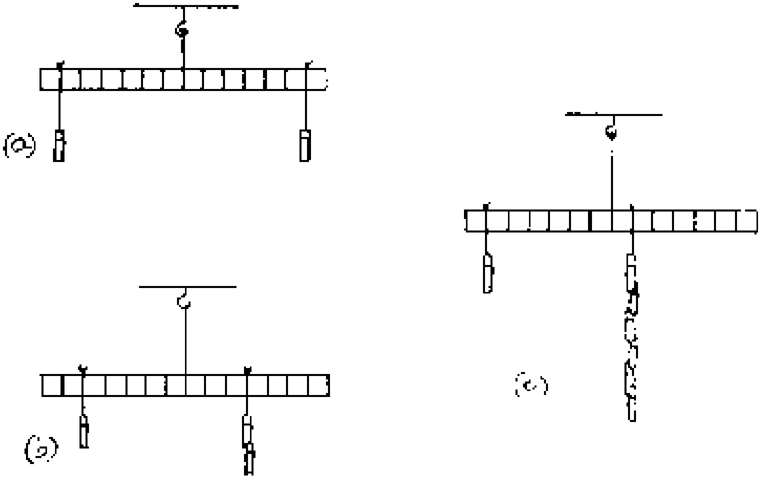
The stability of a body depends on the position of its centre of gravity (COG).

A body is in *stable* equilibrium if a small movement would rise its COG.

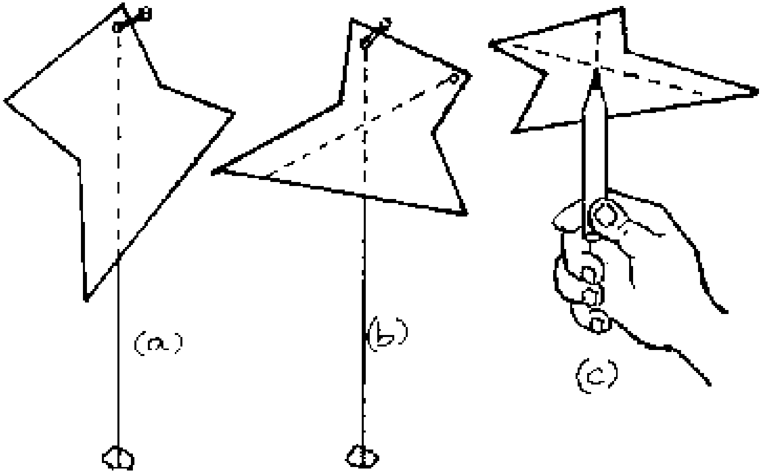
A body is in *unstable* equilibrium if a small movement would lower its COG.

A body is in *indifferent* equilibrium if a small movement would keep the COG at the same level.

3.4.1 Moment of a Force



P: Cut a piece of cardboard 40 cm x 3 cm and attach a supporting string exactly at the middle of it in a hole



P: (a) Cut a piece of card into an odd shape (see fig.(a)). Suspend it from a nail and attach a string with a stone. Mark the position of the string using two crosses. Join these using a ruler to form a pencil line.

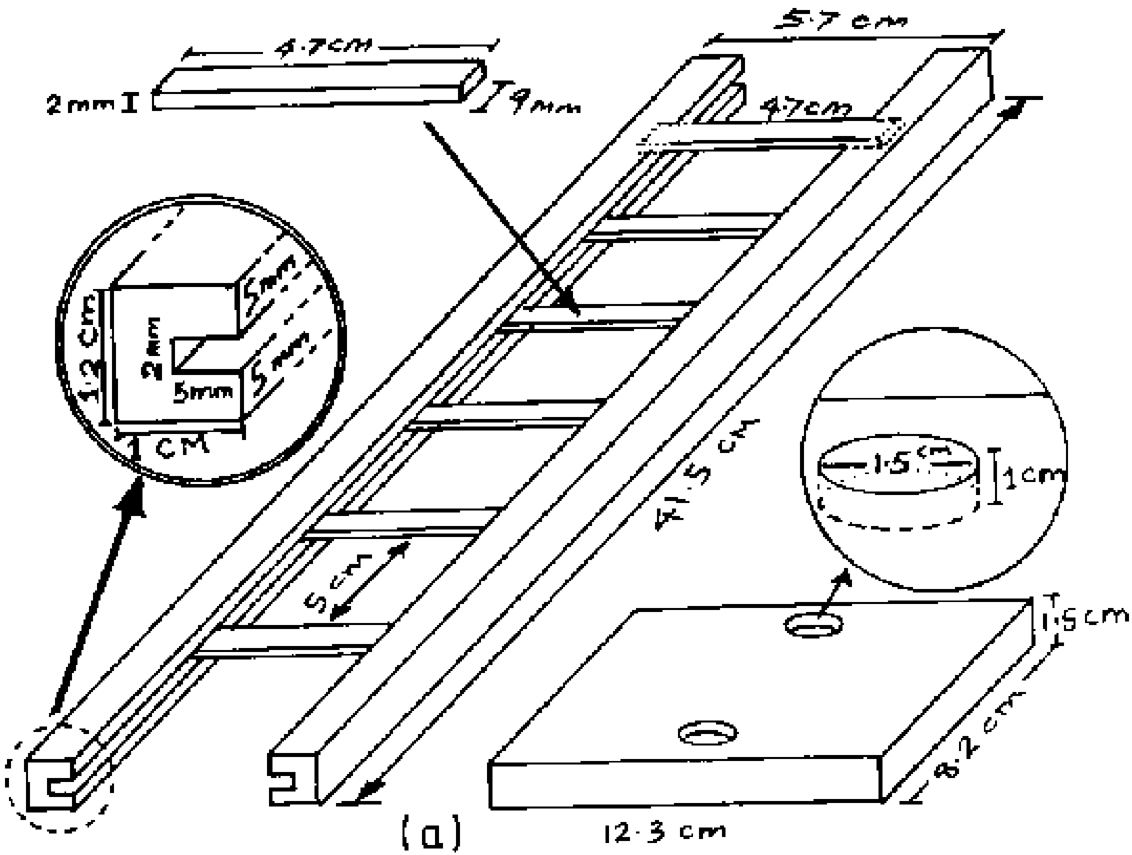
(b) Repeat (a) but fix the nail in another position on the card (see fig.(b)). Where the two pencil lines meet is the *centre of gravity* of the card.

(c) Now support the card with the tip of a pencil below the centre of gravity.

Q: What do you notice about the stability of the position of the card?

E: The position of the card remains stable as long as it is supported in the centre of gravity because now all the moments of the weights of all the mass particles of the card balance.

3.4.3 The Funny Jumper

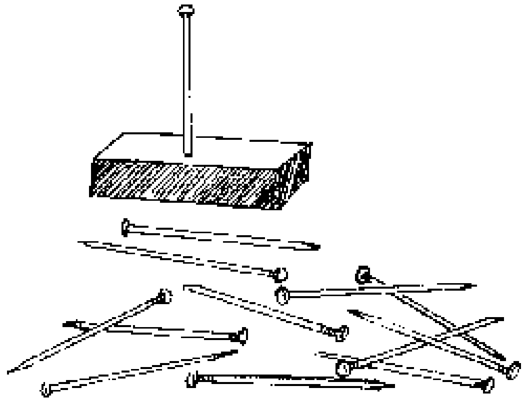

4.7cm
2mm
9mm
5.7 cm
47cm
5mm
2mm
5mm
1.2 cm
5mm
1 CM
41.5 cm
5 cm
1.5 cm
1cm
1.5 cm
8.2 cm
12.3 cm

(a)

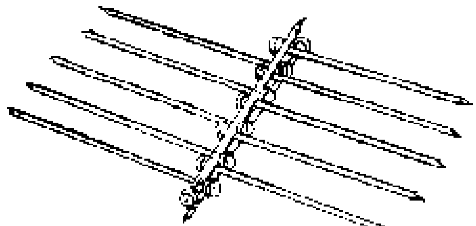
O: The jumper jumps from one step to the next down the whole ladder.

E: First the centre of gravity of the jumper is above a step of the ladder. This is an *unstable equilibrium since* the COG is lowered when the jumper turns round to hang on that step. However, due to the slot it has, it then falls down to be *above* the next step. Thus, the process is repeated until the jumper meets the ground level.

3.4.4 Balancing Nails

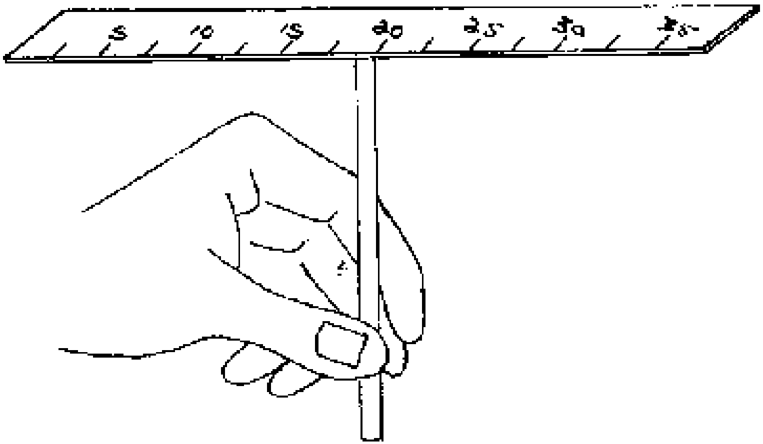


(a)



supporting head of the first nail. Thus, a *stable equilibrium* is reached.

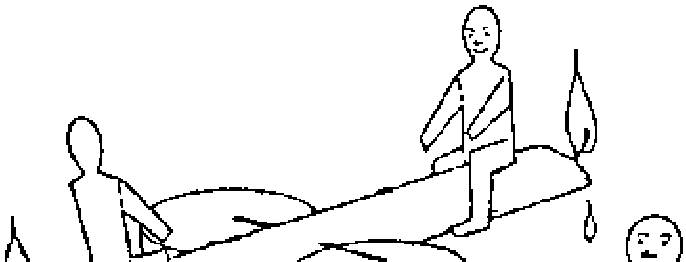
3.4.5 The COG of a Ruler



P: Find the centre of gravity of a ruler by balancing it on the tip of a pencil.

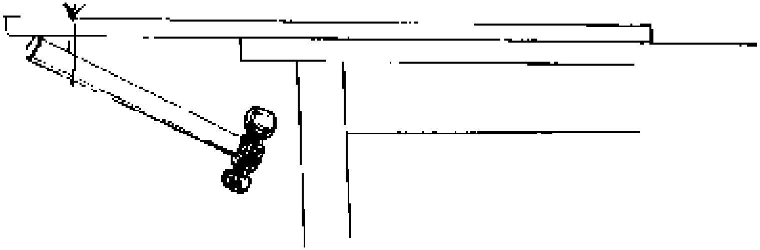
Q: Where does the COG of the ruler lie? Why?

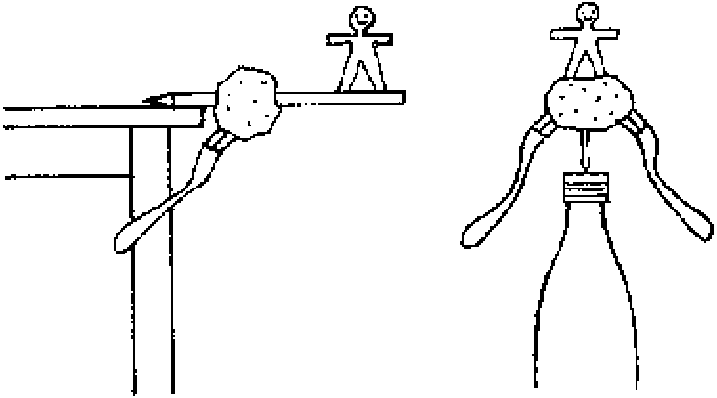
3.4.6 Candle Balance



Q: Why do the coins not fall down?

3.4.8 Riddles

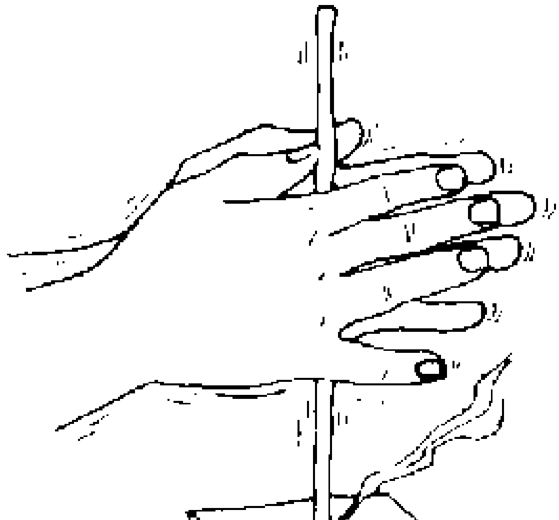


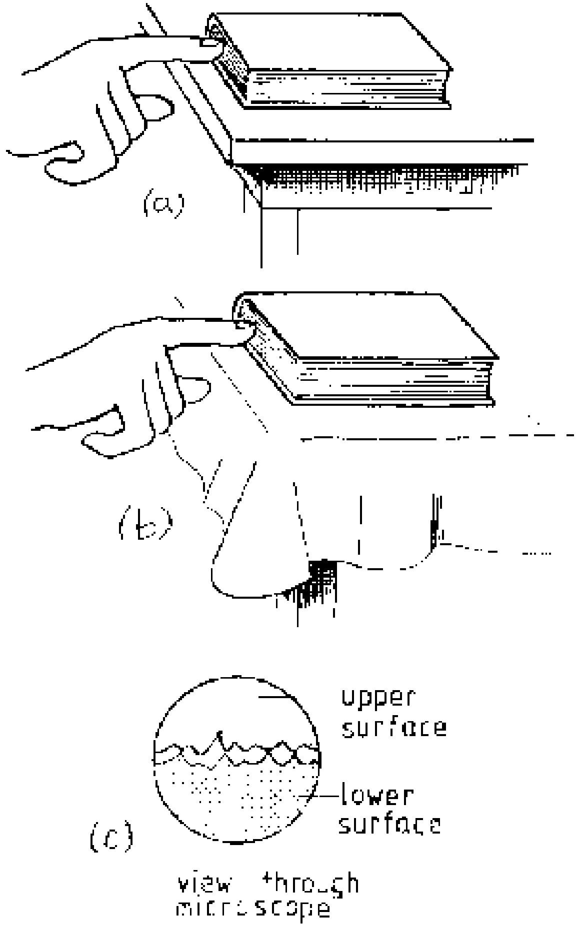


P: Produce the arrangements shown in the figures (a) and (b).

Q: Why do they not fall down?

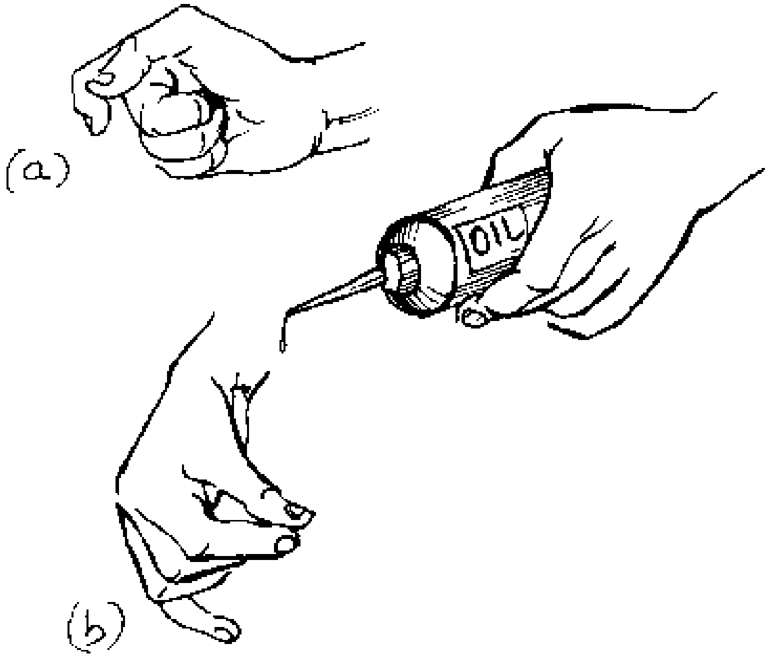
(a)





P: Pull a book on a bare table surface and then on a piece of cloth.

Q: On which surface is it harder to pull? How docs the force of friction compare on the two surfaces? How can

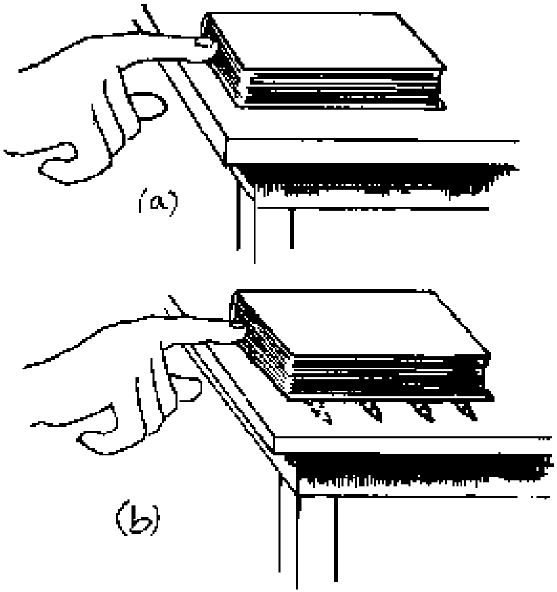


P: Rub your thumb and a finger together. Then place a drop of cooking oil or margarine on your thumb and repeat rubbing.

Q: How do the forces of friction (needed for the rubbing) compare in the two cases? Hence, what can be done to reduce friction?

A: Lubrication of bearings etc. to reduce friction.

3.5.4 Rolling and Sliding Friction

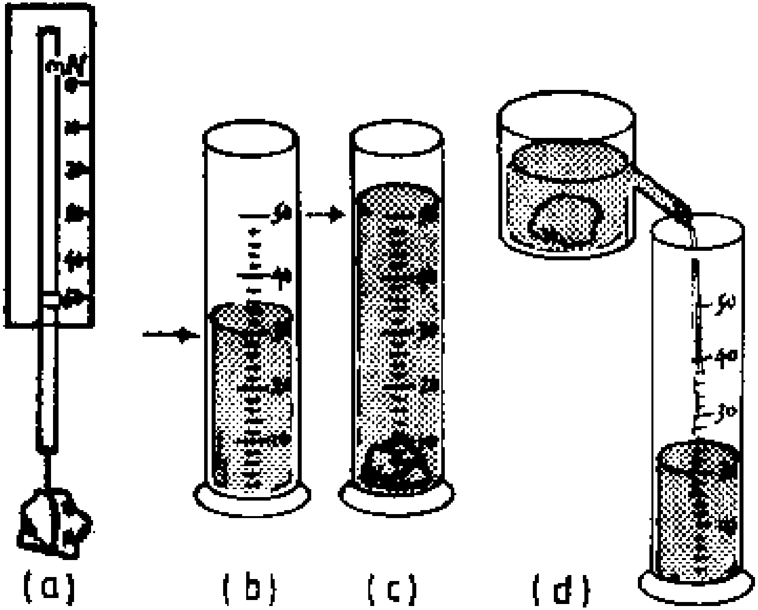


P: Pull a book over a table. Put some round pencils or drinking straws between the book and the table.

Q: How do the forces of friction compare now?

A: Roller bearings, ball bearings.

3.5.6 Where Friction is Needed



P: Attach a stone to a thread and determine the weight of the stone using a Newton balance, see fig.(a). Calculate the mass of the stone. Fill a measuring cylinder partly with water and record the volume, see fig.(b). Now immerse the stone fully in the water and record the new volume, see fig.(c). The difference in volume gives the volume of the stone. Alternatively, you can produce an overflow can from a tin using aluminium foil to make the overflow pipe, see fig.(d). Make the joint of pipe and tin water–tight using glue. Now calculate the density of the stone.

E: Assume that the stone has a weight of 0.5 N. Then its mass is

$$0.5 \text{ N} \div 10 \text{ N/kg} = 0.05 \text{ kg} = 50 \text{ g}$$

(Of course, the mass could be measured using a beam balance.)

Q: Determine the mass of the water and of the liquid. Calculate the volume of the density bottle and the density of liquid A.

E: E.g: Mass of empty density bottle = 15 g

Mass of density bottle with water = 68 g

Mass of density bottle with liquid A = 45 g

Then: Mass of the water = 68 g – 15 g = 53 g

Thus: Volume of density bottle = 53 cm^3

Mass of liquid A = 45 g – 15 g = 30 g

Thus: Density of A = 30 g ÷ 53 cm^3 = 0.56 g/cm^3

H: Be very careful when opening the worn out bulb, see appendix.

3.7 Pressure in Liquids and Gases

The pressure in liquids and gases is caused by their weight. It is defined as follows:

Pressure = force ÷ area

The laws of pressure govern many technical devices like barometers, manometers, pumps, etc.

3.7.1 What is Pressure?

P: Ask a student to support a book as shown in figure (a). Then turn the pencil upside down as shown in figure (b).

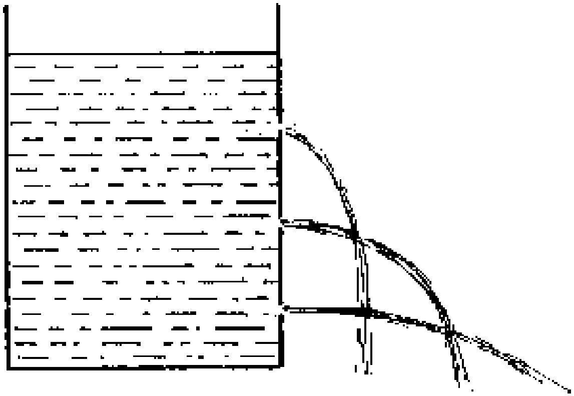
Q: What will the student feel? Why?

O: In case (b) the student will feel pain on the hand supporting the pencil.

E: In case (b) the force with which the pencil acts on the hand is the same (equal to the weight of book plus pencil) as in case (a) but the pressure on the hand has increased very much since the area on which the pencil touches the hand has decreased so much. Hence, the students will understand that pressure = force ÷ area.

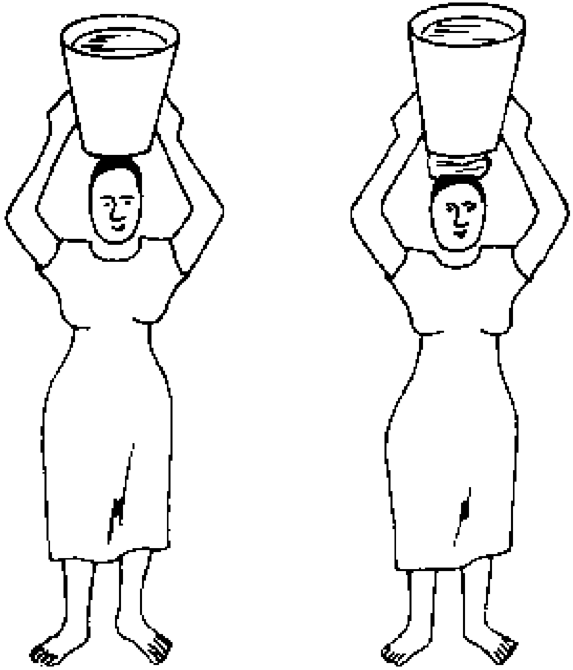
A: Large area feet of elephants; wide tyres of tractors; wide chains of caterpillar machines.

3.7.2 Liquid Pressure Increases with Depth



P: Pinch 3 holes into a tin according to the figure. Fill the tin with water up to its rim. What do you observe?

Q: How does the pressure change with the depth of the water? Why?

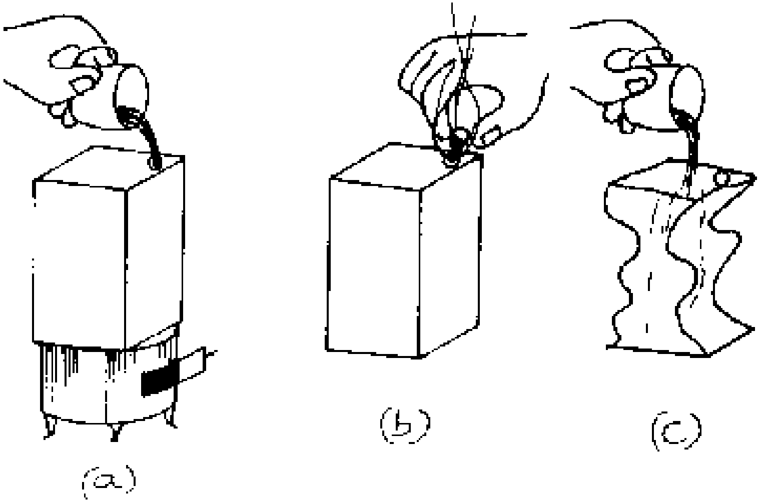


(a) (b)

P: Carry a bucket of water on your head without (fig. a) and with a "ngata" (fig. b).

Q: What difference do you feel? Why?

3.7.4 Liquid Pressure Acts in All Directions



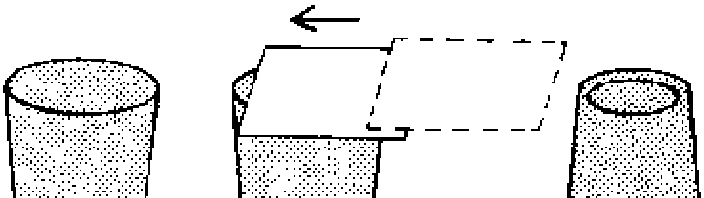
P: (a) Fill one cup of water into the large tin can. Then heat the *open* can to boiling.

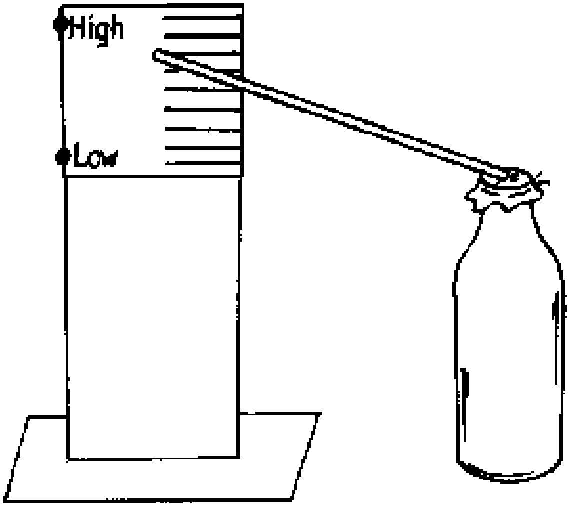
(b) Remove the can from the fire and close it *immediately* air–tight.

(c) Now pour cold water on the can.

Q: What happens? Why?

3.7.6 Air Pressure

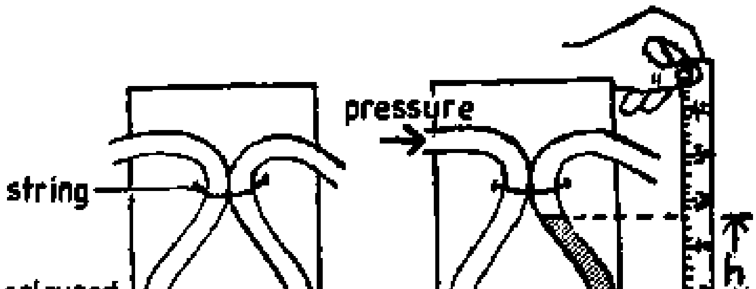




P: Assemble a barometer by closing a bottle *air–tight* by using a piece of plastic bag and a string. Glue the strow onto the middle of the piece of plastic and point the straw to a scale (see fig.)

Q: How does this barometer work, when the air pressure increases or decreases respectively?

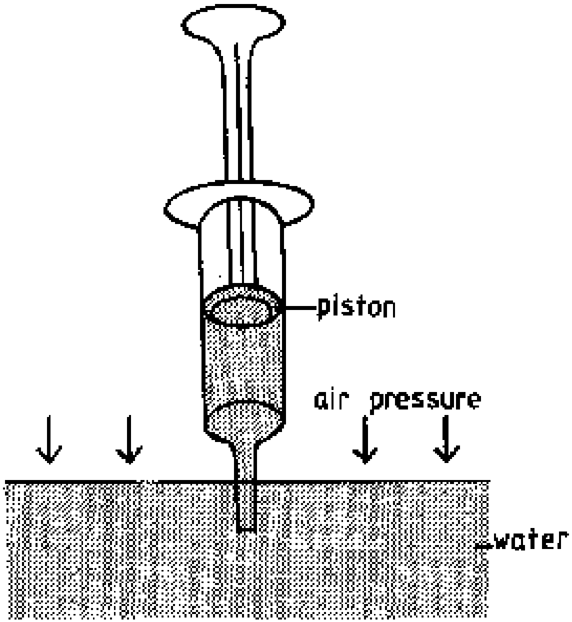
3.7.8 A Manometer



P: Arrange two glasses and a plastic or rubber tube as shown in the figure. Suck at the lower end of the tube.

Q: What happens? Why?

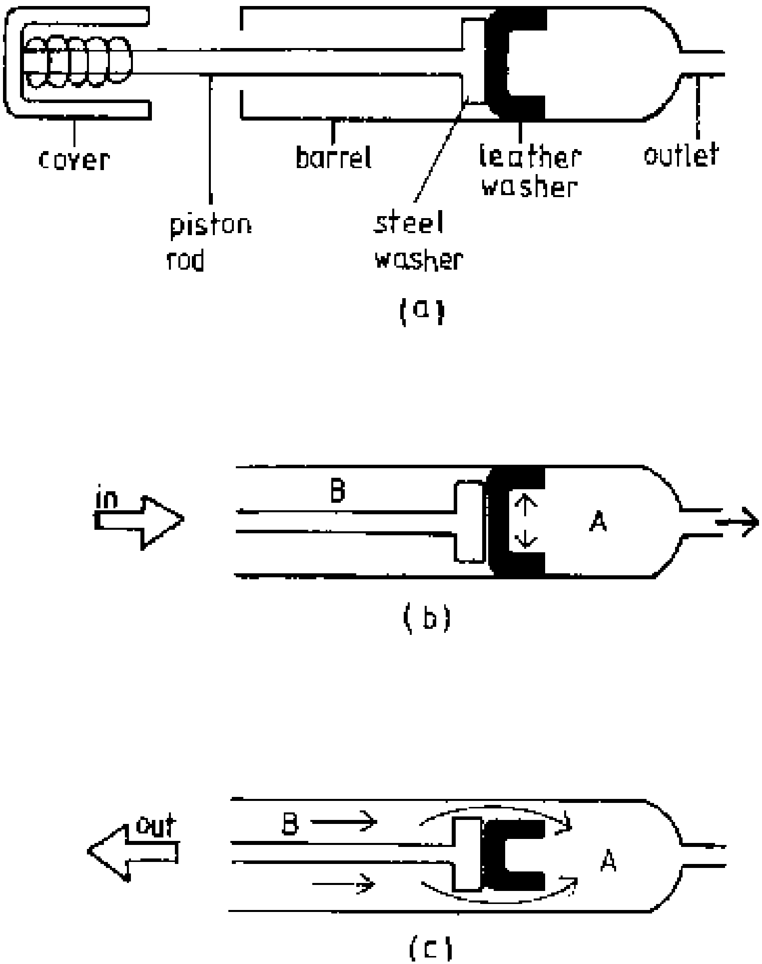
3.7.10 The Syringe



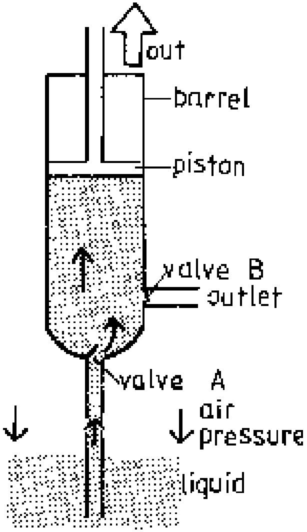
P: Obtain a one–way–syringe from a hospital. Suck water in as shown in the figure.

Q: Why does the water rise in the syringe?

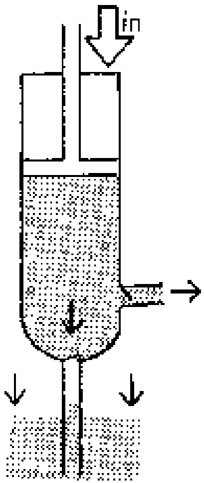
3.7.11 The Bicycle Pump



P: Using a bicycle pump, pump air into a bicycle tyre. Ask students to draw a display chart of the above figure.

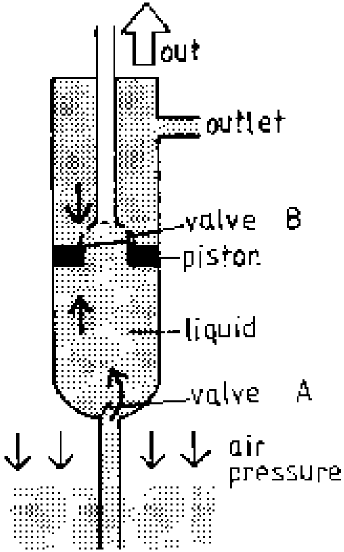


(a)

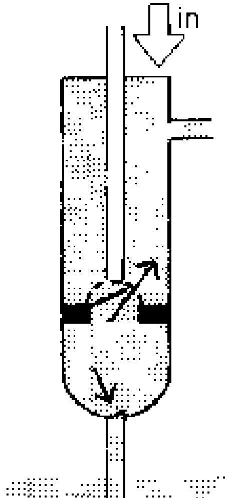


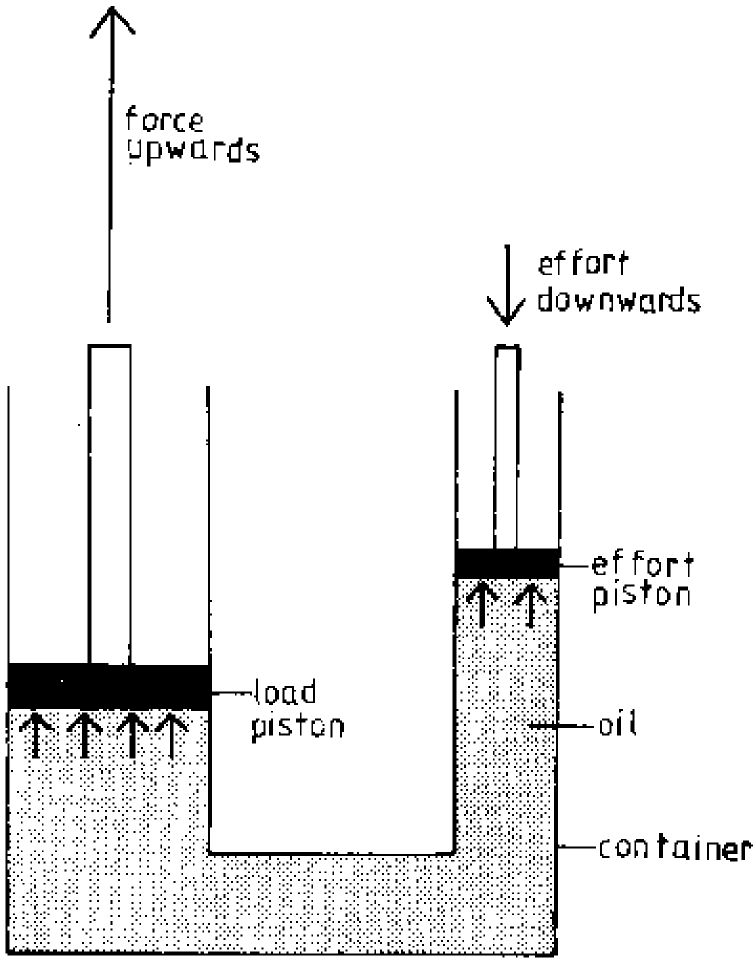
(b)

P: Ask students to draw a display chart of the force pump according to the above figure.

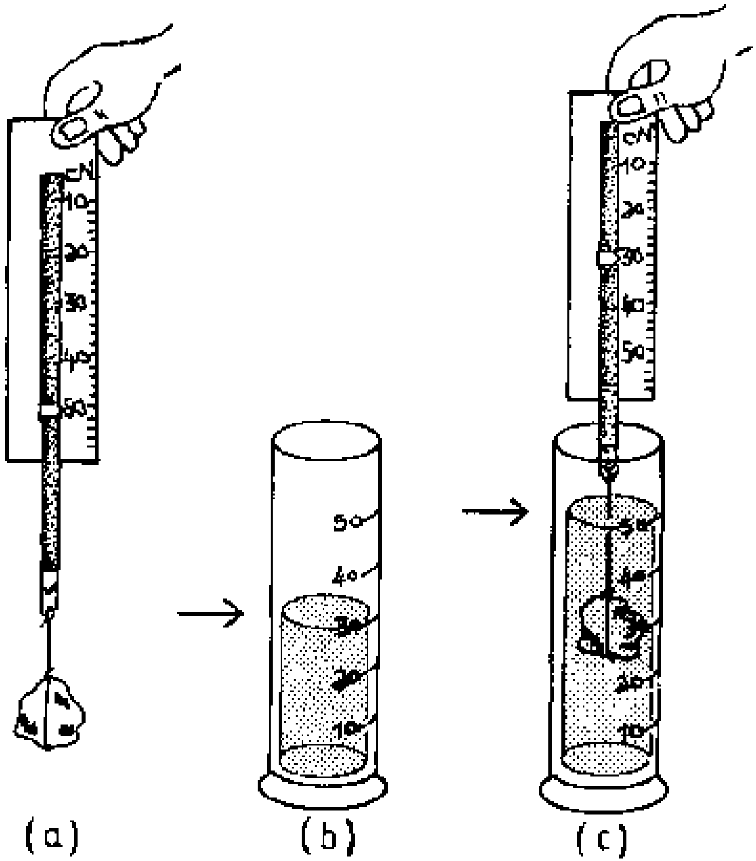


(a)





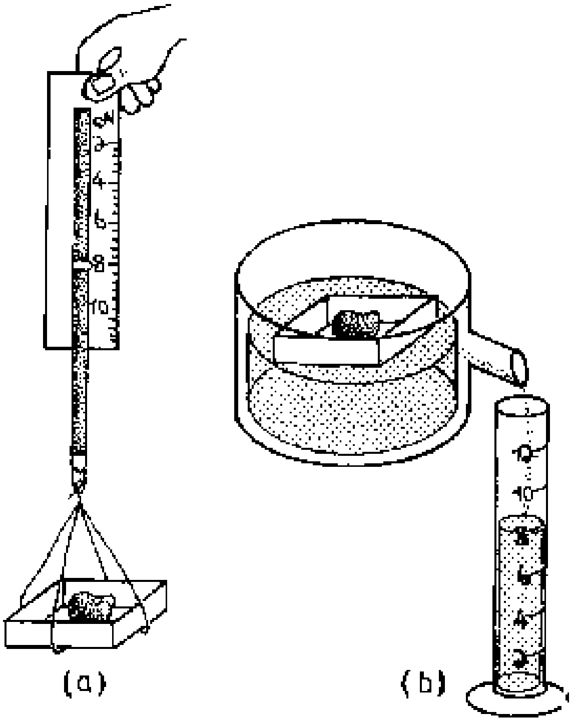
P: Ask the students to draw a display chart of the hydraulic press according to the above figure.



P: (a) Attach a stone to a thread, and fix it on a Newton balance (see p. 15). Note the weight of the stone.

(b) Fill a measuring cylinder partly with water and record the reading.

(c) Immerse the stone fully into the water (without touching the bottom of the cylinder) and record the reading



P: Load a matchbox with a small stone so that it still floats in water. Weigh the matchbox and . stone using a Newton balance to obtain its weight (see p. 15).

Fill the overflow can (see p.25) with water and allow the matchbox with stone to float on it. Let the overflow run into a measuring cylinder. From the volume of the overflow find its weight.

O: For example, the weight of stone and matchbox be 0.08 N. Then you will observe that the weight of the overflow will also be 0.08 N.

E: Thus, you have verified the *law of floatation*.

P: Fill a bottle to the rim with water. Load a small piece of styrofoam with a small nail so that it just floats in the bottle. This is the "diver". Close the bottle with your thumb airtight and apply pressure.

Q: What do you observe? Why?

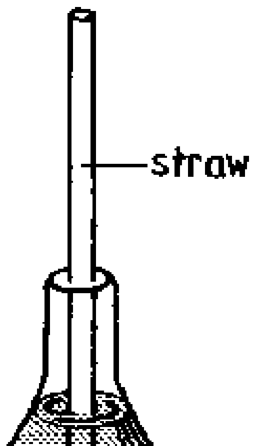
O: According to the pressure exerted by your thumb, the diver will sink or rise.

E: Styrofoam has very many tiny pores which are full of air. Thus, when the pressure of the water increases, the air is compressed, its volume decreases, but its mass remains constant Hence, its density increases, the diver sinks.

When the pressure is released, the air expands, its density decreases, the diver rises.

H: Do not allow the diver to stay for a long time in the water. Always remove it immediately from the water when your experiment is finished. Otherwise it will suck in water (since the styrofoam contains capillaries; see exp. 4.4.6, page 51) and sink even without the application of pressure.

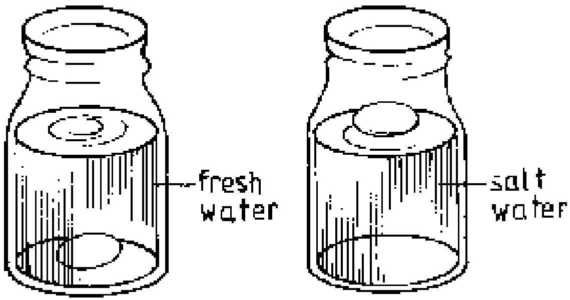
3.8.4 The Hydrometer



H: You might have to compress the sand at the bottom of the straw using a stick (or put a nail inside) in order to make it float vertically.

A: Use the hydrometer to measure the density of e.g. kerosene, sea water and pure milk. Thus you can discover the wateringdown of milk by measuring its density using the hydrometer.

3.8.5 An Egg in Water



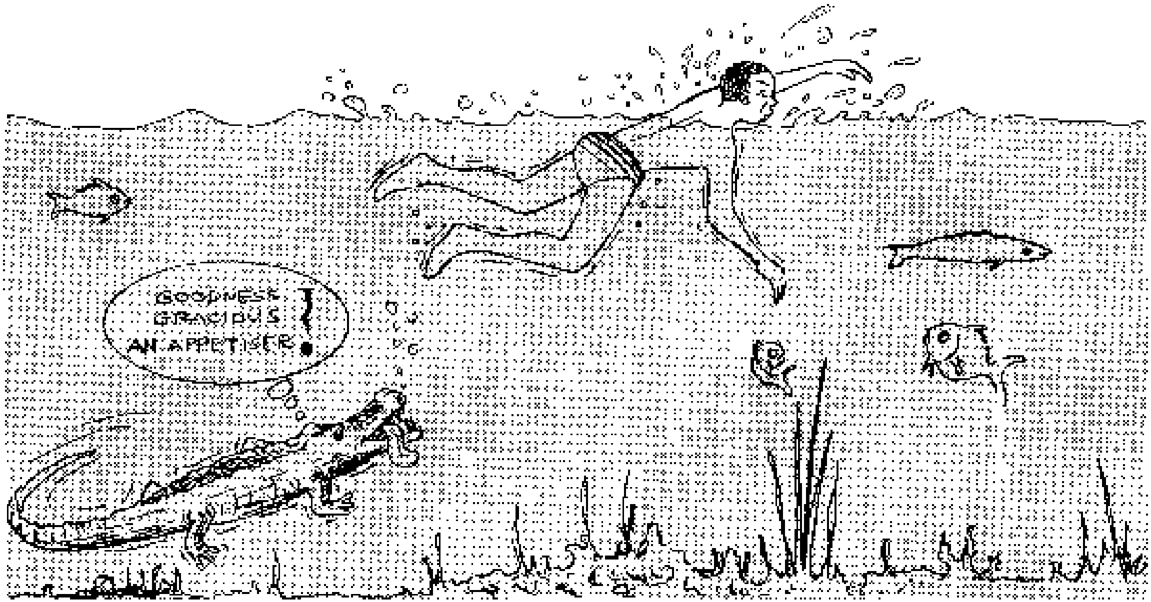
(a) (b)

P: Place a fresh egg in water. Observe. Now dissolve salt in the water while stirring until the egg floats.

Q: Why does the egg float in the salt water?

E: The density of salt water is higher than that of fresh water. Thus, the weight of the displaced salt water becomes equal to the weight of the egg. Hence, the egg floats in salt water of a sufficient salt content.

3.8.6 The Floating Candle



3.9 Work, Energy and Power

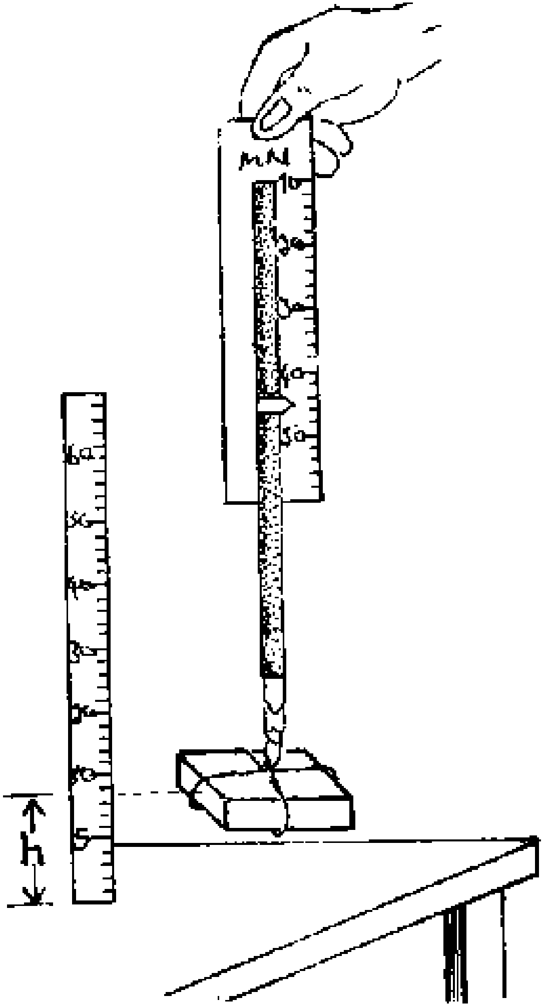
To pull a heavy cart is tiring work. In physics *work* is defined as follows:

Work done = force x distance moved in the direction of the force.

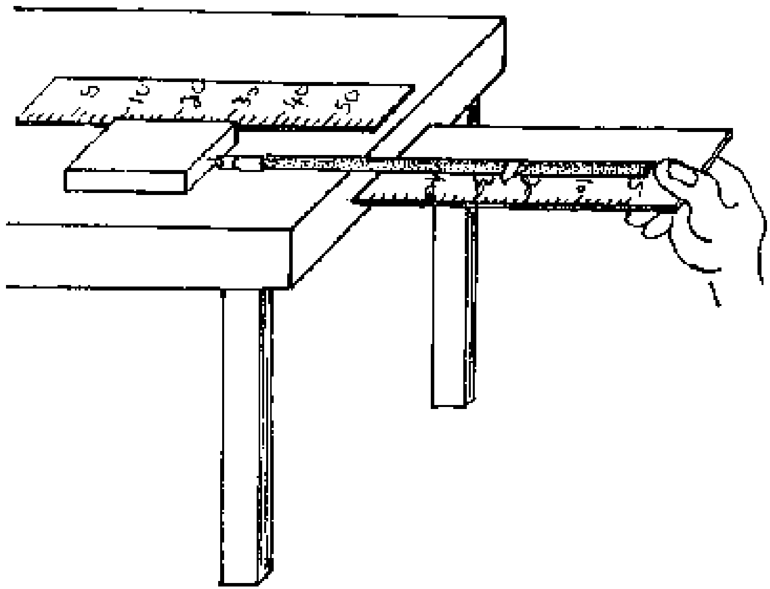
Unit: 1 N x m = 1 J (joule)

Energy is the ability of doing work. Hence, its unit is also 1J.

Power is the rate of doing work, i.e. work per unit time. Its unit is 1 joule/second = 1 watt (1 W)



B: Raise a block of wood from the table using a Newton balance (see p. 15). Read the balance when you lift



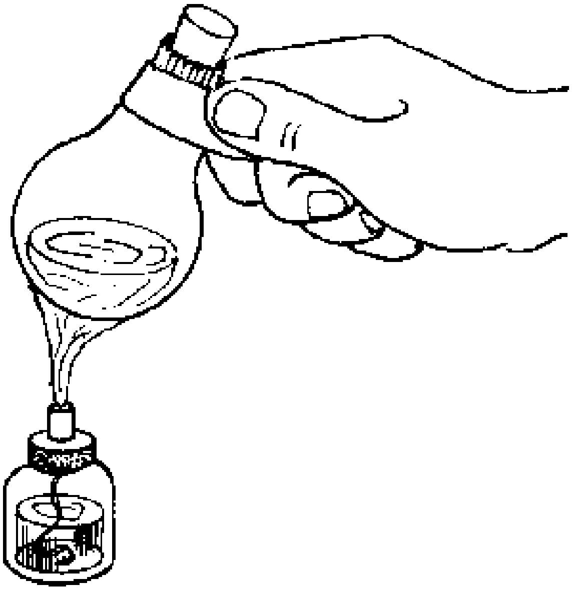
P: Place a block of wood on a table. Pull it with constant velocity using a Newton balance. Measure the distance moved by the block.

Q: Calculate the work done from the reading of the balance and the distance measured.

E: The force which pulls the block at constant velocity is equal to the force of friction in magnitude but has the opposite direction. Thus, the *work done by friction* is

Work done = force of friction x distance moved

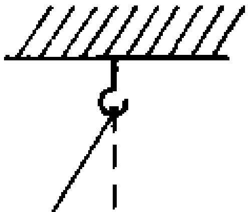
3.9.3 A Catapult



P: Fill some water into an opened electric bulb (see appendix) and close it *slightly* by a stopper. Then holding it with a strip of paper heat it using e.g. a kerosene burner until the water boils.

Q: What happens to the stopper? What energy changes take place?

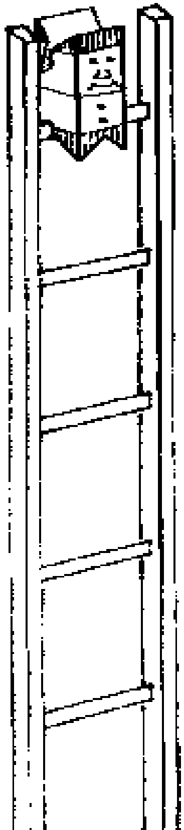
3.9.5 A Pendulum

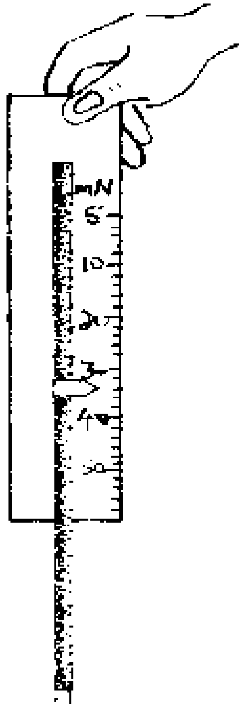


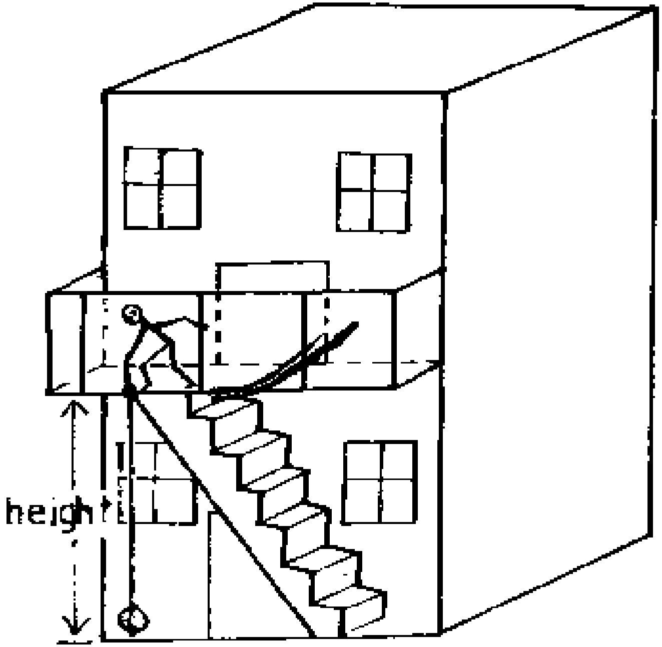
P: Tie the handles of a spring clothes–peg together with *one* loop of thread. Place this peg at the middle of a smooth table and place two other pegs beside it, one against each end of each handle. Bum the thread.

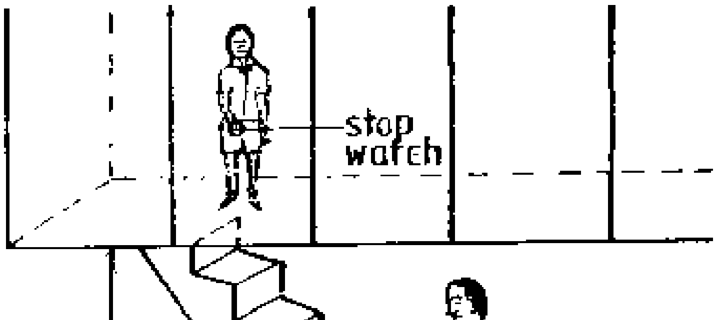
Q: What do you observe? What changes in energy take place?

3.9.7 Energy and the Funny Jumper






height


stop watch

3.10 Simple Machines

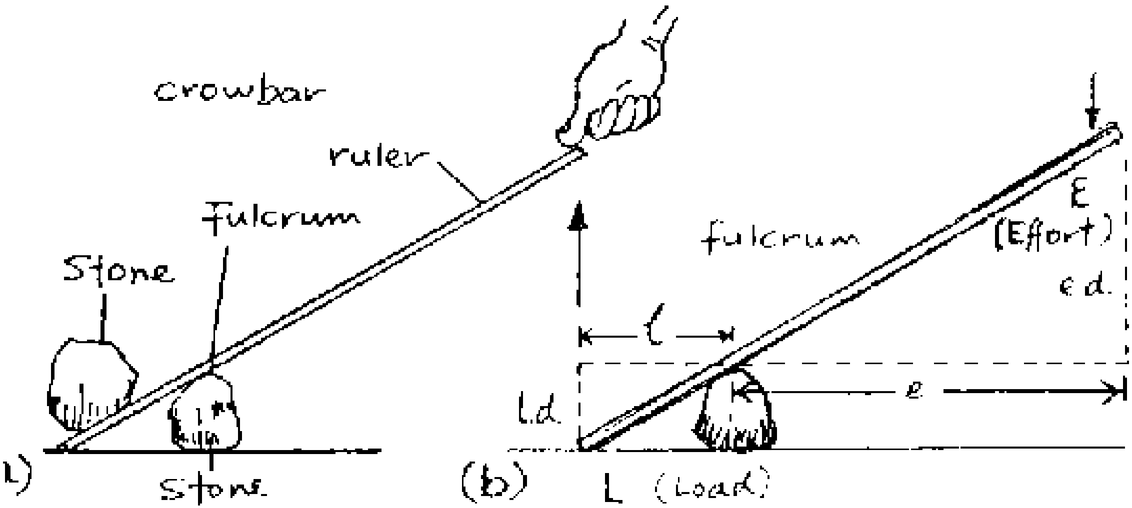
Simple machines use the principles of Physics to give us mechanical advantage, e.g. to *lift a heavy load using a small effort.* Examples are levers, wheel and axle, pulleys, the inclined plane etc.

Mechanical advantage (MA) = load ÷ effort. It depends on friction.

Velocity ratio (VR) = distance moved by effort ÷ distance moved by load. It does not depend on friction.

Efficiency = output ÷ input – work done on the load ÷ work done by the effort = MA ÷ VR. It depends on friction.

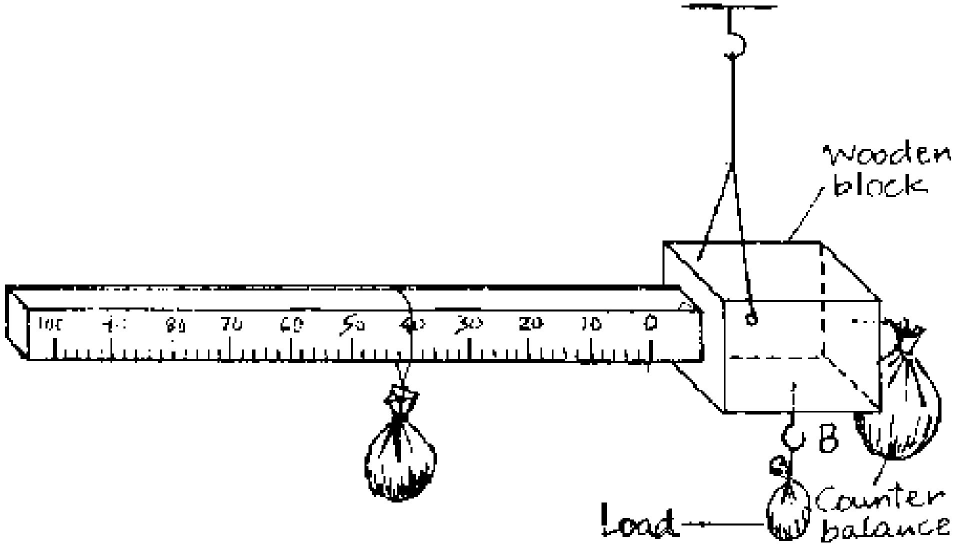
3.10.1 Levers



P: Make a lever using your ruler and a tipped stone. Use it to lift a heavy stone or brick.

The seesaw, pliers, the wheelbarrow, tweezers, the bottle opener, the forearm, the roman steelyard, etc. are all levers.

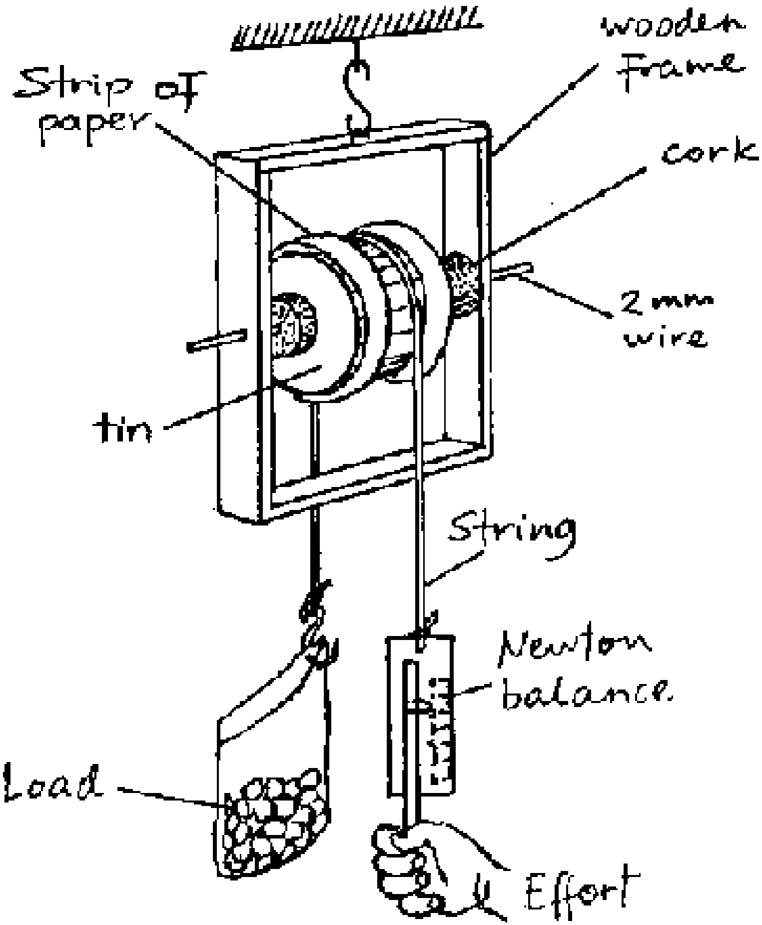
3.10.2 The Roman Steelyard



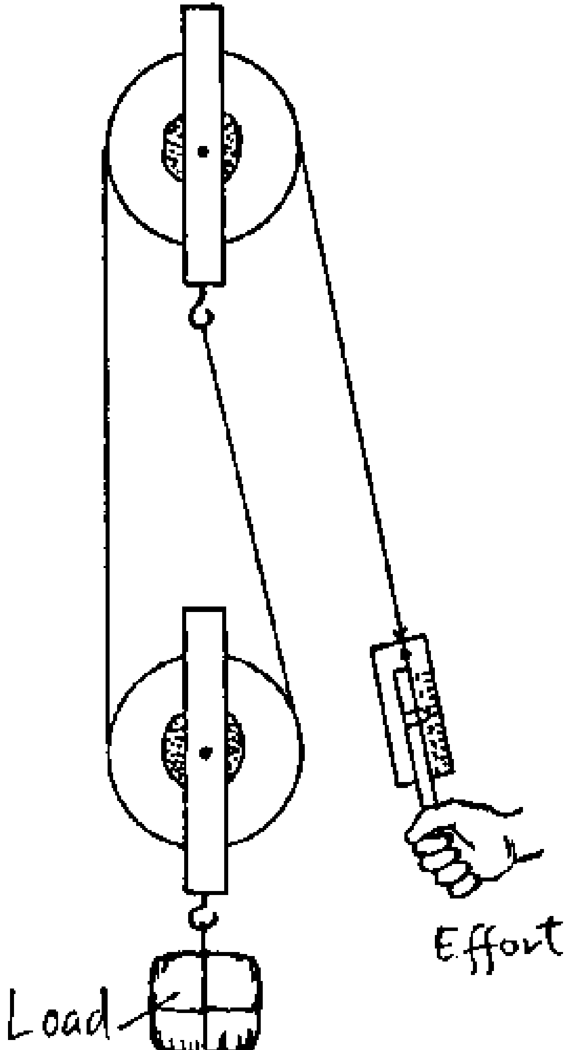
P: Make a roman steelyard according to the figure using wood.

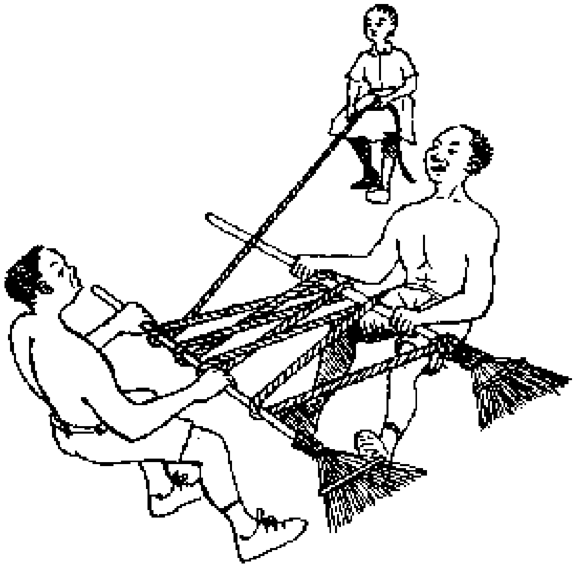
Calibration: Suspend the roman steelyard in air. Then suspend e.g. a 100 g mass on the assumed zero mark. Hang a counterbalance mass on the other side (as shown) so that the whole system balances horizontally. Then hang a standard mass, e.g. 50 g on B and adjust the 100 g along the rod so that the whole system balances horizontally. Mark this point for the standard mass used (e.g. 50 g). Repeat this procedure for other masses (e.g. 100, 150, 200 g, ...).

How to measure an unknown mass (load): Suspend the load (whose mass you want to determine) from B. Then adjust the 100 g mass along the beam so that the whole system balances horizontally. Read and record



P: Produce a pulley by boring holes in the centre of the top and the bottom of a small tin. Take a wire of 2 mm diameter as an axle and fix it in a wooden frame as shown in the figure. Attach strings and use it to lift a load (which should be much heavier than the pulley). Use a Newton balance to measure load and effort.


Effort
Load



P: Ask two strong boys and a girl to take two (broom) sticks and a rope and to arrange themselves as shown in the figure.

Q: Will the girl be able to pull the two strong boys together or can the boys resist the pull of the girl?

O: The girl wins. Why?

E: This is an arrangement of "broomstick pulleys". Thus, the girl needs much less effort to pull the heavy loads of the two boys! However, the girl will have to move farther than the boys do.

3.10.6 The Inclined Plane

Weigh a toy car using a Newton balance. Now pull this toy car up the inclined plane of the table using a Newton balance to measure the effort.

Q: Is the effort smaller than the load (weight of the toy car)? How is the velocity ratio = (distance moved by effort along the slope) ÷ (distance moved by the load *vertically*)?

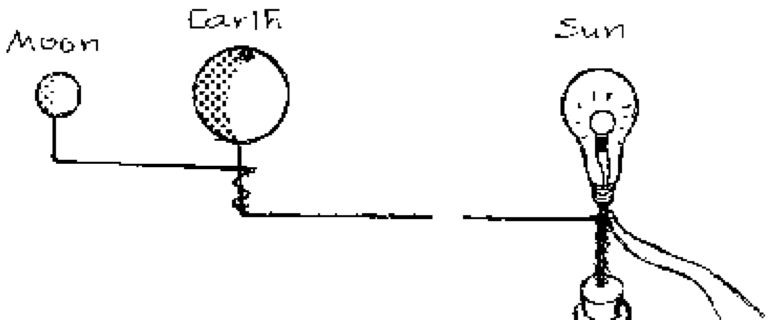
E: The effort is smaller than the load. The MA depends on the inclination of the plane as does the VR which is greater than 1.

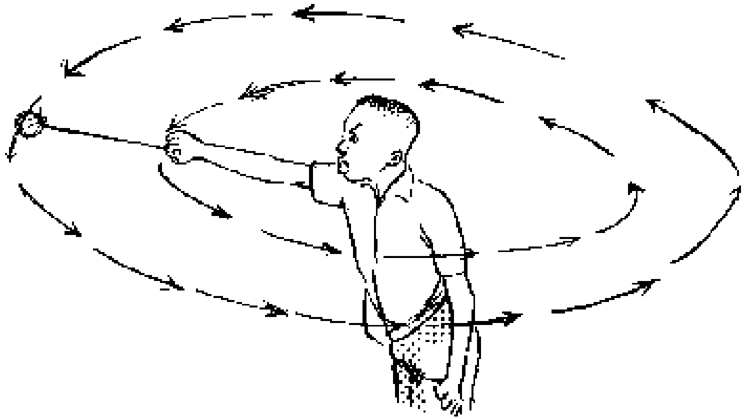
A: Hills, slopes and ramps are examples of inclined planes, screws apply the same principle. The Egyptians used inclined planes do build their pyramids as people do sometimes nowadays to carry the building materials when building a two or three storey house.

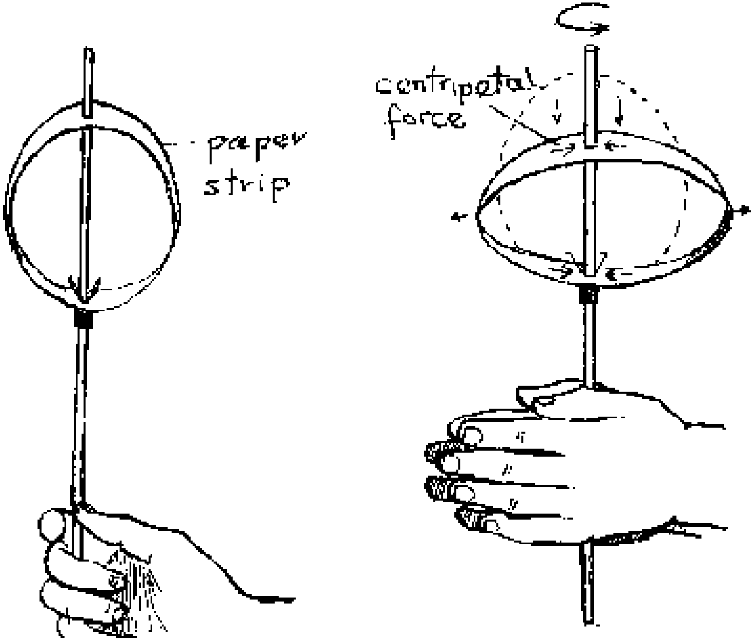
3.11 Astronomy – The Solar System

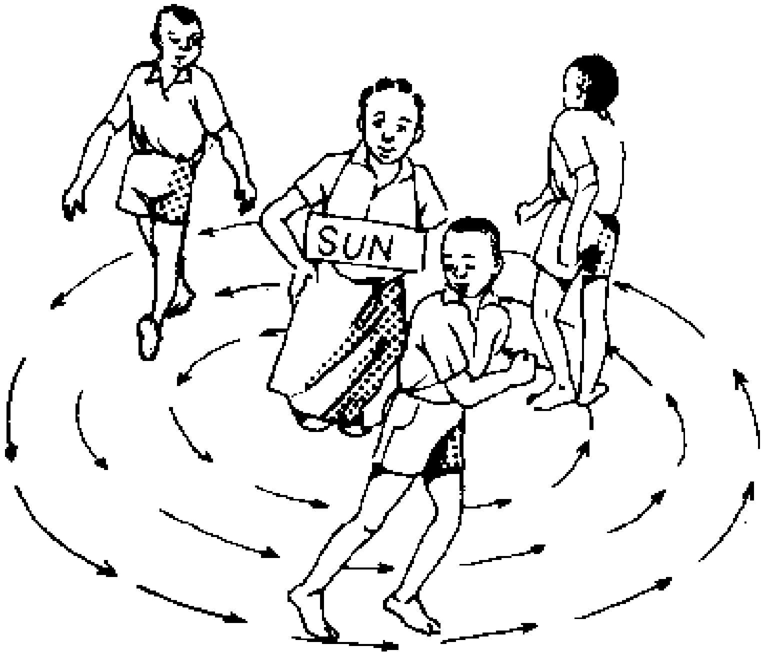
Astronomy is the study of bodies in the universe and of their motion, e.g. the study of the solar system. The sun has nine planets going around it. The planets differ in size and relative distances from the sun. They are kept in their almost circular paths by the *gravitational force* of the sun which acts as *centripetal force.*

3.11.1 Model of Sun–Earth–Moon






paper strip
centripetal force

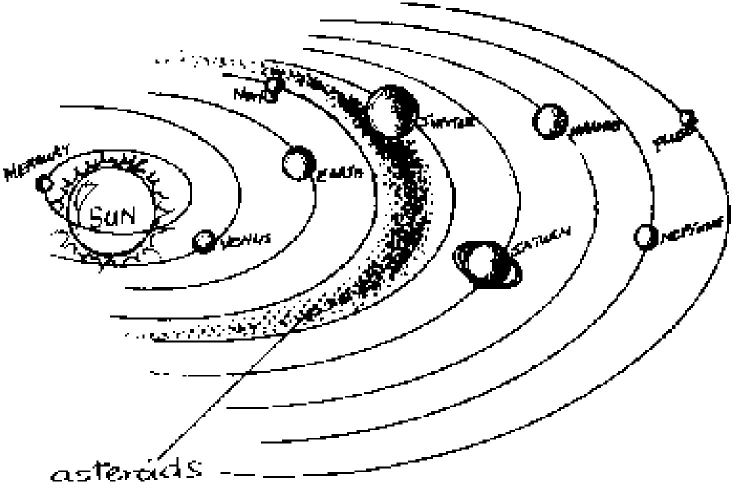


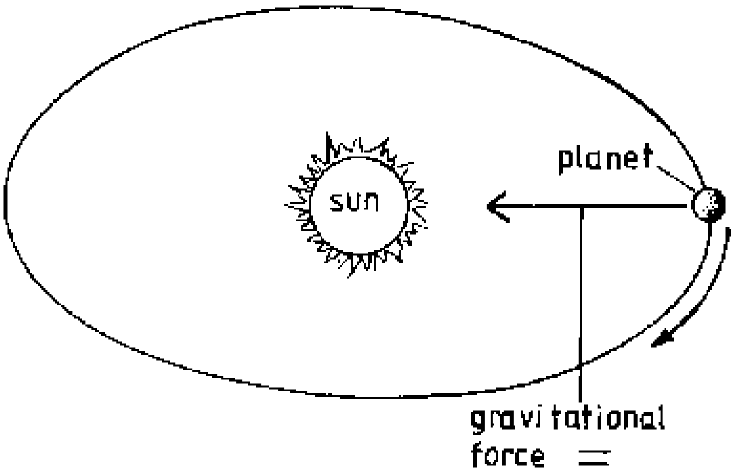
P: Place a chair at the centre of the football field of your school to represent the sun. Now ask nine students to go around the chair in circles to represent the planets. The radius of each circle should correspond to the distance of the respective planet from the sun.

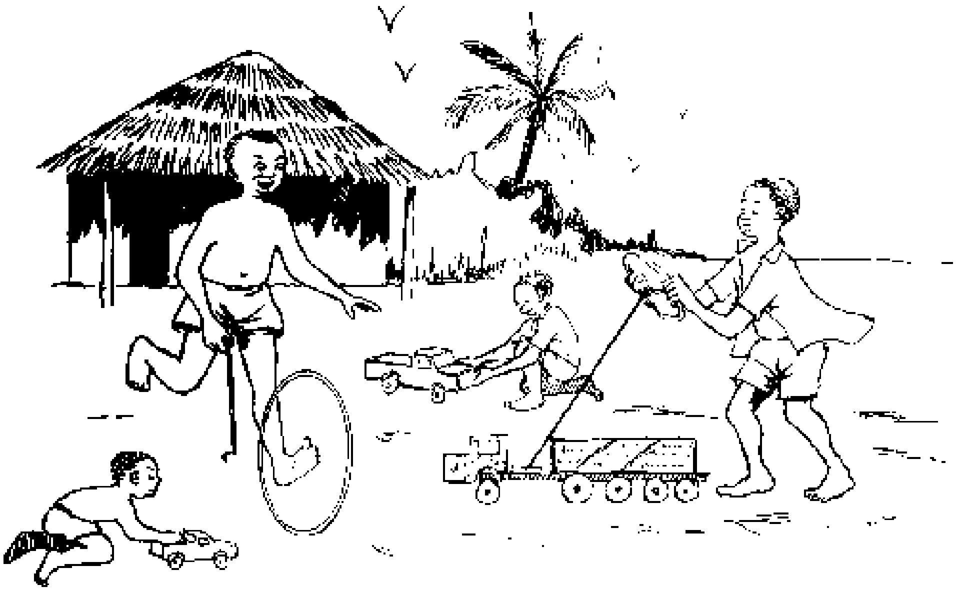
For example, if you use a scale of 1 cm representing a distance of 1 million km from the sun, then (see the table below) the radius of the mercury path must be 58 cm, that of the venus 107 cm, that of the earth 149 cm and so on. (Of course, in this scale, the sun would be a ball of 2 cm diameter, the earth only a grain of sand).

Q: What will be the radii of the paths of Jupiter, Uranus and Pluto respectively in this model?

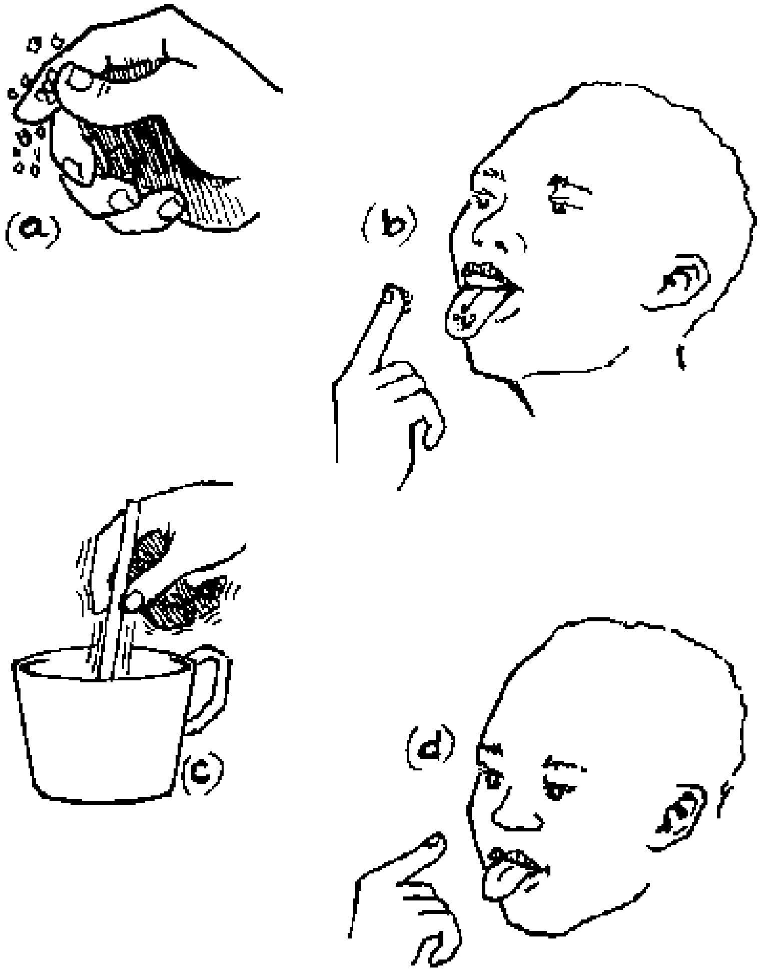
E: They will be 7.8 m, 28.5 m and 58.7 m respectively.


SUN
VENUS
EARTH
SATURN
asteroids

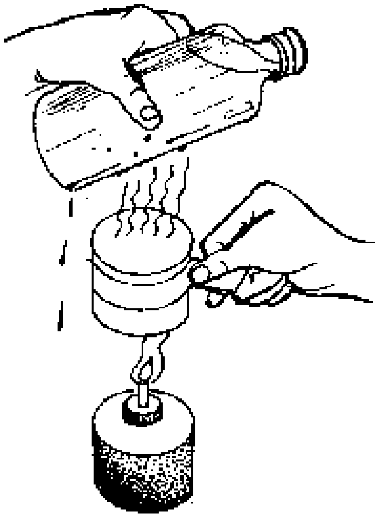

planet
sun
gravitational
force =



4. Matter



P: Take some salt (or sugar) crystals and roll them between your fingers in order to feel their hardness. Taste the crystals



P: Pour a small amount of water into a tin can and heat it until it boils. Fill a bottle with cool water and hold it above the tin can.

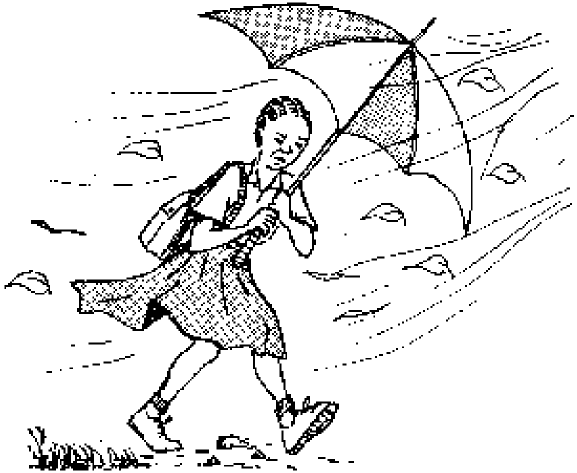
Q: What do you observe?

O: Water drops form on the outside of the cool bottle wherever it is touched by the steam of the boiling water.

E: Water particles escape from the boiling water as vapour and condense on the lower surface of the bottle to form water droplets.

The formation of drops from vapour is an indirect evidence that water is made up of small particles.

4.1.3 Size of Particles

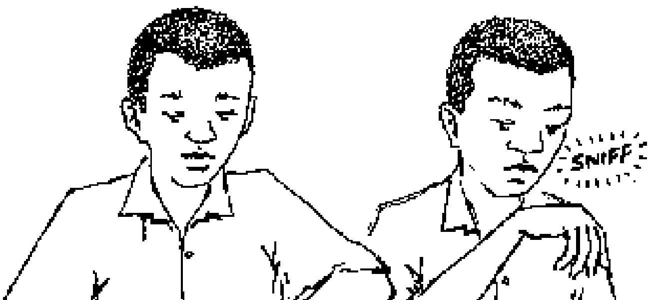


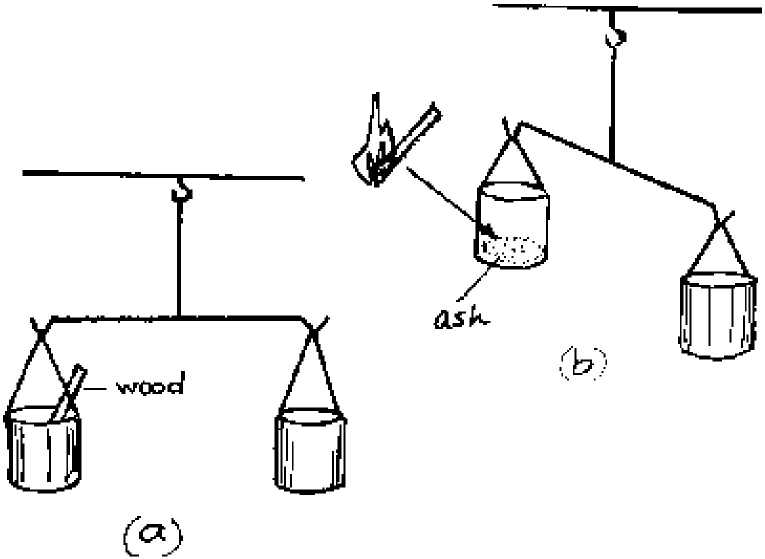
P: A wind is blowing vigorously towards a student carrying an open umbrella.

Q: What will she feel?

E: The umbrella is forced down by the wind pressure. This is due to the current of air particles (wind).

4.1.5 Smelling Particles





P: Ask students to weigh pieces of wood. Record the weight. Burn the pieces of wood and weigh the ash.

Q: Is there any difference between the weight of the wood and the ash?

E: The weight of ash is less than that of wood. The loss in weight is due to particles which escaped as soot and gas.

4.2 States of Matter

Matter exists in three states namely: solid, liquid and gas. The three states can be converted into one another by heating and cooling. In *solids* the particles are very close together and have a definite order. In *liquids* the particles are slightly farther apart than in solids and can move past each other. In *gases* the particles are in fast random motion. The three states differ mainly in the thermal energy each contains and as a consequence

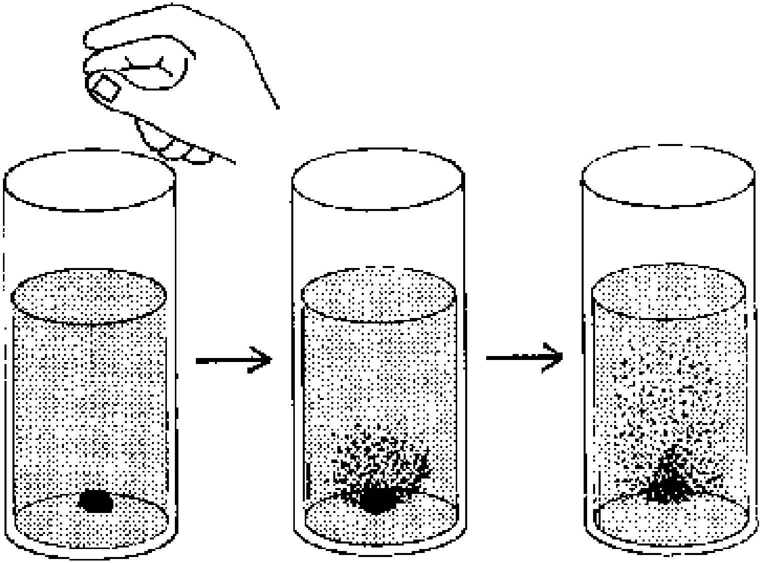
Q: What do you observe?

O: On heating, the solid melts to form a liquid and then by further heating the liquid evaporates as a vapour which is in gaseous state. The gas then condenses at the cold surface. This is similar to experiments performed with water (see 4.1.2, 5.3.1 and 5.3.2).

4.2.2 Explaining the States of Matter

The movement of one kind of substance through a volume already occupied by another substance is known as diffusion. More direct evidence for molecular movement in gases or liquids comes from *Brownian movement.* Small visible particles can be seen in an irregular movement. From this we conlude that rapidly moving invisible gas molecules collide with them.

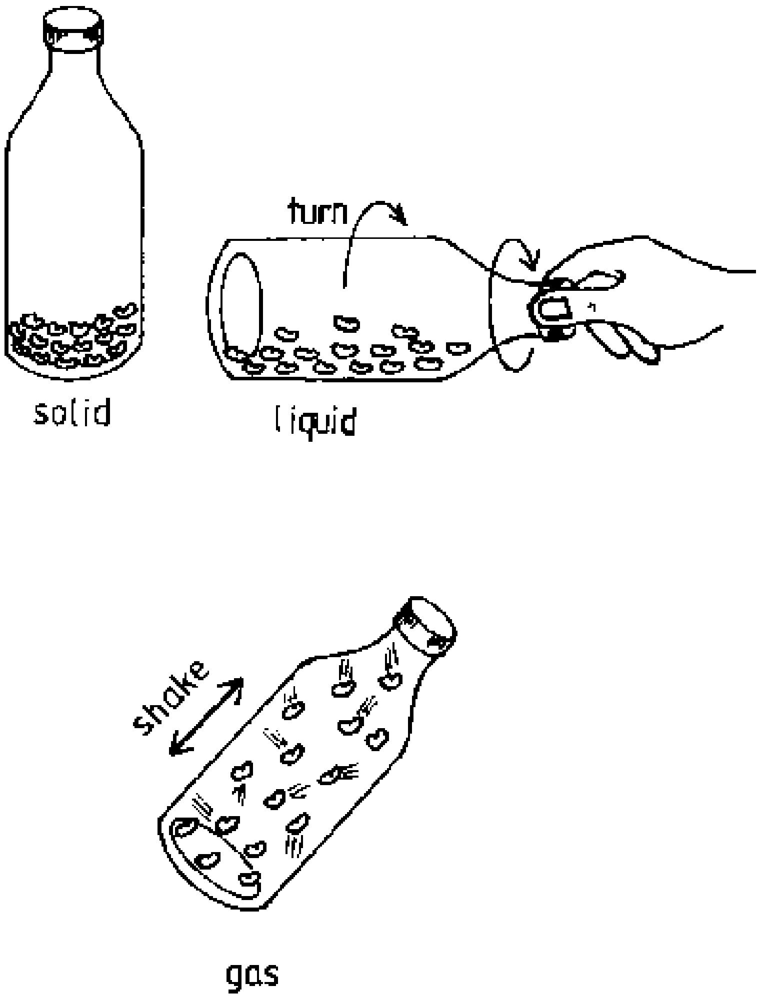
4.3.1 Diffusion in Liquids



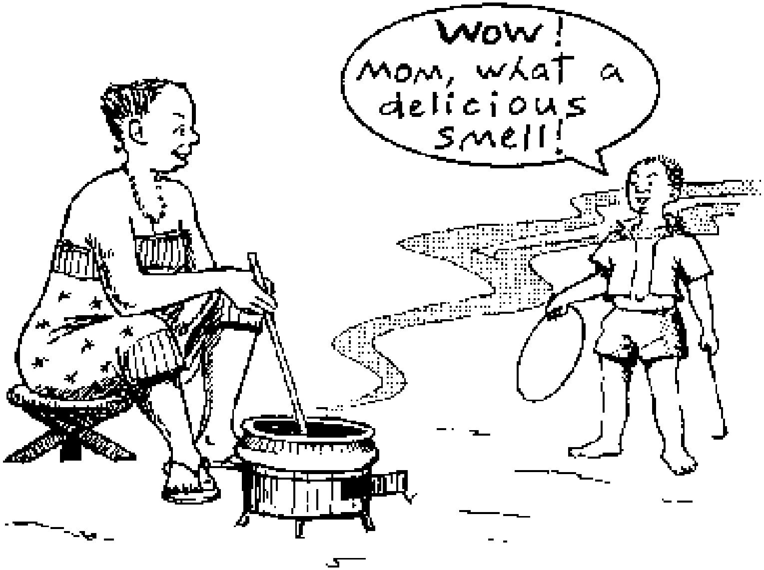
P: Put a crystal of potassium manganate (VII) (permanganate) into a jar containing water. Set the jar and observe.

Q: What do you observe?

O: The purple colour of potassium manganate(VII) (permanganate) will be found to spread gradually throughout the water.



B: Put some dry beans, rice or stones in a transparent bottle. Hold the bottle still (a), then turn it (b). Then



P: Pass near a place where people are roasting meat or cooking.

Q: What do you smell? Why?

E: The smell is sensed even at a distance, because the particles which produce the smell spread by *diffusion.*

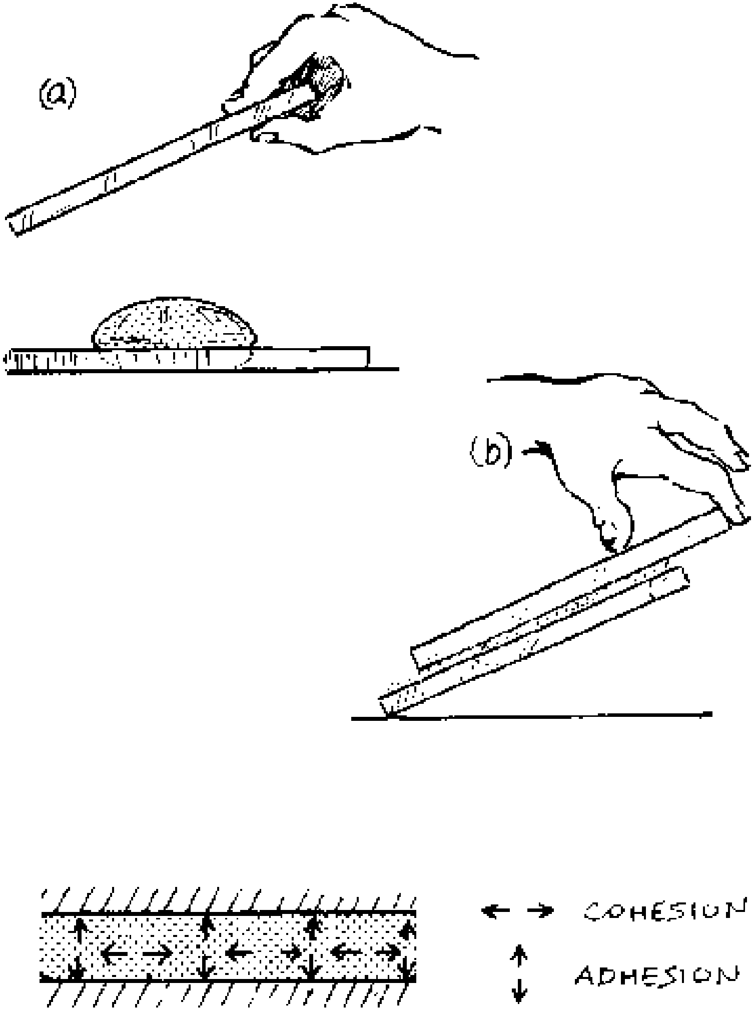
4.3.4 Diffusion and Pollution

P: Observe a beam of light through dust in a dark room.

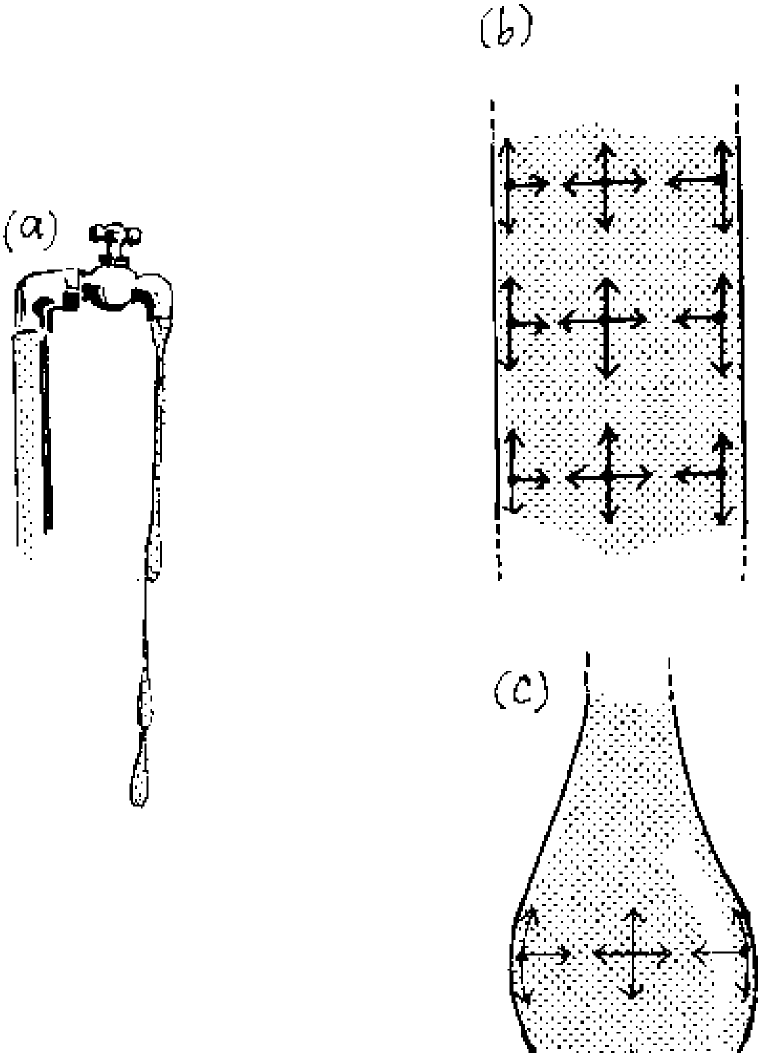
Q: What do you observe? Why?

E: The dust particles can be seen moving randomly. This demonstrates *Brownian motion.* What is seen is the consequence of the bombardment of the dust particles by invisible air particles. This is an indirect evidence for the existence of particles in the air.

4.3.6 Model on Brownian Movement



B. Drip water on a clean glass sheet (a).


(a)
(b)
(c)

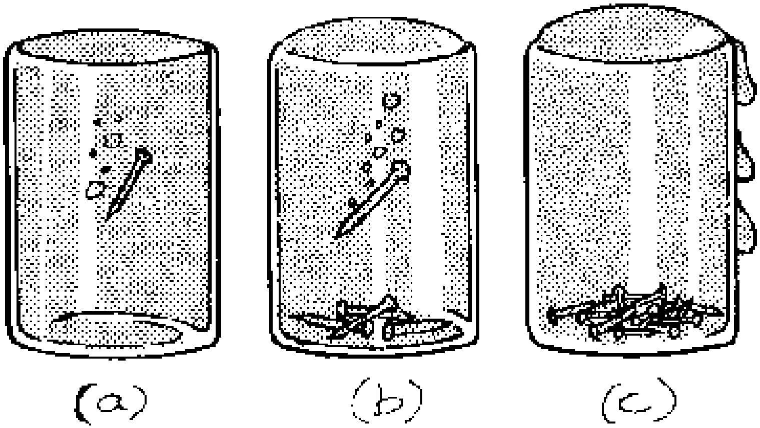
P: Carefully float a needle, a razor blade, a clip and a pin on a water surface as shown.

P: What do you observe?

E: The surface of water behaves like a thin elastic membrane. This is due to forces of cohesion called *surface tension.*

H: The pin can be easily floated with the help of a fork.

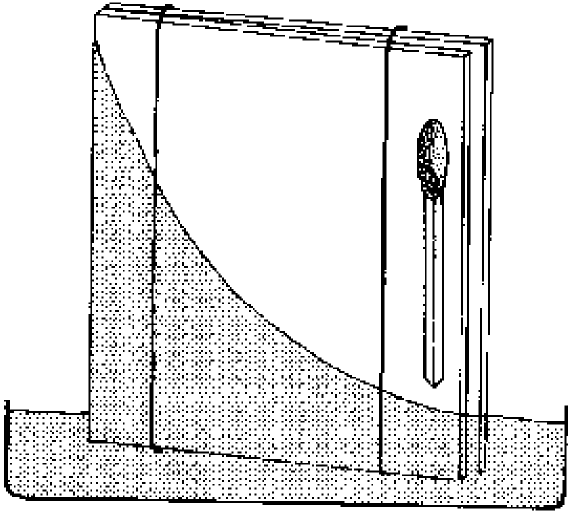
4.4.4 More on Surface Forces



P: Carefully fill a transparent glass vessel with water to the rim. Add nails, one at a time, to the water and count the number of nails sunk just as water begins to spill over.

Q: Explain your observations.

E: The water surface bulges out but does not break immediately because of strong *cohesion forces* between the water particles.

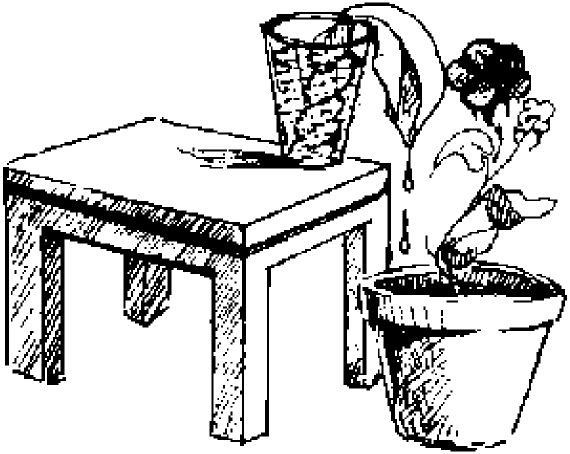


P: With the help of a rubber band and a matchstick, arrange two clean glass sheets as shown in the diagram. Place the arrangement in a plate containing some water.

Q: What do you observe?

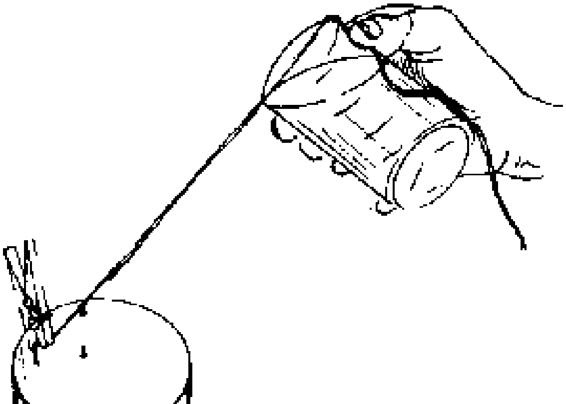
E: Water rises to different heights along and between the glass sheets. This is *capillary action.* Water rises more where the glass sheets are closer together (see also 4.4.7).

4.4.7 Measuring Capillary Rise



P: The knowledge of capillarity can be used to provide an automatic irrigation. Students can perform irrigation by dipping a porous material such as paper or cotton cloth in water.

4.4.9 Inclined Water Transport



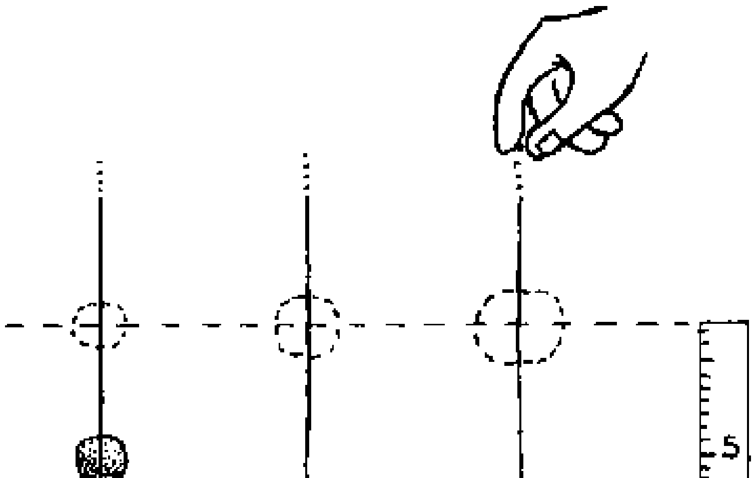
E: The shiny surface gets wet because the *adhesive forces* between water and glass are very great. The sooty or greasy surface does not get wet because adhesive forces between water and these surfaces are very weak.

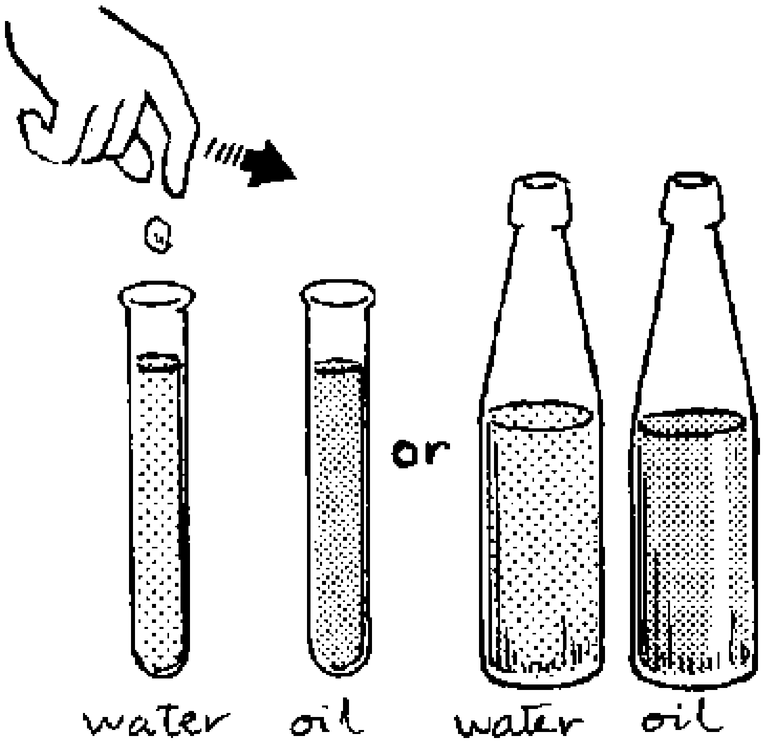
4.5 Elasticity and Viscosity

Elasticity is the ability of a substance to recover its original shape after a distorting force is removed. *Hooke's law* on elasticity states that the extension of a spring is directly proportional to the load applied provided the elastic limit is not exceeded. Most materials are elastic. It is important to know the behaviour of a material when acted by forces before we can use it for a particular job.

Viscosity is the frictional force exerted by a fluid. The flow of liquids is influenced by this force. Where the frictional force is greater, the liquid flows less readily and is said to be more viscous and vice versa.

4.5.1 Elasticity in Solids





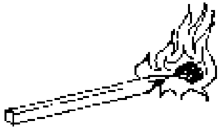
P: Fill one test–tube or a tall bottle with water and another with oil, both to the rim. Put a small stone into the water and record the time taken by the stone to reach the bottom. Repeat the experiment using oil.

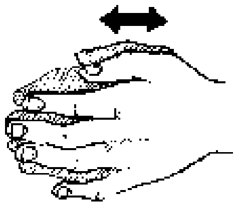
Q: In which liquid does the stone take longer to reach the bottom?

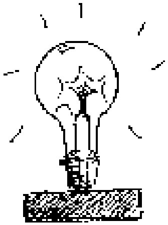
E: The stone takes longer to reach the bottom in the vessel containing oil because oil has a higher *viscosity* than water.

water boiling at standard atmospheric pressure. It is 100°C. The *lower fixed point* is the temperature of pure melting ice at standard atmospheric pressure. It is 0°C. *Absolute zero* is the coldest possible temperature which is –273°C. This corresponds to the zero degree on the kelvin scale.

5.1.1 Sources of Thermal Energy







P: Ignite a match stick. Rub your hands very vigorously. Switch on an electric bulb. Run as fast as you can a certain distance or up a staircase.

Q: Which forms of energy are converted to thermal energy in each case?

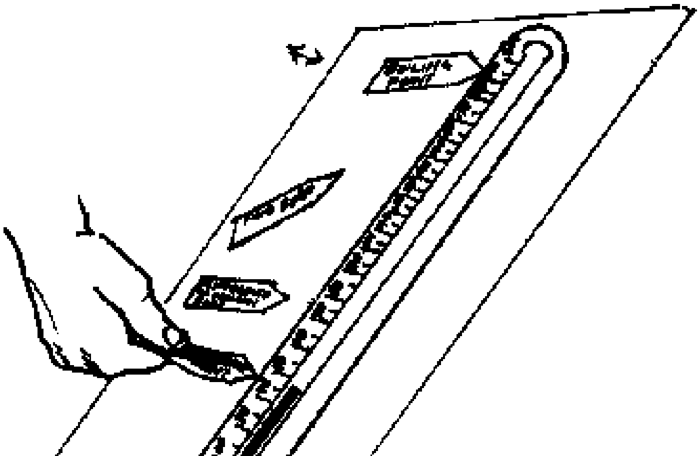
P: Fill a small bottle (about 0.5 litre) with coloured water up to the rim. Tightly fix a stopper which is carrying a narrow transparent tube (e.g. an empty ball pen tube) into the mouth of the bottle. The liquid level should be just visible above the stopper. Then put the bottle into hot water or heat it gently.

Q: What happens to the liquid level in the tube? Why?

E: The liquid level rises, because the liquid is expanding on being heated.

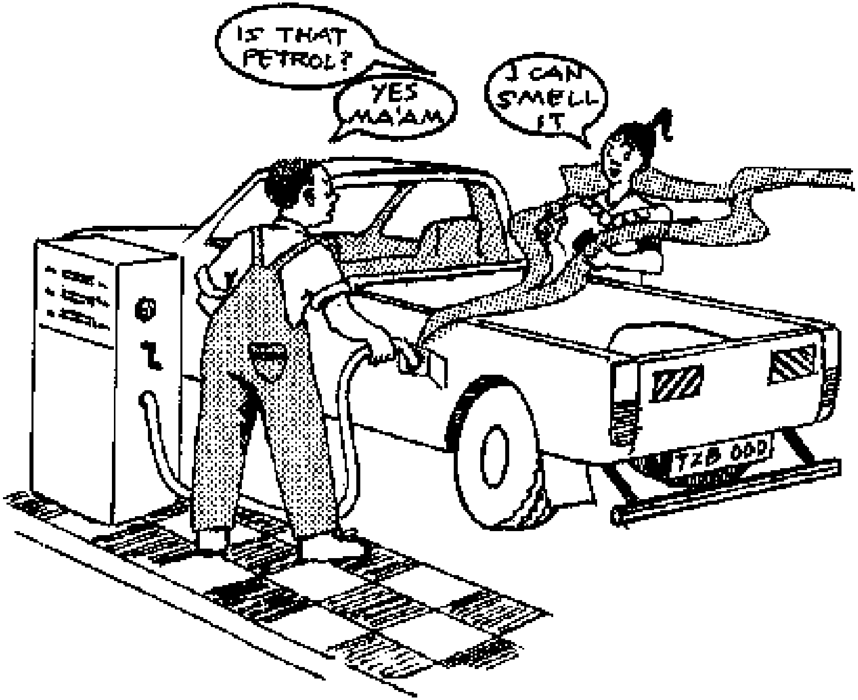
A: The principle of expansion of liquid is used in clinical thermometers. In the clinical thermometer the expansion of mercury is used to measure the body temperature. Obtain a clinical thermometer and discuss its scale. Ask the students to draw a diagram of the thermometer. Some out–door thermometers contain coloured alcohol instead of mercury. The expansion of alcohol is six times greater than that of mercury. Mercury is often used in thermometers for measuring higher temperatures than alcohol because it has a higher boiling point than alcohol.

5.1.3 Fixed Points



E: The temperature of the oil is higher, because it needs less energy to raise the temperature of one gram of oil by 1 °C than that of water. Thus, using the same amount of heat and mass, the temperature of oil must be higher.

H: Great care must be taken when heating oil, for it can catch fire (and you should not put your finger in it, if you have heated it for a long time).

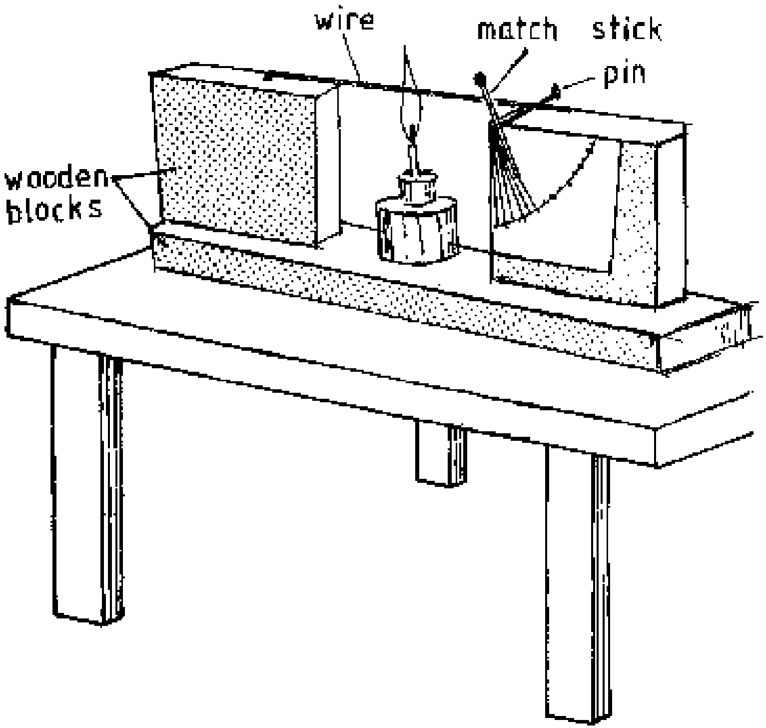


5.1.5 Thermal Energy

P: Using your hand find out how fast a water puddle and a heap of sand warm up during the day. Find out again how fast they cool during the night.

E: A heap of sand heats up faster during the daytime and cools down faster during night, because sand has a lower specific heat capacity than water. (Specific heat capacity of water = 4200 J/kg°C; of sand = 800 J/kg°C).

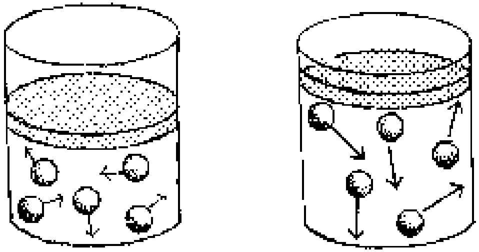
5.2.1 Expansion Apparatus



P: Place a metal rod horizontally with one end fixed firmly on a wooden block. Insert the pin through a match stick and place it under the rod as. shown in the figure. Heat the rod from below with a candle or a "kibatari" (kerosine burner).

Q: What do you observe?

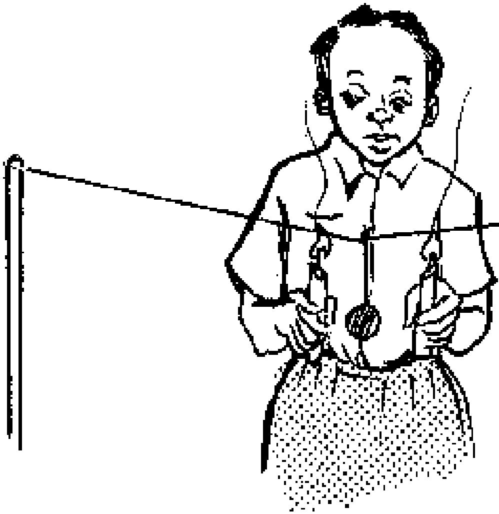
E: The match stick turns in the clockwise direction, because the rod expands causing the pin to roll forward and the match stick to turn. H: For the best results the pin should lie on a smooth surface. A wire of 2 mm



P: Expansion can be explained by a simple human model: When a group of pupils stands still, they are close together and they do not need much space. But if they start to dance or even to run about, each of them needs more space and the group as a whole takes more space. The particles in a body are like the pupils in the group, they only move far apart when they are heated and hence need more space.

5.2.3 Expansion of a Coin

5.2.4 Expansion of a Wire

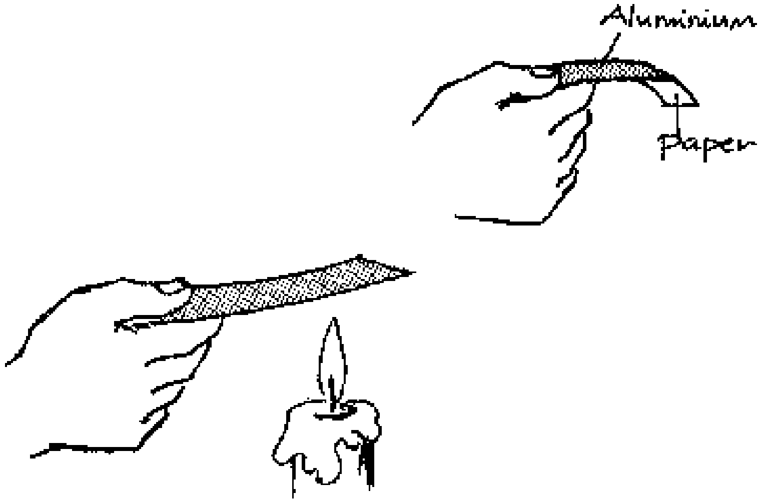


P: A thin copper wire is firmly fixed between two chairs and a weight is hung in the middle to stretch the wire. Then heat the wire along its length.

Q: What happens to the weight?

E: The weight sags further down, because the heated wire expands and hence increases in length.

5.2.5 Applied Expansion

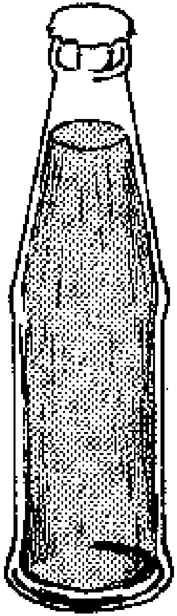


P: A bimetallic strip is made of two different metal strips like iron and brass or iron and aluminium joined together. To show the principle of a bimetallic strip, cut a one centimeter strip of aluminium paper from a cigarette packet and hold it close to a flame.

Q: What happens?

E: The strip bends towards the paper side, because aluminium expands more than paper.

5.2.7 Expansion of a Liquid



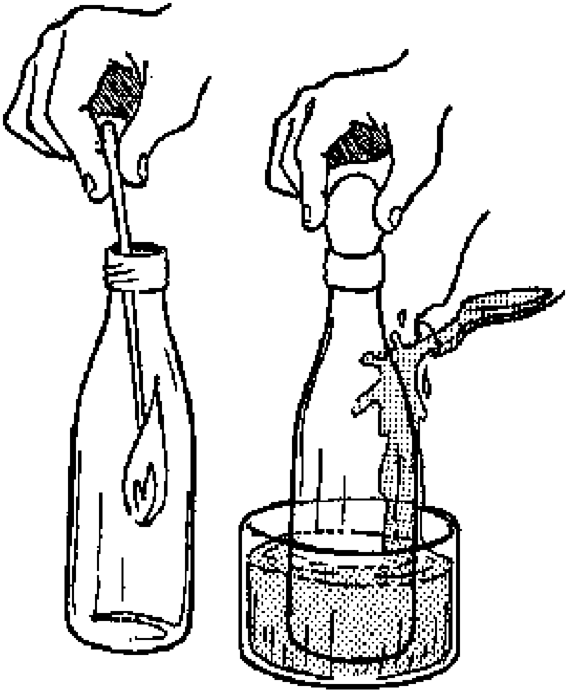
P: Observe the top of soda or beer in a corked bottle.

Q: Why does the bottle contain a small amount of gas trapped above the soda or beer?

E: The space is to allow the expansion of soda or beer when the bottle is stored in a warm place.

5.2.9 The Jumping Coin

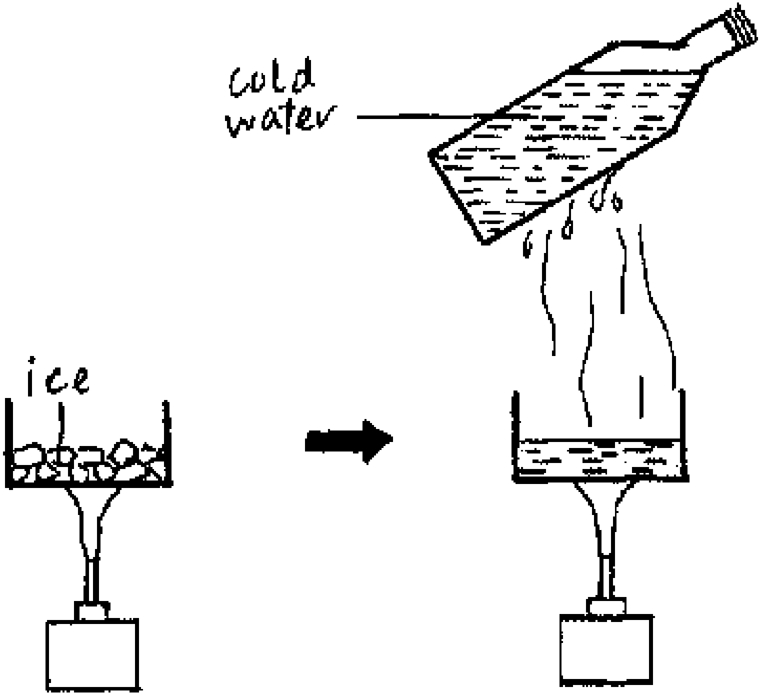
5.2.10 Contraction of Air



P: Place an "empty" bottle into a hot water . bath or burn some paper or a wooden stick in it. After it has warmed up, close the bottle either with your thumb or a boiled and peeled egg. Now immerse the bottle in cold water.

Q: What do you observe?

E: The thumb or egg will be held by the bottle, because on cooling the bottle the air inside contracts and creates a lower air pressure inside.



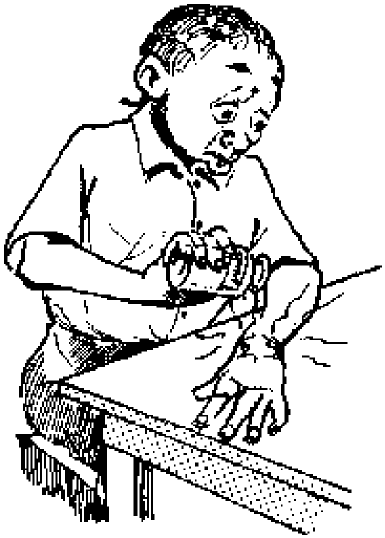
P: Heat ice in an open can for a few minutes and hold a glass bottle filled with cold water above the can.

Q: Which changes of state can you observe?

E: The ice changes from solid to liquid *(melting)* in the can. The liquid changes to gas *(boiling)* and the steam changes to liquid on the cold surface of the cold bottle *(condensation).*

5.3.2 Rain and Hailstone Formation

5.3.3 Evaporation

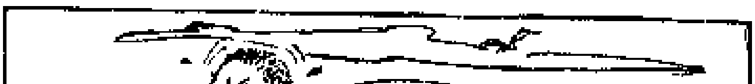


P: Pour some spirit or petrol on the back of your hand.

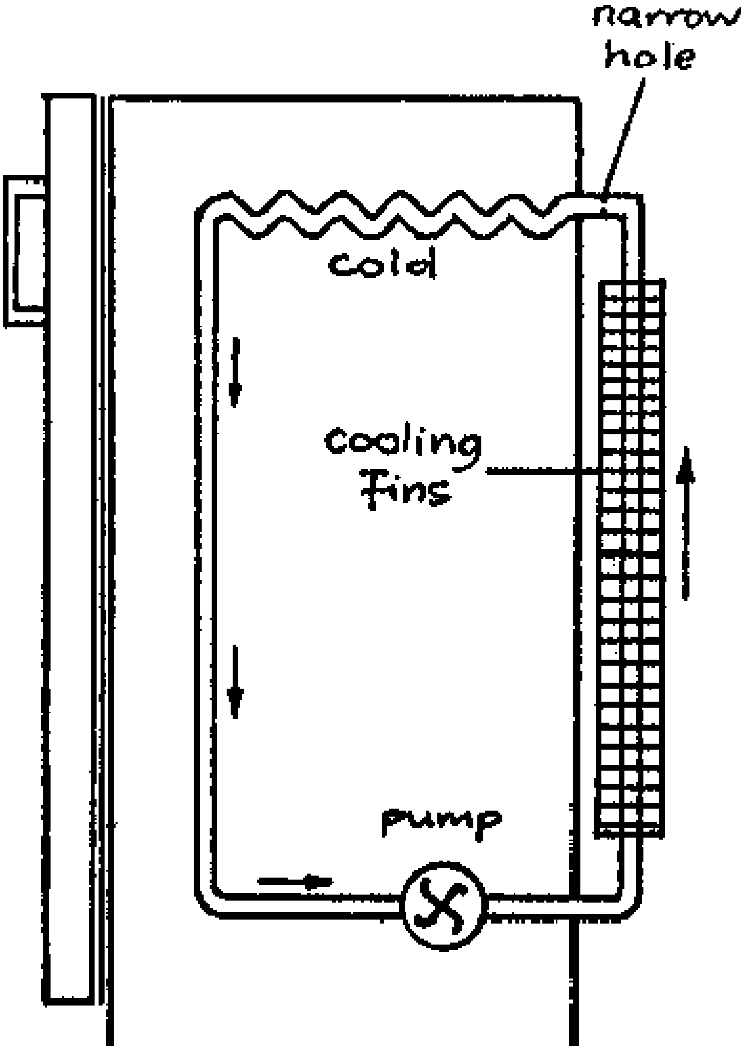
Q: Explain what you feel as the spirit evaporates.

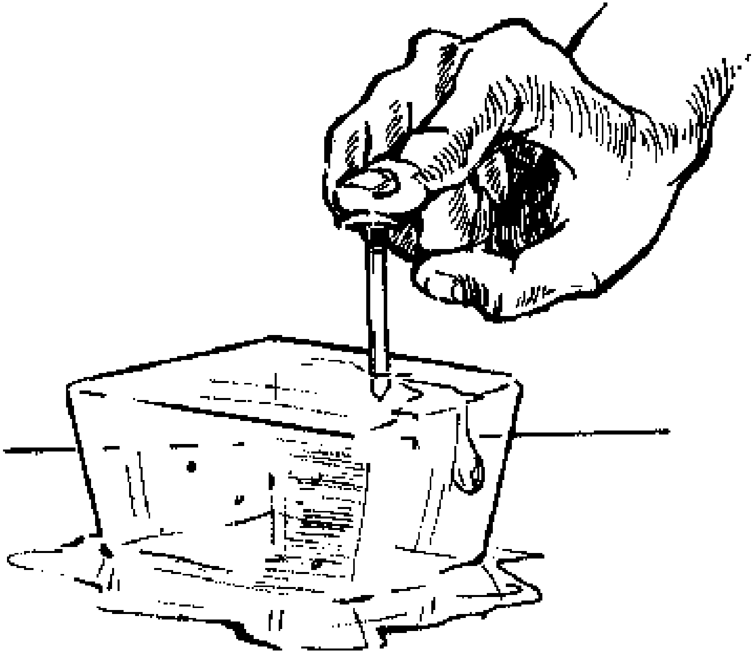
E: The back of the hand feels cold, because evaporation of the spirit needs energy which it absorbs from the skin.

5.3.4 Evaporation



5.3.5 Cooling Water


narrow hole
cold
cooling fins
pump



P: Steadily press a nail or a screw into a block of ice without heating it.

Q: What happens?

E: The nail penetrates into the ice because the pressure causes the ice at the tip of the nail to melt. (This is so, because water has less volume than the same mass of ice.) But when you release the pressure on the nail the water freezes again and "glues" the nail into the block of ice.

5.3.8 Impurities and Melting Point

5.3.9 Pressure and Boiling Point

P: Some people who go for mountain climbing expeditions take pressure cookers with them for cooking on the peak of a mountain.

Q: Can you explain why?

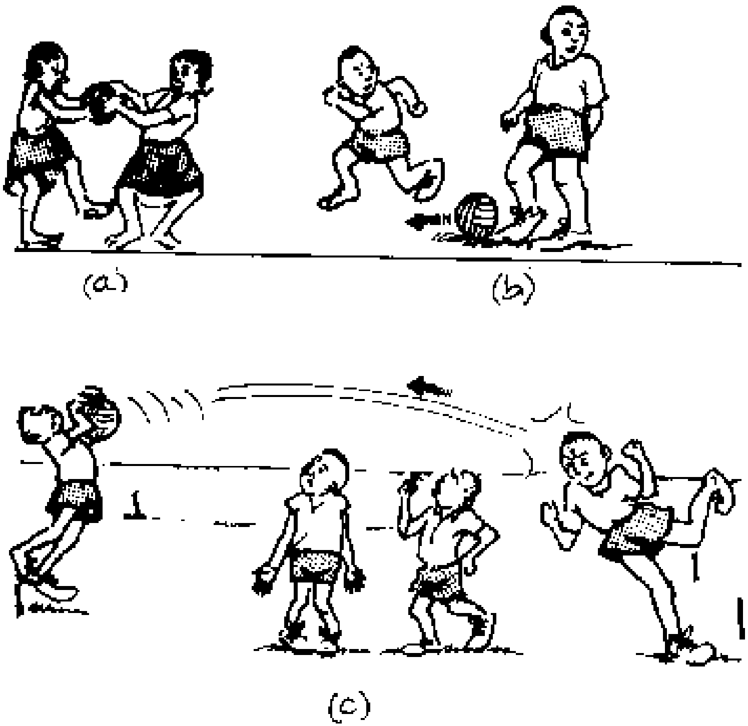
E: The air pressure decreases with the altitude and water will boil at a lower temperature on the peak of a mountain. Generally, *the lower the pressure on the water, the lower its boiling point.* Thus, food would need a very long time to be cooked e.g. on the top of Mount Kilimanjaro. So for food to cook faster we need to use a pressure cooker so that the temperature inside increases to cook the food faster.

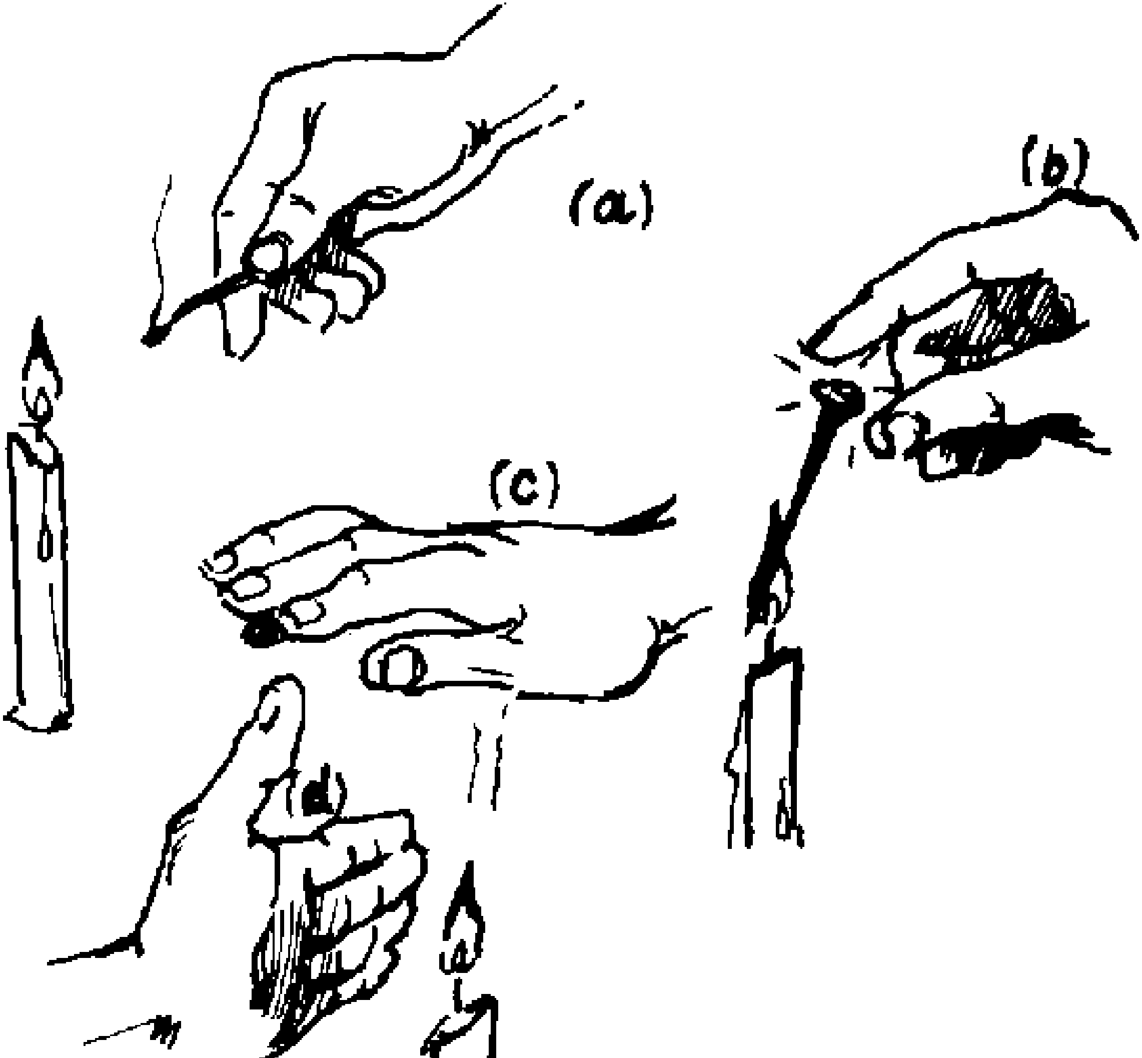
5.3.10 The Pressure Cooker

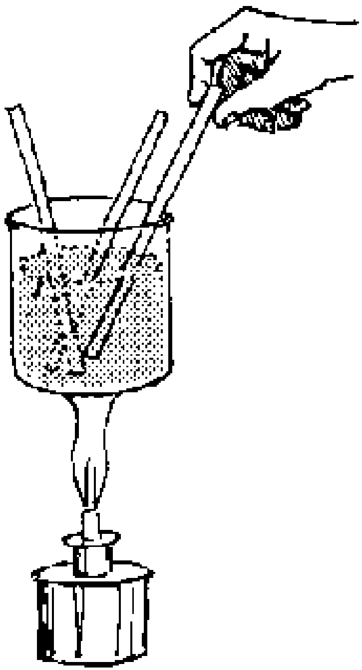
Convection of heat is the transfer of heat energy due to the movement of the material particles of the medium.

Radiation of heat is the transfer of heat energy from one place to another without the use of any material medium.

5.4.1 The Football Model Of Thermal Energy




(a)
(b)
(c)
(d)



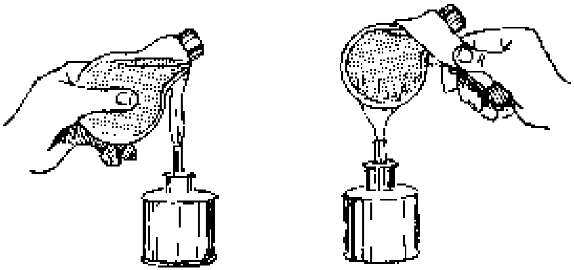
P: Heat water in a container until it is about to boil. Place metal, wooden and plastic rods of the same dimensions vertically into the water. Touch the exposed ends of the rods after 3, 4 and 5 minutes.

Q: What do you conclude about the conductivity of each rod?

E: The metal rod is a good conductor but the plastic and wood arc bad conductors.

A: Plastics and wood are used as handles of saucepans; the saucepans and other cooking pots arc best made of good conductors of heat e.g. metals.

5.4.4 Conduction by a Metal Rod



(a) (b)

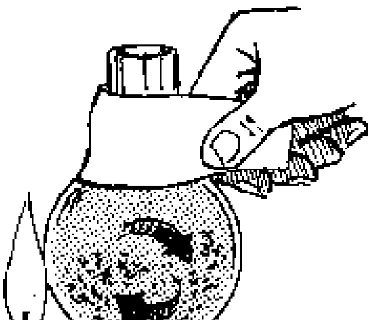
P: Fill a test tube or an opened bulb (see appendix) with water. Heat the water just below the top. Feel the bottom of the test tube with your hand, see figure (a).

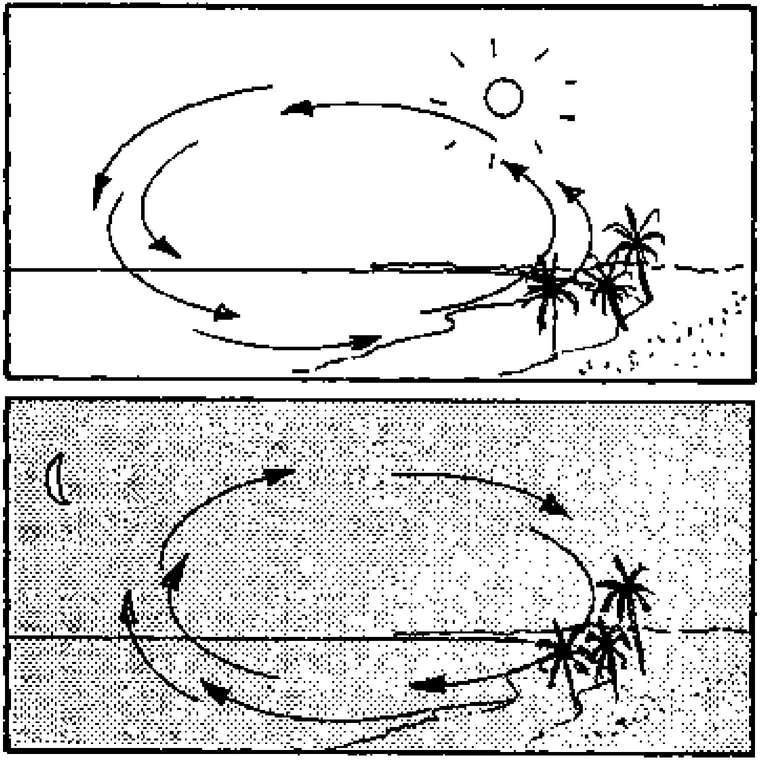
Q: Explain what you feel.

E: The bottom of the test tube stays cold because water is a bad conductor and does not conduct the heat to the bottom.

Q: What would happen if you held the test tube at the top and heat it at the bottom? (see figure (b)).

5.4.6 Convection of Heat

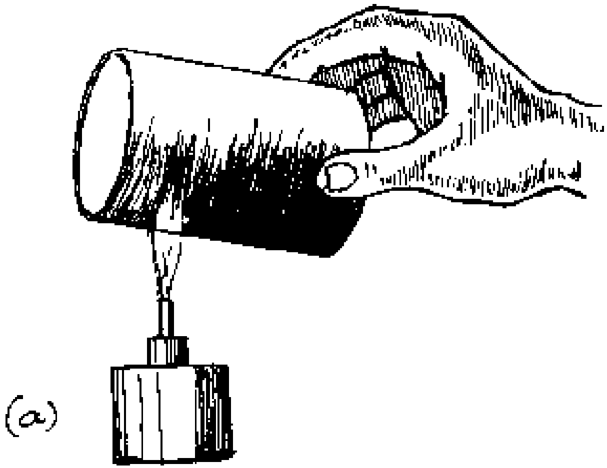


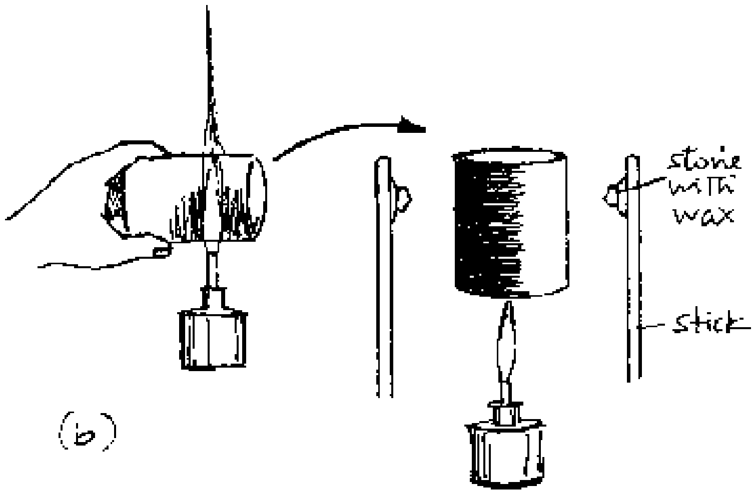


O: At the coast and on lake shores a gentle air stream (breeze) always blows. The direction of the breeze during the day is different from that at night.

Q: How can you explain this?

E: *During daytime* the land warms up faster than the sea. The warm air rises over the land and colder air from the sea flows to the land. This creates a breeze from the sea to the land. *During night,* the water stays warmer than the land, air over the water rises, colder air from the land flows to the sea. This creates a breeze from the


(a)


stone with wax
stick
(b)

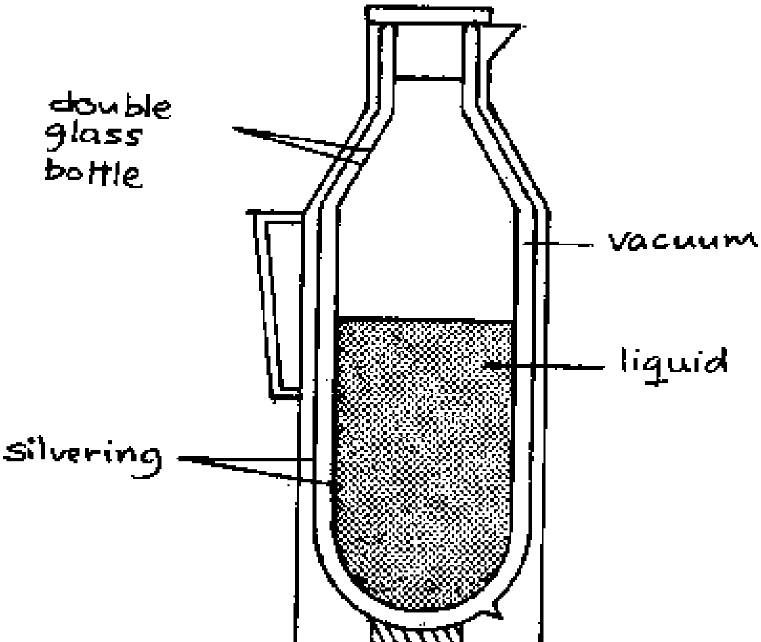
P: Take two shiny and identical cans and paint the outside of one black (soot can do). Place both of them in the sun or place them at equal distances from a fire for some time (about half an hour). Then find out how hot each can feels.

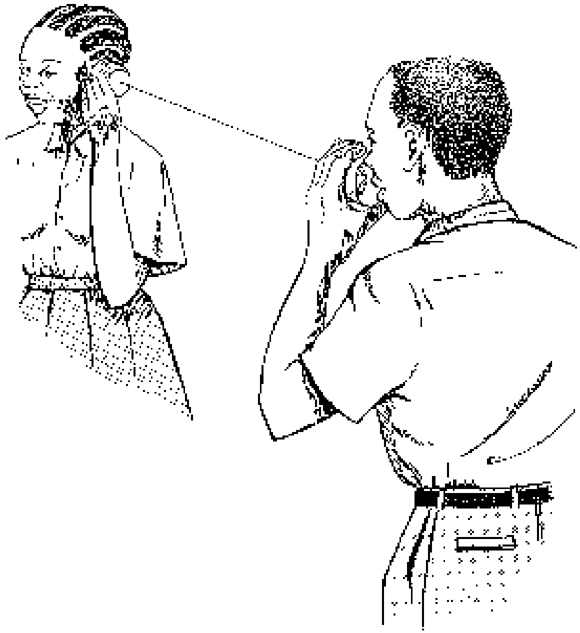
Q: Which can heats up more quickly?

E: The can with a *black surface absorbes heat more quickly than* the one with *a shiny surface.*

A: It is wiser for people in hot areas to wear bright clothes and paint their houses white – so that they absorb less heat. What colour should a petrol tank be painted? Give your reasons.

5.4.10 The Thermos Flask





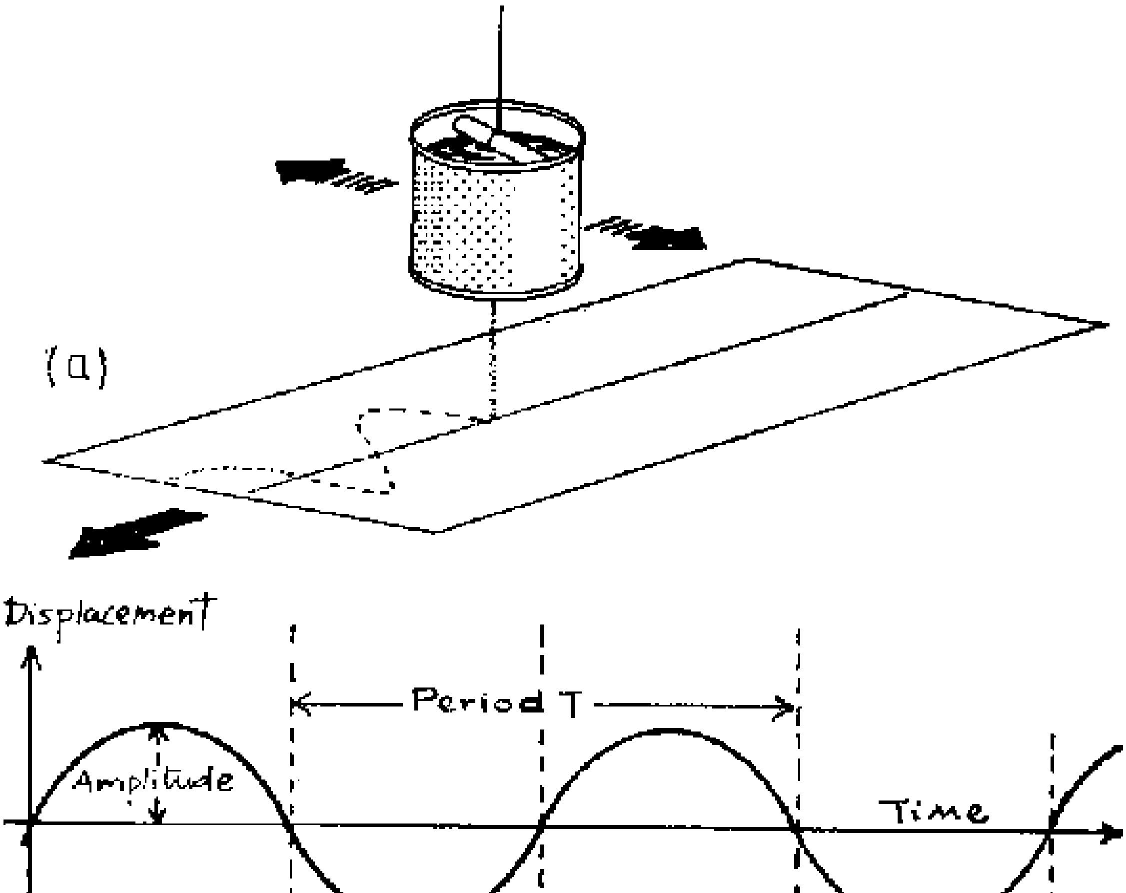
6.1. Production of Waves

If a stone is dropped in a still pool of water, concentric circles spread out from the point where the stone enters the water. These concentric circles are an example of a travelling disturbance. A travelling disturbance is called a *wave.*

In *transverse waves* (e.g. water waves) the vibration of the particles is *perpendicular* to the direction of the propagation of the waves. In *longitudinal waves* (e.g. sound waves) the vibration of the particles is *in the direction* of the propagation of the waves.

rope acts as a source of disturbance which travels along the rope. The direction of motion of the wave is *perpendicular* to the direction of jerking. Thus is a *transverse wave.*

6.1.2 Tracing a Wave Using a Pendulum Container

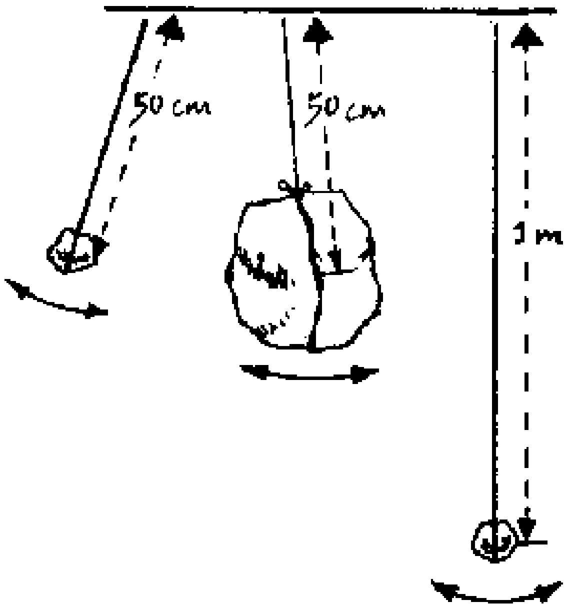


P: Clamp a ruler on a table with its free end protruding. Cause the free length to vibrate and listen to the sound. Repeat this for different protruding lengths of the ruler. Four different lengths are enough.

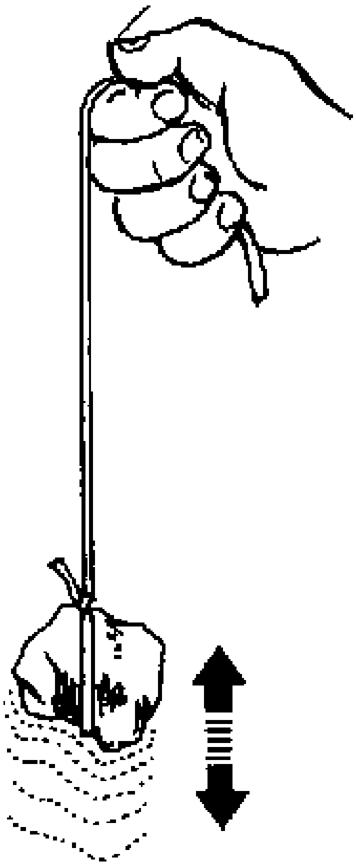
Q: How does the sound and vibration relate to the protruding length of the ruler?

E: When the vibrating length is reduced, a higher pitch sound is heard and the vibrations become faster and faster. When the vibrating length is increased, a lower pitch sound is heard and large masses of air are set into vibration with large amplitude. Consequently a loud sound is heard. Conversely, short lengths cause small masses of air to vibrate with small amplitudes producing a low sound.

6.1.4 A Transverse Pendulum

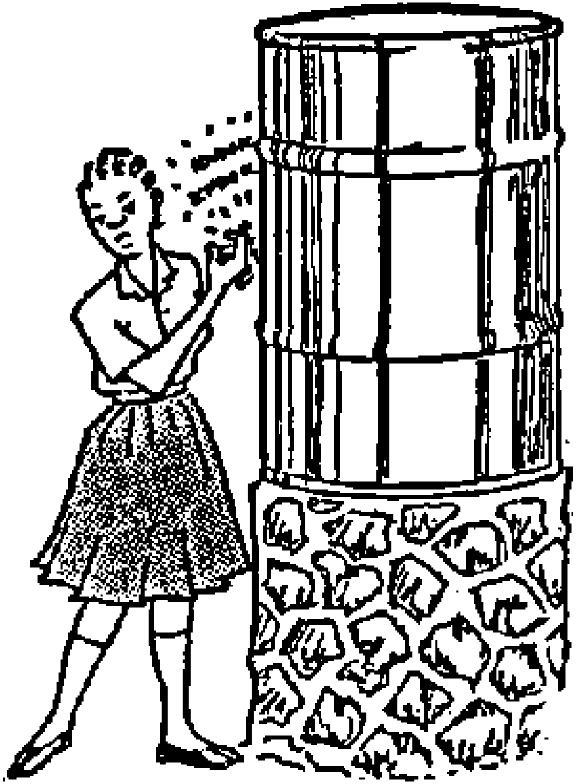


P: Tie a stone to one end of a thread of 50 cm length. Fix the other end of the thread and cause the pendulum



P: Tie a stone to one end of a rubber band and hold the other hand as shown above. Lift the stone up and release it so that it oscillates. Record the time for 20 oscillations. Find the frequency. Repeat the procedure by varying the length of the rubber band and the mass of the stone.

Q: What do you observe?



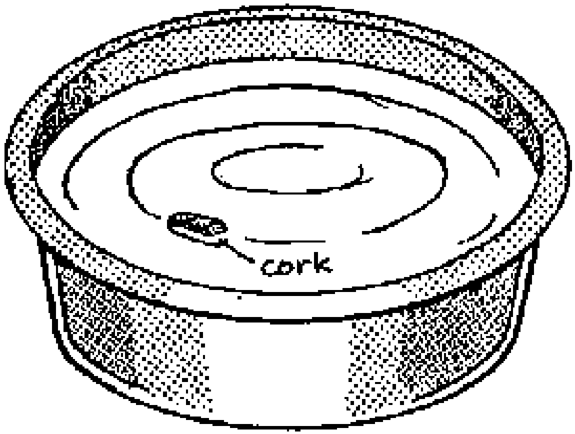
P: Gently knock the side of a wa(...)um from the top downwards to the bottom and listen to the tones (see the figure).

Q: What do you hear?

O: The knock causes the drum to vibrate. At the top, the knocking sets air inside the drum into vibrations giving a loud sound; at the bottom the knocking sets water inside the drum into vibrations giving a soft sound.

O: You will see circular waves spreading out rapidly. The drops disturb the water. The disturbance spreads out in concentric circles from the centre. The concentric circles observed are water waves.

6.1.9 Transfer of Energy



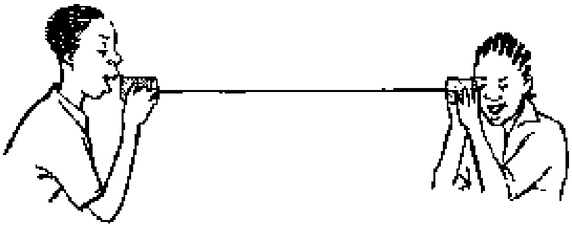
P: Put a small piece of light material (e.g. light wood, polystyrene) on the surface of water in a bowl. With a dropper (see 6.1.8) release a few drops of water onto the centre of the water surface. Avoid wind.

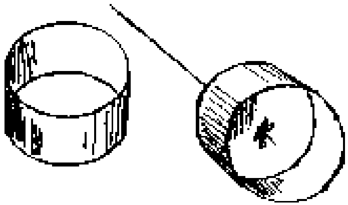
Q: What do you observe?

O: You will see water waves moving from the centre outwards but the pieces of light materia will not travel with the waves.

E: Energy travels with the wave. However, the particles of the wave–transmitting medium (e.g water) do *not* travel with the wave, they only oscillate up and down.

6.1.10 Transfer of Energy



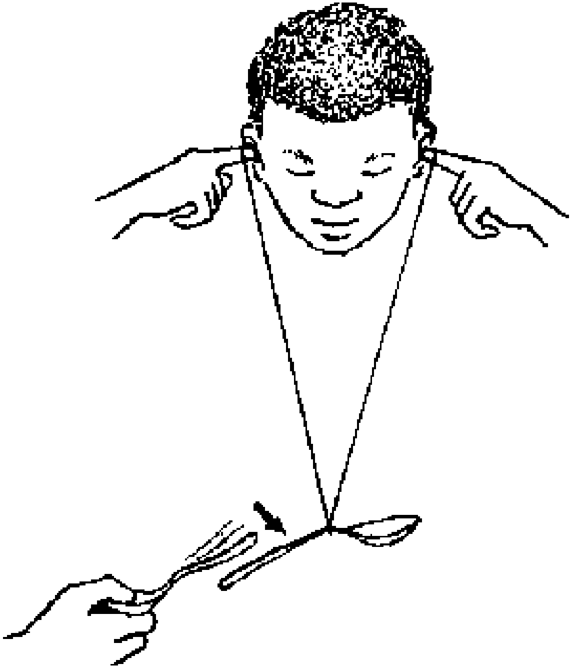


P: Punch a small hole at the centre of the bottom of each of the two empty cans. Connect the cans with a long string knotted inside each can. Hold the cans so that the string is stretched. Talk into one can while your friend is listening (he/she may close the other ear with a finger). Ask your friend to talk to you also and listen to him.

Q: What do you hear?

O: You will hear each other distinctly. Sound has travelled through the string (as a medium) from one can to the other.

6.2.2 Sound Waves in Air

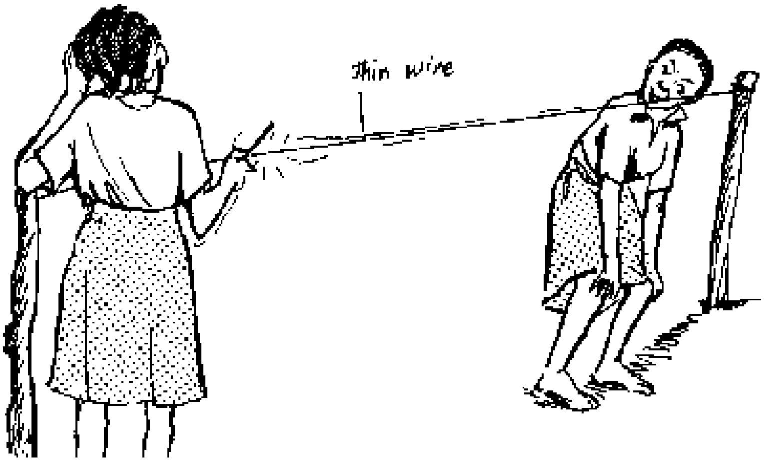


P: Tie a metallic teaspoon at the middle of a one metre long cotton thread. Wind each end of the thread around a fingertip (see figure). Press the fingertips into your ears. Bend down so that the string and the spoon hang freely. Let someone hit the spoon slightly with a nail or another spoon. Listen to the sound.

O: You will hear a chime sound like that of a church bell.

E: Sound travels through the string to your ears. Sound travels better in strings than in air.

6.2.4 Sound in Wood



P: Take a long thin wire and fix it to two posts placed about 5 m apart. Tell your friend to be at one end. Then scratch the other end of the wire. Scratch the wire again while your friend has placed his/her ear against the wire on his/her side.

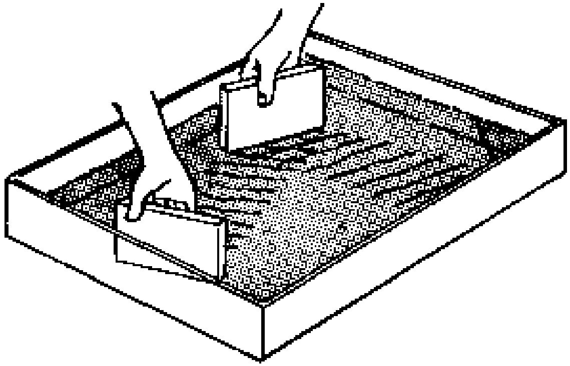
Q: Ask your friend what he/she hears.

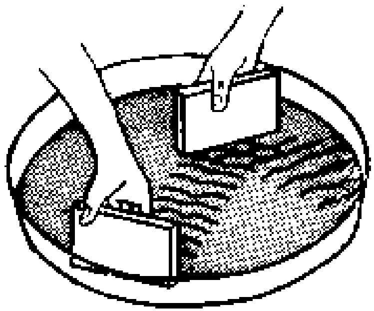
O: Your friend will hear nothing unless he/she places his/her ear against the wire.

E: Sound travels better in metal than it does in air.

6.2.6 Sound in Water

6.3.1 Reflection of Water Waves

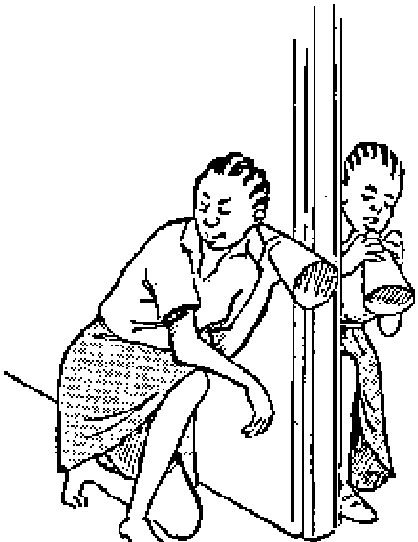




P: Place a straight metal or plastic barrier in the dish containing coloured water. Touch the surface of the water with a rectangular block of wood repeatedly in equal time intervals.

Q: What do you observe?

O: Parallel waves move across the dish and rebound from the barrier.



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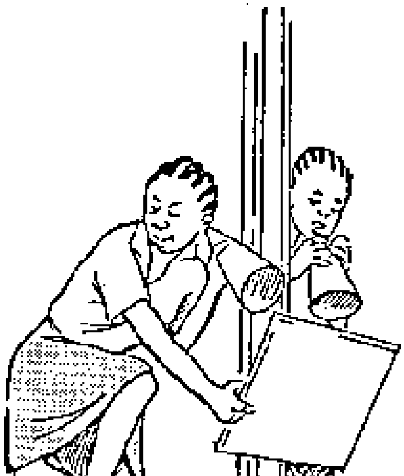
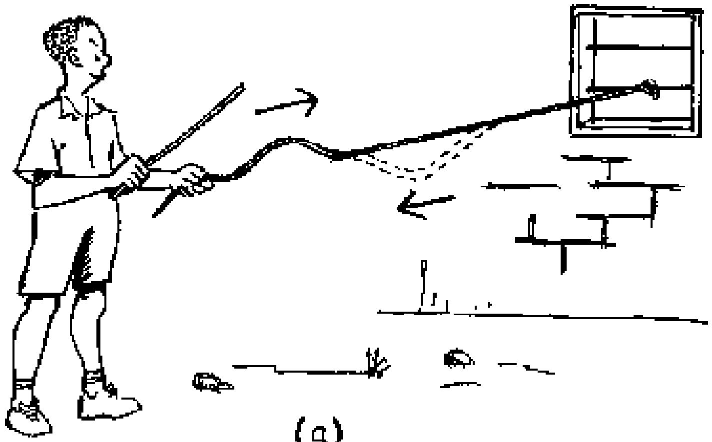
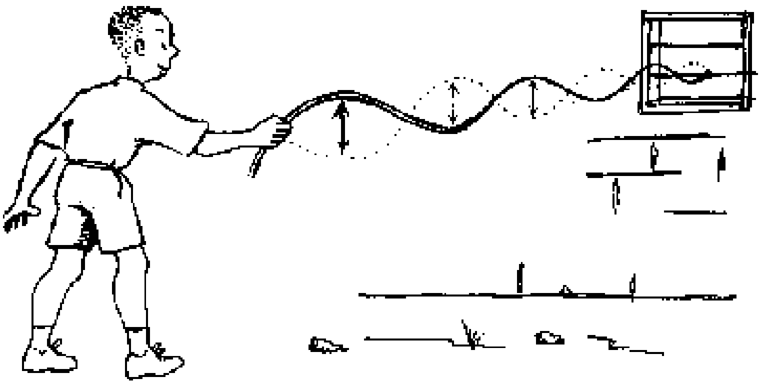




(a)



(b)

P: Take a long piece of an empty garden hose pipe. Listen at one end of the pipe while your friend is whispering into the other end of the pipe.

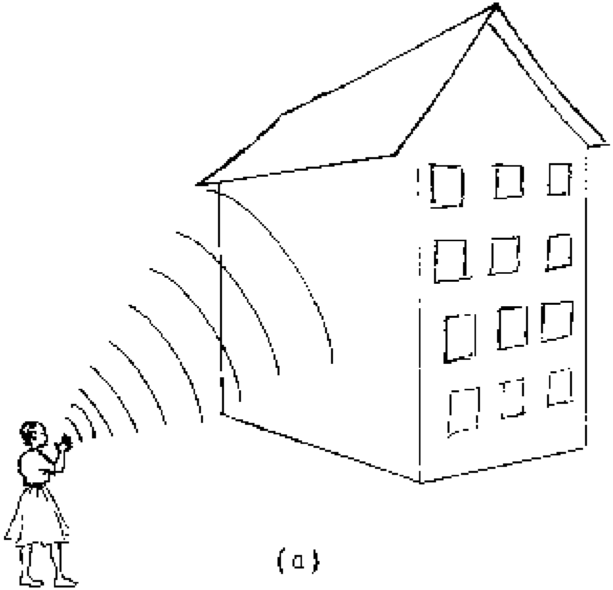
Q: What do you hear?

O: The sound is heard more distinctly.

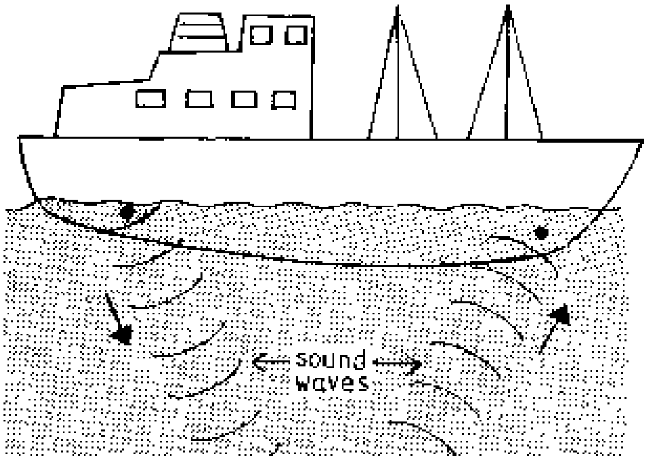
E: When your friend is whispering,, he is sending sound waves into the pipe which are reflected on the walls of the hose pipe. These waves are directed to the other end of the hose pipe where they can be heard.

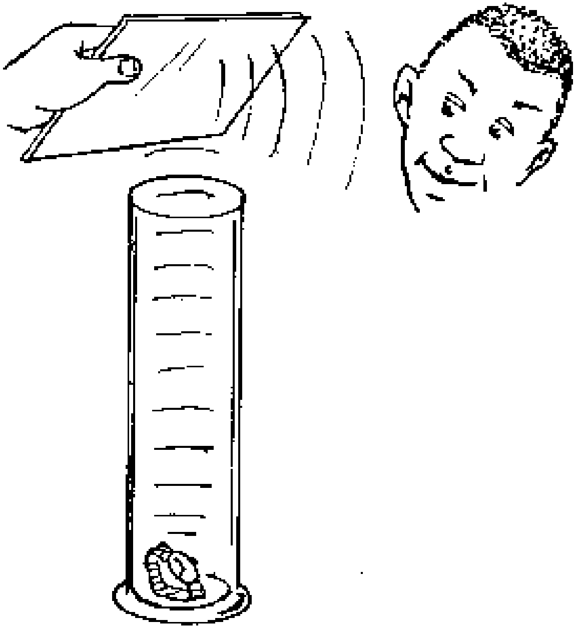
A: Similarly light can be reflected in a glass fibre. Thus, light pulses may be transmitted by glass fibres. This is used for telephone television etc.

6.3.5 Reflection of Sound Waves: Echoes



(a)





P: Take a tall cylindrical container and put a mechanical clock in it. Place your ear close to the side of the container. Listen to the sound from the clock. Then place a cardboard at slant position about 5 cm on top of the container and listen again (change the position of the board).

Q: What do you hear?

O: In the absence of the cardboard no sound is heard. But in the presence of the cardboard the tick–tack sound is heard.

E: This is because the sound from the clock travels vertically up and is reflected by the cardboard towards the observer.

under the thread so as to raise the thread off the board. Pluck the thread between the two pencils. Vary

(a) the distance between the two pencils;
(b) the mass hanging.

Q: What do you hear?

O: (a) A higher tone is produced if the distance between the two pencils is reduced.

(b) A higher tone is produced if the mass is increased.

E: The tone which is produced by the vibrating string depends on its vibrating length and the tension of the string.

6.4.2 Bottle Orchestra

Q: What do you notice?

O: The plucking causes the spokes to vibrate and produce sound. The longer the spoke, the lower the tone.

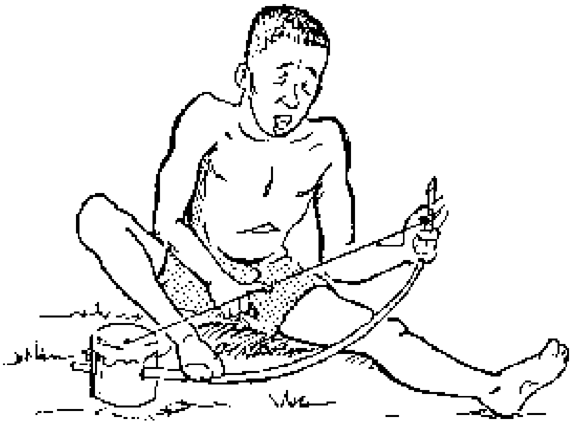
A: Grand pianos produce lower notes than normal ones.

6.4.4 Simple Flute (Bamboo Flute)

P: Take a straight bamboo tube of about 1.5 cm diameter and 30 cm length. Clean the knots inside. Dry it until its colour changes to yellowish–brown. Make a mouth–piece and a row of holes as shown in the figure. Blow air into the mouth–piece while closing some of the holes with your fingers.

Q: What do you hear?

O: Different tones are produced by the flute as you remove fingers from different holes.



P: Make two holes diametrically opposite each other near the upper open end of a tin and then pass a flexible wooden stick through them so that it just protrudes from the can on one side. Bore a small hole at the centre of the bottom of the can. Fix one end of a string at the hole and tie the other end to the end of the stick which is bent into a bow as shown in the diagram. Make the string tight. Pluck the string repeatedly with a finger as if playing a guitar.

(a) Change the tension by further lightening the string.

(b) Change the length of the vibrating portion of the string by touching the upper end with your finger.

Q: What do you hear?

O: (a) The pitch of the tone produced increases with the tension of the string.

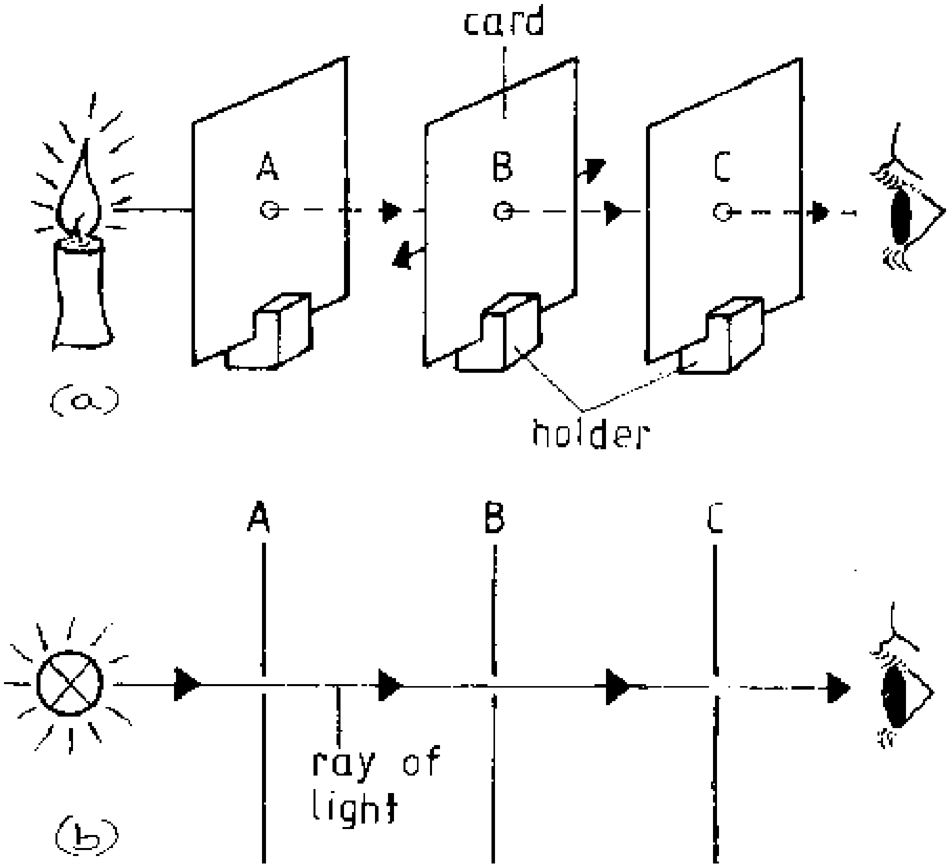
(b) The pitch of the tone produced increases with the decrease of the length of the string.

H: Knotting the string on a nail held horizontally in the bottom of the can helps to anchor the string.

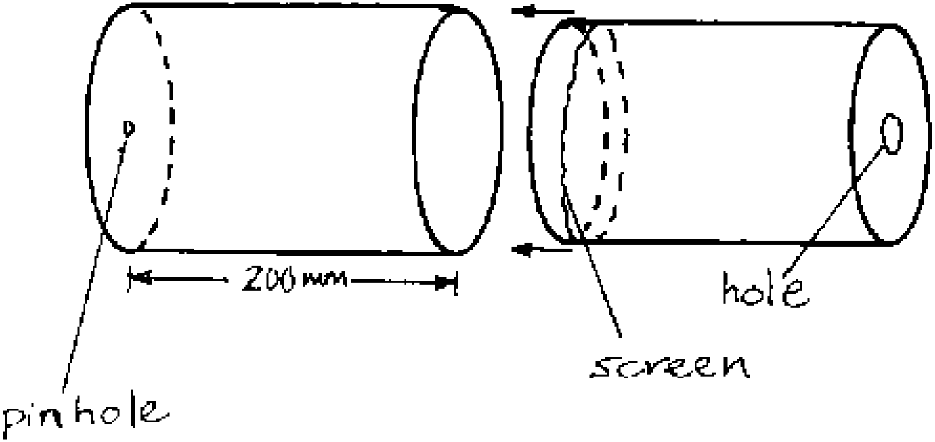
6.4.6 The Xylophone

O: Different sizes of bars give different tones and different types of materials of the same thickness give different tones.

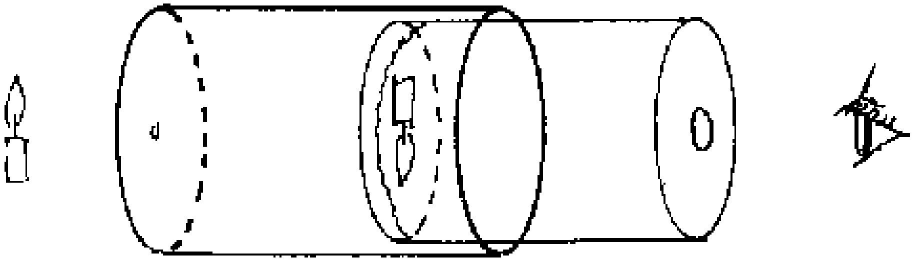
7. Geometrical Optics



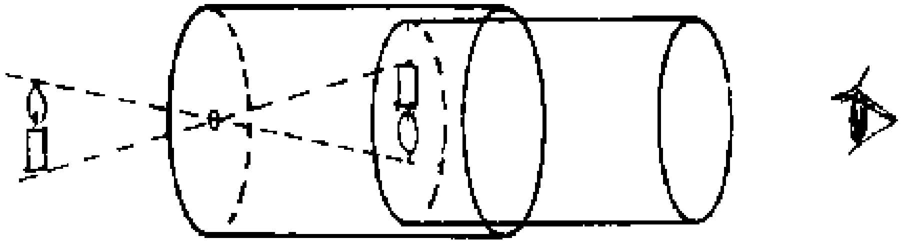
P: Make small holes on pieces of cardboard A, B and C. Place them in front of a source of light as shown. Pass a thread through the holes and pull it at both ends to make it taut. Adjust the cardboards so that all the three holes are in line. Remove the thread. Bring a candle near card A and look through the hole in card C. Record your observations.



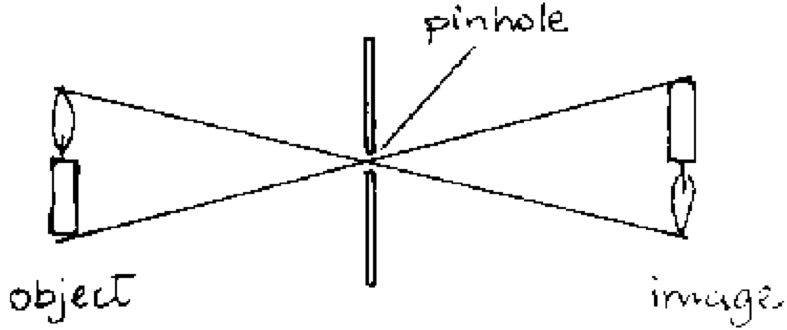
(a)



(b)



(a)

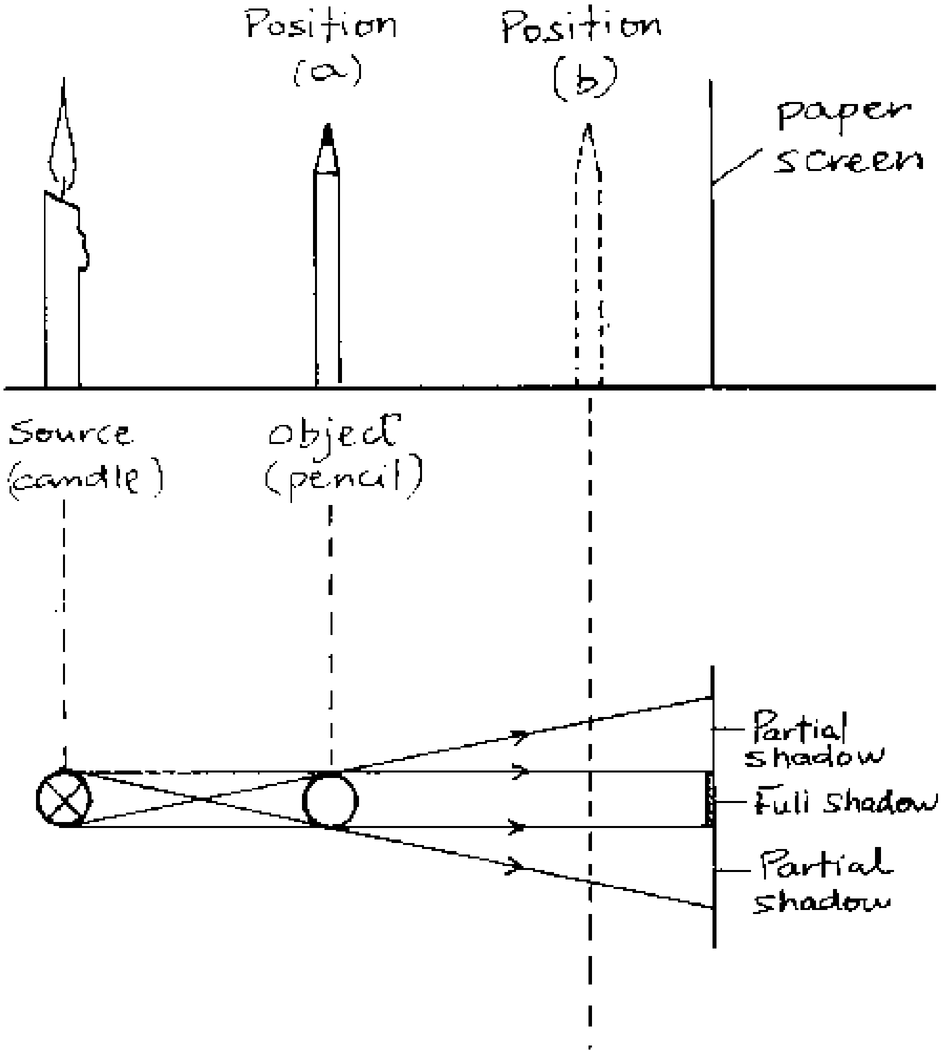


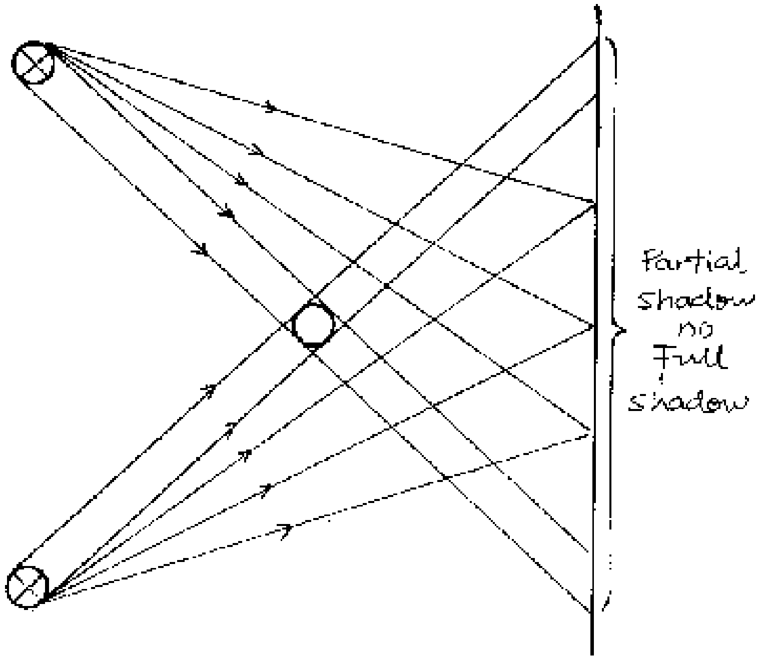
(b)

P: (a) Observe a burning candle using the pinhole camera. Adjust the pinhole–screen distance in order to get a clear, sharp image of the candle.

(b) Change the distance between the screen and the pinhole by steadily pulling the inner cylinder. Observe what happens to the image.

(c) Move the camera slowly away from the candle, and observe what happens to the image.


Position (a)
Position (b)
paper screen
Source (candle)
object (pencil)
Partial shadow
Full shadow
Partial shadow



P: Repeat the above experiment using two candles and one pencil. Observe the shadows formed.

Q: Explain the results and discuss the formation of shadows by a point source and extended source of light.

E: The figure shows that all the points of the screen which do *not* receive rays from candle 1, *do receive* rays from candle 2 and vice versa. Thus, full shade does not exist in this experiment (except the object is brought very close to the screen).

7.1.6 Rays in the Smoke Box

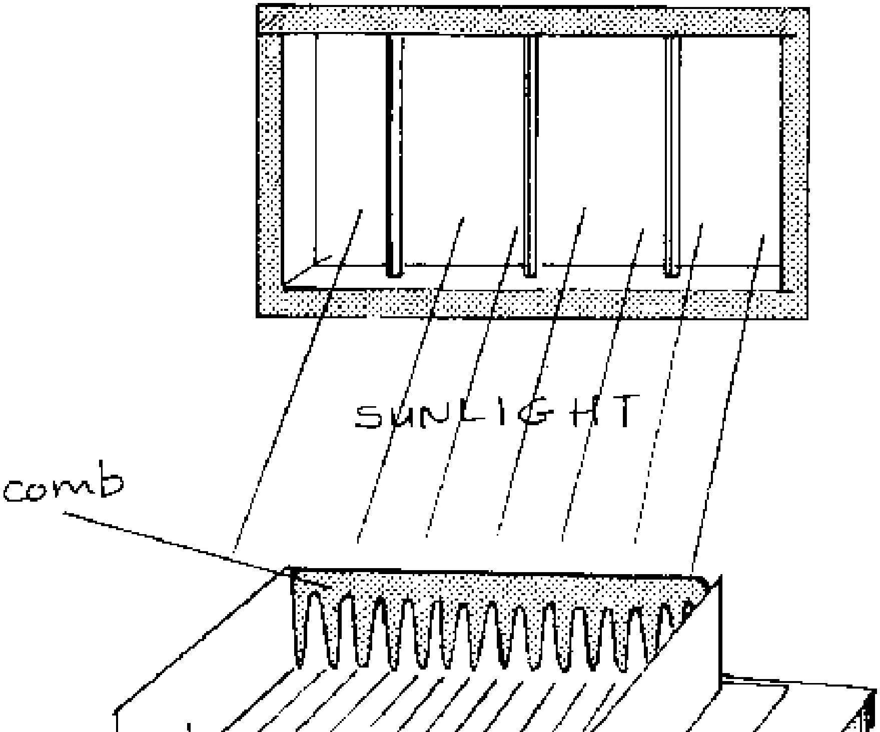
Sunlight or torchlight may be used as a source of light.

Q: How is it possible for smoke or dust to make beams of light visible? Why are sunlight rays parallel?

E: The smoke particles reflect some of the light in all directions and hence make it visible.

Sunlight rays are parallel when they reach the earth, because the earth is 150 million km away from the sun.

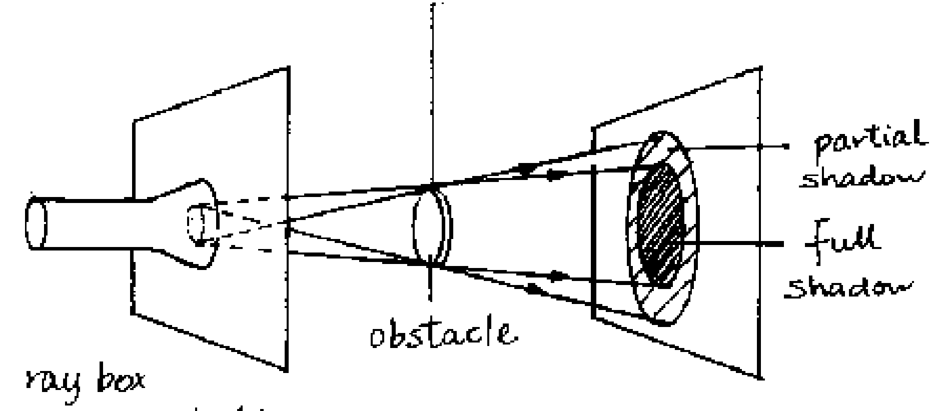
7.1.7 Beams of Light



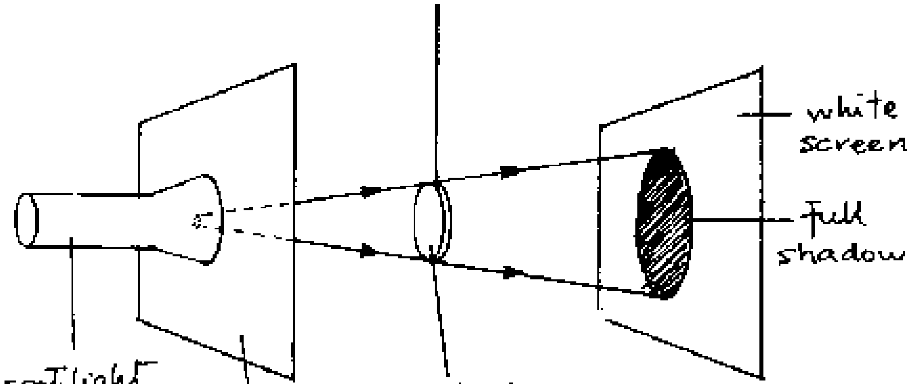
E: A *ray* is the direction of the path taken by light. A collection of rays forms a *beam.*

Since the sunlight consists of parallel rays, *parallel* beames of light will be observed on the white paper.

7.1.8 Shadow Formation by Point and Extended Sources of Light



(a)



Single *point sources* give mainly full shadows. Sharper shadows are obtained when an obstacle intercepts parallel rays, i.e. rays from a distant source. Though the sun is an extended source, its rays reach the earth parallel and therefore produce sharp shadows.

7.2 Reflection of Light

When light strikes a surface separating two different media, part of it is thrown back to the original medium. This phenomenon is called *reflection.*

If the surface is smooth, reflection is regular, otherwise it is diffuse. The position of the object determines the position and attribute of the image.

The *law of reflection* states:

The *angle of incidence is always equal to the angle of reflection.* These angles are always measured *against the normal* of the reflecting surface.

This is sufficient to construct *ray diagrams* for plane mirrors. For *spherical mirrors* the following rules are helpful for the construction of ray diagrams:

(i) *Rays parallel to the axis are always reflected through the principal focus* F.

(ii) *Rays passing through C* (the centre of curvature of the mirror) *are reflected back along their own path.*

(iii) *Rays passing through the principal focus* F *are reflected parallel.* (Reverse light path of (i).)

The distance of F from the mirror surface is called the *focal length* f. For spherical mirrors the *radius of curvature* r is always equal to 2f: r = 2f.

Repeat the experiment with mirrors at angles of 60° and 30° to each other.

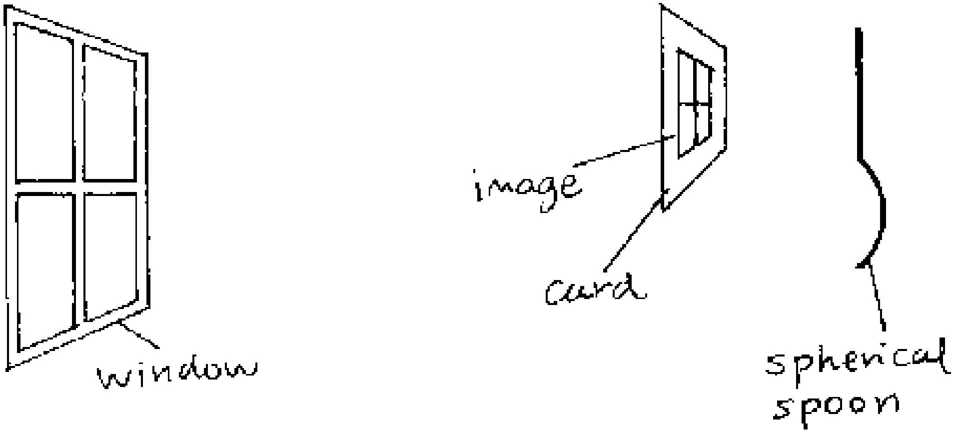
Q: How many images can be seen in each case?

O: When mirrors are at 60° to each other, five images are seen, at 30° eleven images are observed. When the mirrors are parallel to each other, there is a large number of images.

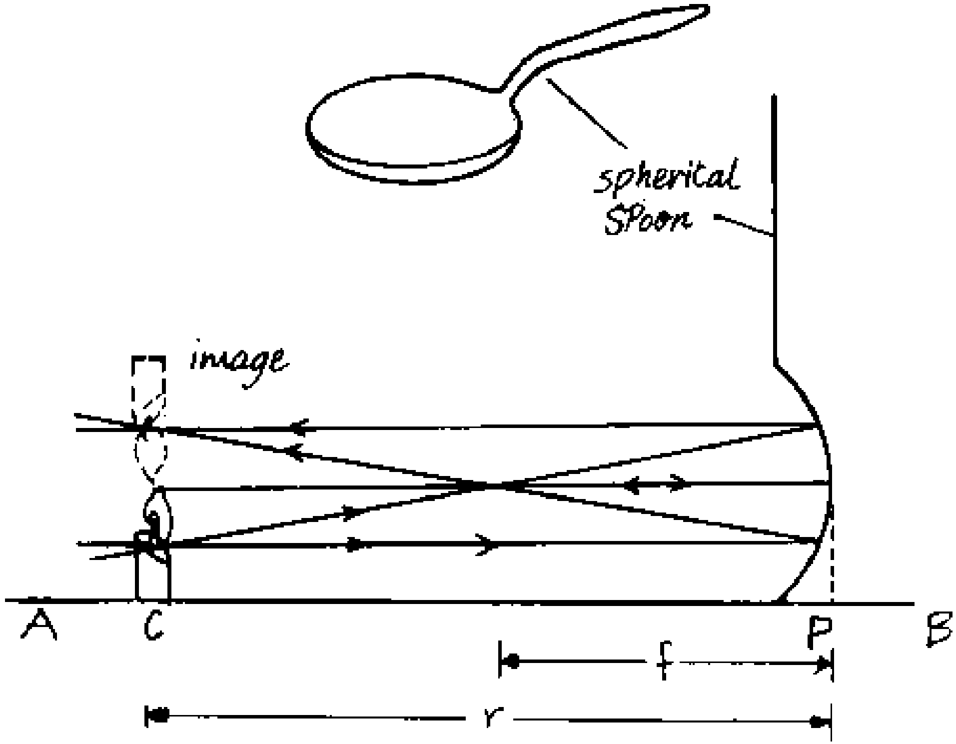
H: Note that the number of images = (360° ÷ angle between the mirrors) – 1

A: The kaleidoscope arrangement is used in shops and pavillions to display items.

7.2.2 The Focus of a Concave Spherical Mirror



P: A simple concave mirror is the face of a shiny spherical spoon. Hold the curved mirror and a white card in front of the mirror as shown in the figure. Point it towards a distant window, so that it throws the image of the window on the white card. Move the mirror back and forth to find a position where it gives you a clear image on the white card. Note the image distance (the distance from the mirror to the card).



P: Draw a line AB on a white sheet of paper. Place a concave mirror on the paper with its centre vertical above point P. Light a candle and place it in front of the mirror on line AB, see in the figure.

Move the candle back and forth along line AB to get a point C on AB, where the inverted image of the candle coincides with the object candle. Point C is a *point of no parallax* because when you move your head slightly to the left or right, the object and image remain inseparable.

Q: Measure the radius of curvature CP = r. Compare your values of f and r. What do you find out?

Arrange the back of a spherical spoon (a convex spherical mirror) and a lighted candle on a white sheet of paper. Locate the image formed by use of a needle or a lighted candle held behind the mirror. The image position is the point of no parallax (see 7.2.3) between the image and the locating needle or candle.

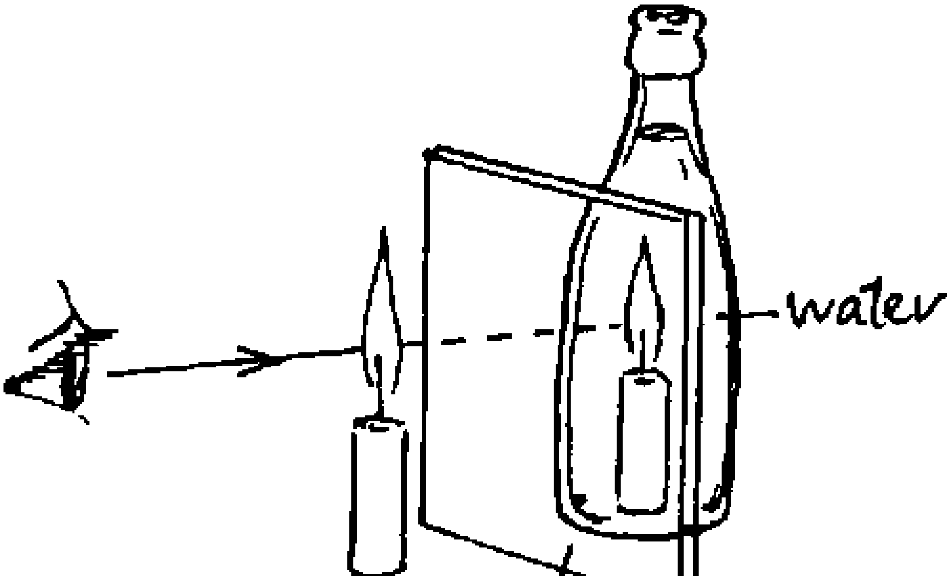
Mark the position of the object, the mirror and the image. Measure the object size, the object distance and the image distance.

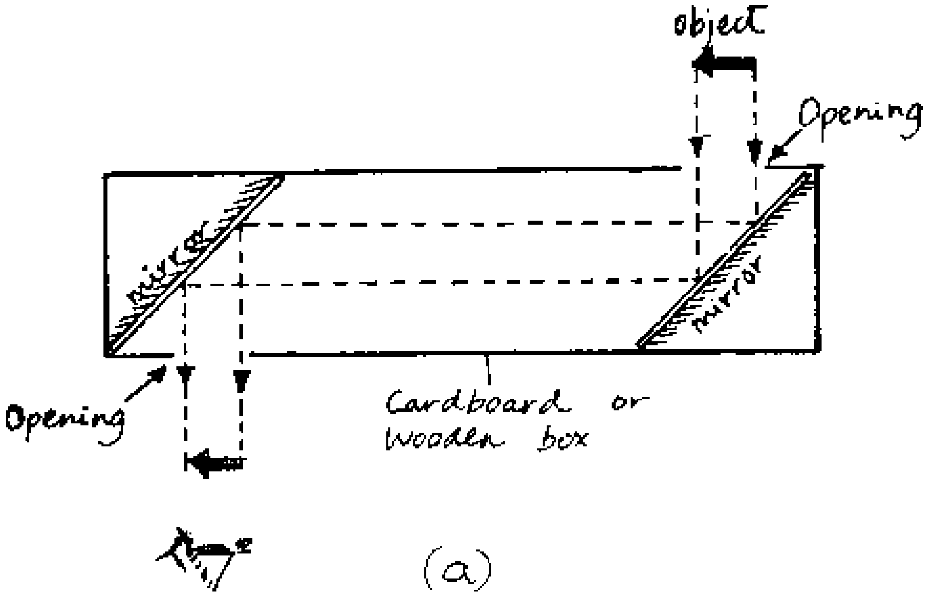
Draw the ray diagram to show how the convex mirror forms an image (see the figure).

E: The image seen is always virtual, erect and reduced in size.

A: The convex spherical mirror is used as a rearview mirror in cars because it gives a broad field of view.

7.2.5 Candle in Water Experiment




object
Opening
mirror
mirror
Opening
Cardboard or
wooden box

(a)


rays
of light
Vertical
Periscope.

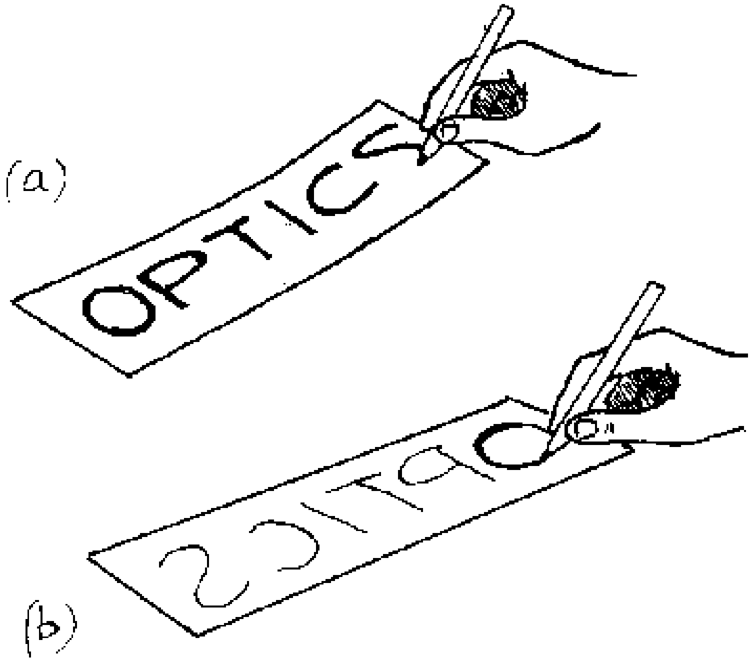
How do they appear?

Write the word OPTICS on a paper and use it as an object. How does the image appear?

Compare your observations with experiment 7.2.7.

A: The periscope is used in dived submarines to see what is above the water surface, see figure (b).

7.2.7 Reversed Image



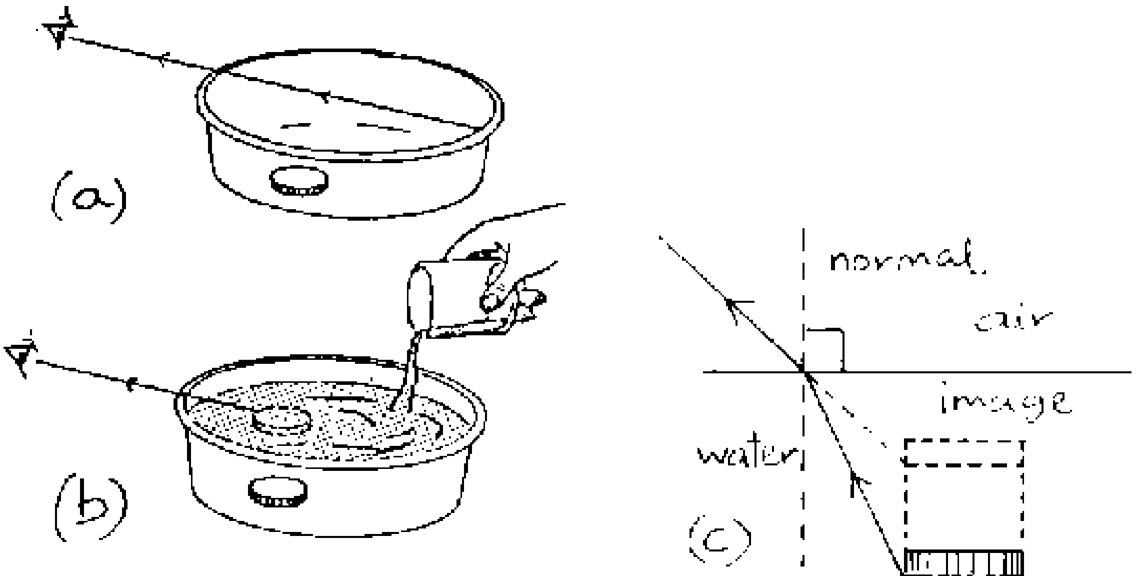
observations with those under section 7.2.6. What do you conclude about the mirror image?

E: Mirror images are reversed images, i.e. the left and right side of the object are interchanged.

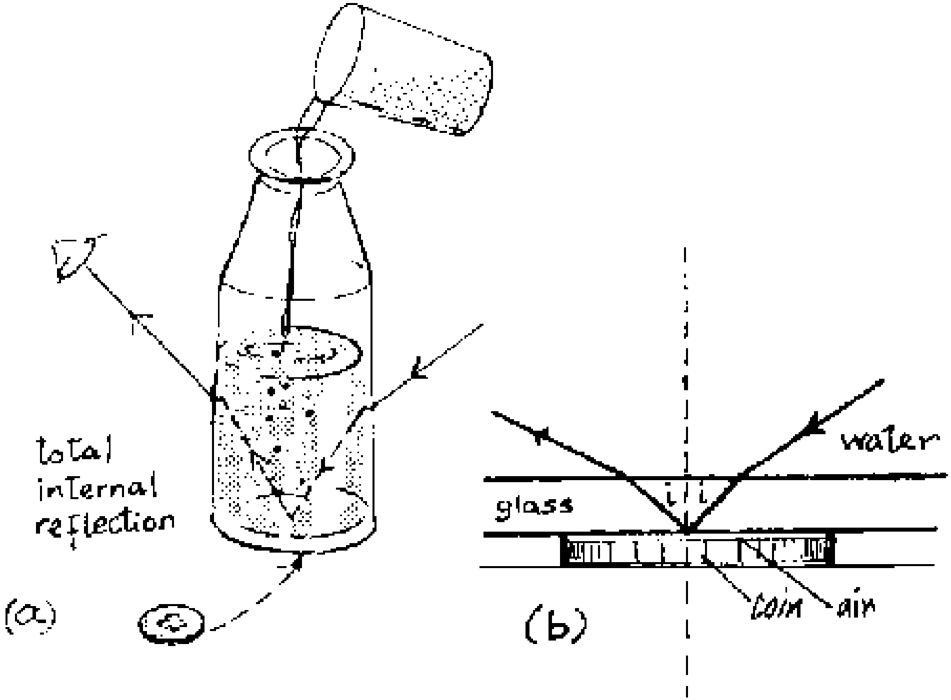
7.3 Refraction of Light

Refraction is the change in direction of light as it passes from one medium into another of different density. Refraction is used in lenses to produce images in cameras, microscopes, telescopes, etc. *Total internal reflection* takes place on the boundary between an optically denser medium (e.g. glass) and an optically less dense medium (e.g. air), when the angle of incidence in the denser medium is greater than the *critical angle.*

7.3.1 The Rising Coin

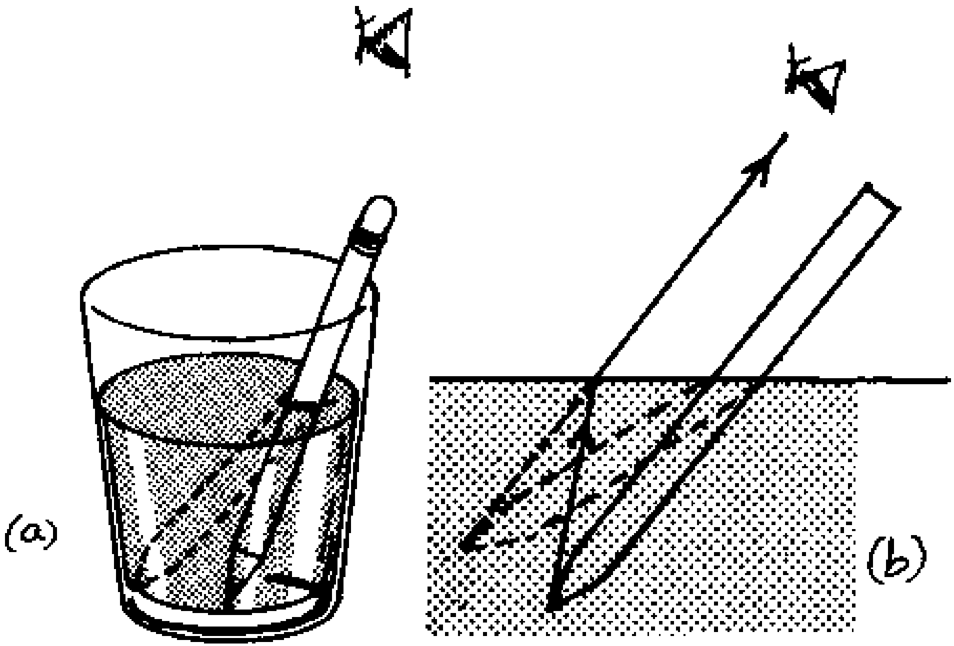


7.3.2 Total Internal Reflection



Place a transparent bottle on a coin and look at the coin from above at an angle from the normal. The coin can be seen. Pour water into the bottle slowly. There is a level at which, when you look at the coin, it disappears from sight, see figure (a).

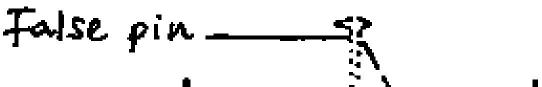
This phenomenon is called *total internal reflection.* It is a special type of refraction. In our experiment, it takes place at the bottom of the bottle where the glass borders the air (above the coin). Total reflection only takes place on a boundary between an optically denser (e.g. glass) and an optically less dense medium (e.g. air) when the angle of incidence in the denser medium is greater than the *critical angle.* In our case the light rays

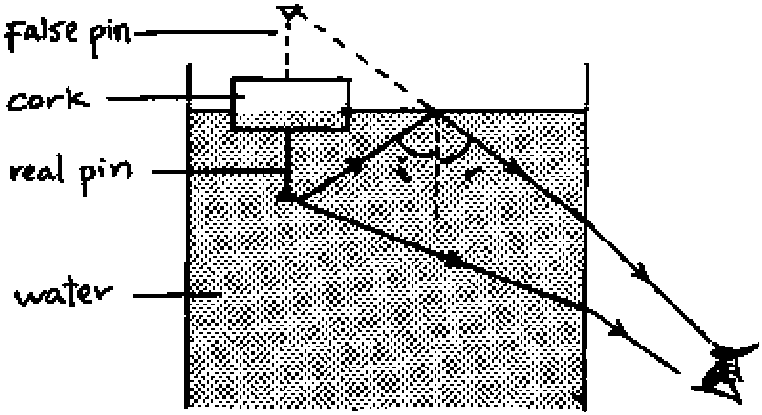


P: Pour water in a glass. Place a pencil in the water at a slant position, see figure (a). Look at the pencil through the surface of the water sidewise along its length and note what you see. Explain your observation by using a ray diagram.

E: Figure (b) gives the ray diagram which explains the observation that the pencil seems to be bent by refraction.

7.3.4 The False Pin





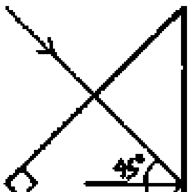
Draw a ray diagram and explain how the false pin appears on top of the cork.

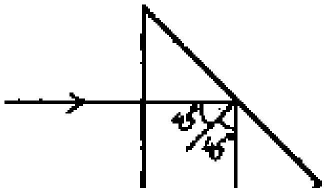
E: Some rays from the pin towards the eye are refracted at the glass–air boundary making the pin visible to the eye.

Other rays from the pin undergo total internal reflection at the water–air boundery. The reflected rays are refracted at the glass–air boundary before they reach the eye. Hence the eye sees a virtual image of the pin on top of the cork as shown in the figure.

Hence both the real pin and the false pin can be seen by the observer.

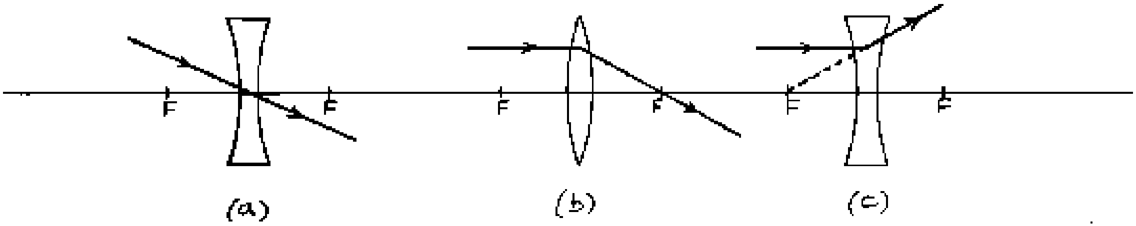
7.3.6 Total Internal Reflection in Prisms



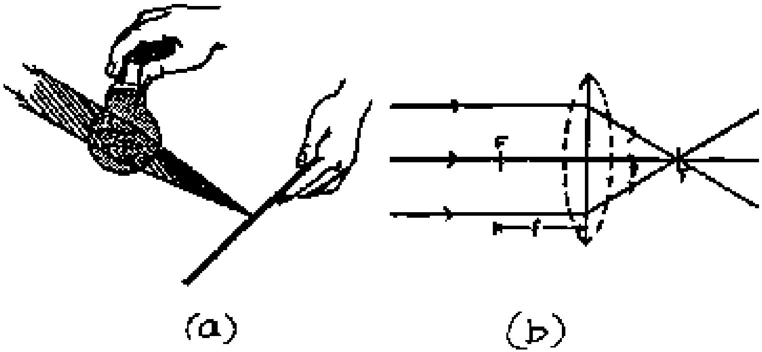


For convex (converging) lenses: rays parallel to the axis are refracted through the principal focus F, see figure (b).

For concave (diverging) lenses: rays parallel to the axis are refracted away from the nearer principal focus F, see figure (c).



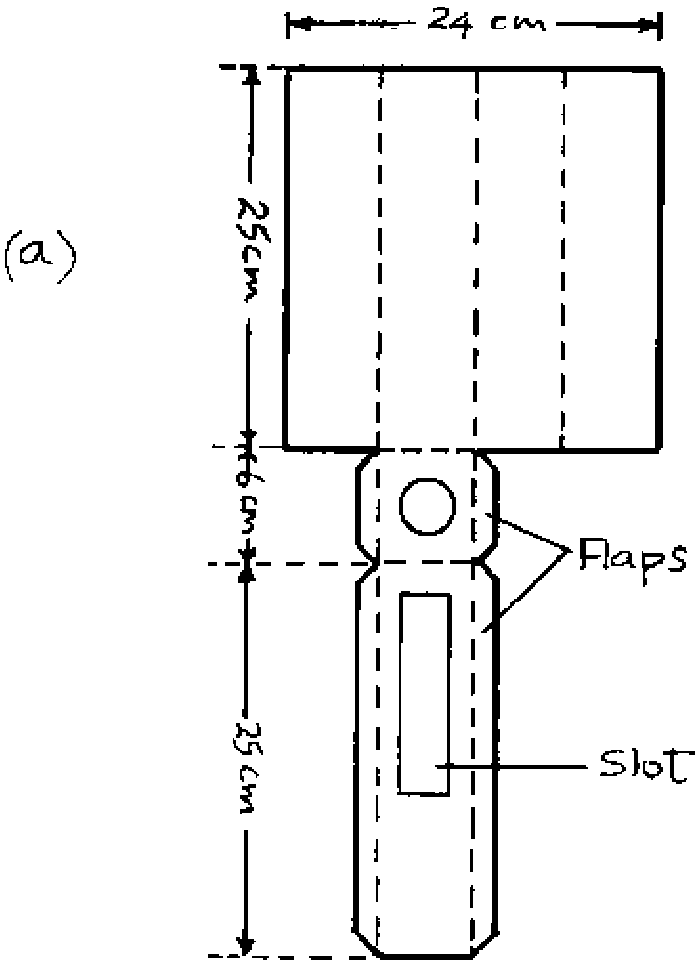
7.4.1 Action of a Convex Lens on Parallel Rays



P: Hold a water filled opened bulb (see appendix) or a concave lens into the direct sunlight and focus the light on one spot of a paper.

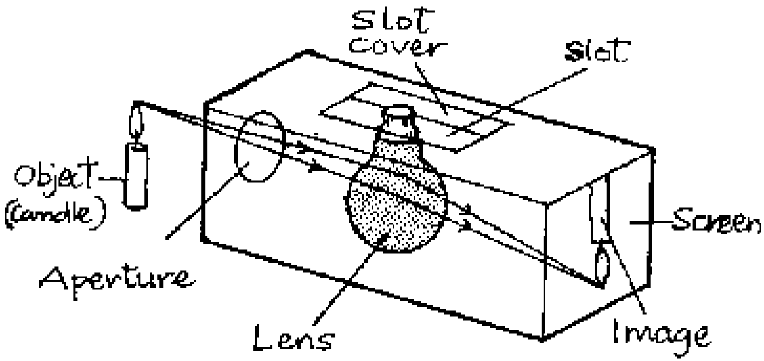
E: The distance between the centre of the bulb or lens and that spot on the paper is called the *focal length* f. We can draw a ray diagram for this experiment, see figure (b). The focal points are denoted as F. The action

7.4.3 How to Construct a Simple Box Camera



H: Make sure that the box is light–tight (light–proof).

7.4.4 Using the Simple Box Camera



P: Use the simple box camera to produce images of illuminated objects like a candle, a window etc. Change the position of the lens (bulb) so that you obtain a sharp image on the screen.

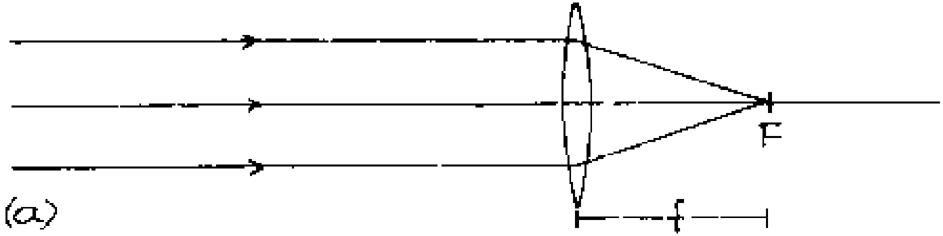
(i) Find the focal length f of the lens (bulb) by focussing a distant object (e.g. a distant window) on the screen. Then the image distance v is equal to f. Measure the image distance v on top of the camera from the centre of the bulbs neck to the screen.

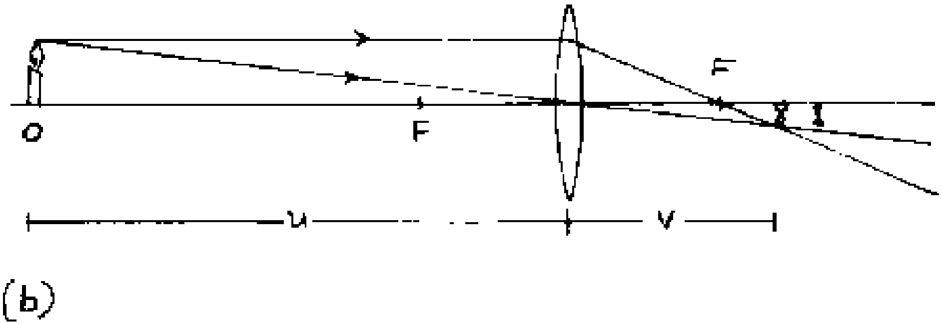
(ii) Choose a large object distance u of a lit candle (the distance between the centre of the lense (bulb neck) and the candle) and adjust the lens so that you obtain a sharp image on the screen.

(iii) Now decrease the object distance by moving the camera towards the object and adjust the image distance each time.

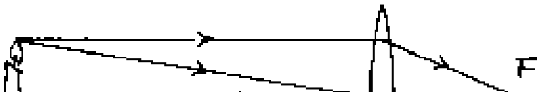
(iv) Note u and v at which the image size becomes larger than the object size.

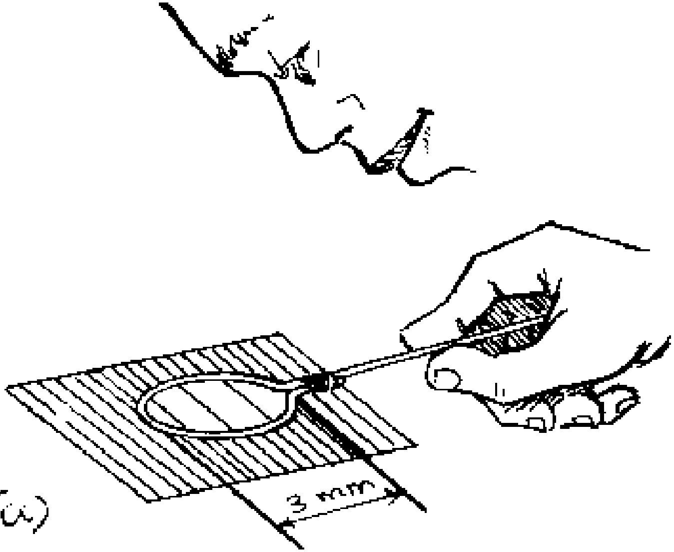
Q: Why is v = f in case (i)? How is the image distance v in each case? How is the size of the image (e.g. of the candle flame) as compared with the size of the object in each case? What kind of image do you obtain?



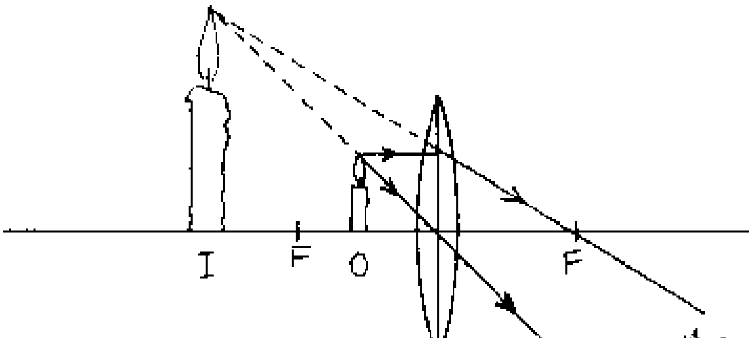


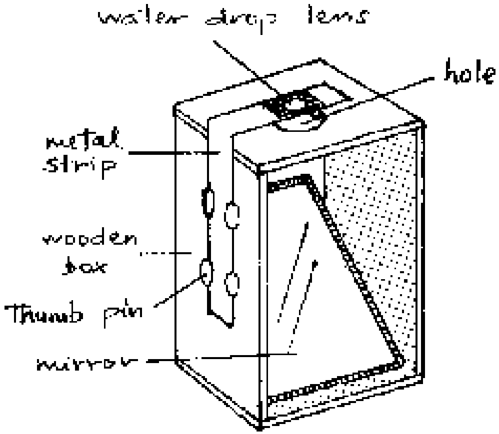
P: Ask the students to draw ray diagrams using thin converging (convex) lenses for the cases (i) to (iv) of experiment 7.4.4.



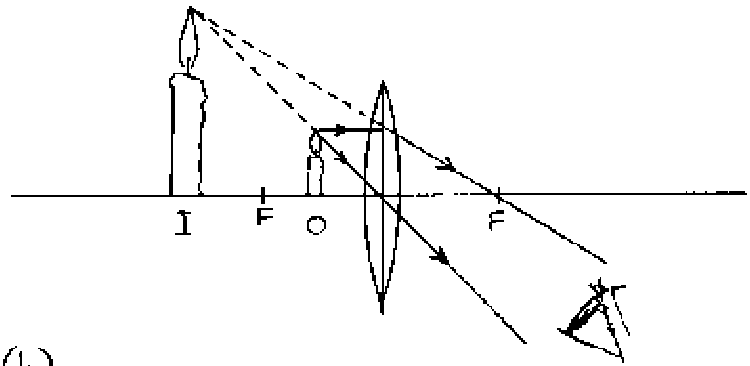


(a)





(a)



(b)

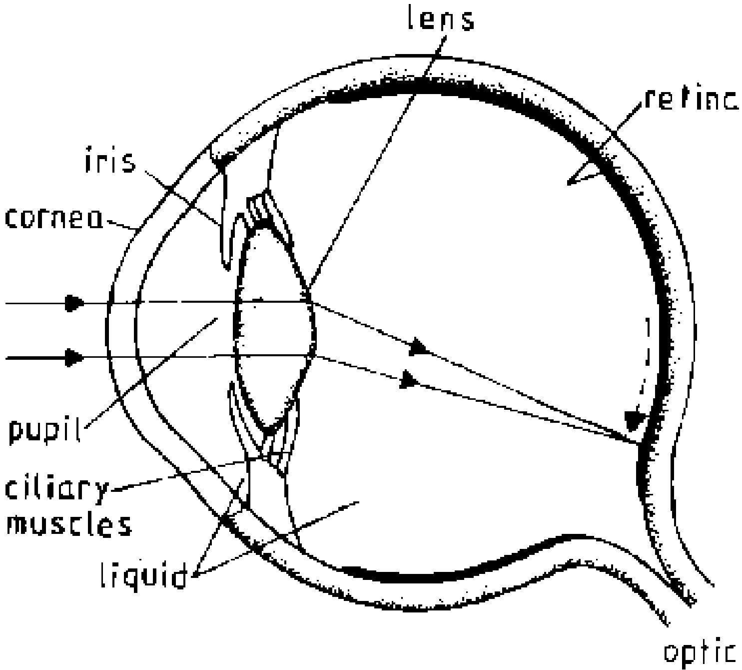
P: Produce a simple microscope according to the above figure. Adjust the mirror so that sun rays will be reflected to the hole below the lens. Place a transparent object (e.g. wing of a fly) on the hole and adjust the

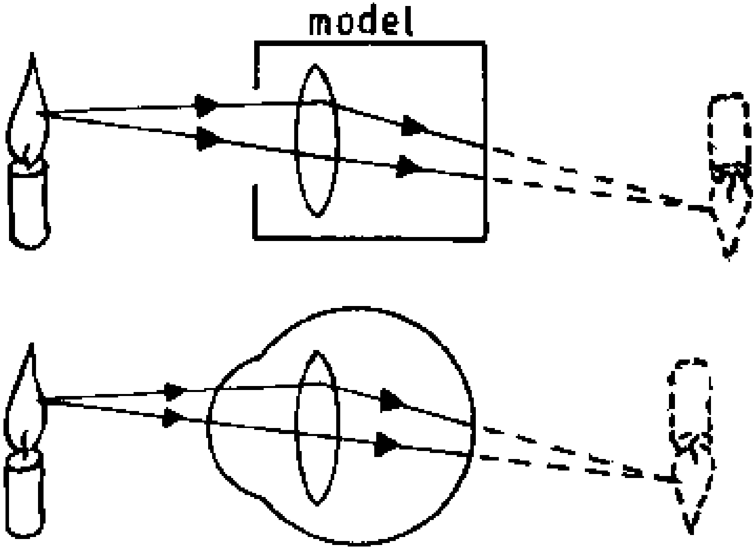
P: Modify the box camera (see p.90) according to the above figure using a mirror and another sheet of parchment paper to provide the top screen. Now this camera can serve as a model of a mirror reflex camera.

Q: Explain how a mirror reflex camera works.

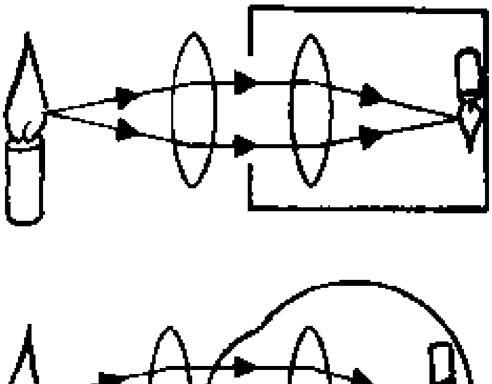
E: In the mirror reflex camera the film is there where the screen is in the box camera (see p.90). The screen on top is just to view the same image (and to focus it) which will be produced on the film when the mirror has been removed. Thus, when taking a snap with the mirror reflex camera, the mirror is turned so that the image falls on the film instead on the top screen.

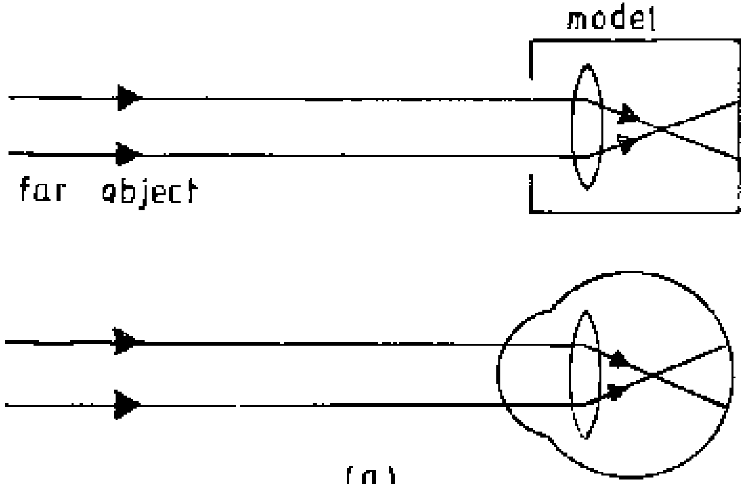
7.4.9 Display Chart of the Eye



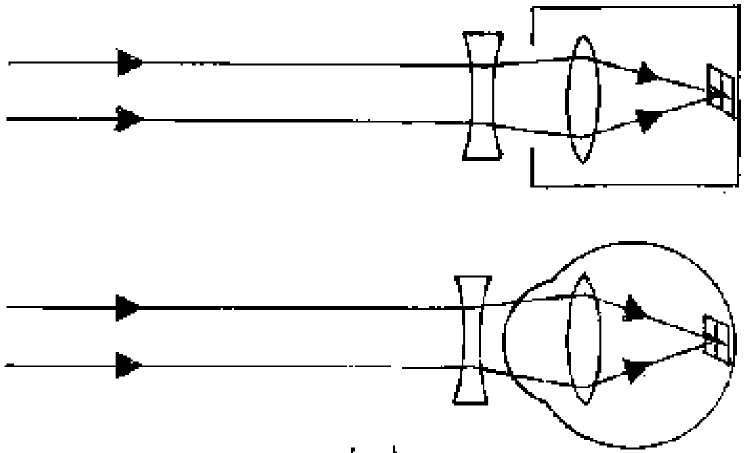


(a)

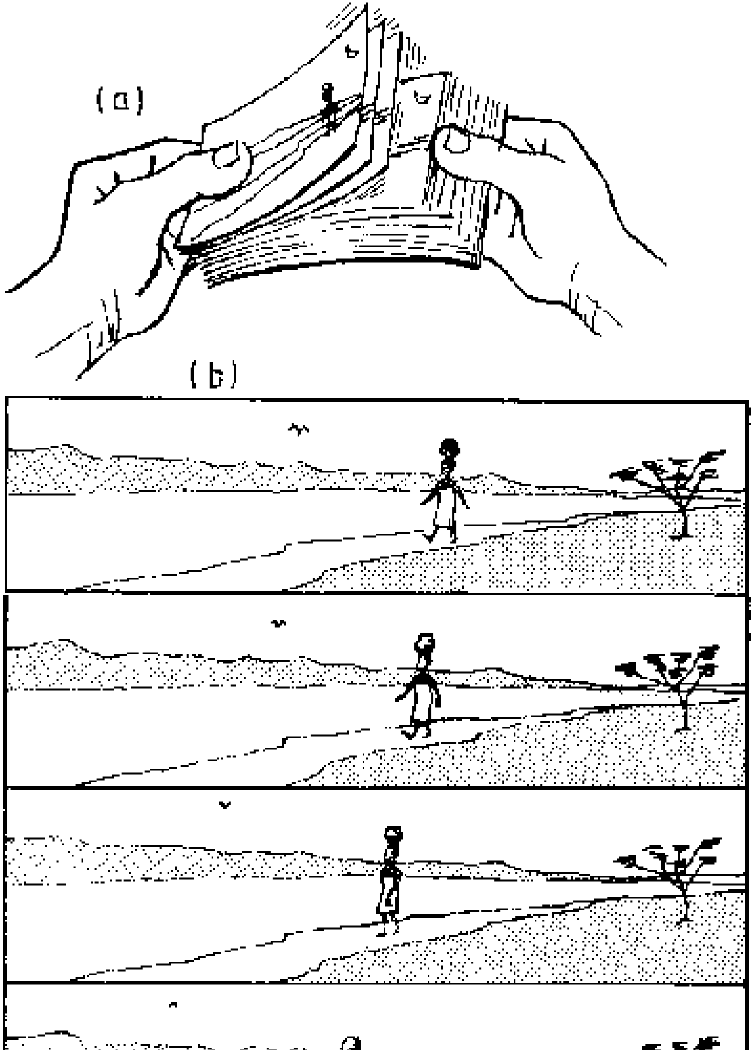




(a)



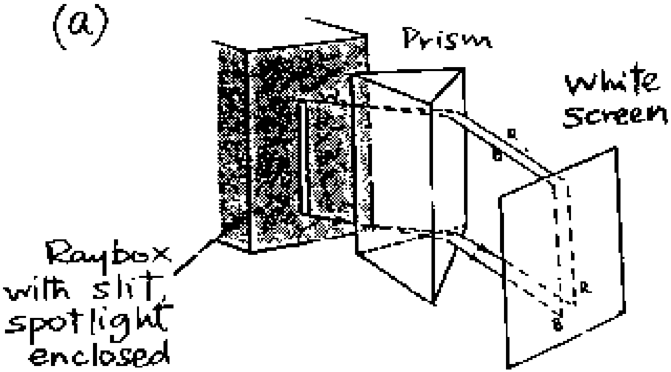
(b)

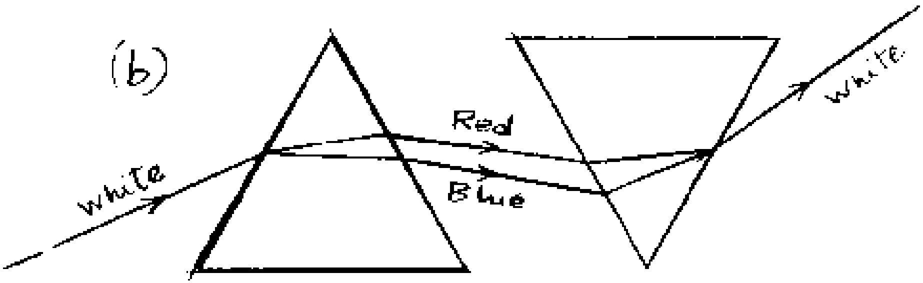

(a)
(b)

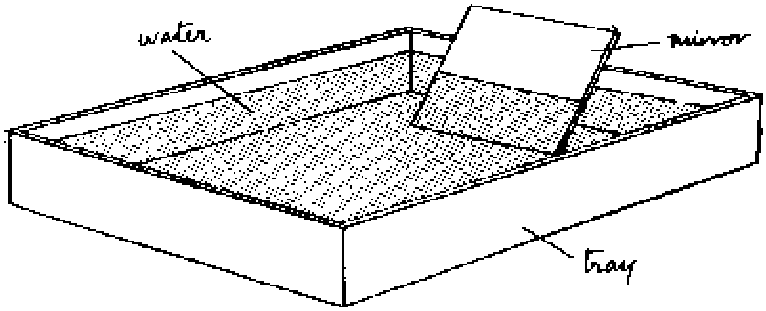
7.5 Dispersion and Colours

The separation of white light into its component colours is called *dispersion.* Each colour has a particular value of refractive index. Hence by passing light through a glass prism, each colour is refracted through different angles.

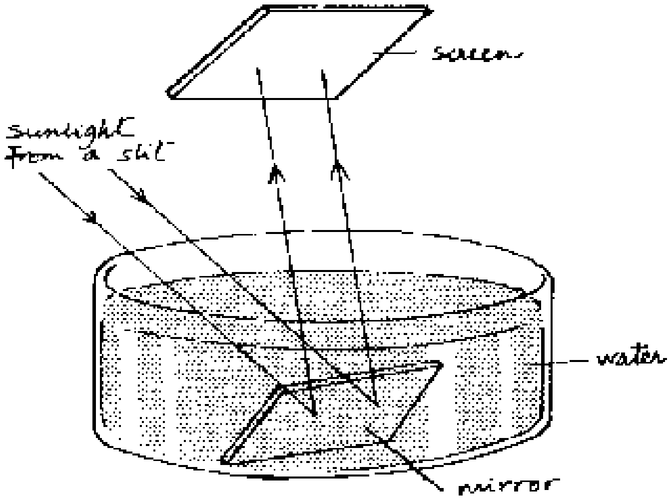
7.5.1 Dispersion by a Glass Prism



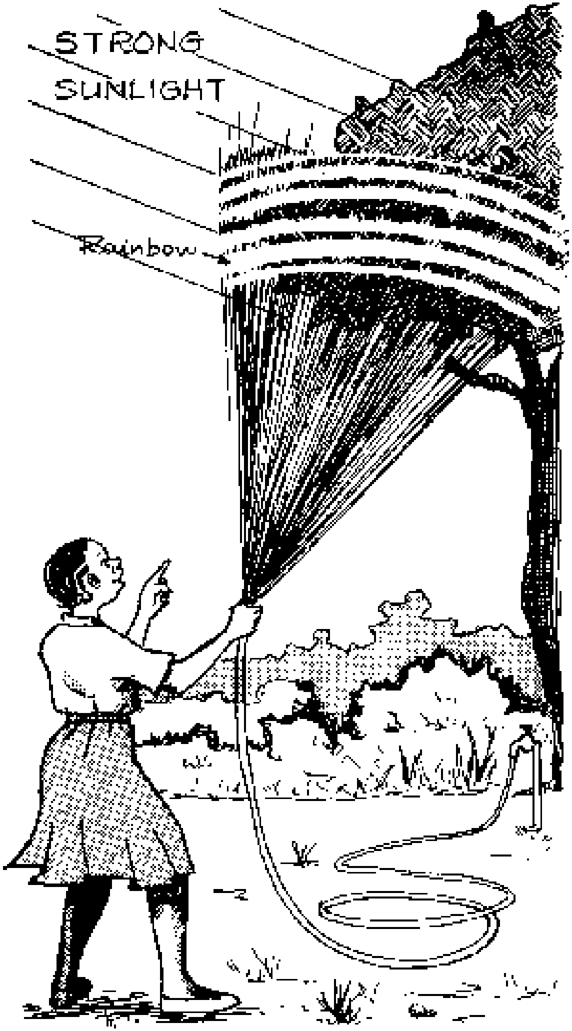


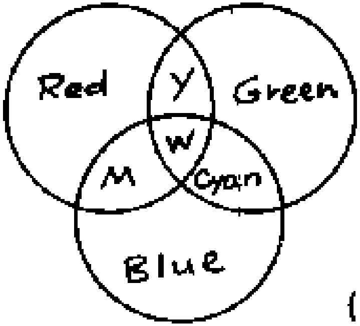


(a)

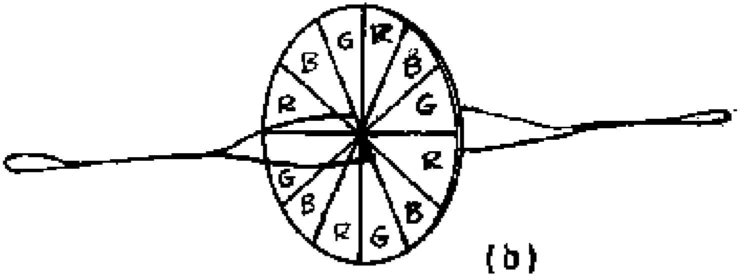


(b)

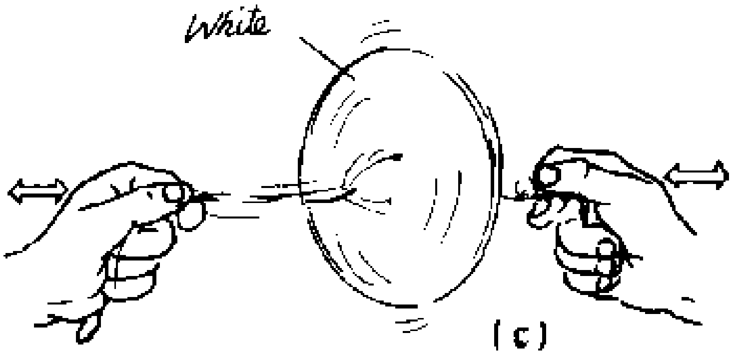

STRONG
SUNLIGHT
Rainbow



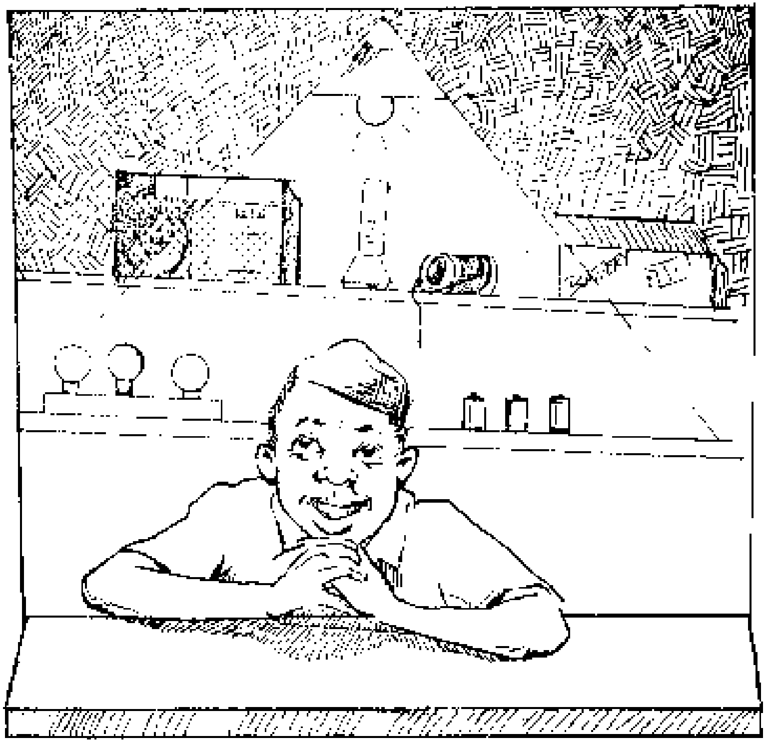
(a)



(b)



(c)

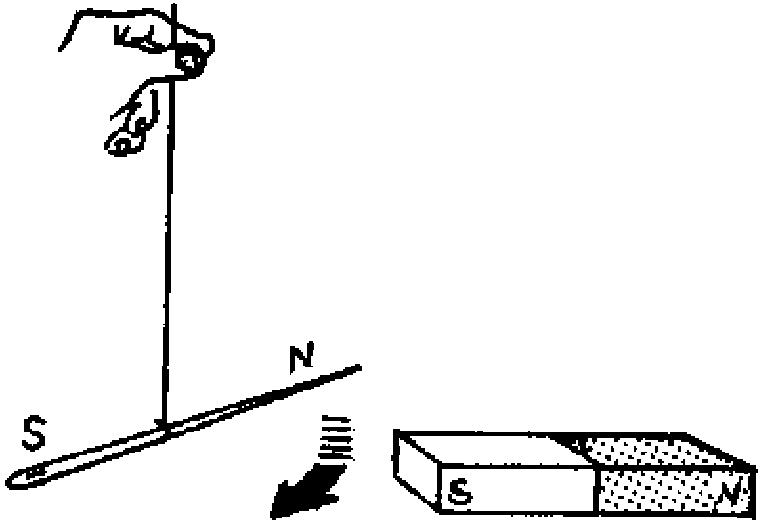


8.1 Magnetism

There are some materials which can attract iron. These kind of materials are said to have *magnetic properties.* The earth is a very weak magnet. Hence, a freely suspended magnet can be used as a *compass.* The end of a magnet pointing to the north is called the north (N–) pole, the end pointing to the south is called south (S–) pole. Thus, each magnet has a N–pole and a S–pole. Magnets can be found, for example, in loudspeakers and bicycle dynamos. Magnets are remarkable because they exert a force on iron or other sand.

H: The materials used in this experiment should include copper, iron, aluminium, plastic, porcelain, wood, nickel etc. if ever possible.

8.1.2 Interaction between Magnets

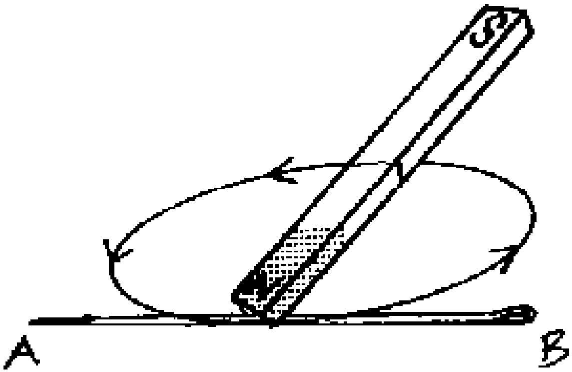


P: Suspend a magnetized steel needle (see experiment 8.1.3) and a bar magnet, one at a time. In each case mark the end pointing to the north as N–pole, and the end pointing to the south as S–pole.

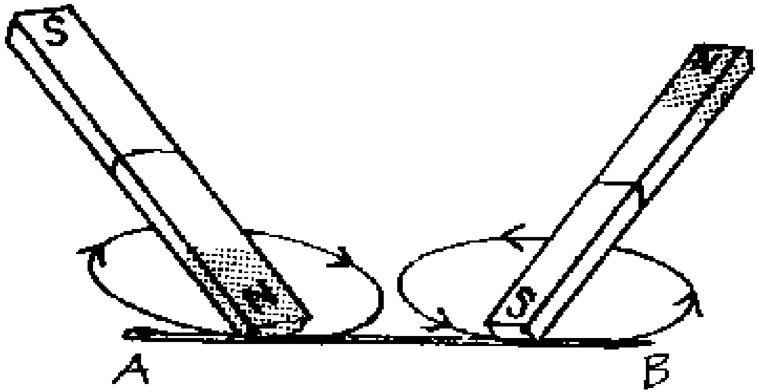
Bring the N–pole of the magnet near the S–pole of the suspended needle.

Bring the S–pole of the magnet near the S–pole of the needle.

Now bring the N–pole of the magnet near the N–pole of the needle.



(a)



(b)

P: Move one pole of a bar magnet many times along the needle as shown in figure (a).

P: Magnetize one pin (or needle). Fix the pin or needle on the beak of one the paper ducks. Fix an unmagnetised pin on the beak of the second duck. Place the ducks to float in a bowl of water.

Q: What do you observe?

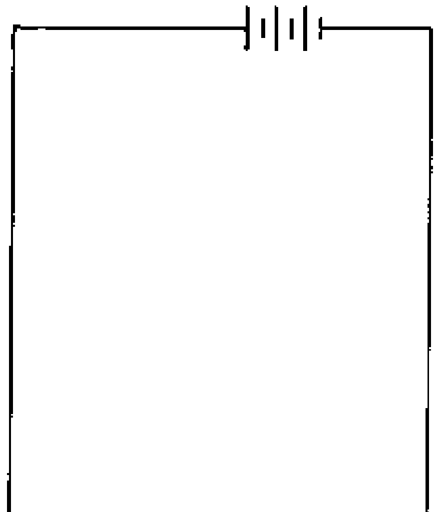
O: The beaks of the ducks come together as if they were kissing each other.

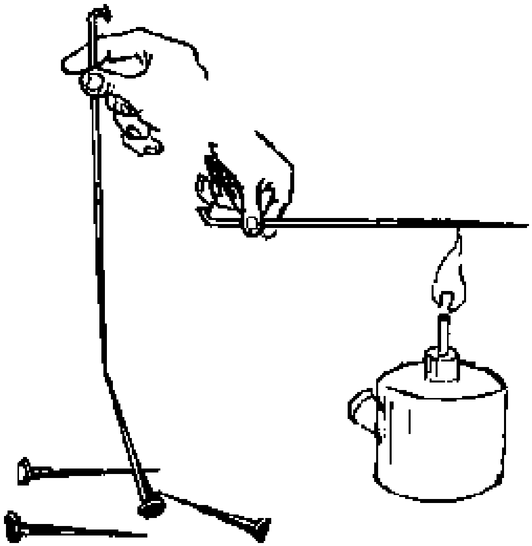
E: This is because the end of the magnetised pin in the beak of one duck attracts the end of the unmagnetized pin in the beak of the second duck.

H: To make the ducks, cut four pieces of paper in the shape of a duck and stick two of them together to make a duck. Fix each duck on a piece of wood so that it can float.

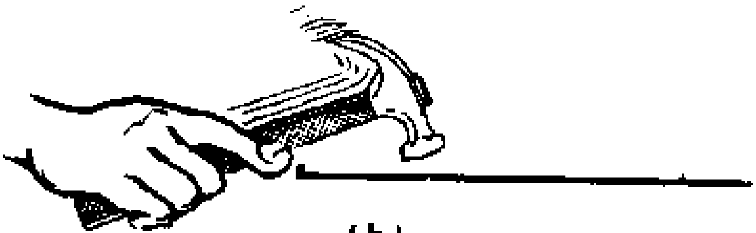
P: Magnetise both pins which are inserted into the beaks of the ducks and observe what happens.

8.1.5 Magnetisation by Electric Current





(a)



(b)

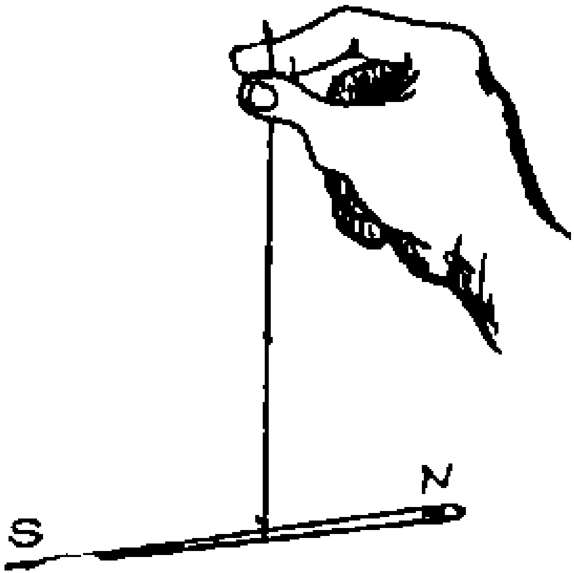
P: Magnetise a bicycle spoke and check if it attracts small nails or iron filings. Heat the spoke in a flame as in

Q: What pattern do you observe being formed by the iron filings? Draw a sketch diagram of the pattern formed.

O: The iron filings form a pattern as shown in the figure above. The iron filings are aligned along lines called *magnetic field lines* or lines of magnetic force.

H: Instead of iron filings small bits of iron wool may be used.

8.1.8 Making a Simple Compass Using a Knitting Needle



P: Suspend a magnetized knitting needle using a cotton thread. Allow the needle to settle and lable the N–pole and S–pole of the needle.

Turn the suspended needle through various angles and release it.

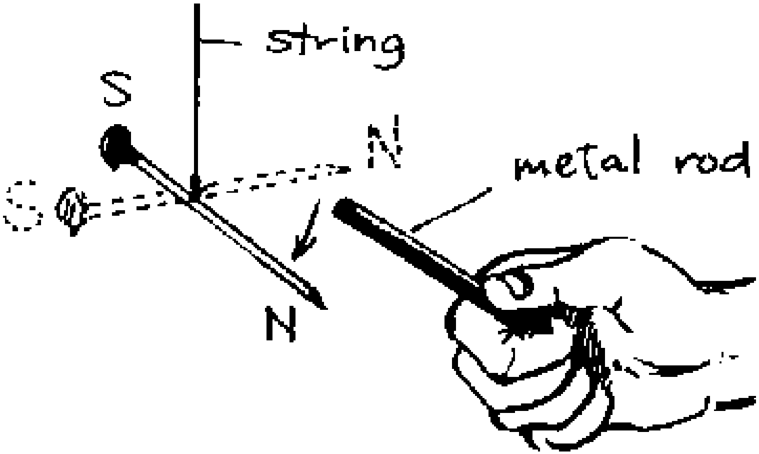
First gently rotate the bowl. Then rotate the blade through any angle and leave it

Q: What do you observe in each case?

O: In the first case the blade will continue to lie in the N–S direction. After the blade has been rotated, it returns to lie in the N–S direction.

A: This arrangement can be used as a simple compass.

8.1.10 Testing for Magnets

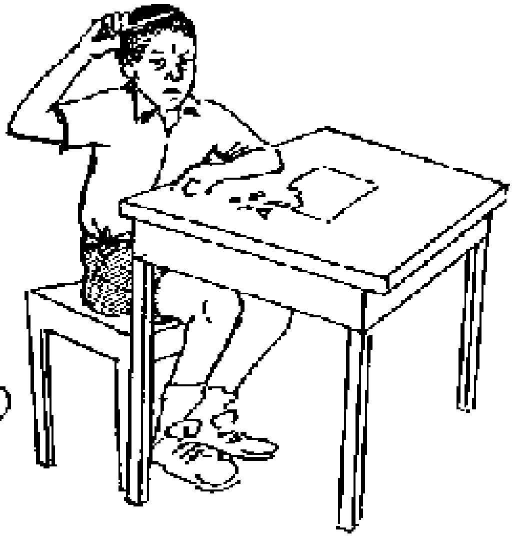


P: Bring the first end of a metal rod close to one pole of a suspended magnetized steel nail. Bring the second end of the metal rod close to the same pole of the suspended steel nail.

Repeat the above procedure with an iron rod which is magnetized.

Q: What do you observe with the magnetised and with the unmagnetised rod respectively?

(a)

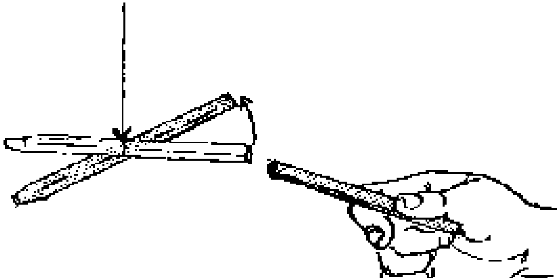


(b)

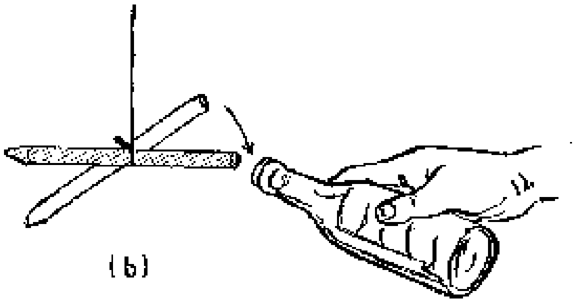
P: Rub a plastic pen on your hair, on woolen or synthetic clothes and bring it near small pieces of paper or pieces of thread.

Repeat the experiment by rubbing a glass bottle with a piece of "baibui" (made of silk) or polyester.

Q: What do you observe?



(a)



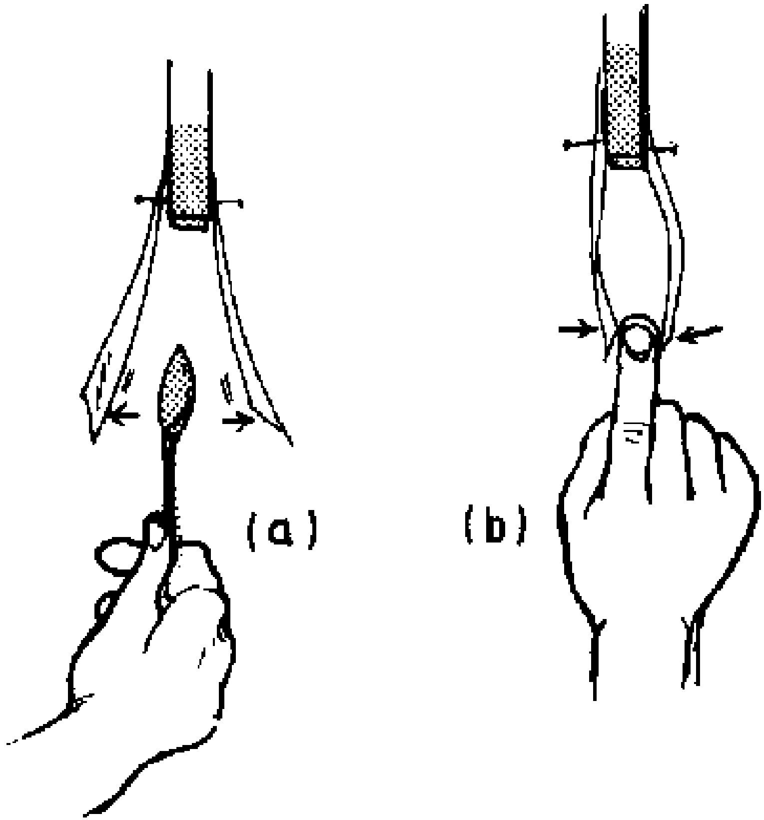
(b)

P: Rub a plastic pen on your hair or on a woolen or synthetic cloth and bring it near a suspended plastic pen (also charged by rubbing it on your hair).

Repeat the experiment by bringing a glass bottle charged by rubbing with silk or polyester material near the freely suspended *charged* plastic pen.

Q: What do you observe in both cases?

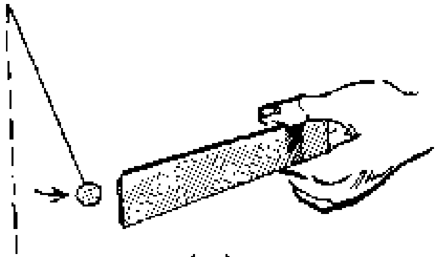
O: In the first experiment the two plastic pens repel each other; and in the second experiment, the plastic pen is attracted by the glass bottle.



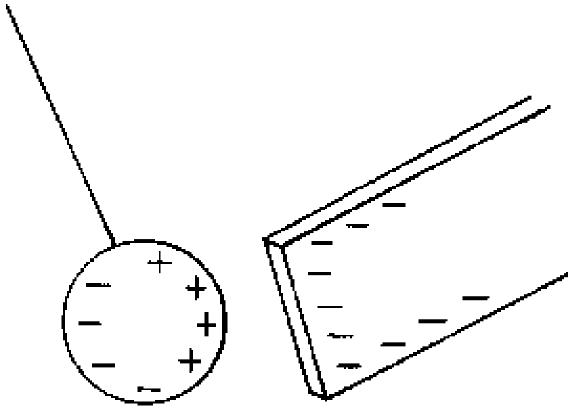
P: Cut two strips of polythene sheet. Fix the strips to a piece of wood as shown in the figure. Charge the strips by rubbing them with a clean duster.

(a) Introduce a charged plastic spoon between the charged strips.

(b) Introduce your finger between the charged strips.



(a)



(b)

P: Make an aluminium ball (by using aluminium foil) and suspend it freely using a cotton thread. Bring a charged plastic ruler (negatively charged) near the aluminium ball without touching it.

Q: What do you observe?

O: The aluminium ball is attracted by the charged plastic ruler.

E: The force of attraction occurs due to the fact that the negative charge on the plastic ruler repels some of

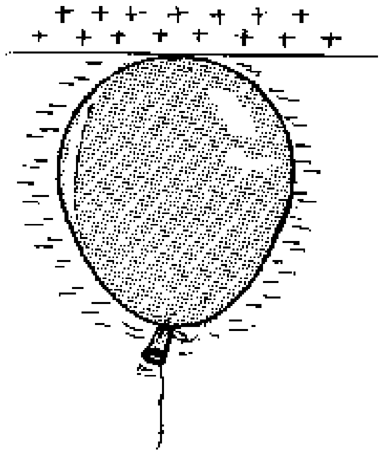
Q: What happens?

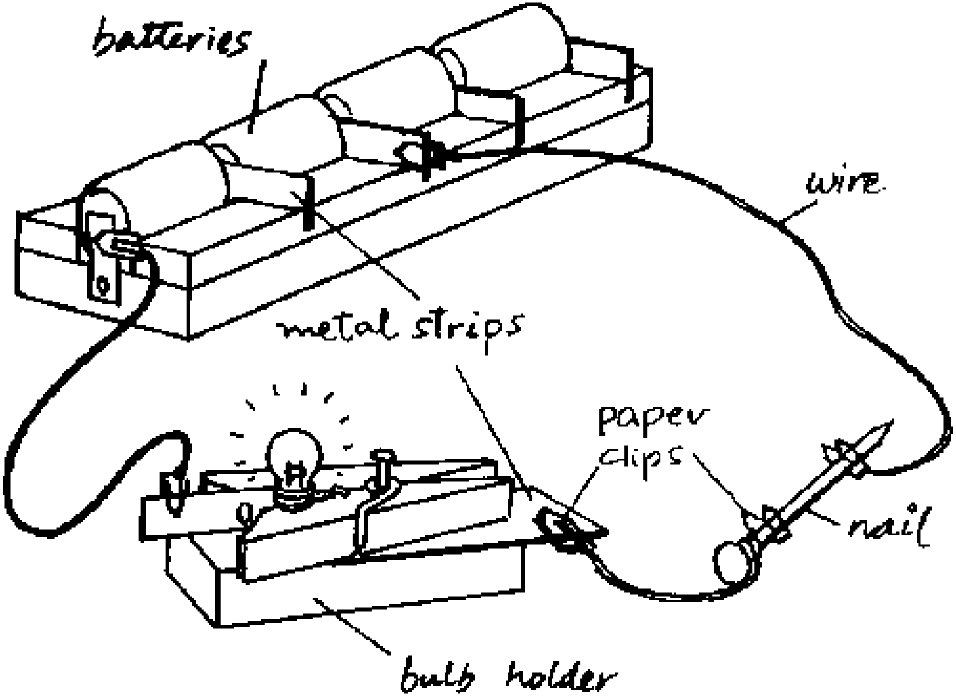
O: The thin stream of water *is attracted by the plastic object.*

E: The negative charge on the plastic object causes the water stream to be attracted.

(For teachers only: The water is *not* charged. This effect is due to the dipole nature of the water molecules. The pupils cannot understand this yet in form one or two. Since the *water molecules* are *dipoles,* they have a positively and negatively charged end, yet the total charge of the molecules is zero since the two charges balance. When the charged object comes near the water stream, the oppositely charged end of the water molecules is attracted, the other end repelled. Thus, the molecules turn so that the attracted end gels nearer to the charged object than the repelled end. Since the electrostatic forces become weaker with the increase in distance to the charged object, the attracted end of the water molecules is more attracted by the charged object than the other end is repelled. Hence, the water molecules are always attracted. It does not matter whether the object is positively or negatively charged).

8.2.6 Charged Air Balloon



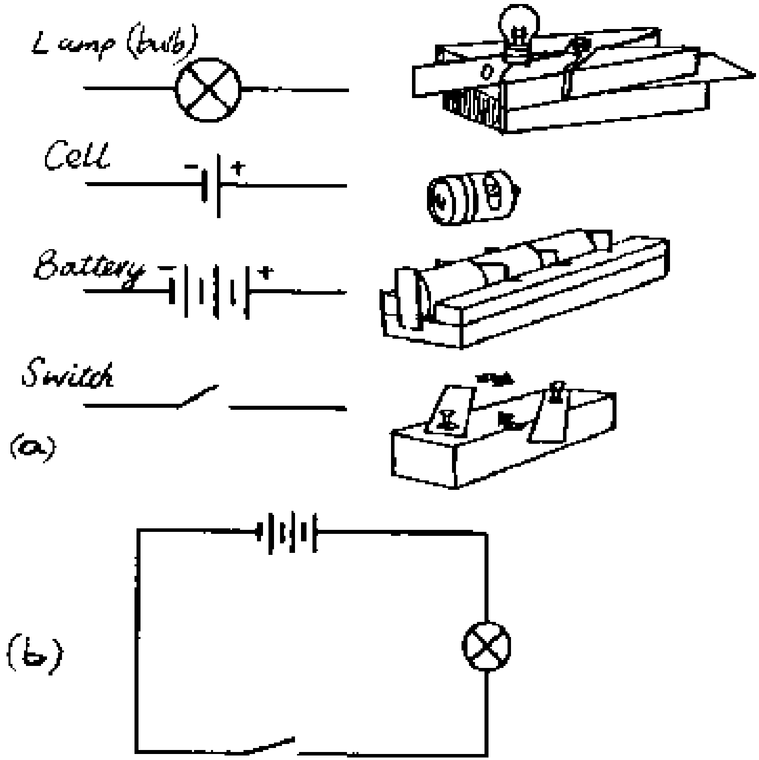


P: Connect a nail, a bulb and two cells with wires as shown in the figure. Successively replace the nail with cotton thread, a plastic spoon (or any plastic material), wood, aluminium foil (from a cigarette packet), paper and a piece of graphite from a pencil.

Q: What happens to the bulb in each case?

O: The bulb lights for some materials and does not light for others.

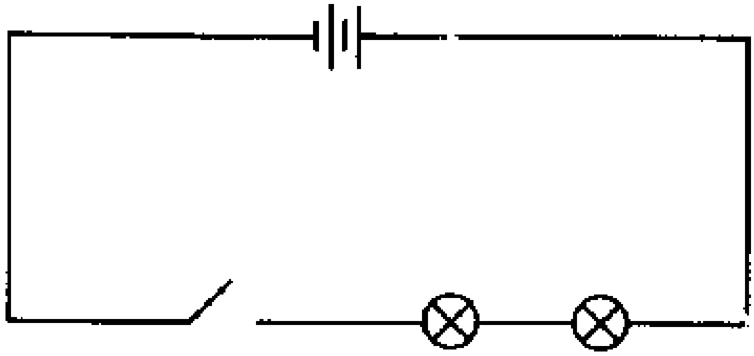
E: The bulb lights when current is allowed to flow through it and does not light when no current passes. The materials, which allow current to pass are called good *conductors* and those, which do not allow current to



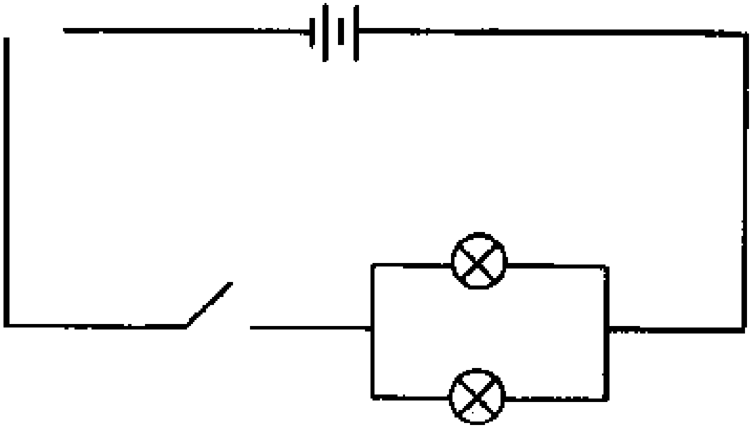
P: On the left side of diagram (a) we have placed the symbols used for a bulb, a cell, a battery of three cells, a switch. Connect a battery of three cells, a switch and a bulb with wires as shown in the circuit diagram (b). Close the switch.

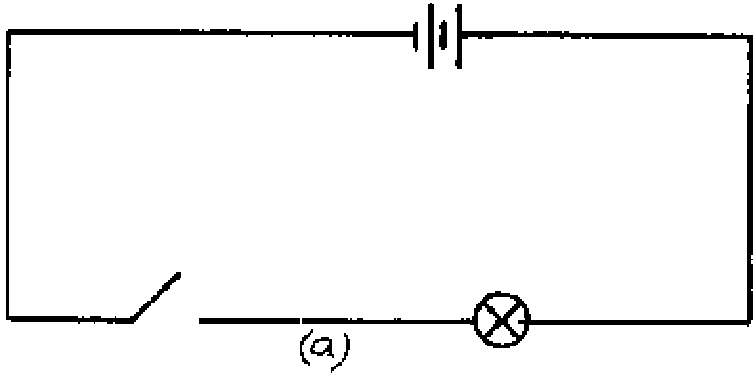
Q: What do you observe at the bulb when the switch is closed?

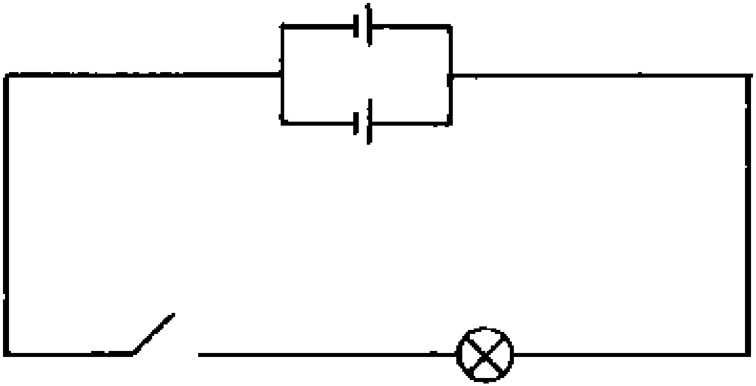
E: When the switch is closed, the current flows through the bulb from the positive terminal of the battery to the negative terminal. Note, that this is *the conventional* current which flows from the positive to the negative



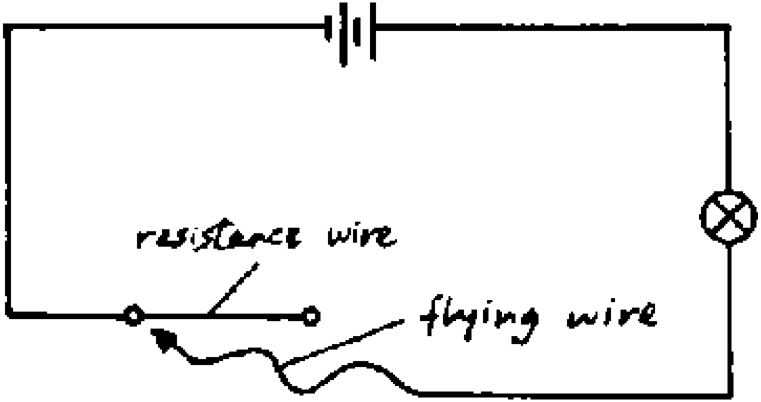
(a)







P: Connect two dry cells in series, that is the positive terminal of one to the negative terminal of the next as



P: Connect the circuit as shown in the diagram. Slide the free end of the flying wire along the resistance wire.

Q: What happens to the brightness of the bulb?

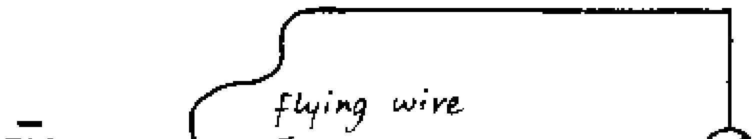
O: The bulb becomes dim when the flying wire is placed at the free end of the resistance wire.

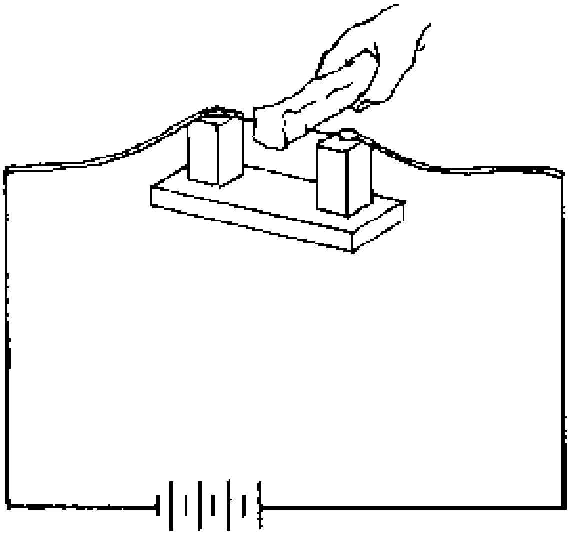
E: As the length of the resistance wire increases, the brightness of the bulb decreases. The current passing through the bulb decreases as the length of the wire increases, since the resistance of the wire increases.

A: Rheostats are long coiled wires used to vary the current in circuits.

H: For the resistance wire you can use a long steel wire from steel wool.

8.3.6 Ohm's Law: Increasing the Voltage





P: Set up the circuit as shown. Press a piece of styrofoam (polystyrene) gently across the steel wire.

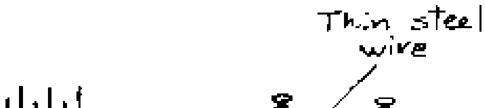
Q: What happens to the styrofoam?

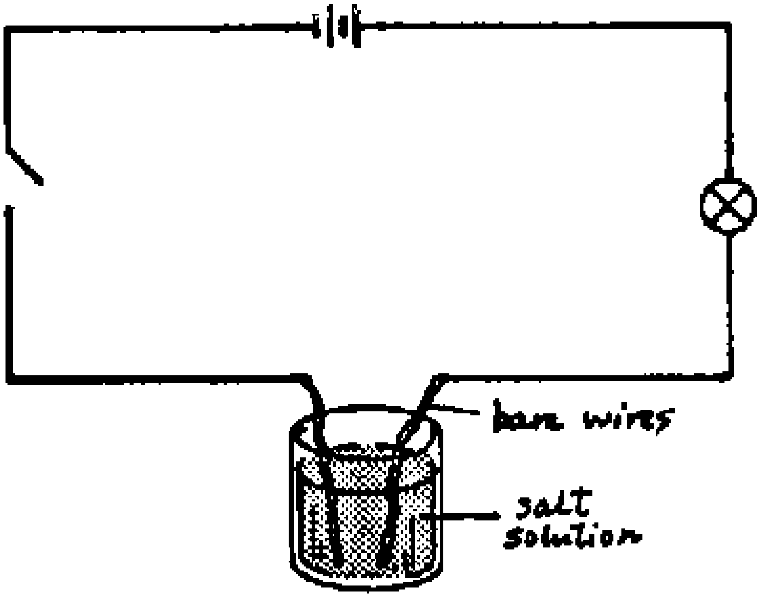
O: The styrofoam piece is easily cut.

E: The electrical energy has been converted to . heat energy which melts the styrofoam.

A: Electric iron, electric kettle, electric cooker etc.

8.3.8 The Fuse





P: Connect the circuit shown in the diagram and close the switch so that an electric current passes through the salt solution.

Q: What do you observe in the salt solution?

O: Bubbles are produced on the bare wires in the salt solution.

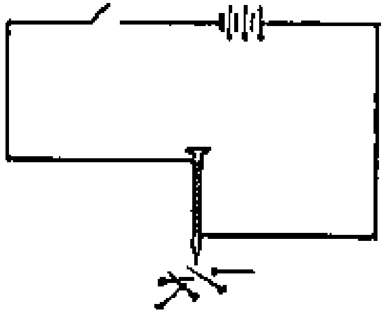
E: When electricity is passed through a liquid like a salt solution, a chemical reaction takes place which gives off gas bubbles. This process is known as *electrolysis.*

A: Electrolysis is used in electroplating and coating of iron with different metals.

8.3.10 Magnetic Effect

A: Electromagnets.

8.3.11 An Electromagnet



P: Wind about fifty turns of insulated wire around a nail. Connect the ends of the wire to the cells. Place one end of the nail close to office pins lying on the table and close the switch. After a while open the switch.

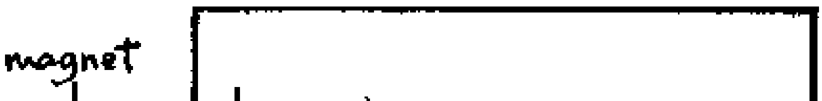
Q: What happens to the pins?

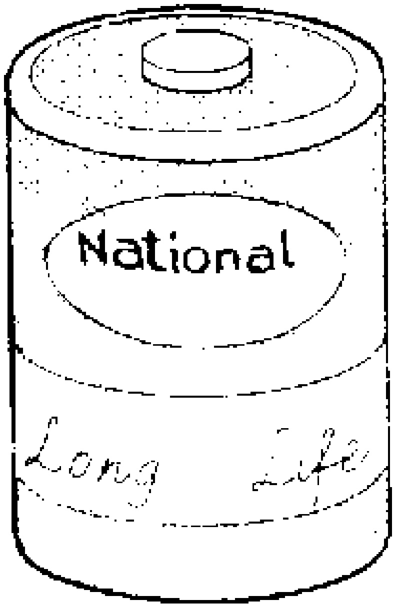
O: The pins are attracted to the nail, when the switch is closed, and fall off when the switch is opened.

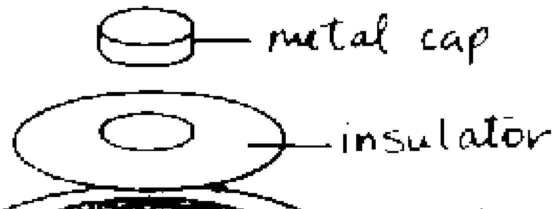
E: When the switch is closed the current flows through the coil and magnetizes the nail. The magnet formed is known as *electromagnet.* The nail is made of soft iron. Thus it loses the magnetism when the current is switched off.

A: Used in harbours for lifting heavy loads with iron containers. In electric motors.

8.3.12 The Force on a Current in a Magnetic Field

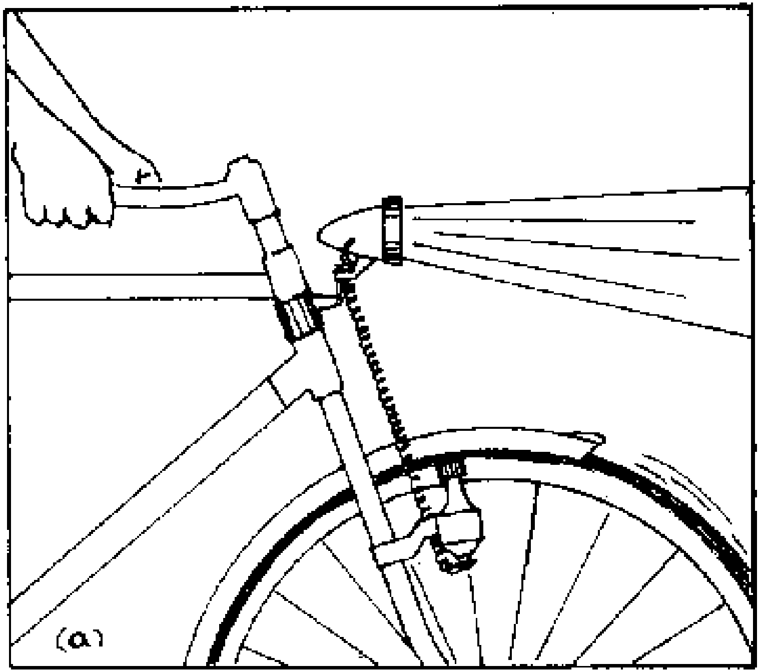


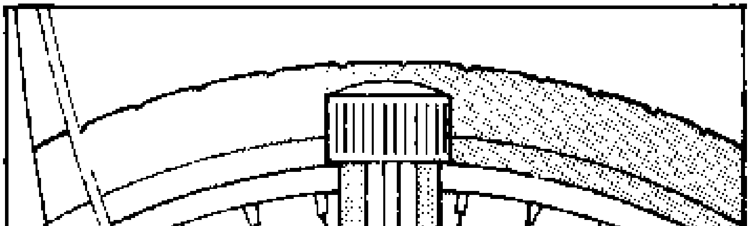

National
Long Life


metal cap
insulator

The electrical energy is produced by a chemical reaction between the zinc and the ammonium chloride paste.

8.3.14 The Bicycle Dynamo





Appendix

A Sootless Kerosene Burner

Spirit for burners is not always available, but kerosene can be purchased nearly everywhere. For the heating of tins or other things a sootless *kibatari* (kerosene burner) will do.

With a simple and cheap additional device which the same 'fundi' can make who produces the normal *kibatari,* you can get a nearly sootless flame. The principle behind is to improve the draft of the air stream in order to obtain a *more complete combustion* of the kerosene. The flame of the kibatari should bum in contact with a metal wall, which acts as a catalyst.

The basic device consists of 4 parts:

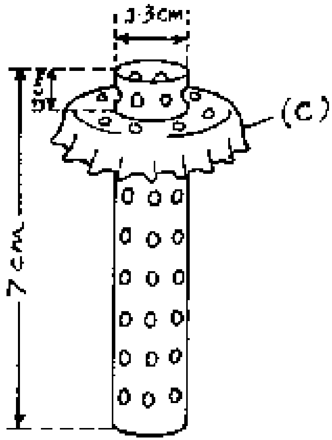
(a) A *perforated inner chimney* is made from a tin which is about 1.3 cm wide and 7 cm long. If the diameter of this tube is too small, the flame will not burn; if it is too wide the effect will be small. The holes can be made with a nail and should have a diameter of 2 mm. There should be 3–4 holes per square centimetre.

(b) An *outer chimney* which serves at the same time as a wind shield. The holes below are about 5 mm in diameter.

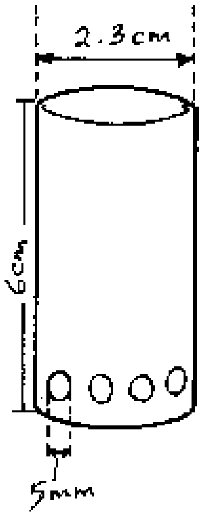
(c) Both chimneys fit together in a *per forated soda bottle cap* as shown.

(d) Ask the fundi to solder another soda bottle cap around the *wick holder (d).* This holds the chimneys better.

The flame is optimized by adjusting the length and shape of the wick: it should have contact with the perforated tube. With this burner temperatures of about 650°C can be achieved.

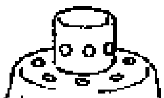


(a)

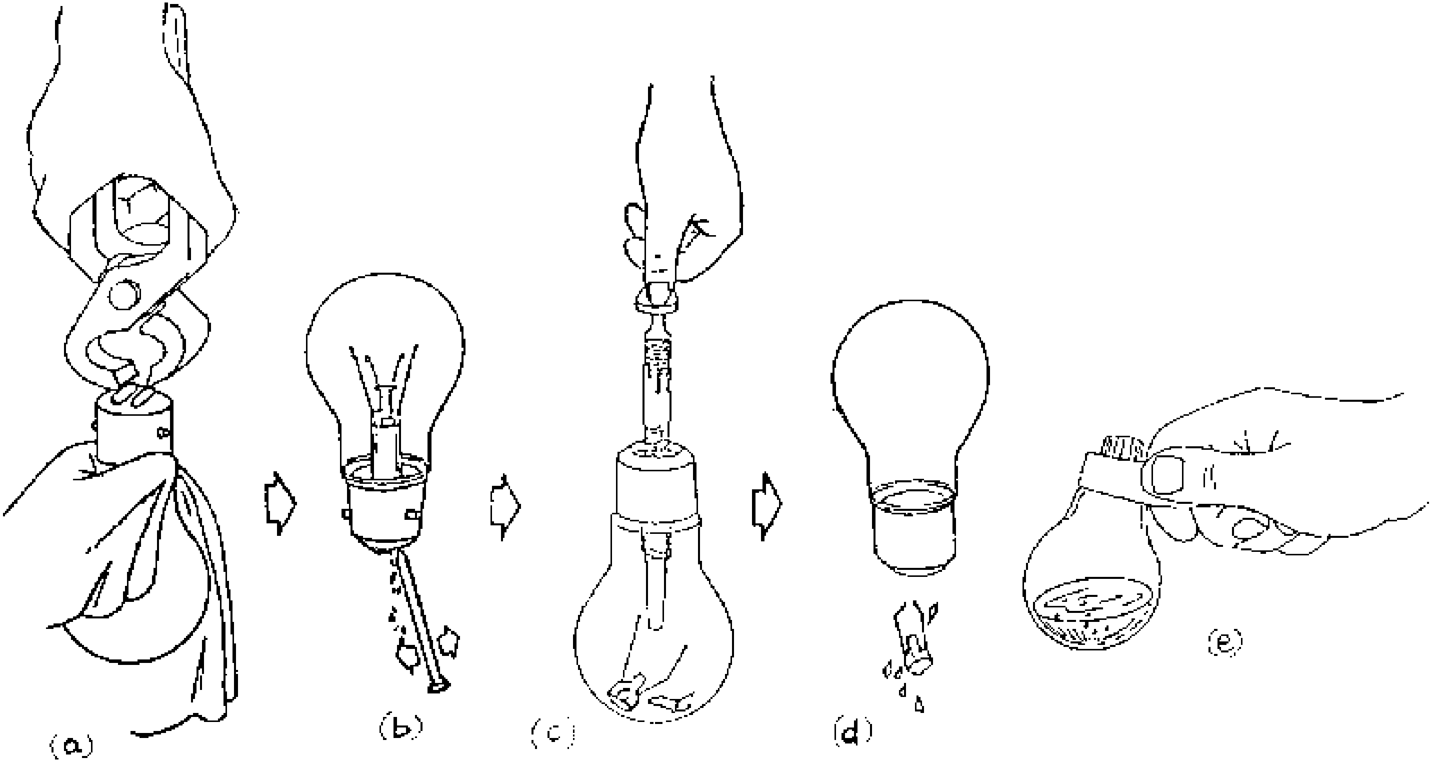


(b)

7mm



Special clamps are not needed. Fold a sheet of paper and you have the cheapest test tube or bulb clamp, see figures (c).



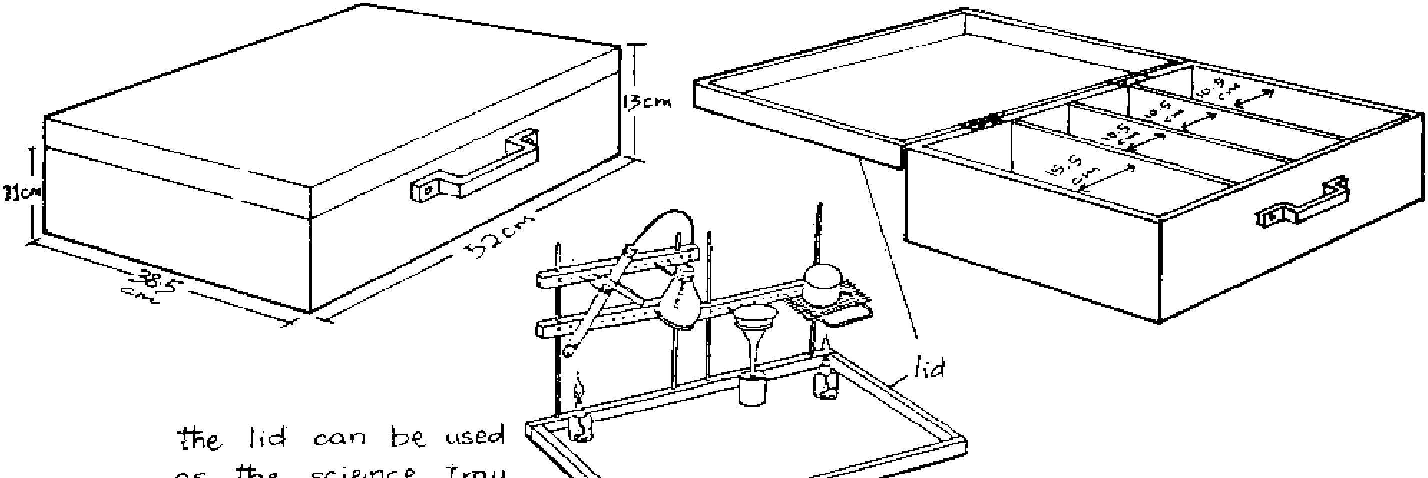
List of Materials

This is the list of materials needed for a workshop on "Teaching Physics to Beginners with Locally Available

1 sharp knife
1 combination plier
1 hammer
1 set of weights
1 balance (see p. 10)
1 measuring cylinder
1 magnet (e.g. from a discarded loudspeaker)
1 drill borer for 2–3 mm holes
1 tin opener
1 pair of plate–shears
1 pair of scissors

To be done by craftsmen:

Chimney for sootless kibatari (see p. 109)
Funny jumper (see p.21)
Box with lid and handle for physics kit, sec the figure below



3.2.6 –
3.3.1 Stone
3.3.2 A large and a small stone, string, ball
3.3.3 Newton balance, see p. 15
3.3.4 Beam balance, weights, see p. 10
3.3.5 A pencil, a strip of paper, (table)
3.3.6 A toy pick–up or an open box, some card
3.3.7 A large paper
3.3.8 A large paper
3.3.9 A large paper
3.3.10 A large paper
3.4.1 Sheet of cardboard, thread, 7 equal clothes–pegs
3.4.1 Sheet of cardboard, stone, string, pencil
3.4.3 –
3.4.4 14 nails of 2–inch length, piece of wood
3.4.5 Pencil
3.4.6 A candle, some card
3.4.7 A coin, 2 forks
3.4.8 A potato, 2 forks, pencil, bottle, some card, string
3.5.1 Wooden stick, a flat piece of wood
3.5.2 Book, table, piece of cloth
3.5.3 Oil or margarine
3.5.4 –
3.5.5 Book, about five round pencils or drinking straws
3.5.6 Large paper
3.6.1 Stone, thread, Newton balance (see p. 15), measuring cylinder
3.6.2 Rubber stopper, piece of glass or transparent plastic tubing, beam balance, (see p. 10
3.7.1 Book, pencil
3.7.2 –
3.7.3 Bucket, a 'ngata'
3.7.4 Plastic bag
3.7.5 Large tin with air–tight lid, e.g. a charcoal stove, small tin or cup
3.7.6 Drinking glass or jam glass, smooth card or plastic sheet

3.11.2 Stone, string
3.11.3 Long string for measuring distances
3.11.4 –
4.1.1 Some salt
4.1.2 –
4.1.3 Pieces of cotton, canvas cloth, small polythene bag
4.2.4 Orange peels
4.2.5 Umbrella or big plastic sheet
4.1.6 Simple balance (see 2.1.5)
4.2.1 –
4.2.2 –
4.3.1 Some potassium manganate(VII) (permanganate; or other solid colouring agents)
4.3.2 –
4.3.3 –
4.3.4 –
4.3.5 –
4.3.6 –
4.4.1 2 clean glass pieces (of a broken window)
4.4.2 –
4.4.3 Razor blade, fork
4.4.4 –
4.4.5 Some detergent or soap
4.4.6 2 glass sheets of about 10 cm x 10 cm, rubber bands or string
4.4.7 Stick of chalk, plotting paper or newspaper
4.4.8 Piece of cloth
4.4.9 Thread
4.4.10 –
4.5.1 Rubber band, plastic bags (groundnuts)
4.5.2 2 tall small bottles (or test tubes)
5.1.1 –
5.1.2 Small bottle, cork stopper, empty ball point tube
5.1.3 Large sheet of paper, ruler, writing facilities
5.1.4 Some oil

5.4.8 Shiny tin, 2 wooden sticks
5.4.9 2 identical shiny tins
5.4.10 –
6.1.1 A rope of about 6 m length
6.1.2 Tin, string, some newspaper, glue, ink or fine sand
6.1.3 Table or chair
6.1.4 Thread, stones of different masses, watch
6.1.5 Rubber band, stones of different masses, watch
6.1.6 Tin, paper, string
6.1.7 Water tank, etc
6.1.8 Ink or potassium manganate(VII) (permanganate), a plate, plastic bag
6.1.9 Piece of cork, light wood or polystyrene, dropper (see 6.1.8), plate
6.1.10 –
6.2.1 2 empty tins, string
6.2.2 2 pieces of metal
6.2.3 2 spoons, string
6.2.4 Table
6.2.5 Some metres of a thin wire, two poles
6.2.6 Plastic bucket, 2 stones
6.3.1 Plate or tray, straight metal, plastic or wood barrier, rectangular block
6.3.2 Wall or door, 2 paper cones, a sheet of cardboard
6.3.3 A window with burglar bars, rope of about 5 m length, a stick
6.3.4 A garden hose pipe
6.3.5 Tall building or wall
6.3.6 Tall tin or jar, a clock, a sheet of cardboard
6.4.1 A soft board, thread, 2 pencils, various stones
6.4.2 4 equal soft drink bottles
6.4.3 A wooden block (better: a box), bicycle spokes
6.4.4 A bamboo tube (1.5 cm x 30 cm)
6.4.5 Empty tin with lid, wooden stick, string
6.4.6 Wooden box, timber bars of different wood and thickness, 2 sticks
7.1.1 Wooden blocks as stands, cardboard, candle
7.1.2 Manila sheet, string

7.4.11 Box camera (see p.90), concave lens
7.4.12 Some paper
7.5.1 Glass prism, white paper as screen, second glass prism or convex lens
7.5.2 Plane mirror, dish, white paper as screen
7.5.3 Hose pipe
7.5.4 White card, blue, green and red pencils or felt pens, string
8.1.1 Magnet (e.g. from discarded loudspeaker) plus materials listed on p.98
8.1.2 Magnet, magnetised steel needle (see 8.1.3), thread
8.1.3 Needle, magnet
8.1.4 Needle, magnetised pin or needle (see 8.1.3), paper, small pieces of wood or cork
8.1.5 Bicycle spoke, thin insulated copper wire (from old motor coil), 3 radio batteries, insulated wire, iron filings or bits of steel wool
8.1.6 The same as in 8.1.5 plus burner
8.1.7 Paper, bar magnet or magnetised steel needle, iron filings or bits of steel wool
8.1.8 Magnetised knitting needle (see 8.1.3), thread
8.1.9 Wooden pin, bowl, magnetised razor blade
8.1.10 Metal rod or needle, 2 magnetised needles or steel nails, thread
8.2.1 Plastic pen, piece of paper
8.2.2 2 plastic pens, thread, glass bottle, silk (e.g. baibui) or polyester material
8.2.3 Polythene sheets from transparent covering of a cigarette package or a plastic bag, piece of wood
8.2.4 Small piece of aluminium foil, cotton thread, plastic ruler or pen
8.2.5 Tap with water, plastic pen, woolen cloth
8.2.6 Balloon, wooden or synthetic cloth
8.3.1 2 radio cells, torch bulb, connecting wires, 2 metal strips, clothes–peg, plus materials listed on p. 104
8.3.2 Torch bulb, 8 metal strips, 3 radio cells, insulated wire for connecting
8.3.3 2 radio cells, 2 bulbs, 2 bulbholders (see 8.3.1), switch (see 8.3.2), insulated wire
8.3.4 2 radio cells, bulb holder (see 8.3.1), switch (see 8.3.2), insulated wire
8.3.5 2 radio cells, bulb, bulb holder, resistance wire or long wire from steel wool, insulated wire for connections
8.3.6 4 radio cells, insulated wire, torch bulb, cell holder, bulb holder
8.3.7 Styrofoam, 8 cm steel wire (from steel wool), insulated wires, 4 radio cells, some pieces of wood
8.3.8 3 radio cells, very thin steel wire (from steel wool), torch bulb, switch, insulated wire, piece of wood
8.3.9 2 radio cells, bulb, bare copper wire, insulated wire, switch, salt

I like ....
....

I dislike ....
....

The book helped me ....
....

I think the following parts should be omitted ....
....

I would like to see the following topics added to the book when a new edition is made ....
....

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Back cover

This book .....

• emphasizes learning Physics by doing without which no scientific development can take place.

• describes how to make a Physics Kit which is a minilab by itself. It can be used to equip schools which luck laboratory equipment for Physics with locally available materials.

Tailor–Made Textbooks – A Practical Guide for the Authors of Textbooks for Primary Schools in Developing Countries

Table of Contents

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Tailor–Made Textbooks – A Practical Guide for the Authors of Textbooks for Primary Schools in Developing Countries

Marie Chātry–Komarek

CODE Europe
Oxford
1996

Published in Association with Deutsche Stiftung für internationale Entwicklung (DSE), Bonn

Originally published in 1994 as *Des Manuels Scolaires sur Mesures: Guide pratique a l'intention des auteurs de manuels scolaires pour le primaire dans les pays en développement.*

ISBN 0 9528651 0 6

A CIP catalogue record for this book is available from the British Library

Ranaivoarisoa; without their ideas and comments, and the dogged determination they displayed from 1986 to 1993, this guide would certainly never have been written.

I would also like to thank everybody who went to the trouble of reading the manuscript and making many valuable suggestions, in particular:

Guy Berger, University of Paris VIII

Herbert Bergmann, German Institute for International Pedagogical Research, Frankfurt am Main

Gustave Chené, Consultant to the World Bank's CRESED project in Madagascar

Rémi Clignet, Orstom

Marcel Crahay, University of Liege

Carmelle Denning, International Book Council, London

Sakhevar Diop, World Bank, Washington D.C.

Annick Dumont, Antananarivo

Gisela Frommer, GTZ, Eschborn

Utta von Gleich, Institut für Iberoamerika–Kunde, and the University of Hamburg

Waltraud Heidenreich, GTZ, Eschborn

Ingrid Jung, Ministry of Education, Lima

Claude Rabenoro, Editions Tsipika, Antananarivo

quality[4]. But the results have often been disappointing; most education projects implemented to this end have run into difficulties of scale, the most common being

- the almost total absence of any national textbook policy which could be used to identify the main shortcomings in the supply of school books in each country, and which would contain precise recommendations on how to remedy these;

- the major deficiencies in the education system; in particular the upstream and downstream services, i.e. curriculum design and pre– and in–service service teacher training;

- the frequent shortage of national authors with the skills required to devise books that are specifically tailored to the needs and the possibilities of the country;

- a general lack of the national structures and/or the publishing capacity needed to ensure a regular and general supply of books;

- the lack of an overview of the publishing chain: in some cases, there is no serious preliminary needs analysis, while in others the difficulties of distributing materials to rural areas have not been taken into consideration.

The first reasons advanced to explain the current lack of textbooks tend to be social, economic and political in nature. Our attention is drawn to the explosion in enrolment after universal primary education was introduced in the 1960s, to the austerity which forced many governments to cut non–salary costs in the education sector in the 1980s and to the fact that the education budget is considered to be of only secondary importance in many developing countries and by the international aid community[5].

We should add that there are also technical reasons. It is extremely difficult to devise a strategy and the pertinent activities which would guarantee a regular supply of quality textbooks nationwide, and ensure that teachers and pupils put these to the best possible use. The efforts of international and bilateral aid organisations illustrate this difficulty to some extent: some fifteen years ago, attributing the shortages of textbooks to the lack of production capacity, they set up printing houses here and there, which rarely work at full capacity, at least partly because there are so few manuscripts worth printing. Today, these aid agencies

It should be noted that this book is not a case study. The specific experiences mentioned are used primarily to illustrate explanations which might otherwise be overly abstract. It is primarily a general interest publication for all those responsible for supplying high–quality textbooks to primary schools in developing countries. And above all it is a guide for authors of these books, all of whom should be able to find valuable information here, although it should be of most use to “apprentice authors” and those who have not had the benefit of an in–depth training in publishing. The points picked up in this book are those that in our experience constitute the commonest stumbling blocks. The contents can be broken down into two rough categories.

General Information

The first two chapters are dedicated to general information. Chapter 1 looks at work relating to the production of textbooks in industrialised countries and at recommendations for developing countries, to enable authors to identify the nature of the textbook production system within which they operate, and the duties which will fall to them.

Chapter 2 looks at the skills and attitudes required by authors, and at the tools which will allow them to preserve group dynamics while enhancing the quality of the individual contributions.

This is background knowledge which we consider indispensable for all those involved in the development of textbooks. We should point out that the information contained in these chapters cannot be harnessed directly by authors in their day–to–day work, unlike the other chapters which do give detailed instructions that can be put into practice immediately.

Detailed, Step–by–Step Description of How to Produce a Textbook

The rest of the guide covers the work involved in writing textbooks in developing countries, from the preliminary research to the preparation of a pilot version, ready to be printed.

What is unique about the approach taken here is that activities are described in chronological order. It is a sort of guide which takes authors through the process step by step, from forming a working group to submitting the final manuscript to the printer. In this we differ from other publications which look at this topic and then go on to analyse the various aspects of books, without aiming to follow every detail of the work of the authors[9].

same topic which have been published in industrialised countries. The contents, on the other hand, ought to be better adapted to the target group, even if they sometimes appear somewhat unorthodox to specialists from industrialised countries: the work described here is both necessary and sufficient to allow authors who do not yet have much experience to produce high–quality textbooks for and in developing countries.

This book cannot take the place of either practical experience or a long–term training course. We hope, nevertheless that the approach presented here, and the examples given will be instructive and useful. We equally hope that this testimony stimulates those working in the field, and encourages them to publish their own experience, which would be an invaluable contribution to the search for ways to overcome the current shortage of textbooks in developing countries.

Using this Guide

We entitled this book “A Practical Guide” because we intended it to be a genuine tool to assist textbook authors. To ensure that it is used as such, here are a few pointers which should help you find your way around the book and locate the information you need with ease.

Chapter Topics

The basic structure of every chapter is identical, i.e.

- A summary which puts the work in context and underlines the essentials

- A description of the work involved in this particular phase, as precise as possible and in chronological order as far as possible

- Illustration of the main body of the text, generally in the form of boxes referring to experience gained in producing reading and writing books in Malagasy within the framework of the German–Malagasy Tef'Boky Project already mentioned. For reasons of clarity we have decided to concentrate on *Garabola,* the first book to be produced in this series, which we will present in more detail below.

designed as a guide for textbook production.

As a result of this dual goal – training and production – the guide comprises different sorts of texts. Firstly it presents general information which the reader should assimilate if possible. Secondly it gives detailed advice similar to a user's manual, which is far too compact to be memorised.

This explains why it is not advisable to try and read the book from cover to cover at one sitting. Neither, however should you merely dip into it from time to time. We recommend using the book as follows to ensure you get the most out of reading it:

- Read the first two chapters carefully, more than once if necessary, as an introduction to the problems of textbook production and to the layout of this guide.

- Read through chapters 3 to 7 rapidly. This is crucial to enable you to find the detailed information you need later.

- Consult the book throughout the process of producing a textbook as and when required to check information, or read in more detail about a specific point. You can only consult the book properly if you can put the specific information into the overall context.

These different approaches will help the reader extract a maximum of information from the book, and will help enhance the quality of the textbooks he or she is responsible for producing – and that is our aim.

Reference Material

In this book we will make frequent reference to the didactic materials produced by the German–Malagasy Tef'Boky Education Project; particular importance is attached to the *Garabola* set of materials designed to teach reading and writing in Malagasy.

For reasons of clarity, we will outline the main features of the pilot version and the revised version below.

- 18 lessons on the 16 consonants and the vowels **e** and **y**; every four lessons two pages to read to consolidate what has been learned

- 16 pages of supplementary reading.

The book was printed in two colours to make it of a comparable standard to a book for learning French as a foreign language which had just been published in 4–colour, and which was being distributed nationwide at the time.

The writing book contains

- 10 pages of preparations

- 3 pages of writing for each of the 21 letters of the alphabet, following the same order as the reading book

- 2 pages of revision, corresponding to the consolidation reading

- 3 times 2 pages of evaluation, which correspond to the Christmas, Easter and summer examinations.

The teachers' guide contains

- 20 pages of general information on the subject “Malagasy” and the material

- A 12–page first part, which corresponds to the work of the first two weeks of the school year for the pupils in this class

- A 160–page second part, containing a real script for all elocution, reading and writing classes scheduled for the year

With the exception of the first three lessons, which focus on learning the vowels, the presentation of all chapters is identical:

- 2 pages for reading
- 2 pages for writing.

Although the basic layout of the revised teachers' guide is the same as the pilot version, i.e. detailed instructions for each of the speaking and listening, reading and writing lessons scheduled for the year, fundamental changes were made as regards visual presentation.

Notes

[1] Cf. Heyneman, S.P. et al *Textbooks and achievement. What we know.* Washington D.C.: World Bank, 1978.

[2] Cf. Buchan A. et al *Etudes sur le secteur du livre en Afrique,* p. 17. Washington D.C.: World Bank, 1991.

[3] Cf. World Bank *Education in Sub−Saharan Africa,* p. 42. Washington D.C., 1988.

[4] Between 1965 and 1983, for instance the World Bank helped finance 48 projects which tackled the preparation, supply and distribution of textbooks; the proportion of textbook projects, which accounted for 6% of all education projects in 1974, had risen to 43% of the total by 1983. Cf. Searle B. The provision of textbooks by the World Bank. In: Farrell, J.P. and Heyneman, S.P. *Textbooks in the Developing World,* p. 17. Washington D.C.: World Bank, 1989.

[5] In 1989 only 23% of international aid went to the social sector, and only 7% of the aid pledged to the education sector went to primary education. Cf. United nations Development Programme. *Human Development Report,* p. 8. New York, 1991.

This percentage is all the more surprising since the importance of primary education and textbooks is recognised. The need to invest in author training and in the production of textbooks specially tailored to the needs and abilities of those concerned should long have been accepted as a self−evident fact and been elevated to a priority of international aid.

Getting Down to Basics

Who decides to produce a new textbook? What steps must we take to produce it systematically? Who is responsible for preliminary research? Who produces the concept? How much time is needed from the finalisation of the concept until the finished book is distributed to schools? Who interfaces with the graphic artist? And with the printer?

These are a few of the questions facing first–time authors, and are probably the questions most likely to cause headaches for those of you who have already produced several books without having been specifically trained on the job. You may feel that you are unable to pinpoint the weaknesses of your own products, and thus improve them. To answer these questions, we will start by looking briefly at the various steps involved in producing a textbook, before going on to look at the respective responsibilities of the agencies and individuals involved in industrialised countries and in developing countries.

Why should we look at the various production systems, you may ask. Not to pronounce a value judgement, but to give you a framework of reference. Firstly we will look at the procedure adopted by major publishing houses to produce works that are competitive in terms of quality and price, and only then will we go on to identify the special nature of the production process in developing countries, and thus to deduce your responsibilities as authors.

This chapter, which contains general information and ideas, differs from the subsequent chapters which give precise descriptions of the steps involved in producing a textbook. We suggest nevertheless that you read it carefully since this will allow you to situate the various individual steps described later in the book within the context of the overall process.

> **Try to become familiar with the various steps in the publishing chain, since this will allow you to identify the special features of the production system within which you operate, and to pinpoint your own role within that system**
>
> **A private publishing house accompanies its “baby” every step of the way, until it is in the hands of the user**

number of pages, number of illustrations and their format, and the layout of the text and illustrations on the page).

At the end of this phase the publisher will generally have produced a preliminary plan or “design” of the future book, which serves as a guide for authors and illustrators, and can be used to draw up an initial quotation.

Producing Texts and Illustrations

Authors and illustrators now enter the scene: the authors write their texts and devise exercises on the basis of findings identified during the conceptual phase; their work is subjected to various internal controls within the publishing house and sometimes to spot checks in one or more schools. The illustrators produce the graphics in line with the instructions they receive from the publisher and the authors. In general a final quotation can be drawn up at this stage.

Preparations for Printing

All the elements to be printed must be prepared: the manuscript has to be typeset, i.e. composed into pages suitable for printing; illustrations must be prepared in a photoengraving workshop. Composition and photoengraving work is done on films for offset printing.

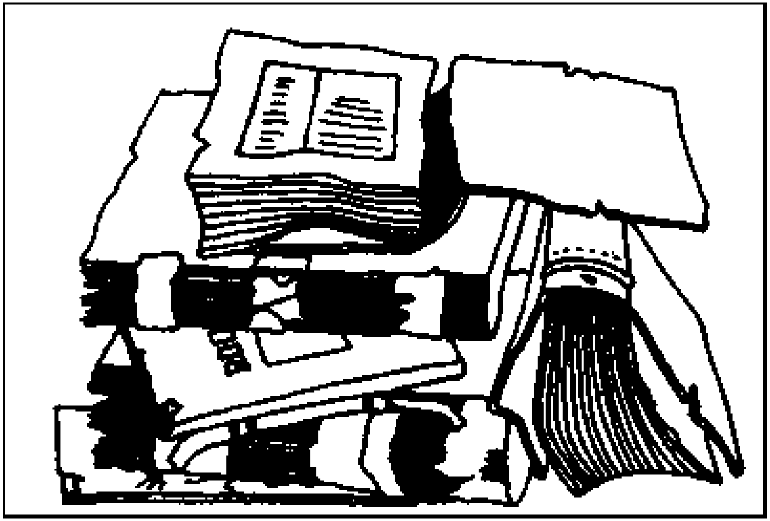
The text and illustrations are then arranged on each page: the design drawn up during the conceptual phase is finalised and a model or “layout” produced, which is used as a sort of template for the future textbook.

Following the instructions given in the layout, the films produced for the text and illustrations are arranged for every page, and the pages are “mounted”, i.e. all the pages that are to be printed at the same time are stuck onto a transparent background.

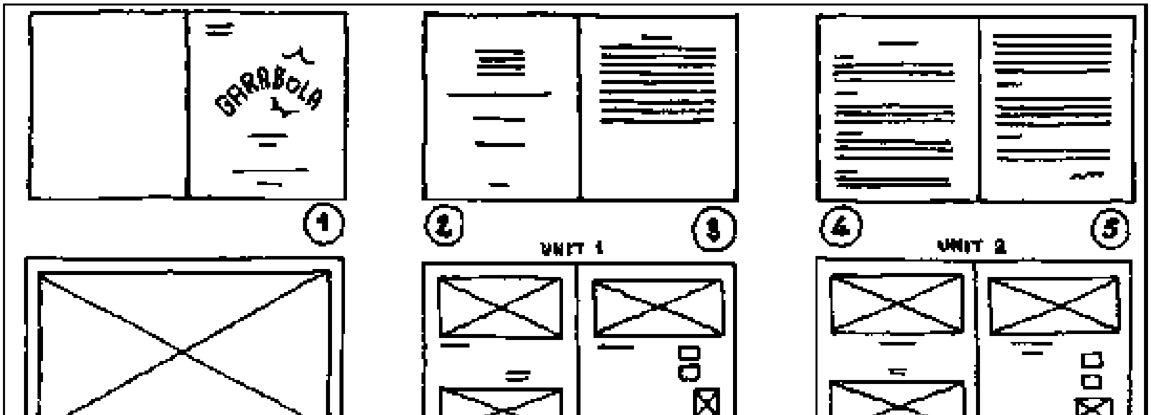
This montage produces the forme which can then be used to print the book.

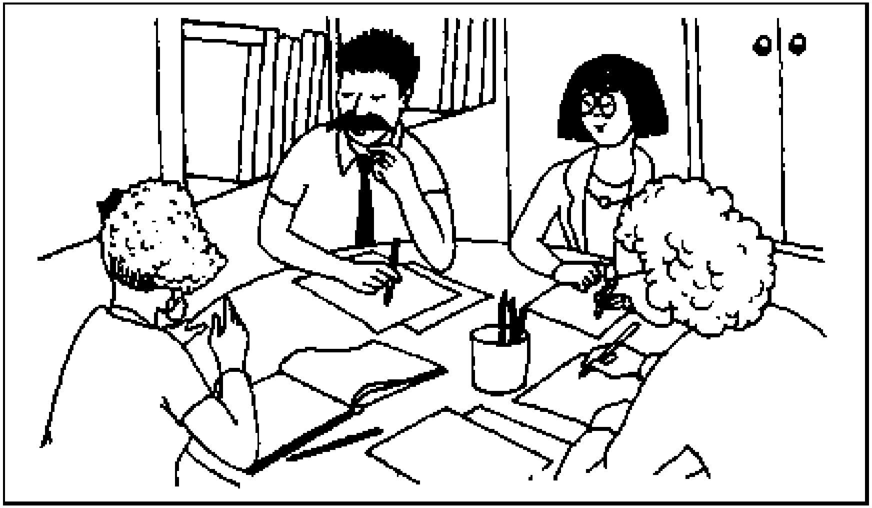
Printing and Finishing

The textbook is now ready to be printed. Large–format sheets are placed in the printing press. Several pages of the future textbook will be printed at once, as they have been mounted.



1. Preliminary Research: The most common reasons for publishers to produce new textbooks are that the old ones are tattered and worn, have become unusable or have become obsolete as a result of major changes in the official curricula.





shape and size.

• The layout artist then makes a precise dummy make–up on paper, arranging texts and illustrations.

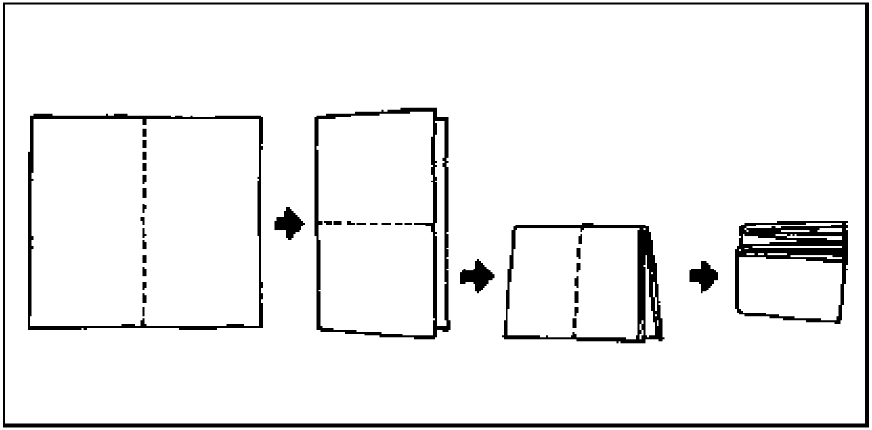
These explanations and the illustrations above will have helped you to familiarise yourself with the various steps that make up the chain, as practised by large publishing houses.

Given the fact that it is imperative for you to start to memorise the sequence of work involved, we will, however, come back to the production phases for a textbook one more time, summarising the main phases within the publishing chain and the results of each phase. Before you proceed to the next section, we would thus recommend that you look at Table 1.

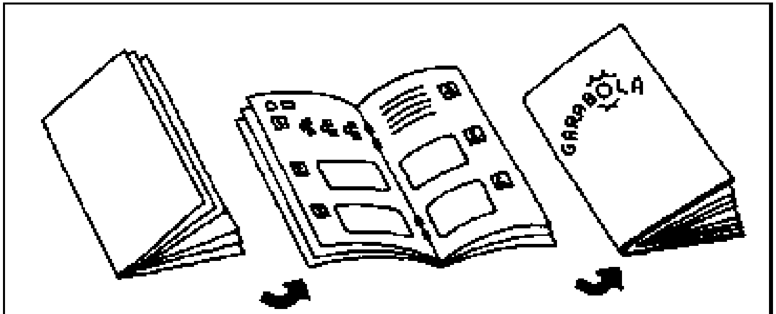
Production Cycle in Developing Countries

After this introduction to the steps involved in the commercial production of textbooks, let us now turn our attention to the procedure that should be adopted in developing countries.

5. Printing and Finishing Once again you must distinguish between various phases.



• Firstly the new textbook is printed on large sheets of paper which are folded several times to make what we call “signatures”, so that the pages are in the correct order.



illustrations		
	Texts	Manuscript
	Illustrations	Graphics dossier (photos, drawings)
4. Preparations for printing		
	Typesetting the text	Galley proofs
	Processing illustrations	Films
	Paging on paper	Imposition scheme
	Make–up and imposition	Film
	Report	Blueprint
5. Printing and Finishing		
	Printing	Printed sheets
	Folding	Printed signatures
	Assembly	Inside of book (unbound)
	Binding	Inside of book (bound)
	Attaching the cover	Book with irregular edges
	Trimming	Finished product

We will look again at the steps in the publishing chain we identified above, and see where the procedure adopted in developing countries differs from the above scheme. Let us also point out that we will not go into the process of translating or adapting textbooks, however justified this may be under certain circumstances. What we describe here is how to produce an original textbook, what to do when one cannot adapt or translate existing books[1].

specific level. In developing countries, however, the publisher often knows little about the target group, and the reference material available tends to be fairly unreliable and inadequate. It is thus crucial to conduct field studies to collect detailed data on teaching and learning conditions.

The second unique feature: preliminary research must look at teaching and learning conditions

Pilot Textbook

Devising, writing, illustrating, paging, printing and finishing the textbook (1 year).

The description and sequence of the tasks that make up this phase of the production work do not differ significantly from those undertaken in industrialised countries, even if textbook projects often lack the resources that a commercial publisher would have.

The result, however, is different in that it cannot be considered a final product. It can only be a pilot textbook.

Testing and Evaluation

Distribution of the textbook to selected schools and presentation to teachers at these schools, testing and evaluation (1 year).

In industrialised countries, given the degree of uniformity that exists from one school to another it is often enough to test one or two units of the new textbook at a few schools before moving on to produce a final version. In developing countries, given the lack of basic data, and given above all the great heterogeneity of teaching and learning conditions often found, the textbook must be tested in its entirety at a representative sample of schools for a minimum of one academic year before it is evaluated.

Producing a Revised Version

Revision of the pilot textbook, official check, printing the revised version (1–2 years).

• Testing the new book at a representative sample of schools for a minimum of one academic year, and then evaluating the results

• Systematic revision of the pilot version of the textbook

• Development of a national distribution strategy

• Presentation of the new book to the teachers who will have to use it.

Textbook Projects

You will have realised by now that the systematic production of textbooks in developing countries would overtax any single department or unit. How, you may ask, can didactic material be devised and produced taking into account all the relevant aspects of the system? Who has the human, technical and financial resources to undertake a task of this scope?

Some developing countries can meet their textbook requirements using their own skills and funds – but these are the exceptions. More often projects, generally funded by international or bilateral technical or financial cooperation, are charged with the systematic production of textbooks.

We think that it is instructive for those of you who are still relative newcomers to the field of textbook production to realise that projects of this sort can generally manage to perform the work described above. By way of example we will describe below the main phases of production for the very first textbook devised, developed and produced within the scope of one such education project, the Tef'Boky Project[3].

2. A Textbook Emerges Step by Step
At the end of 1986 an education project, the Tef'Boky Project, was launched in Madagascar. It aimed to train a group of authors and to develop textbooks in the national language for primary school pupils. To pursue the two–fold goal of training and production, the group of authors responsible for the subjects Malagasy and mathematics produced the materials step–by–step in a way which may be considered fairly exemplary. This table shows the chronology of *Garabola*, the first reading and writing book to be produced

6. Universal Introduction	
	The structure set up with the help of the World Bank[4] is currently in charge; it is responsible for working out the nationwide distribution plan. *Garabola* should be used throughout the country as from the academic year 1993–94. Some ten years have thus elapsed since the feasibility study.

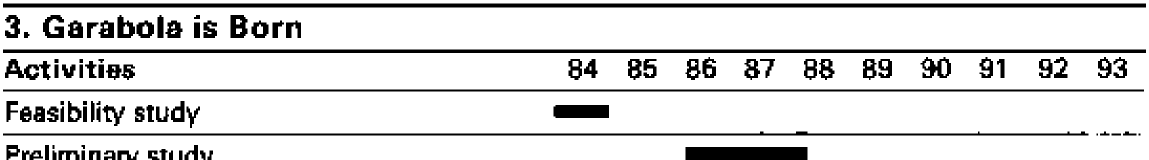
Writing and Production

Test your book systematically and evaluate the results before printing a large run
Plan the entire series of textbooks from the outset

If you do not yet have experience in the field of textbook production, you may think that, once the appropriate funds have been approved, the revised version of a textbook can be rapidly distributed to all schools in a country. Nothing could be further from the truth, however. If you look carefully at Table 2, you will see that no less than three years elapsed before the textbook was finally distributed (in 1993), although the finished version was completed and the funds available in 1990.

It is important to know that the authors can only influence the rate of progress on the work for which they are directly responsible. Where your textbook is to be printed in large numbers you have no control over the printing or the distribution; your "product" slips completely out of your hands and there will be delays and break–down which you will almost inevitably feel are out of all proportion given the long, complex development work, particularly if you attacked your part of the work with great gusto.

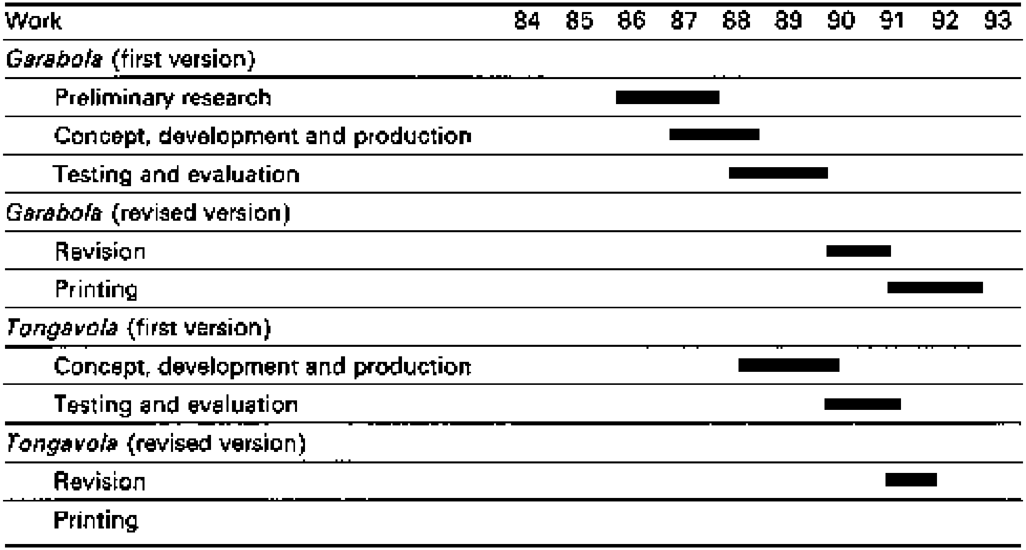
Table 3 gives you an idea of the imbalances that can occur between the development phase and the production phase. This table follows the progress of *Garabola,* indicating a few crucial times in the printing and distribution of the 450,000 books.



Throughout the industrialised world, the production of textbooks follows a rigid scheme, spanning several years; in developing countries no other procedure should ever be adopted. Yet the planning is always most difficult in this part of the world, where the publishing chain is longer and more complex. When we aim to produce a series, we must coordinate the activities needed for several different textbooks at once; to put it more clearly, while the first textbook is being tested and revised, plans must be made for the development of the second, such that the books in the series are printed without "losing" any academic years, and without missing the start of the academic year.

To illustrate this, Table 4 shows the actual time schedule used in the Tef'Boky Project to produce the pilot and revised versions of the first two reading and writing books produced in Malagasy, *Garabola* and *Tongavola*[6].

4. Time-Frame for Work on Garabola and Tongavola



2. Those Responsible

As a general rule, three entities are involved in the commercial publishing chain – the Ministry of Education[7], a publishing house and a printer, the latter two always being private enterprises. The duties of each of the three have been clearly established for some time.

Each of these three can, naturally, sub–contract certain operations to another enterprise. It is, for instance, common practice for ministries to contract a research institute to modify curricula or to evaluate didactic materials; the publishing house may contract educational consultants to define the contents of the new textbook; and finally the printer does not as a rule perform every stage of the production work himself, and may well farm out the stitching or binding work.

In Table 5 we have only indicated which of the three entities is responsible for each task, regardless of whether they perform the work themselves or delegate it.

You will see that "evaluation", so important in developing countries, is not even mentioned in the table. There are two main reasons for this.

• Firstly a rigorous external control is often conducted before a new textbook is granted the official authorisation, compulsory in some countries, where the publisher must have every book produced approved by the Ministry of Education. This procedure ensures that the products submitted by the publisher for approval are of a high quality.

• Secondly, where no official approval is required the publisher bases his decision on whether or not to order a reprint firstly on commercial considerations (sales figures), while head teachers, members of textbook examination committees and teachers play a not insignificant part in that they select the books, and thus help ensure certain quality.

5. Principal Duties of Those Responsible for the Textbook	
Entity	Duty
Ministry	

	Performs / checks photoengraving work
	Defines provisional layout in more detail
	Prepares the dummy make–up
	Prepares the file to submit to the ministry for the imprimatur
	Decides how to print and finish the book
	Selects a printer
	Has a final quotation drawn up for printing and finishing
	Selects and orders the desired paper from the printer
	Submits the job to the printer for printing
	Checks mounting work and gives the printer the go–ahead
	Pays for printing and finishing
	Is in charge of marketing the finished product
	Prepares and ensures the monitoring of the book in the field
Printer	
	Draws up the quotation for printing and finishing work
	Mounts text and illustrations
	Prepares the type forme
	Procures paper and other inputs
	Prints, finishes and delivers the textbook to the publisher as instructed

In this system too, it is rare for the textbooks to be tested and systematically presented to teachers; they tend to be placed at the disposal of teachers or imposed from above. The textbooks produced in this way are generally cheap, but very often the quality is poor, especially in terms of the graphics (illustrations and layout).

This system has been used in Tanzania, Madagascar and other African states.

National and/or Foreign Commercial Production

The ministry turns to other countries to provide the textbooks it needs to attain pre–determined objectives. There are two possible scenarios: either the publishers contacted produce the textbooks with national support; the manuscript is often produced by a team of local civil servants while the layout, illustrations and printing are executed outside the country; or the publisher simply imports its own textbooks and markets these. These are almost always attractive books, but they are also expensive, and the contents, particularly the graphics, are not always very well adapted to the country in question.

The large English and French publishers can thus be found to a greater or lesser degree in many African countries.

Several systems may co–exist: we may find private national production of text–books in European languages alongside state production of national–language books, where the financial rewards are not attractive enough for private publishers.

Each of these systems has its own shortcomings, but some specialists recommend moving towards the first of these; they claim that competition must be honed and the private sector encouraged to take part in the textbook sector, wherever possible[9]. It is true that the production of textbooks demands creativity, profitability and functionality which a civil service can rarely provide, but at the same time commercially produced textbooks, whether they are produced in the country or abroad, primarily address the well–off urban classes, with purchasing power and easily accessible without a complicated distribution network; poor pupils who represent the majority of the target group, or those living in rural areas which may be very isolated, are thus *de facto* discounted.

Let us for the moment just note that although authors naturally cannot modify the system within which they operate, it is imperative for them to understand the features of that system. This will allow them to understand

Managers

The publisher firstly surrounds himself with a team of managers, the main duties of whom are listed in Table 6.

6. Main Duties of Managers within a Publishing House	
Manager	**Duties**
Publishing Manager	
	Identifies textbook production project
	Defines contents and how they are to be arranged
	Selects authors and contracts them
	Supervises and reviews authors' contributions
	Analyses the way the book is used in schools
Art Director	
	Decides on the graphics for the textbook
	Selects illustrators and photographers
	Supervises and reviews the illustrators' and photographers' contributions
	Designs and manages the layout
	Selects typographic characteristics
Production Manager	
	Defines physical features of the textbook

Technicians		Duties
Working with the Publishing Manager		
	Educational consultants	Help specify pedagogical features of textbook
	Authors	Write and take stock of manuscript; run preliminary tests; read proofs
	Proof readers	Correct manuscript; read proofs
	Publisher's secretary	Prepares manuscript
Working with the Art Director		
	Authors	Help with the graphic concept
	Illustrators / photographers	Help design graphics, produce illustrations and check the quality of photoengraving
	Documentation expert	Researches the necessary illustrated documents
	Layout artist	Visualises the design, finalises layout; produces make–up
	Graphic artist	Decides on typographic characteristics of text
Working with the Production Manager		
	Publisher's secretary	Prepares elements to be printed, texts and illustrations
		Monitors ongoing activities (quotations, planning, contacts with type–setter, photoengraver and printer)
Working with the Commercial Manager		

the authors, and even the printer frequently see themselves forced to take on responsibility for considerably more than their traditional tasks.

Redefining the Traditional Role of Publishing Specialists

In those countries where textbook production is in the hands of a public–sector publishing house or a publishing unit within the Ministry of Education, the roles and responsibilities of the various actors are not always clearly defined.

There are two common scenarios. In the first case the officials, often with no well–founded publishing skills, approach the printer directly with only a manuscript, i.e. a text rather than an imposition scheme including the final layout and illustrations – and expect him not only to print the textbook, but also to take on responsibility for publishing, or to contract this work out. The traditional publishing chain is thus reversed, since the publisher, rather than supervising work from the start, is only consulted at the end, if at all.

In the second scenario the officials entrust the authors with the overall responsibility; without realising the enormity of their demands, they expect the authors to produce a product which can be handed to the printer, and printed immediately. The authors have no choice but to assume some or all of the work of the publisher, without necessarily being up to the task.

To allow you to pinpoint the duties of the publisher, the author and the printer in industrialised countries and those characteristic of the production system within which you operate we have summed them up in visual form in Table 8. The illustration indicates how the traditional roles can be modified and the repercussions this has on the work of the various actors.

Rough Orientation of Textbook Projects

It is interesting to see how donors who have specialised in textbook production react to a situation of this sort, or to put it more succinctly, how they organise their large–scale textbook projects. Their current efforts seem to pursue two objectives on different time–scales.

8. Main Duties of Principal Actors in the Publishing Chain	

It is just as urgent to set up a publishing unit as to train authors

Those who give precedence to a short–term strategy, aim firstly to respond to urgent needs, in some cases the total absence of textbooks in schools. To this end they focus first on the authors who they train in basic publishing techniques, wherever there is no publishing capacity in the country in question, to allow them to produce didactic materials against the odds. They generally manage, and the quality of the materials produced is acceptable, if not always excellent. We should, however, specify that when the projects come to an end, having trained authors and given the country the textbooks it needs, the authors cannot continue their work within a strong publishing structure and the know–how generally vanishes rapidly. When new textbooks are needed, generally about five years down the line, the whole process starts from scratch.

By contrast, those who accord priority to a medium– or long–term solution attempt to establish a sound publishing system, and there can be no doubt that this is what we ought to aim for; they focus on providing training for technicians and the various other book–related occupations, rather than on producing textbooks immediately. This formula too has its risks, of course, the two main ones being staff changes, with the result that individuals are given several years of training as technicians and then leave before they have ever worked productively, and the lack of competent authors on whom trained publishers can rely. In other words there is a risk of producing well trained publishers – who then have nothing to publish.

We would like to stress that, in view of the sheer scale of the demand for textbooks on the one hand, and the general lack of publishing skills on the other, these apparently divergent efforts should always be considered as complementary approaches, and pursued energetically without delay in many developing countries.

Responsibilities of Authors in Developing Countries

Your responsibilities as authors will depend on the production system within which you work

Some of you may think that the previous section is more relevant for decision–makers at national level and international donors than for authors, in view of the fact that it is difficult if not impossible for the latter to modify the textbook production system. But you will not be able to define your own duties until you have a firm courses in Madagascar and overseas[11].

4. In Conclusion

Beyond the Textbook

Whatever the system within which they operate, i.e. whatever the tasks expected of them, groups of authors in developing countries always play a crucial part in ensuring a supply of high–quality textbooks, as we have seen in this chapter. But, however heavy this workload alone, their responsibility is rarely limited to producing textbooks; in fact it is generally the authors who must prepare the way so that their product is well received by teachers and parents.

Information and awareness measures must always be handled by a ministerial department specialised in this field, which will mean that it has the equipment it required. When the textbooks reflect curricular changes, for instance if a national language has replaced a European language as the language of instruction, these activities go well beyond the scope of a small group of authors who already have more work than they can handle. Nevertheless they are often left with the responsibility. The authors then find themselves faced with the choice of concentrating all their energy on writing and not preparing people for the launch of the new material, thus running the risk that the finished product will be rejected by insufficiently well informed users, or of adding one more string to their bow and running the risk of producing mediocre and superficial books[12].

Before you start work on the textbook we thus suggest that you analyse the school situation and gauge the textbook's chances of being accepted without further action; this will enable you to make provision, if necessary, for information and awareness measures, without which your heavy workload as authors may be pointless.

Make preparations for the launch of your textbook from the very start of the project

Notes

two years (In: Institut für Bildungsmedien. *Die kleine Schulbuchschule.* Frankfurt am Main, 1989). In France on the other hand "there are no official textbooks any more than there are textbooks that are recommended or approved by the Ministry of Education" (A. Savary. In: Huot H. *Dans la jungle des manuels scolaires,* p. 145. Paris: Seuil, 1989).

[9] Buchan A. et al *Etudes sur le secteur du livre en Afrique,* op. cit. p. 13.

[10] As we noted at several points during the Tef'Boky Project this lack of transparency often worries authors, who find it difficult to pinpoint their own part within the system as a result of their poorly defined publishing responsibilities.

[11] A separate publication, scheduled to be printed in 1995, deals with the experience gained in the Tef'Boky Project regarding training authors in developing countries who are responsible for producing textbooks for the primary level.

[12] The Tef'Boky Project managed to undertake some information and awareness measures (producing posters, calendars, supplementary reading materials and even a film), but this increased the workload of the authors, although they were only indirectly involved, such that they were pushed to the absolute limit.

Recommended Reading

Textbook Production in Industrialised Countries

BERTHELOT, J. *Petit guide à l'usage des auteurs débutants et de quelques autres.* Paris: Hachette, 1991

BERTHELOT, J. *Edition et techniques éditoriales.* Paris: Hachette Supérieur, 1992

FINELSC, G. AND SASSIER, D. *Un livre, des hommes. De l'auteur au lecteur.* Paris: Nathan, 1988

GREENFELD, H. *Bücher wachsen nicht auf Bäumen.* Munich: Ellerman, 1979

GROUPE DE LA CITE INTERNATIONAL *Le livre. Sa conception, sa réalisation. Documentation.* Paris, undated

purchaser can choose any one of a number of textbooks which are comparable in terms of quality and price.

In developing countries, the demand for textbooks is enormous, but textbook publishers are rarely able to produce enough books of a suitable quality as rapidly as needed. The central problem appears to be that we have not yet managed to adapt the publishing chain, which has proved so valuable in industrialised countries, to an environment which either fails to appreciate the importance of this chain, or lacks the human, financial and technical resources to put it properly into practice.

This guide addresses novice authors, who have been instructed to produce textbooks that are adapted to the teaching and learning conditions in their own country, at relatively short notice. We aim to strengthen their skills as authors, by giving them a basic understanding of the publishing process. The first chapter introduced the steps involved in systematic textbook production, to allow them to identify, by contrast, the steps needed to produce textbooks that are specially tailored to the needs and resources of their own country. We then looked at the organisation of large publishing houses and the responsibility of the professionals involved in textbook production, to help them pinpoint their own place within the system, and thus allow them to develop and react accordingly.

We believe that this is vital prior knowledge for all teams expected to produce textbooks in developing countries, if they are to bring their work to a successful conclusion.

mediocrity of a textbook[1]. What is decisive is the profile of the authors and their working methods, two factors to which this short chapter is dedicated.

Another general information chapter with no immediate application, some of you will think, impatient to find the "recipes". If this applies to you, try and force yourself to read this chapter nevertheless; as you will have realised after reading the first chapter, the responsibility that you will have to assume demands special preparations.

1. Profile

Whether they write for primary or secondary level, textbook authors are not given specialised training, but those writing for primary level appear to be the least well prepared: they often have only the skills they have acquired on the job, in front of a class[2].

Yet, as you will have realised after reading the first chapter, all authors have a great responsibility which ought to preclude any amateurism. Those whose duties go beyond writing and touch on publishing work in particular should never improvise. They must be professionals, well prepared for the unique nature of their work and fully aware of the skills and behaviour they will need to adopt if they are to perform their work satisfactorily.

Before looking at the preliminary research phase then, let us examine the profile of the textbook author, which will allow you to identify the skills and attitudes so essential in your situation.

Basic Know–How

The essential know–how for all textbook authors regardless of the level and the subject they write for, and the system within which they operate are as follows:

- Well–founded knowledge of their subject; this may be mathematics, science, linguistics or any other subject;

- Skills in adapting didactic material to suit the profile of future users;

It has become indispensable for everybody to learn to work in a group, since the trend is for more and more books to be written by a team of authors rather than by an individual.

But when the publishing unit is weak, and the authors bear most of the responsibility for the textbook, genuine team work is vital given the sheer scope of the work to be performed – and it is not easy to organise: agreement on even hotly contested points must be hammered out by the team, among equals as it were, without having recourse to a higher–level arbiter in the person of the publisher.

If you find yourself in this situation, where the responsibility of the publishing unit is limited to word processing, you must learn to create an atmosphere of tolerance and openness which will allow all team members to optimise their inputs. To this end, you will have to learn to formulate criticism or at least reservations, to argue a point, to listen to observations of others and take them into account, and finally to identify fully with the common decision.

Otherwise your work runs the risk of being slowed down or even paralysed well before the book ever goes to press.

Multi–Sectoral Attitude

Decisions regarding didactic material always demand a cross–sectoral approach, whether they concern the publishing side or the domain of the authors.

If, for instance you wish to define the sort of materials needed to learn to write, you should look not only at the pedagogical and didactic factors (What is the best aid for learning to write? What is the best one for teaching writing? Exercise book or slate?), but also at the financial considerations (How much does an individual exercise book cost? And a slate? How many parents will be willing to pay this amount?), the logistics (Will it be possible to supply the schools with exercise books in time every year?), the working conditions (Are classrooms suitably furnished to allow pupils to write in exercise books? Would a slate which is rigid and can thus be used by pupils working without tables or desks, not be more practical?), the production considerations (Can slates be produced on the spot?), etc.

The less effective the publishing unit, the more you will have to take into account factors other than the purely pedagogical and didactic. If you were to refuse to look beyond the confines of your own subject–specific

Be open to new ideas and look for appropriate solutions as a group

Accepting the Constraints

Finally, you will have to know how to accept major constraints and make the most of the leeway you have.

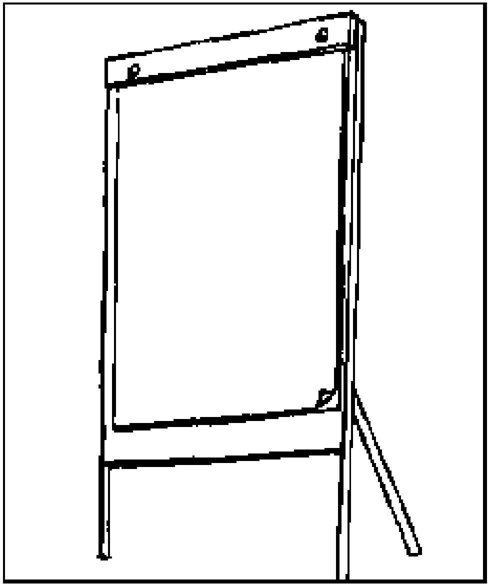
The single most important constraint will be the financial one; as textbook authors you must always distinguish between what is desirable and what is feasible for your country, and must decide on the didactic material without losing sight of the financial implications for those concerned.

If necessary, you must thus accept that your book be printed in two colours, or even in monochrome; or you must refuse to write a textbook if the country cannot finance it, concentrating instead on a teachers' guide, if this helps achieve pre–defined goals. There is no place in a group of authors in a developing country for anyone who refuses to accept constraints, or who imposes unreasonable financial burdens on others in the name of artistic freedom[4].

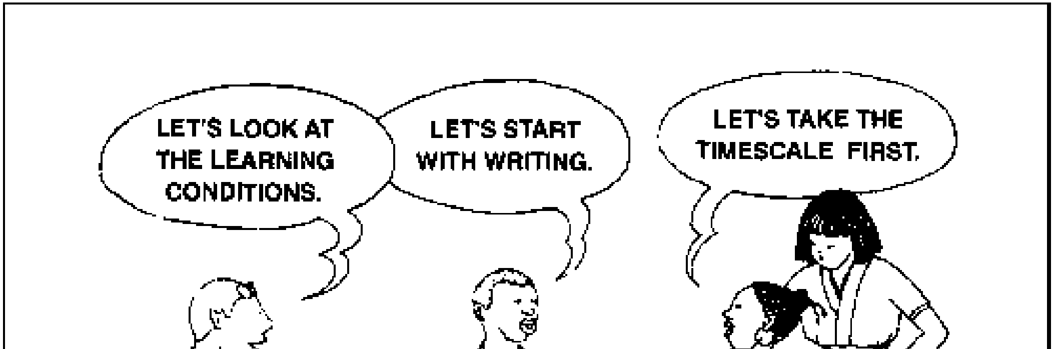
If we have dwelt on the attitudes and behaviour demanded of textbook authors in developing countries it is because the importance of these factors is almost always underestimated, not only by education authorities, but also by those concerned. It is felt that a good teacher will automatically be a good author, for instance, ignoring the fact that the skills demanded of a teacher are quite different to those demanded of a writer or a publisher. We are astonished when otherwise brilliant specialists produce mediocre textbooks, poorly adapted to the target group, and when authors prove unable to properly identify the root cause of this mediocrity, which would allow them to remedy it.

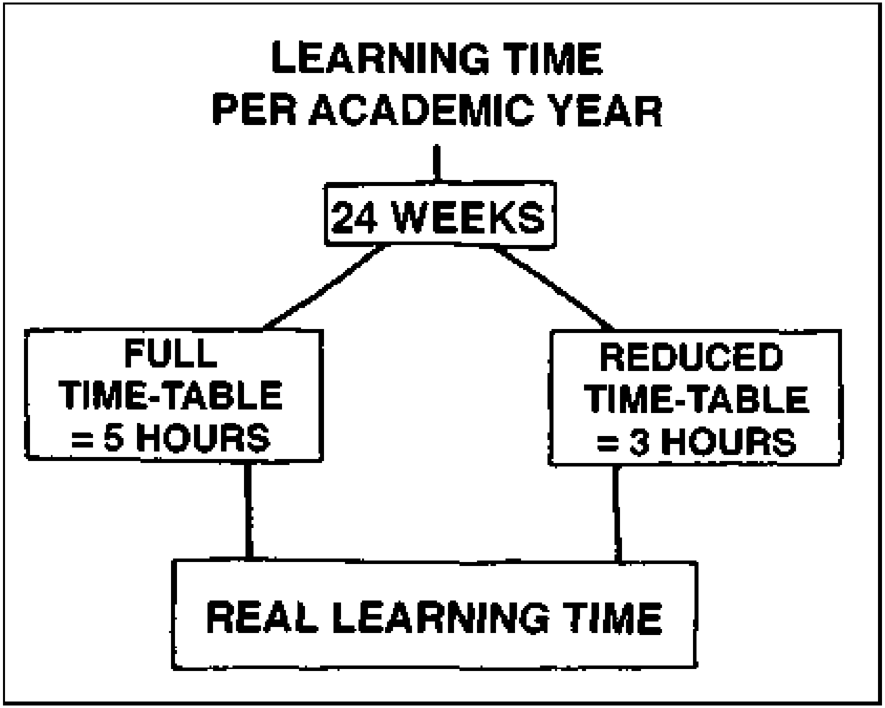
These considerations aim to help you gear your work from the very start to the production system within which you operate. Do not let them discourage you, use them, even if they only help you to analyse the tensions which will inevitably arise in your group, and to remedy these more easily.

2. Tools of the Trade



1. Preparing your tools: You should obtain a pin board made of porous material if possible, as well as several boxes of round–headed pins, a large number of cardboard strips or packing paper, the size of which will depend on the type of contributions. You will also need some marker pens and biros.





4. Pinning up provisional contributions: One participant gathers up all the cards one by one and reads them aloud. He pins them on the pinboard, arranging them in a provisional order. He does not comment on them at this stage, to allow all participants to re–read the cards for themselves. The cards are then taken one by one, corrected, and arranged definitively.

3. In Conclusion

Notes

BERGER, G. AND BRUNSWIC, E. *L'éducateur et l'approche systèmique.* Paris: UNESCO, 1984

CROZIER, M. AND FRIEDBERG, E. *L'acteur et le système.* Paris: Seuil, 1977

FERRY, G. *La pratique du travail en groupe.* Paris: Bordas, 1985

ZALTMAN, G., DUNCAN, R. AND HOLBEK, J. *Innovations and organizations.* New York: Wiley, 1973

To Sum Up

In industrialised countries the responsibilities of textbook authors are well–defined and relatively limited; in developing countries, they tend to be greater, even if they are not always well defined.

This is why authors in developing countries must prepare themselves particularly well for the work ahead.

Firstly it is, of course, vital for them to have certain basic know–how: there can be no question of planning to produce learning materials for mathematics, for instance, if the group cannot count on the support of a specialist in this subject.

Authors will also need certain attitudes, the most important being the ability to work in a group, a cross–sectoral attitude, an openness to new ideas and the ability to work within the given constraints. These are the attitudes which will enable authors to design, write and produce high–quality textbooks, that are genuinely adapted to the needs and resources of the country in question. They are all important, but we would like to stress the need for every textbook author in developing countries to be open to new ideas. In these countries a good textbook author cannot avoid being a researcher, looking for original answers to unique problems, where there are no cut and dried solutions.

Certain tools can be a great help to ensure the systematic development of textbooks; the methodical visual display of team members' contributions and of the main decisions made at the end of each session improves group dynamics and enhances the quality of the team's work.

exhaustively here; we will give you only a few pointers which you can adapt to your own situation.

To avoid discouraging you in any way, we would like to point out from the outset that the research work described here is only possible with special technical and financial inputs: you should analyse the recommendations, use them as best you can, and continue to push forward, even if you are forced to admit that it is impossible to apply the model in the form presented here. You should also note that this work is only essential for the first book in a series: the data thus gathered are generally sufficient to allow you to produce the following books, verifying only individual points on the ground.

First task of the author – Analyse teaching and learning conditions

Get to know everybody involved in the textbook to ensure that the finished product will be appropriate

1. The Need for Research

Is it really essential to undertake preliminary research, some of you will ask. Does it have to be so complex and so wide–ranging in view of the urgent need for new textbooks?

Before you can conduct optimum research work, you must first be convinced that it is absolutely vital. You must understand that the textbook is part of a complex environment, that it affects groups which must be examined if the finished textbook is to be in line with their needs and possibilities.

To convince yourself of the need for preliminary research look firstly at the list of those involved in the main stages of the publishing chain in a state production system, for instance.

9. The textbook and its environment	
Stages	**Main individuals/groups involved**
Decision to produce textbook	

Utilisation of finished textbook	
	Teachers
	Pupils
	Inspectors and educational advisers

Field research work demands human resources, time and technical and financial inputs

2. General Overview

Highly developed planning and organisation are needed to gather data on the school environment. For a period of several months you will have to manage relatively extensive human, technical and financial resources.

Given the complexity and scope of this work, we will start with a general overview, which will enable you to evaluate the extent and nature of the research work and the ways and means of conducting it. This will give you a frame of reference to allow you to put the more detailed explanations which follow within the overall context.

To this end, we will summarise the approach taken in the Tef'Boky Project, the main phases of work and the duration of each phase. These are listed in Table 10.

10. Field Study in Madagascar
In November 1986 the German–Malagasy Tef'Boky Project started the work that was to allow it to produce appropriate didactic material for reading and writing in Malagasy. Given the dearth of information available on primary schools in Madagascar and the lack of any evaluation of the few existing textbooks in Malagasy that did previously exist, the project saw itself forced to prepare a

	Based on a number of criteria, the apprentice authors selected a representative sample of schools which fairly reflected teaching and learning conditions in the country.
	The sample involved 40 schools in one educational district. Preliminary research for the textbooks to be produced was conducted at these schools and the pilot version of the books was later tested and evaluated there.
Gathering data (2 months)	
	The entire team of apprentice authors and the three animateurs working in the test zone helped gather data in schools and villages. After one week of familiarising themselves with the research instruments, each member of the team was able to work independently examining one school per week.
Processing and interpreting data (4 months)	
	The data thus collected was processed, systematised and interpreted; the authors performed some of this work and delegated the rest to students and teachers (transcription of all recordings, counting the graphemes in the language, identifying words most frequently used by children, etc.).
Publishing data (3 months)	
	The authors prepared a fairly complete preliminary working paper to allow them to proceed with the conceptual phase without further delay.
	Parallel to the conceptual work, a final document was drawn up and submitted to the education authorities for their information.

3. Taking Stock

Having looked at this overview of what preliminary research can, and often does, entail within the scope of textbook production projects, let us return to the beginning. The first step must be to identify the factors that must be examined, evaluated or quantified before you can devise a systematic concept for new didactic well–targeted, we recommend that you systematically eliminate all factors that are not relevant for the material to be produced.

Table 11 shows the factors that should generally be examined before designing didactic material for primary level. To allow you to gauge the importance of these factors we have outlined the main reasons for including them in the analysis, and the repercussions they are likely to have on the new material.

11. Main factors to analyse regarding conditions in schools

Field	**Factor**		**Relevance for new materials**
Political and educational framework			
Educational legislation			General direction, e.g. language of instruction
	Curriculum[1]		Learning targets
	Official guidelines		Officially recommended learning methods
	Organisational set–up of ministry		Chances of having innovative material approved
How education is organised			
	Length of academic year		Volume of subject matter that can be covered
	Length of school week		Ditto
	Physical framework		
		Storage space, furnishings	Quantity and type of materials available
		Lighting	Level of legibility required in textbook
		Blackboard	Blackboard–based learning activities
		Ratio of teachers–pupils	Group and individual learning activities

	Teachers		
		Level of education	Degree of complexity innovation of material
		Professional training	Contents and presentation of teachers' guide
		Social background	Ditto
		Integration in community	Ditto
		Linguistic skills	Ditto
		Motivation	Degree of innovation of materials
	Pupils		
		Social background	Topics contained in pupils' material
		Focus of interest	Ditto
		Linguistic skills	Linguistic contents of book, instructions to teacher
		Previous knowledge, results in subject	Level and complexity of content matter
		Economic duties	Topic–related and pedagogical contents
	Parents		
		Socio–linguistic features	Language taught/language of instruction
		Level of education	Active support for children's education
		Economic resources	Cost of material
		Attitude to school	Planning information/awareness activities

Textbook Projects

years, while others use several different alphabets, none of which is really adapted to the needs of primary schools. Other still have not yet been written.

Let us look at the steps to take if one of these languages is to be the language of instruction and/or the language taught.

Fundamental linguistic analyses

When we are dealing with a national language that has not yet been written, UNESCO[3] recommends that work be structured in Table 13 (page 52).

- Conduct a phonemic analysis which will be used as the basis for a scientific alphabet
- Conduct a grammatical analysis
- Prepare a preliminary lexicon.

12. Factors regarding the environment of a textbook project		
Factors	Aspects	
Writing Conditions		
	Capacities of the curriculum unit	
		Will the unit undertake any revision of the curriculum, or will you be officially charged with this

		regulated?
Production Conditions		
	Identification of sources of funding	
		Is the financing of the pilot version guaranteed? Is financing guaranteed or are there prospects of obtaining finance for the final version?
	Size of the market	
		Are there reliable statistics on the number of schools and the number of pupils per class? Are there forecasts of the growth in school rolls? Has any research been performed on the financial status of parents?
	Definition of conditions of use	

		quality? Are the technicians properly trained? Can the printer operate competitively?
	Inputs	
		Are all inputs required available on the spot? What is the quality like? Must paper be imported? Ink? Printing plates? etc.
	Finishing	
		Is the printer equipped to finish books? In particular, what type of binding can he produce? Can the printer cope with a large run? Can he pack the books properly?
Distribution Conditions		
	National statistics	
		Does the unit in

		distribution and/or the financial resources to have the materials distributed?
Teacher Training		
	Capacities of the teacher training unit	
		Who is to plan the necessary training activities to accompany the introduction of the revised material? Who is to conduct the training?
	Capacities of future trainers	
		What is the level of training, experience and motivation of those in charge of teacher training?
	Technical and financial resources	
		What technical back–up resources and what budget

Examine the writing, production and distribution conditions particularly closely

13. Textbooks in a National Language		
Political Preconditions		
	Language of instruction	
		Is the national language in question officially recognised as a/the language of instruction for native speakers?
	Languages taught	
		Which language or languages are taught? Will the national language be used purely as a medium of instruction, or will it also be one of the languages taught? Will primary school pupils also learn a world language? If so, as from which class and in what way?
	Making the alphabet official	
		Is the alphabet of the national language you intend to use officially recognised? Is it accepted as such by users of the language? Do other alphabets co–exist with this one, and are they also known and used?
	Promotion of the national language	
		Is there a clear political will to support work in the national language, and your work in particular? Are there any political activities to support national languages that go beyond mere declarations of intent?
Scientific Factors		
	Ensuring a pertinent and suitable alphabet	
		Does the alphabet selected for use in textbooks correspond to a scientific analysis of the

		Does the training of primary school teachers include the study of the national language in question?
	On–the–job training for teachers	
		Are there in–service training programmes to prepare teachers to teach in the national language in question?
	Reference works	
		Is there a research institute responsible for producing reference books concerning the national language in question, in particular, grammar books and basic dictionaries?
	Terminology	
		Is a unit or a body responsible for enriching the language, and in particular, for creating the technical and scientific terms that are vital for consistent, diversified, precise instruction? Are efforts being made to standardise these new terms?
	Standardisation	
		Is a unit or a body responsible for standardising the national language, in particular, for proposing punctuation rules corresponding to the superstructure of the language?
Practical aspects		
	Characters	
		Can the characters used to write the national language in question be found on a standard keyboard?

4. Planning

The preceding phase will have enabled you to identify those factors which will have to be examined before to what extent and how you are prepared to take into account institutional pressure, to ensure that the quality of your research work is not jeopardised.

Human Resources

You must also take into account the people involved when you plan activities.

The Authors

Field research will have to be performed by all the members of your team; even those who consider themselves well enough informed about the school situation must take part.

In this way you will ensure that all team members expand, deepen and update their knowledge, and that the group begins to come together, before going on to devise the material on the basis of a uniform level of information. If you do not harmonise points of view in the field you risk running into serious disagreements afterwards, particularly when you come to devise your material.

All authors without exception should be involved in field research work

Short–term consultants

It is rare for a group of authors to have the necessary skills to perform all preliminary research work independently. You should thus identify the aspects requiring skills only available outside your team.

In line with your needs you should make provisions for the sporadic help of a linguist if you are going to have to write textbooks in a national language which has still not been sufficiently standardised, of a sociologist to prepare the field research work, of animateurs who are familiar with the test area where you aim to gather data or of a statistician who will help you to process and interpret certain results.

It is up to you to identify the areas where you will need occasional assistance from other professionals. You must then contact the latter and ensure that they will be available when required.

All the data will have to be typed so that the authors can use it, before they start work on devising didactic material; this is a long and exacting secretarial task, the scope of which is often underestimated by authors.

You should bear in mind, when you draw up a schedule for your activities, that you will have to correct all the data that you collect. There is no point in conducting extensive research in the field if you cannot use the information you gather. You should thus always distinguish between what is possible, and what is desirable but unrealistic. Identify the research work which you cannot reasonably conduct and the work which can be postponed without any major impacts on your first didactic materials[6].

At the end of this phase you will have two schedules, the first of which will be a short–term schedule for the research phase. It will indicate the main research activities, the deadlines, the persons responsible and the evaluation of costs.

The second, medium–term schedule will concern the actual writing and production of the materials.

It is important to gear your work from the outset to the start of a specific academic year. You should decide on the first year of introduction and make absolutely certain that you do not miss it, and perhaps the date of publication for any second set of materials. You should then inform the education authorities as soon as possible.

Refer back to the first chapter and look at Table 3 (the birth of the *Garabola* textbook) as a yardstick to help you gauge how must time you should allow.

5. Instruments

The objective of the current phase is to develop the research tools which will allow you to examine, quantify or verify the data required.

The approach taken in the field of social sciences to define an analytical model is discussed in several specialised publications; if concepts, hypotheses and indicators are completely new ground for you, it would certainly be a good idea to consult a sociologist or to refer to the literature on this subject listed at the end of

	Analyse official guidelines[7]
1985 Official Curricula	
	Analyse the subject “Malagasy”
	Analyse the targets for the first grade
	Analyse the profile of the pupil at the end of primary education
Textbooks Used	
	Identify the main textbooks used
	Define criteria to evaluate these
	Analyse the most widely used in class
Pedagogical Directives	
	Inventorise, collect, exploit

Table 14 was drawn up to this end by the Tef'Boky Project. It could be useful to you for reference purposes.

Hypotheses, Indicators and Instruments

The above list still tells you nothing abut how to study each element. You should proceed as follows to determine how to approach the matter, i.e. how to identify the sort of instrument you will need.

Firstly you should draw up your hypotheses; these are sort of provisional answers, formulated in a relatively summary fashion, which you propose for each element to be studied, and which will later have to be verified in the field.

Secondly, you should define the indicators which will allow you to verify these hypotheses; indicators should be factors which are easily observable, verifiable or quantifiable.

	Questionnaires
	Interviews with teachers
	Classroom observations
Importance attached to handwriting by parents	
	Inventory of equipment purchased by parents and available in classroom
Quality of handwriting	
	Tests involving copying a text
Spelling of certain common words	
	Tests involving dictation of words
Comprehension of texts copied by pupils	
	Tests involving the comprehension of a text

If you have little experience in the subject we recommend that you seek the support of a specialist. It is not easy to prepare instruments that are both appropriate for the survey conditions and targeted so as to give you the information you require.

Within the scope of this publication we will limit ourselves to giving a few practical hints and some examples taken from the work of the Tef'Boky Project.

Research Conditions

Instruments should firstly be designed with the investigators in mind. Sometimes you will have to involve teachers or educational advisers in your work, particularly as regards interviewing parents. You must thus design instruments on the assumption that however willing they are, they are novices when it comes to investigating, and will need tailor–made instruments, especially if you expect them to work relatively independently.

human resources, funds and organisation, and it is rare for projects to have the free time and the resources for a second test run.

Select a sample for your investigations

The Final Instruments

You are now ready for the final step in preparing your instruments. Modify them on the basis of the preliminary test runs and prepare a sufficient quantity for the number of villages and/or schools which you should now identify. It is generally a good idea to put together all the instruments to be used at any one location in one file; this will prevent the investigator misplacing documents or wasting time looking for them in front of those he wishes to interview – an embarrassing situation which can happen to even experienced investigators, and is bound to happen to novices unless you give them proper back–up.

Take great care with attainment tests; the education authorities are always particularly interested in these results

1. List instruments which will guide the investigator.

File No. 2	Instruments for Field Research Work

Investigation conducted by..
Period: from to..

List of Instruments

To give you an overview tick the relevant box after each instrument has been used

1. Instrument Group 1

Collecting data at CIRESB ○

9.	Instrument Group 8	
	Linguistic, cultural, etc., profile	○
10.	Instrument Group 9	
	Aptitude test	○
11.	Instrument 10	
	Test–decoding graphic representation	○
12.	Instrument 11	
	Reading test	○
13.	Instrument 12	
	Concerns and interests of pupils	○
14.	Instrument 13	
	Writing test	○
15.	Instrument Group 14	
	Physical working conditions at the school	○

2. Recall the hypotheses to be verified on each file

File No. 2	Instruments for Field Research Work

INSTRUMENT GROUP 5

Importance / Activity	Agriculture	Animal Production	Crafts	Fishing	Commerce	Miscellaneous
Main activity						
Secondary						
Tertiary						

Comments: ....

....

3. Formulate questions precisely and give enough space for answers

File No. 2	Instruments for Field Research Work

3.1.4. Course of lesson:

Did the teacher revise subject matter?

Yes ○ No ○

What did he take as the starting point?

Real–life experience ○

Text ○

Engraving ○

Short story ○

Observation ○

What phases did he

participated

Some pupils participated ○

No pupils participated ○

Pupils reacted in the following ways

They wanted to speak come what may ○

They waited to be asked ○

They responded spontaneously ○

They responded hesitantly ○

They repeated what the teacher said ○

Comments: ....
....
....

4. Allow enough space for comments which do not apply to any of the individual questions

File No. 2	Instruments for Field Research Work

SUPPLEMENTARY QUESTION No. 3

Ask the teacher how he goes about solving the major difficulties encountered by pupils learning to read.

1. *Materials:*

Sheets of paper

Pencil

2. *Instructions:*

2.1. Separate children as far as possible to avoid copying

2.2. Hand out per pupil

1 sheet of paper

1 pencil

2.3. Ask the children to draw

• their favourite *person:* WAIT 10 min.

• their favourite *animal:* WAIT 10 min.

• their favourite *thing:* WAIT 10 min.

2.4. At the end go and see *every* child

• Ask him/her to explain *each* drawing to you.

• Record the explanation on the sheet of paper (e.g. grand–father, pig, flower)

• Add the age of the pupil.

• Collect papers

6. Prepare forms as a record of documents

File No. 2	Instruments for Field Research Work

16. Testing Attainment Levels

Among your instruments you are bound to have some tests to evaluate the attainment levels of schools. You will test the level of the class for which the new material is to be produced, to determine whether or not the pupils have achieved the official targets in the relevant subject so that the new textbook can be designed to bridge as many of the gaps thus identified as possible and/or to improve existing skills. Design these tests with care, and ensure that they are systematically applied and rigorously interpreted. Since evaluation tests are the focus of an expanding field of research, the suggestions below cannot be considered exhaustive. We will merely look at ten aspects concerning the contents, the mechanism and the interpretation thereof, which we feel are of particular importance.

1. Congruence with objectives

All tests taken together must allow us to determine whether or not the pupil has achieved the attainment targets, as laid down in the official curriculum for the subject and the class concerned.

2. Pertinence of tests

Each test should correspond to one specific, clearly formulated objective which will, in its turn allow you

7. Preparing the class	
	The investigators must be able to create an atmosphere of trust which will allow the pupils to sit the tests in relatively satisfactory conditions.
	They must then be fluent in the pupils' native language, and be able to explain clearly to the teacher and then to the pupils what they are expected to do, and encourage them without putting an answer in their mouths; if so decided in advance, they will be able to instruct the teacher such that he can conduct the tests, while the investigators merely observe.
8. Explaining the exercises	
	Each type of exercise will be introduced on the blackboard, while every pupils should solve it in writing.
	To distinguish between understanding the mechanism and the knowledge or skills of the pupil, all exercises should be presented systematically on the blackboard, even where the mechanism appears to be self–evident. The investigators should always check to ensure that they do not present any particular comprehension difficulties.
9. Pupil profile	
	An individual information slip will give the information needed to interpret the results.
	Remember to note the age and sex of the pupil, whether he or she is repeating the year, attendance rate at the school, and if appropriate language skills.
10. Systematic collation and interpretation	
	To allow you to organise and interpret the results a points system should be drawn up, not when you come to process and interpret the results but when the tests themselves are devised. This system, and the interpretation of the results must be simple and clear enough for the education authorities, who do not necessarily have any statistical training, to understand them.

6. The Sample

Feasibility

A good sample should not overtax the available resources and possibilities of the textbook production project.

Look at

- the geographical proximity of the test zone: the distance between the test zone and the project headquarters should be such that the authors, and perhaps also the animateurs and some teachers can easily commute between the two on a regular basis.

- the ease of access to all the schools selected: you should only select schools which you can reach in one day without major transport problems.

- the size of the sample: the number of schools selected must be limited to allow relatively regular monitoring of each one of them over a period of several years.

Representativeness

A good sample must allow you to gain a global impression similar to that you would have obtained had you been able to look at every individual school in the country. Look at

- the teaching and learning conditions: the teacher to pupil ratio, the number of pupils per class and the number of classes per teacher, as well as the status of the schools (private or state for instance), must correspond to the national statistics, or where there are none, to the conditions observed in at least two other regions of the country.

- language and culture: the linguistic and cultural practices of the sample must reflect those found at national level. This may be a thorny issue if the global target population is spread over a large area which tends to encourage cultural and linguistic variations.

- the professional and economic profile: the professional occupations and income of those

You should make your final selection in the field, once you are certain that your choice is a good one and that you have the active support of the education authorities, teachers and parents.

From the outset, you should bear in mind the fact that you stand on the threshold of cooperation between your working group on the one hand and the village and its school on the other, which is likely to last several years. You must thus make an effort to create an appropriate climate of respect and trust.

7. Gathering Data

The quality of your work in the field will naturally depend to a great extent on the quality of your instruments. But, if you ignore the logistical and material aspects of the mission, your instruments, however perfectly honed, may be ineffective.

We would thus suggest that you plan your field trip meticulously and that you evaluate it periodically, in the following way.

Preparing Materials and Logistics

Think of your field research work as a project. To ensure success, the project must be prepared and implemented systematically; you must plan everything from the daily visit schedule for each investigator down to the last detail that every team member will need if they are to go and live and conduct investigations in a village for several days at a stretch. One oversight may cause serious delays in your already busy schedule.

Field Monitoring

As far as possible you should organise regular visits to check that things are running smoothly for each investigator; they may be faced with surprises, a school may be closed or villagers may be hostile when confronted with an outsider, for instance, which may make it necessary for the investigator to leave the village rapidly.

Regular Comparing of Notes

(different pupils sitting different tests, etc.), and neither will the school environment (prolonged absence of the teacher, school closed periodically, etc.).

Since the results you obtain will not give you an image which corresponds exactly with the reality, you will constantly be trying to enrich your data and make them more precise.

You should thus consider your research work in the field as the foundations for the new didactic material, but take care not to stem the flow of information.

During the conceptual phase and after the writing phase you should call on animateurs and some teachers who you will have identified during the field work, to confirm or refute certain results. Afterwards, when the material is tested, you should conduct classroom observation, talk to teachers about using the new material, and finally, of course evaluate the functionality of the material with the help of evaluation tests.

Thus, step by step, you will complete the mosaic of which the field research was the first piece.

The results of the investigation must be complete and precise

9. In Conclusion

A Reference Document

The results of field research work are rarely published; so as not to waste time, the authors generally make do with a preliminary version, on which they base the conceptual work.

Yet, the results should always be documented in the form of a particularly carefully put together publication. Field research work often provides information which is new or which those in authority prefer to overlook in the capital, where major decisions are made. The findings may have repercussion for certain parts of the school system. For instance, the discovery that the actual learning time is half the official learning time could lead the authors to propose a revision of the official attainment targets, a decision which the education authorities would be reluctant to make.

estados y educación, Lima, 1989.

[6] In the German–Peruvian Project mentioned above, the authors of the reading books in Quechua would have liked to conduct research to identify punctuation responding to the supra–segmental characteristics of the language, which had not yet been sufficiently standardised. However, because of the lack of resources and time available, they were forced to write the textbooks for the first three grades of primary school without the assistance of this important research.

[7] The Charter of the Malagasy Socialist Revolution, published in 1975 in Madagascar, advocates democratisation, decentralisation and Malagasisation in education, for instance.

[8] These instruments prepared in 1986–87, were reproduced in their entirety in the third book of the *Garabola* series, entitled *Les Dossiers I.*

Recommended Reading

Preliminary Work for Textbook Production

AFOLAYAN, A. The Six–Year Primary Project in Nigeria. In: BAMGBOSE, A. *Mother tongue education.* London: Hodder and Stoughton and Paris: The UNESCO Press, 1976

FARREL, J.P. AND HEYNEMAN, S.P. (Ed.) *Textbooks in the Developing World.* Washington D.C.: The World Bank, EDI Seminar Series, 1989

KOMAREK, K. (Ed.) *Les dossiers I.* Eschborn, Antananarivo: GTZ, 1993 READ, A. *A guide to textbook project design and preparation.* Washington D.C.: The World Bank, 1986

RIEDMILLER et al *Diagnóstico sociolingüístico del área quechua del departamento de Puno.* Lima, Peru: Instituto Nacional de Investigación y Desarrollo de la Educación, 1979

Linguistic Research

CALVET, L.J. *La guerre des langues et les politiques linguistiques.* Paris: Payot, 1987

produce a high–quality product within a few months.

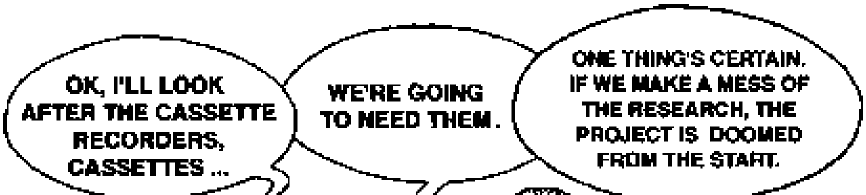
Mission impossible. The team which has just been set up, is never able to start the conceptual work immediately. Indeed, this newly born entity will have to conduct a long and difficult mission, the need for which has not generally occurred to the education authorities, involving the following.

Firstly a genuine working group must be set up, without which no textbook, no matter how mediocre, will see the light of day; this presupposes that the authors identify the mechanisms which will allow every individual to contribute his and her best to the team throughout the several years of in–depth cooperation.

Then, although the authors are almost always recruited from the ranks of the teaching profession, they cannot have the in–depth, complete and systematic knowledge of the target group of the textbook that they will need. They will have to devise, plan and manage research on the lesser known aspects of day–to–day school life, collate these in a systematic form and interpret the results.

Finally, although no decision should ever be taken to produce a textbook before a serious feasibility study has been conducted, and before ensuring that certain preconditions are met – things often look different in practice. The feasibility study is not complete, sometimes no study has been conducted; it is the authors who often have to bridge these gaps.

In the best case scenario, the authors will need one full year to complete their research, the quality of which will largely determine the quality of the book produced, in particular the degree to which it is in line with the needs and possibilities of subsequent users. The sheer scope of this work explains why some teams of authors take only the unprocessed results and race on to the conceptual phase without further delay. But, the results of the research should be scrupulously documented and presented to the education authorities to enable them to understand the pedagogical choices reflected in the textbooks.



ensure that every important factor has been taken into account, to re–analyse these factors, weigh them up again and then make the appropriate decision.

You should read this chapter without losing sight of the fact that the order in which the work is presented will never be followed to the letter in practice.

> **Take a "spiral" approach to determining the contents of your textbook, always going back to re–examine your decisions and ensure they were correct**

1. Time Management

Time is the first aspect you should examine in the conceptual phase. The objective of this phase is to draw up a precise frame of reference for the time effectively allocated to the subject in hand.

Why, you may ask, should our first step be to analyse the time available rather than the contents of the materials we aim to produce? Firstly, because you will not generally have detailed data on the effective learning time dedicated to the subject for which you are producing new materials, and secondly because it would be imprudent to launch yourselves head over heels into an analysis of the contents of the material without first defining the general framework, and in particular the time available for the teaching of the subject in question per academic year and per week.

Consider the following aspects which will allow you to identify the time frame, step by step.

> **The first element to look at when deciding on the contents of your book – the time factor**

The Academic Year

You should start by counting the number of teaching weeks available for the new material. To this end, consult the official curriculum which will probably state the official number of teaching weeks.

In many industrialised countries all pupils follow the same officially prescribed time–table, which has not been substantially altered for several decades; textbook authors do not then generally have to worry much about the time aspect. The situation is often different in developing countries, where pupils do not necessarily all follow the same time–table, and where the official time–table or time–tables is or are not always observed in schools. In some countries, for instance, one group of pupils follows a so–called "full" time–table (5 hours a day), while another group follows the so–called "short" time–table (3 hours a day), and a third group follows an even more seriously slashed time–table with only one or two hours instruction a day[2].

Sometimes this practice is officially sanctioned, but the existence of several different time–tables rarely has any impact on the level of attainment targets. To avoid any form of discrimination, the education authorities set the same targets for all groups.

Make the distinction between official guidelines and practice in the field

This situation directly affects your work as textbook authors; you will be tacitly expected to produce materials which will allow different target groups to achieve the same targets at the same time.

At this stage you should concentrate on a thorough examination of the official guidelines and the general practice in schools to allow you to decide which timetable or time–tables you wish to take into account in your material. Do not take this decision lightly. If you discover that the majority of your target group follows a short time–table, and you wish to take this into account in the material you produce, you will be opting for a drop in the volume of knowledge to be acquired, which will in turn have repercussions at the level of the education authorities, the teachers, parents and pupils. Do not hesitate then to take one step backwards and check that your decisions are correct, if not legal, correcting them if necessary. You still have time.

Breaking Down the Time–Table

This is the third aspect you will need to bear in mind when determining the contents of your materials and the sequence in which you aim to present them.

Not all official curricula follow the same procedure here; some indicate only the overall time allocated to each subject, while others lay down the time allocated to every component of every sub–topic, i.e. for the subject

This sort of break–down is generally useful. If the subject in question is the “Mother tongue”, which is traditionally made up of speaking and listening, reading and writing, which tend to overlap, it becomes indispensable. Before you can define the content matter to be learned in each of these sub–topics, you will need a detailed framework. If you are also addressing pupils following different time–tables you will not be able to progress in a coherent manner without determining the number of sessions within each of the time–tables to be taken into account.

Table 17 should help you better understand the importance of our recommendation. It shows how to break down two different time–tables so as to produce a single textbook for all pupils[4].

Official Teaching Time

This is the last analysis you will have to perform regarding time management in schools[5].

It is indispensable to know how the teacher officially breaks down his classroom teaching time. To calculate this you must know the number of pupils and classes he is in charge of, and if appropriate the amount of administrative work he has to perform. To this end you should once again consult the official statistics and compare them with your observations in the field.

> **Check the legality of your decisions regarding the time to be taken into account for your textbook**
>
> **Write a textbook that addresses all pupils in the grade whatever time–table they follow**

17. One Textbook for Two Different Time–Tables
In Madagascar, the official 1985 curricula refer to a short time–table of 3 hours a day and a full time–table of 5 hours a day. It follows that the length of time dedicated to

<table>
<tr><td>Reading</td><td>10 x 25 min.</td><td>5 x 20 min.</td></tr>
<tr><td>Writing</td><td>10 x 25 min.</td><td>5 x 25 min.</td></tr>
<tr><td colspan="3">On the basis of this table the team produced an initial break–down of the subject matter to be taught and learned, i.e.</td></tr>
<tr><td></td><td colspan="2">• in the textbook: for each of the 24 weekly modules, two pages for reading and two pages for writing, each corresponding to five 20–minute lessons, i.e. applicable for all pupils no matter what time–table they follow.
• in the teachers' guide: on the one hand the instructions for exercises common to all pupils, and on the other hand additional speaking and listening, reading and writing activities addressing primarily pupils following the full time–table.</td></tr>
</table>

We should underline the fact that it is less the average class size which is important for your textbook than the average number of classes per teacher. Your approach will not change significantly whether there are 30 or 70 pupils in one classroom provided they belong to the same class. On the other hand, if the majority of teachers are in charge of more than one class at once, you must take into account the fact that they will have to teach these classes parallel to one another, which will mean eliminating or strictly limiting certain activities such as exercises or practical work out of doors. You will have to encourage more independent learning from the very start, and give the teachers very detailed instructions on how to manage the class in the teachers' guide. If one–teacher schools make up the majority of your target group this is the only way to take this fact into account.

By the end of this phase you will have identified the temporal framework within which your material will be used; we recommend that you record your results in the way suggested in the second chapter. This will allow of training of teacher trainers, educational advisers and animateurs and their working conditions, in particular as regards the budget and the material inputs allocated to them for training activities. As we will see later, this information will have a significant impact on your choice of an approach.

Subject–Specific Research

You should not be satisfied with merely adopting the methods currently advocated by teachers, and will thus have to undertake some research into the main trends in international research in the relevant subject. You should consult not only specialised literature, but also textbooks recently published in other countries if possible.

Level of Innovation

Analyse the level of innovation that is likely to be accepted by teachers as regards methodology – the level that they will accept and understand. To this end you will have to be able to bring the scientific findings for your subject into line with the current practices in the schools.

Sometimes you will have to opt for a relatively low level of innovation. If the teachers are poorly trained, and badly paid and if only limited funds have been budgeted for training, the approach you select must be familiar enough to teachers for the textbook to be accepted immediately, and used without a systematic introduction. Any complete break with current practices, which would require a great deal of additional effort on the part of the teachers, is unlikely to be accepted under these circumstances.

We cannot stress the importance of this enough; remember how reading books adopting an overly analytical method, or materials for maths using the theory of sets have failed when introduced to poorly trained teachers, largely as a result of the high level of innovation in terms of methodology.

> **You should preferably select a traditional methodological approach with a limited level of innovation**

3. Defining Content Matter

As textbook authors you are not normally responsible for curricular revision; generally the ministry delegates this task to a special unit. But, experience shows that this is not always the case. Indeed relatively often in developing countries textbook authors find curricula that are hopelessly out of step with the reality of the education system in their country, and the curriculum unit declares itself unable to modify them[7]. Where this is the case, the authors themselves must revise the relevant curricula on a pilot basis to avoid producing textbooks that are inappropriate before they have even been published.

Be that as it may, analyse the situation thoroughly. It is now more important than ever before to gauge the leeway you have and, if you see yourself forced to reduce the volume of content matter covered gird your loins for major repercussions in the classrooms and negative reactions outside – as described below.

Temporal Framework and Learning

If the time effectively available is significantly less than that stipulated in the current curricula, you will doubtless intend to reduce the subject matter to be covered correspondingly. You should, however, bear in mind that a decision of this sort will have major repercussions on the teaching and learning process which we will now look at in more detail.

> **Do you intend to opt for progression in step with pupils' progress, which is difficult to reconcile with a rigorous learning programme?**

The shorter the time effectively available for learning, the more rigorous your planning must be to guarantee that pupils acquire a minimum of knowledge, without which the school would not be meeting its commitments. This inevitable strict planning of learning time does have its advantages: it allows you to produce a detailed methodological guide for teachers, for instance, a sort of script which is bound to be a valuable aid to teachers who are often poorly trained.

This planning does, however, also have one major drawback: the teacher becomes a prisoner of the clock. He cannot take more time or repeat a lesson, without running the risk of jeopardising the entire course. He thus cannot adopt a “mastery” approach, according to which “generally a learning unit should be mastered before progressing to the next unit”[8]. This does not, naturally, mean that he should allow pupils to carry on learning without evaluating their progress. But, after the evaluation he is forced to carry on immediately with the next

Teachers

- Vague fear of innovation which will inevitably mean curricular change
- Fear of having to deal with angry parents

Parents

- Categorical refusal to accept mass education for their own children.

Curricula in Other Countries

To allow you to have all the information at your fingertips before you make a decision it might be a good idea to compare the content matter you plan to incorporate in your textbook with that found in foreign curricula in both developing countries and industrialised states.

Analysing these documents, looking in particular at the time−frame reserved for teaching and learning, you will often help you become more aware of your own position. Thus, if you are faced with the criticism that you are proposing “bargain basement education”, as you may be if you suggest cutting the volume of knowledge to be acquired, a reference to experience in other countries can help confirm that your decision is correct and help you argue your case in front of hesitant and poorly informed education authorities.

If you consider it vital to reduce the volume of material, you should proceed with caution, and agree to a compromise if necessary. Let us take an example: in grade one at primary school, the figure 100 is often considered a symbol of mathematical knowledge, held dear by teachers and parents alike. If this is the case, and you have limited the subject matter to be covered such that children are expected only to be able to count to 20, you can summarily present the figure 100 at the end of the year. A compromise of this sort may be enough to break down serious resistance to your textbook, resistance which will not always be technical in nature.

especially if the conditions for writing and producing new material are less than ideal.

If you conclude, having explored these options, that the production of new didactic material really is indispensable, you should pursue your work, laying down attainment targets in line with the volume of knowledge to be acquired, which you have already defined.

Take your inspiration from curricula in other countries, but don't simply adopt these lock, stock and barrel

5. Attainment Targets

During this phase of your work you will draw up the attainment targets for your new material, which will correspond to the contents you have already specified in functional terms.

You may encounter one of two situations here. Either you decide only to clarify and supplement the objectives laid down in the official curricula, without moving far from these, or you will see yourself forced to define objectives that are quite new in full or in part.

Lay down clear attainment targets to allow you to define the contents of your textbook

In either case you should consider that you will be touching on an area where you are probably not experts; if you can, you should thus call on the services of a specialist or at least consult the relevant literature, such as the books listed at the end of this chapter.

For our part we will merely illustrate, in Table 18, the difficulties that can arise when objectives are not properly formulated, and why it is important to remedy these.

6. Set of Materials

	Firstly what exactly is to be achieved? Must pupils be able to form the characters as perfectly as the model? Or is it enough if their writing can be deciphered? What are the conditions needed to achieve this? Have pupils achieved the objective if they write without an example or need they only be able to copy an example they are given? If the latter is the case, is the model also in joined–up writing, or must the pupil be able to translate a printed model into cursive style?
The term “letters”	
	What exactly is to be achieved? Do we mean initially the 21 letters of the Malagasy alphabet or also the 13 complex graphemes in the language? Are pupils expected to write individual letters, or put them together to form words and sentences? A fundamental point, because the difficulty of joined–up writing is putting the letter together to make a word. In the latter case will pupils have achieved the target if they forget elements or add extra elements, i.e. if they make a spelling error? Or must they write without error? And so on.
To allow them to devise their material, the authors thus added the following details to the original targets: “By the end of grade one the pupils can copy simple, short sentences in Malagasy in joined–up letters on the basis of a model in either joined–up or printed characters; the sentences should be written in lower case characters only and involve only the letters of the alphabet. The pupils should write legibly without errors” *(Garabola teachers' guide,* 1988, p. 4)	

Analyse the situation before deciding which materials would be most suitable. We suggest that you look in particular at the following aspects.

Pedagogical and Didactic Aspects

You should first identify the materials that would be desirable to ensure high quality learning and teaching. The preliminary research should have given you precise information as to the level of training and experience of teachers, which will allow you to identify the tools that teachers will need to teach the subject in question as well as possible. This research should also enable you to pinpoint the materials that pupils need to raise the level of attainment significantly, given the conditions that you yourself observed in the field.

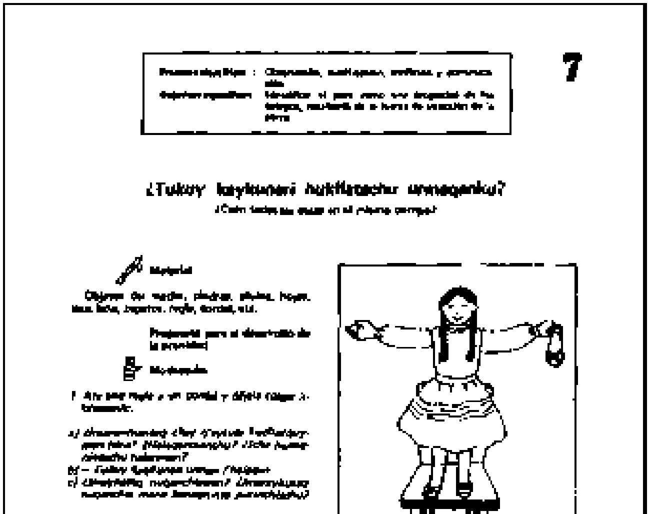
Financial Aspects

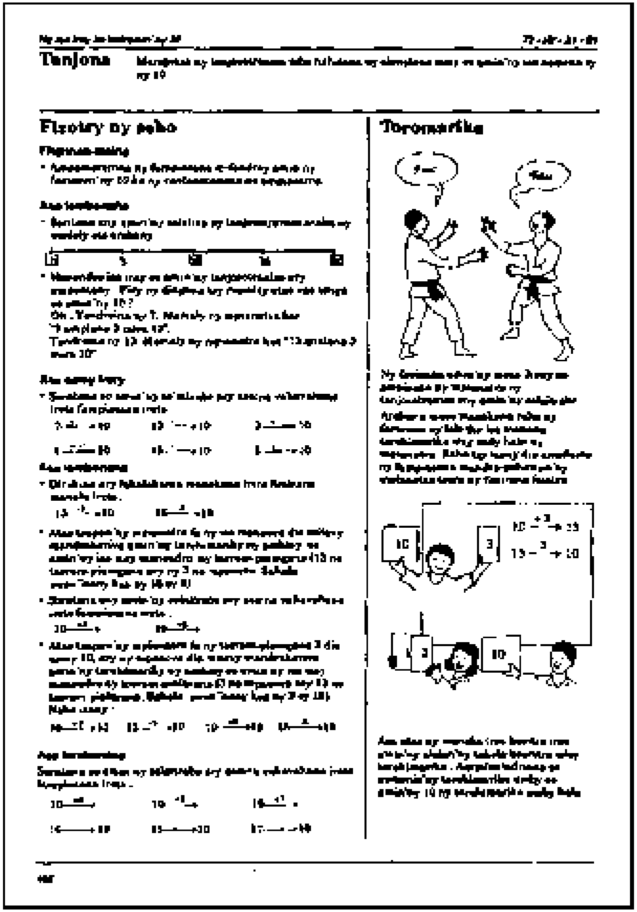
In some subjects a teachers' guide is more important than pupils' material
Interchangeable, individual material is always a luxury

Practical Aspects

Before you decide on the composition of your set of materials, look at the working conditions in schools as you observed them during your preliminary research. Even if it were possible to finance everything planned, it must be possible to use the material and store it in the schools. You should then consider the average number of pupils working at one table, the storage facilities and the existence of a desk where the teacher can open his guide, consulting it at his leisure during the lesson.

In our experience, the lack of storage facilities in the schools is a serious constraint to the production of pedagogical tools which would be very useful. If we take word cards, for instance, they should certainly not be produced as an integral part of learning to read if schools have no cupboard or safe, for they are almost bound to vanish rapidly.




Tanjona

Toromarika

Kajy Mampisaina First–Grade Mathematics Antananarivo, 1993

Logistical Aspects

Even if you are preparing a limited number of pilot copies in the first instance, you should bear in mind the

	1.1. Writing is considered to be of secondary importance
	1.2. Writing, classed as an artistic discipline, is seen merely as a manual skill, unrelated to speaking and listening or to reading
	1.3. Attainment targets are vague
2. Physical Conditions	
	2.1. There is a lack of furniture (benches and tables).
	2.2. There is a lack of working materials (slates, exercise books, pencils).
	2.3. There is a lack of visual aids (pictures, exercise books, books) which would help pupils to memorise letters.
	2.4. The blackboards, the only visual aids, are of poor quality.
	2.5. The large classes preclude teachers checking the progress of individuals.
3. Teacher's Activities	
	3.1. Teachers are poorly trained; they do not know how to provide perfect models on the blackboard; they have not learned to introduce the writing of characters systematically; they do not put a stop to bad habits in time.
	3.2. They have no time to prepare their lessons.
	3.3. They have no reference books.
	3.4. They do not know how to make the best use of the few documents that do exist.
4. Pupils' Work	
	4.1. Pupils have not systematically practised finer motor coordination (no official preschool education).
	4.2. They see writing as only a senseless and boring copying exercise.

write without any special materials! Interviews with the teachers and the analysis of the writing exercise books revealed the following:

	The exercise book was an innovation in a context where printed materials are rare; teachers, parents and thus the pupils were reluctant to use such a pretty book as a learning tool. It was thus not used for the exercises, which might "sully" it, but only to verify what had been learned; it was only used when the pupils were sure that they could write well, but at the same time less time was spent practising on slates or in normal exercise books.
	The teachers concentrated so fully on the exercise book that they forgot to introduce writing systematically and to monitor pupils' progress. They saw the book as a sort of "monitor" which allowed them to turn their attention to other sections while the first grade were learning to write. Thus pupils' progress was monitored only sporadically, and few notes were made, if any, as can be seen from the exercise books. During the revision phase the exercise book was thus abandoned. The new set of materials is made up of an individual slate, purchased with the help of a World Bank loan, a revised textbook comprising texts for reading and models and exercises for pupils to write, copy and solve on the same slate, and, of course, a teachers' guide.
	This new set of materials was fairly well received, but in 1992, some parents who had followed their children learning to read with the help of the exercise book, continued to complain about its withdrawal...

The first step is of course to identify the contents of each component part of the set: if you have decided to produce a textbook and a teachers' guide what information will you put in each of these?

If all pupils follow the same time–table, you will distinguish primarily between the teaching and learning aspects, but if the materials address pupils following different time–tables, and if the majority of your target group are following a reduced time–table, it may be better to reproduce the supplementary exercises for pupils following the full time–table only in the teachers' guide. You should then proceed as follows.

Reduced Time–Table

You should refer to the plan you have already drawn up for the reduced timetable and note the number and length of lessons dedicated to the sub–topic in question.

guessing games involving words starting with **o**. The learning target remains unchanged. The exercises will merely reinforce the knowledge acquired by pupils following a full time–table.

Now you can distinguish between the contents that must appear in the textbook, including writing exercises that are crucial for achieving the target and which thus address all pupils, and the supplementary exercises which can easily be placed in the teachers' guide along with the teaching directions.

An oversight when you decide on the composition of your set can be counter–productive

There is no universal formula for organising the contents of a guide

8. Contents of the Textbook

Having worked out the rough break–down of subject matter to be covered by each item of the set, you can go on to the next phase, which aims to organise the contents of the textbook.

This is a complex task, and the teams of authors which we have been able to observe have adopted various procedures. Some organise the contents little by little, feeling their way forward, rather like a jigsaw, while others make do with very rough plans, some of which can be very vague, which they firm up afterwards. Others again lay down in detail at the outset exactly how they plan to organise the content matter.

We do not believe that there is one correct way of organising the content matter, but we will take the liberty of outlining our own experience, in the hope that this will help you to adopt a more systematic approach.

First Break–Down of Contents

Whatever the subject and the grade in question, you should undertake a first rough break–down of the content matter, stipulating the relation between the time unit and the work unit. You may take a week, or a fortnight or a month as your time unit, while the work unit may be a letter, if the subject in question is reading, or a series of numbers in maths. This will give you the skeleton of the textbook as it were.

Fitsinjaram-potoana ao anatin'ny taona

Volana	Heri-nandro	Fotoam-pialan-tsasatra (F. p. t.) na hafa	Herinandro la-sana	Lesona
Oktobra	1 2 3 4	F4 • • •	★ 1 2 3	★ Fiomanana ho a/.sekoly Fiomanana ho a/.sekoly Fiomanana ho a/ sekoly
Novembra	1 2 3 4	• • • •	4 5 6 7	o (vak.= tak. 8-9] i (vak.= tak. 10-11) a (vak.= tak. 12-13) n (vak.= tak. 14-15 ; sor.= tak.16-17]
Desambra	1 2 3 4	• • F. p. t. Noely F. p. t. Noely	8 9 ★ ★	l (vak.= tak. 18-19 ; sor.= tak. 20-21] m (vak.= tak. 22-23 ; sor.= tak. 24-25) ★ ★
Janoary	1 2 3 4	F. p. t. Noely F4 • •	★ ★ 10 11	★ ★ v (vak.= tak. 26-27 ; sor.= tak. 28-29) y (vak.= tak. 30-31 ; sor.= tak. 32-33)
Febroary	1 2 3 4	• • • •	12 13 14 15	e (vak.= tak. 34-35 ; sor.= tak. 36-37] r (vak.= tak. 38-39 ; sor.= tak. 40-41) t (vak.= tak. 42-43 ; sor.= tak. 44-45) s (vak.= tak. 46-47 ; sor.= tak. 48-49]
Martsa	1 2 3 4	Andron'ny Sekoly • • F. p. t. Paska	★ 16 17 ★	★ h (vak.= tak. 50-51 ; sor.= tak. 52-53) g (vak.= tak. 54-55 ; sor.= tak. 56-57) ★
Aprily	1 2	F. p. t. Paska F4	★ ★	★ ★

20. Order of Graphemes in a First Reading Book

Malagasy has 21 simple graphemes and 13 complex graphemes, involving two or three elements. When the authors responsible for preparing learning materials for first–grade reading and writing lessons started work on *Garabola,* they stipulated the order in which the graphemes were to be presented in the textbook taking the following factors into account

Frequency of the grapheme

The authors counted frequency on the basis of three texts of some 1000 words, the first of which was a newspaper article, the second a literary novel and the third a story told by a child. The frequency of punctuation such as apostrophes and hyphens was also counted. It emerged that the vowels, o, i and a had the highest frequency; with few exceptions, such as the "ts" used in negations "tsy" (not), simple consonant graphemes were found more frequently than the complex graphemes.

Complexity of the form of each grapheme

Given the fact that pupils learn to write what they have learned to read, the authors then analysed the complexity of the form of graphemes, and modified the list based on frequency as follows:

- Numbers of elements making up the grapheme
- Single element graphemes (n, t, m, etc.) were put ahead of those made up of two elements (tr, dr, nk, etc.) or three elements (ndr, ntr); even ts, in spite of its high frequency, was relegated to a place behind the single element graphemes.

- Shape and complexity of the form of the letters
- Letters that are relatively simple to write (I, t, etc.) were given priority over more difficult forms (f, z, etc.)

Aural distinction

Certain phonemes in Malagasy are relatively close to one another, and can cause interference in young children; the graphemes corresponding to these phonemes were presented separately; thus j and z were

- when you begin to organise the subject matter page by page
- when you present the subject matter in the form of exercises, two phases that we will be looking at in the following chapters.

9. Contents of the Teachers' Guide

By the end of the conceptual phase you will have identified the subject matter you will wish to cover in your teachers' guide. Although this book deals more with the production of textbooks, we will spend a moment looking at the guide, given the vital importance of this publication in the hands of teachers who are often poorly trained.

> **Take the vital role of the teacher into account and decide on the contents of the teachers' guide with great care.**

Many of you may ask if it is appropriate to write a sort of “user's manual” which would help the teacher day by day by giving detailed instructions, or if you should aim to write a “training manual” which would allow him to acquire the basic knowledge he needs to teach the subject in question, or again, if you should try to combine the two.

Given the fact that the didactic material you produce will stand or fail on the ability of the teacher to use it, you should attach great importance to the contents of the teachers' guide. We would suggest that you base your decision on an analysis of the needs and possibilities of teachers; to illustrate what we mean we have summed up the approach taken by the Tef'Boky Project to define the contents of the *Garabola* teachers' guide in Table 21.

The main shortcomings of the existing teaching process were identified, enabling the authors of the revised version of the *Garabola* teachers' guide to decide on the subject matter that would best remedy these. The following list was drawn up:

- General information on the language

• “Peripheral” information

Articles on the lexical enrichment of other languages;
Articles on the history and creation of the Malagasy alphabet.

• Reminders

Interruptions to recapitulate the progress of work and look forward to the lessons to come;

Regular invitation to refer back to the beginning of the guide to read the general information.

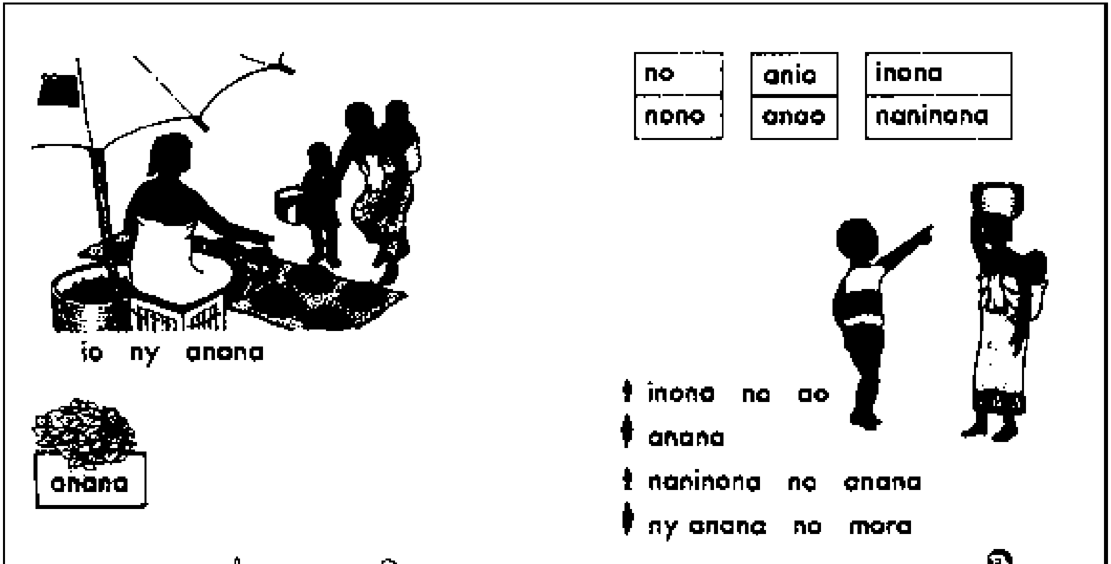
21. Contents of the Garabola Teachers' Guide			
When the authors revised the teachers' guide for teaching Malagasy in the first year of primary school, they defined the contents in a systematic form. Firstly they identified the central problem regarding the use of the guide, basing their work primarily on the data collected during the preliminary research and on the results of testing the pilot version of *Garabola.* Then they looked for the reasons for these problems and the consequences thereof in day–to–day school practice.			
Central Problem			
Teachers do not use the guide as they should			
Reasons 2	Reasons 1	Consequences 1	Consequences 2
1.1. Having read the guide the	1. Teachers do not pay	1. Teachers are not	1.1. Teachers

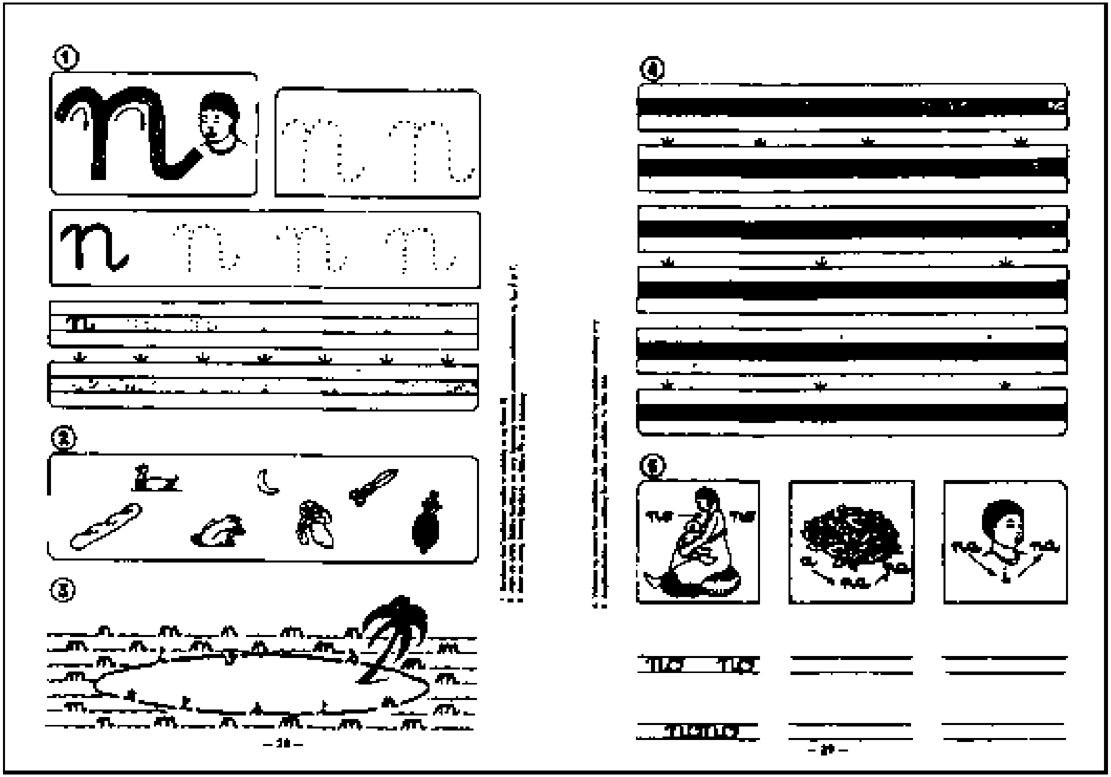
7.1. Teachers doubtful about applying certain parts of the guide	7. They do not read what upsets them	7. Teachers are not rigorous enough in their lessons.	
8.1. Problems of readability, particularly because of the move from the verbal to the written mother tongue, terminology and communication difficulties	8. They are afraid of not understanding what they find in the guide	8. Too much time is wasted in class	

Garabola

To illustrate the points we have looked at in this chapter here are some typical pages taken from

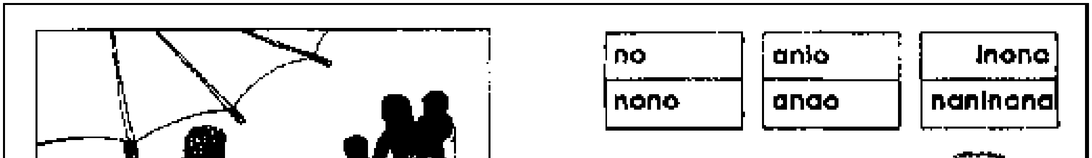
Garabola, which we have often quoted as an example.

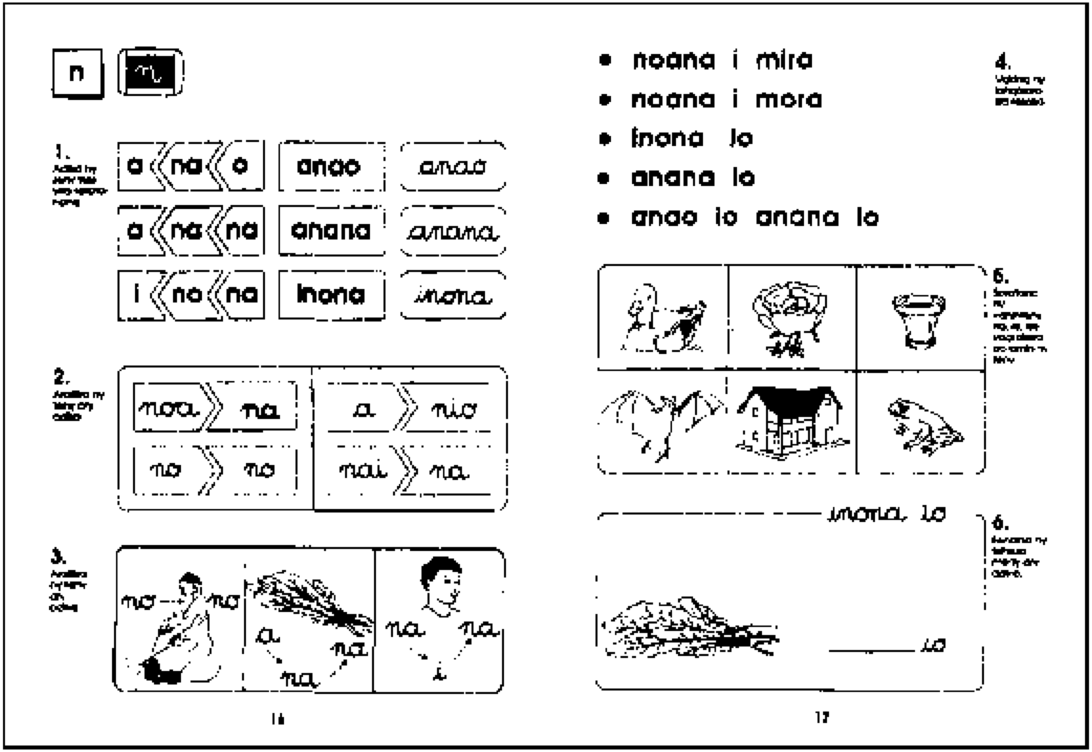




2. Pilot version of the exercise book: Two typical pages of writing.

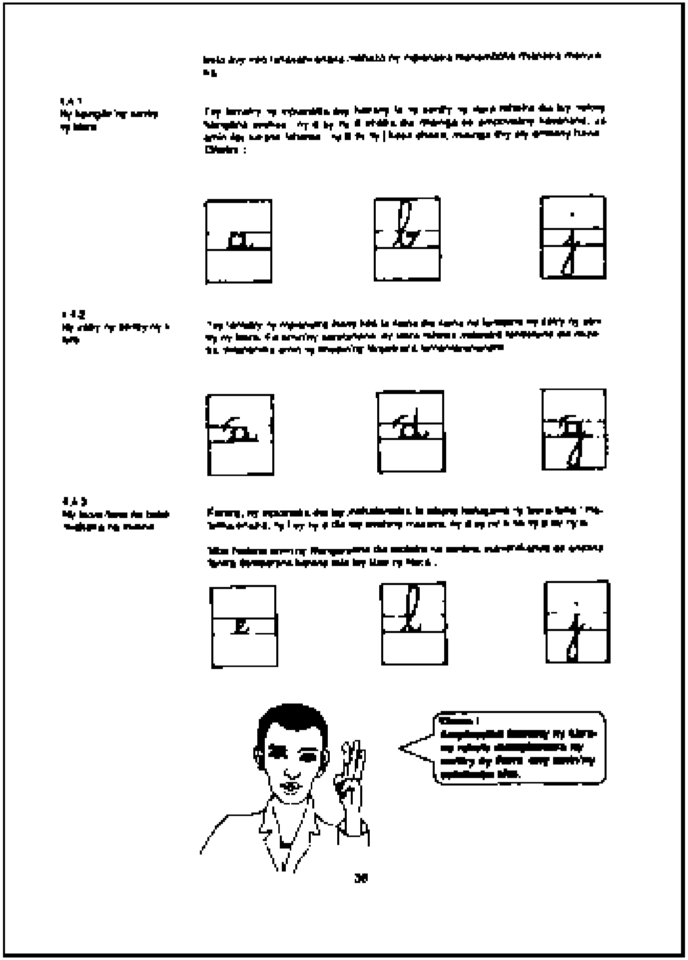
Revised version of the textbook





2. Typical writing lesson

Revised Version of the Teachers' Guide

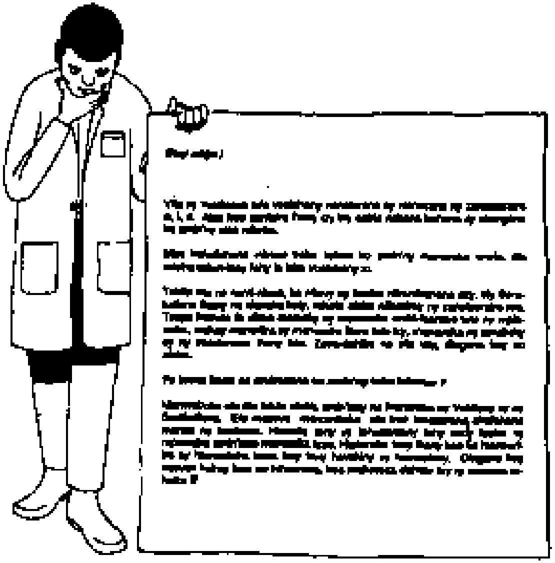


2. Brief refresher – here joined–up writing and writing activities

3. Practical recommendations for each sub–topic in cartoon form

4. Presentation of attainment targets and corresponding activities for each week

5. Script for speaking and listening, reading and writing activities – one page a day



6. Periodic summaries of the work already done and the activities to come

7. Anthology of 24 reading texts and 24 poems

[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]
[illegible]	[illegible]	

8. Caricatures to retain the attention of the teacher

of the Tef'Boky Project decided to discount schools that did not operate for a minimum of 24 weeks a year, considering that these establishments were not in a position to provide an education worthy of the name.

[3] In our experience the first version of some textbooks may well encounter major resistance on the part of the education authorities. But if this resistance is not based on well–founded technical or political criteria, and is merely a more or less deep–seated wariness of anything new, the revised version will carve out its own niche.

[4] This table indicates one of the major difficulties that the new materials will have to cope with: the full time–table dedicates twice as much times to reading and writing as the reduced time–table. This represents a major challenge for authors, and becomes more of a problem from year to year, if we take into account the fact that as from the third grade the study of the mother tongue involves grammar, vocabulary, conjugation, spelling and composition, whereas the reduced time–table remains the same.

[5] It is, of course, quite impossible to verify the actual teaching time left, once you have deducted everything which does not involve teaching, such as lines, time taken to hand out books and exercise books, or to wait for silence; although this information would be very useful, it would not have any direct impact on the concept of your material.

[6] Seguin, R. *L'élaboration des manuels scolaires,* op. cit, p. 5.

[7] This is often seen where a new education policy is approved. In Peru, for instance there had always been a department within the ministry responsible for producing the traditional curricula which were based on the assumption that Spanish was the mother tongue of all pupils. When “bicultural and bilingual education” was introduced in 1979 this department asked the German–Peruvian Bilingual Education Project, which has already been referred to several times, to develop curricula to match the didactic material produced in Quechua, Aymara and Spanish as a second language, since the textbook authors were felt to be better able to perform this work.

[8] More precisely, “the mastery theory is based on the finding that the vast majority of pupils in a normal class can master a given target if they are given enough time and the support they need to overcome their difficulties”. In: Landsheere G. *Dictionnaire de l'évaluation et de la recherche en éducation,* op. cit., p. 197.

[9] In the curricula which the authors of the Tef'Boky Project proposed to the education authorities in

HAVELOCK, R.G. AND HUBERMAN, A.M. *Solving educational problems. The theory and reality of innovation in developing countries.* Paris: UNESCO, 1977

To Sum Up

Once authors are in possession of the main information regarding the production conditions and the circumstances in which their textbook will be used they can start work on the conceptual phase. Their first task must be to lay down the sequence of subject matter to be covered. To achieve this it is important to define each of the following:

• The actual learning time in the grade and subject in question, which is not always the same as the official learning time;

• The targets, in line with the teaching and learning conditions;

• The composition of the set of didactic materials which will allow pupils to achieve these targets, and which must be in line with the needs and possibilities of the target group;

• The break–down of the subject matter to be covered by the various types of material to be produced

Conceptual work is always complex in developing countries.

The official instructions often bear little resemblance to the reality in the schools, and the teams of authors must gauge how much leeway they have before deciding. Finally they must make a distinction between what is desirable (often the tacit wish of parents and the education authorities) and what is suitable for the given situation but often more difficult and almost always less attractive to both the authors and the various target groups. Every aspect of the new textbook must be examined on the basis of a number of criteria, including the material, psychological and social aspects, which it is often difficult to reconcile satisfactorily.

In spite of this complexity, however, or perhaps because of it, you must invest the necessary time and care in this conceptual phase if your textbook is not to be built on sand.

If you are still new to the profession of textbook writing, you may feel that you have spent so long on all the work to date that now it is time to close the conceptual phase. But, if you go on to write your textbook without a proper plan for the form, you will run the risk of writing texts that are too short or too long, producing exercises that are difficult or impossible to present visually, preparing artwork that is far too expensive or producing an unhappy mix of text and illustrations.

To avoid these eventualities, you should thus examine the physical and graphic aspects of your textbook before closing the conceptual chapter. Since the contents and the form are interdependent, you can create them in a two–pronged action, so that the texts and illustrations fit into a pre–established framework without major difficulties.

In large publishing houses, the work described in this chapter does not concern the authors directly[1]; if you are lucky enough to have good publishing back–up, you need only read through this chapter to understand the constraints that the publisher is bound to impose on you. If, however, you have to decide personally on the physical and graphic aspects of your book, you should read this chapter carefully, bear in mind that it is generally errors in the form which reveal the lack of professionalism of authors, and take appropriate precautions.

Contents and form must be devised in tandem

Don't leave the format to chance; analyse all possible consequences of your choice

1. Format

To allow you to visualise the initial arrangement of the contents of your book on the page, we suggest that you first decide on the dimensions of the book.

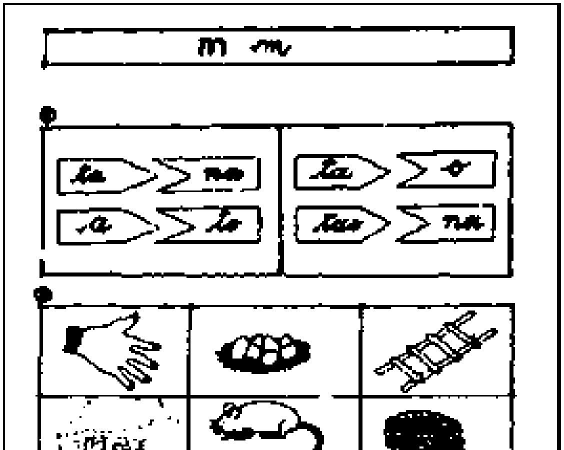
If you look at textbooks designed for primary level, you will see that the basic form is rectangular[2], but that the dimensions vary: some are scarcely larger than a standard paperback (200 x 130 mm), others are almost A4 size (297 x 210 mm) and most are somewhere between these two extremes (e.g. 240 x 170 mm).

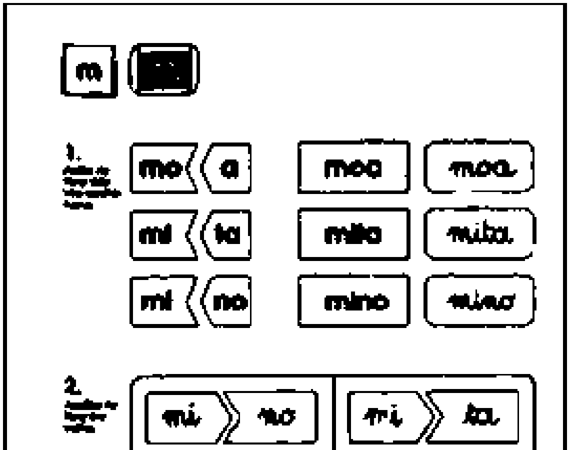
Micro-legibility – letters and words

The dimensions of your textbook must also be such that it can be easily and effectively read by users. This readability is governed by several factors, which you must bear in mind at the end when determining the layout of your book. At this stage we will look only at those factors that have a direct bearing on the format, i.e. the size of the characters used.

You should take your lead primarily from the research conducted in industrialised countries over a period of several years now into the readability of printed characters. M.A. Tinker, one of the best known experts in this field, concludes that the characters used in textbooks should be in indirect proportion to the level of education: the further down the educational ladder you go, the larger the characters should be[4]. The dimensions of the textbook must thus allow you to use the size of characters recommended for the grade in question.

This is always important, but it is vital for a first reading book. Since it is not recommended to hyphenate words at this level, and we would advise you not to spread sentences over more than one line in the first lessons, the textbook dimensions must enable you to write a sentence in one line using the size of characters recommended[5]; a paperback format would thus be inappropriate at this level.





textbooks are normally used in developing countries you may have to scale down your book.

Before deciding, consider the following factors.

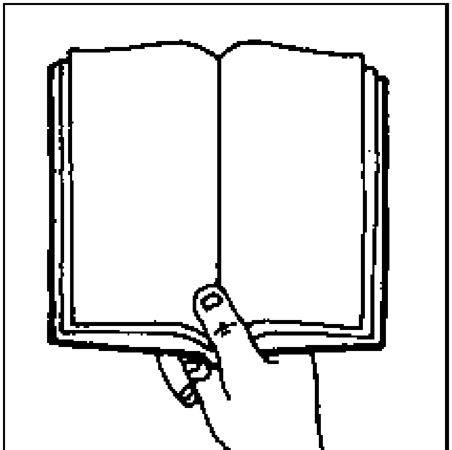
Ease of Handling

A book is always made to be visually attractive, as we have seen above, but it must also be easy to handle.

When you select the format, you should think firstly of the pupils of course: they must be able to hold the book closed with one hand without difficulty or open using both hands. You should also think of the teachers. Since some of them will be teaching several classes at once, and since they will almost always have to stand to better direct proceedings, you should choose a format which is small enough for the teacher to hold it in one hand during the reading lesson as they prefer to do.

Test your book for ease of handling by holding it in one hand as shown below.

Large formats meet pedagogical needs best, while smaller formats respond to practical and financial considerations



Economic Considerations

By analysing users' needs you have worked out your first ideas as to the dimensions of your textbook. You should now check whether the desirable is financially feasible. The cost price of a book being closely linked to the price of the paper used[8] you should decide on an appropriate format in terms of the format of the paper and printing materials so as to avoid wastage, which can be very expensive.

We are now entering the technical domain with which authors are not, as a rule, familiar. Given the scope of this publication we will look only at the essentials. We recommend that you consult your printer who should be able to give you the additional information you need, and that you read the works listed at the end of this chapter.

Contact your printer at this stage

Format of Paper to be Used

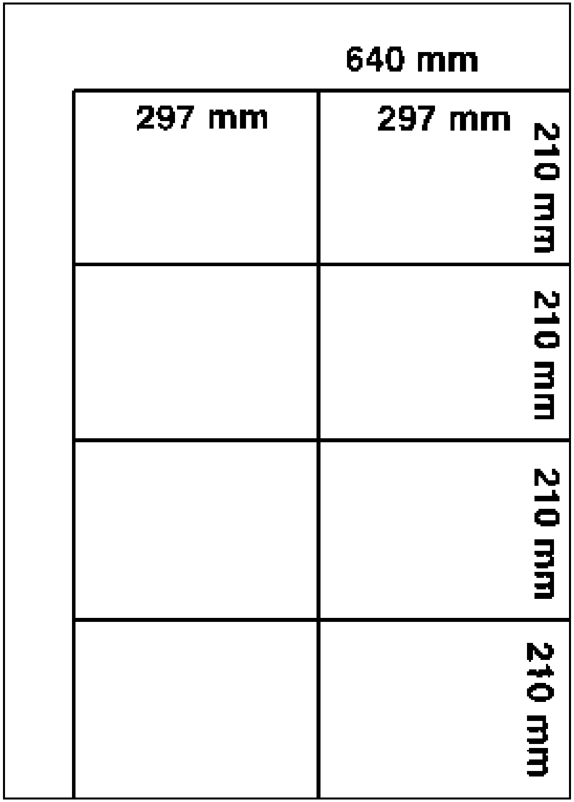
Paper is manufactured from pulp, which is in turn produced on the basis of certain raw materials (wood, but also plants and textile waste). Paper machines produce large rolls of paper which can then be cut into sheets.

The rolls of paper are sold by weight, whereas sheets are sold in reams (packs of 500). The format of rolls is determined by the width of the strip; reams of paper come in standard sizes[9].

To avoid unnecessary wastage, make sure that the format of your textbook corresponds to the dimensions of the sheets of paper used in printing, folded once or more, as indicated briefly at the start of chapter one.

Avoid paper wastage which will put an unnecessary strain on your budget

You should thus contact your printer to find out whether or not he will have to import paper; if he can, you will have a certain leeway regarding the format, since large paper manufacturers can often produce paper to your specifications provided you order a large enough quantity and provided the order is not urgent. If, on the other hand, he is obliged to use locally–manufactured paper, or if you have been donated paper, as is relatively frequently the case with textbook projects, you should determine the format of the textbook on the basis of the



You should, however, be very careful in this field. Although it is vital for you to understand the importance of the relation between the format of a book and of the paper used for printing, you must be aware that the information given here is far from complete. The printer, who has experience in this field, will often know how best to reconcile the financial considerations with the format you want. You should always consult your printer before making a decision which it will be difficult to change at a later date.

Publishing Considerations

this phase.

Learning Pages

Firstly you should count the number of pages that are to be dedicated to learning; this will give you an idea, and allow you to plan the number of printed signatures that will make up the finished textbook.

To this end you should look again at the draft contents for each learning unit – i.e. the lesson – and identify the number of pages required per unit or lesson. Take into account the format envisaged, and the learning stages or the major parts of each lesson. Then estimate the number of pages needed to present the subject matter in a systematic way – and multiply this figure by the number of units you intend to incorporate in the book.

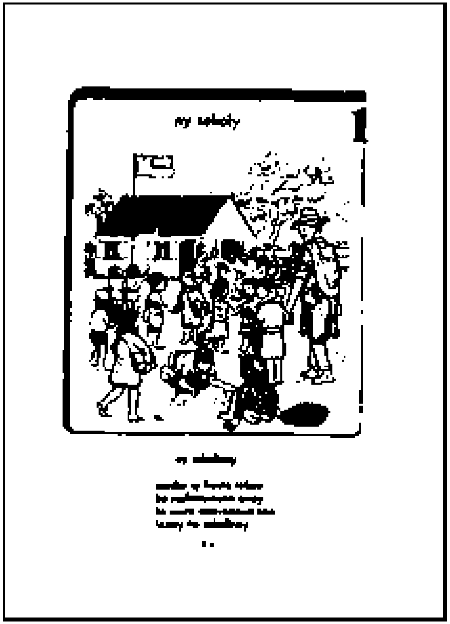
If, for instance, you have planned 24 units for the year, your results will be as follows:

- For 2–page units 48 pages
- For 3–page units 72 pages
- For 4–page units 96 pages
- For 5–page units 120 pages
- For 6–page units 144 pages.

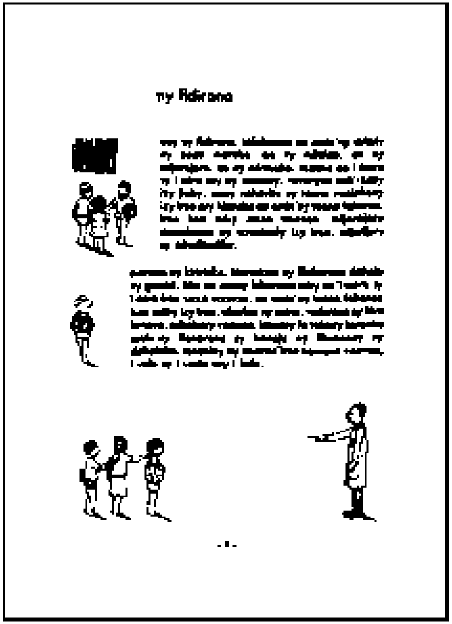
Some of you will probably wonder how you can go about identifying the space needed to present the contents satisfactorily on a page; if this applies to you, look briefly at section 3 of this chapter, which deals with this question, even if you have to come back to it in more detail later.

At this stage, of course, your results can only be provisional; as you will see, the total number of pages you have just calculated does not correspond to the total number of pages in the book. This exercise is only important to give you a first rough idea of size. Commit it to memory and put it up on the pinboard.

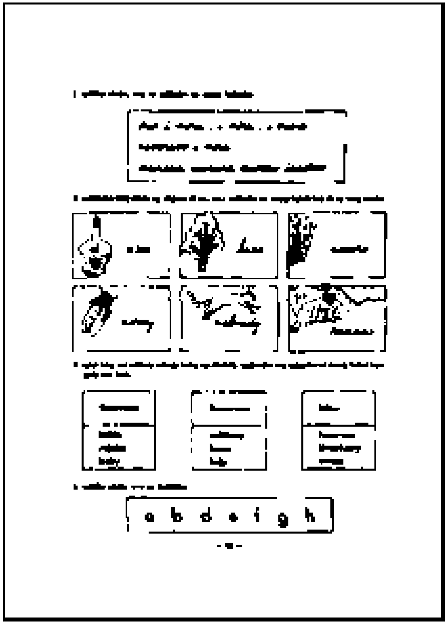
The number of pages in a textbook is decided before the book is written



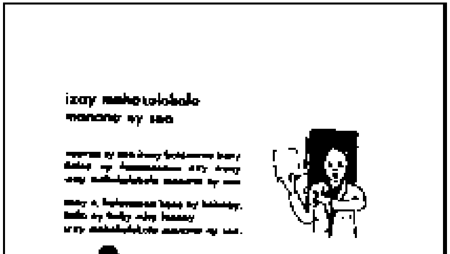
1. Visual introduction to the topic of the week, which is also used for speaking and listening lessons, followed by the poem of the week

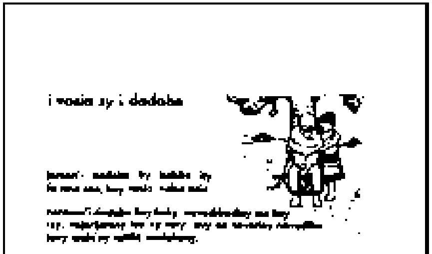


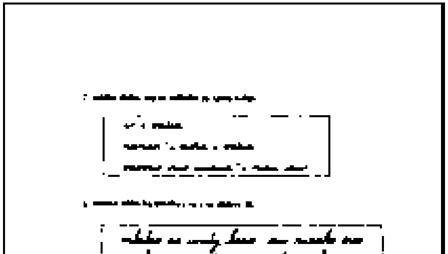
2. First reading text, descriptive in nature



3. Writing practice: handwriting, spelling and vocabulary







So, keep to the number of pages you consider essential for each unit and modify this if necessary to keep costs within acceptable limits.

Technical Considerations

The figure you have calculated is still not the total number of pages of your textbook. It is merely a rough calculation, which you will be able to make more precise when you take the technical factors into account.

To this end you should go back to the format you plan to use, and the format of the sheets of paper to be used for printing, which will allow you to check how many pages can be printed at once. You will see that it is best to choose a multiple of 8 (16, 32, etc.) pages for your book. The difference between the number of pages reserved for learning and the total number printed will depend on what we will term "non–text information", which we will look at in more detail below.

Let us assume that you consider 96 pages essential to present the subject matter, and you have to choose a multiple of 16 pages. To get a round number, you will have to use an entire signature for non–text information[11].

Bibliographical Conventions

A book does not only contain information in the main body of the text, but also in the form of non–text information, which may be found on the title page, or at the start or end of the book. And in a book destined for true booklovers the first pages must be left blank.

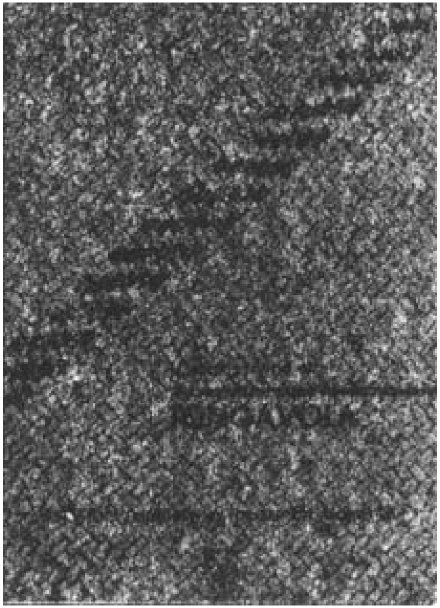
It is acceptable for there to be no blank fly leaf in your book; but you must provide what we have chosen to term non–text information.

In an attempt to explain this briefly and as precisely as possible, we have printed the cover page and the first few pages of the revised version of *Garabola* opposite. Below each page we have descried the information contained on that page and outlined the reasons for including this information.

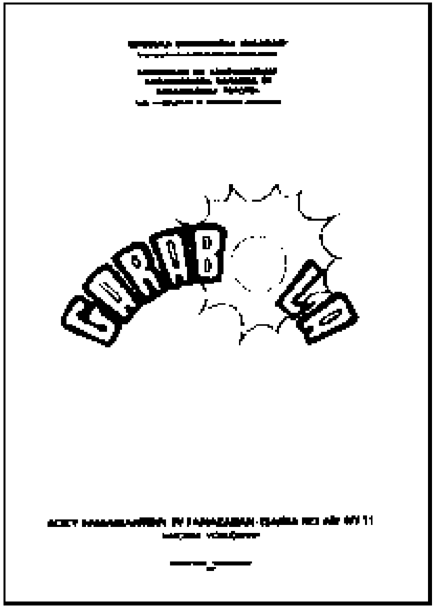
Publishing Constraints

page before the supplementary texts, for instance). If, however, you have forgotten a page in your calculations, which can happen to even the most experienced authors, it will be difficult to add one at a later stage, and the later you discover your error the more difficult it will be: sometimes you will have to redesign the entire layout with all even pages becoming odd pages, etc.

Front Cover
Contents: Title of book:
Contents (subject and grade):
Illustration
Reasons: Practical reasons: The potential purchaser must be attracted by the illustration, informed as to the contents of the



Back Cover
Contents: Announcement regarding the publishing of the textbook for the next grade:
Reminder of contents: Printer's logo
Reasons: Practical reasons: The purchaser must be told whether or not the book is part of a series;



Full–Title Page
Contents: Name of ministry;
Name of sponsor; Title of book;
Contents (subject and grade);
Version (pilot); Date and place published
Reasons: Institutional reasons;
Practical reasons: Even if the cover

rights of authors, illustrators and the publishing unit	official seal of approval for the book and its contents	Reasons: Practical reasons; To enable teachers to use the book even without a teachers' guide; To boost the book's credibility with teachers: it has been tested and revised

To avoid this, make a mock–up of your book; write the unit number and the main contents on each page. You need not respect the finished format for your mock–up – a mini model is every bit as good.

> **Ascertain that you have calculated the number of pages correctly before progressing to the next stage**
>
> **The cover of a textbook is a very special place; take great care in selecting the information to be printed on it**
>
> **You should always reserve a few pages at the start of your book for general information**

3. Basic Visual Structure

By laying down the format and the number of pages of your textbook you have defined the framework within which you must now insert the contents. The objective of the phase that you are now starting is to design an initial arrangement of the contents on the page, or to be more precise to put together texts and illustrations in an appropriate way on each page.

This is not the final layout. It is a draft, the first translation of your ideas into physical form. This overview will allow you to judge the general rate at which you aim to present the contents. The decisions you will make should be just precise enough to allow you to progress to the writing phase, gearing your work to a framework, which will probably have to be modified, adapted and specified in greater detail later.

• Will the learning units or lessons be similar or will they be divided into easily distinguishable blocks with different structures?

• Will you present all the texts and exercises in the main units, or do you plan to distinguish between those that are indispensable for learning, and supplementary texts and exercises which could be put at the back of the book?

• Should the first page of each unit be on the same side of the book? On the right–hand side or the left–hand side?

• Will the reading texts and writing exercises be separated and printed on different pages or will they be printed on the same page?

• Will the reading and writing work be presented on a full double page or will one page of reading always alternate with one page of writing?

• What is the average length of texts for reading and the dimensions of accompanying pictures?

• Will some texts require a special layout?

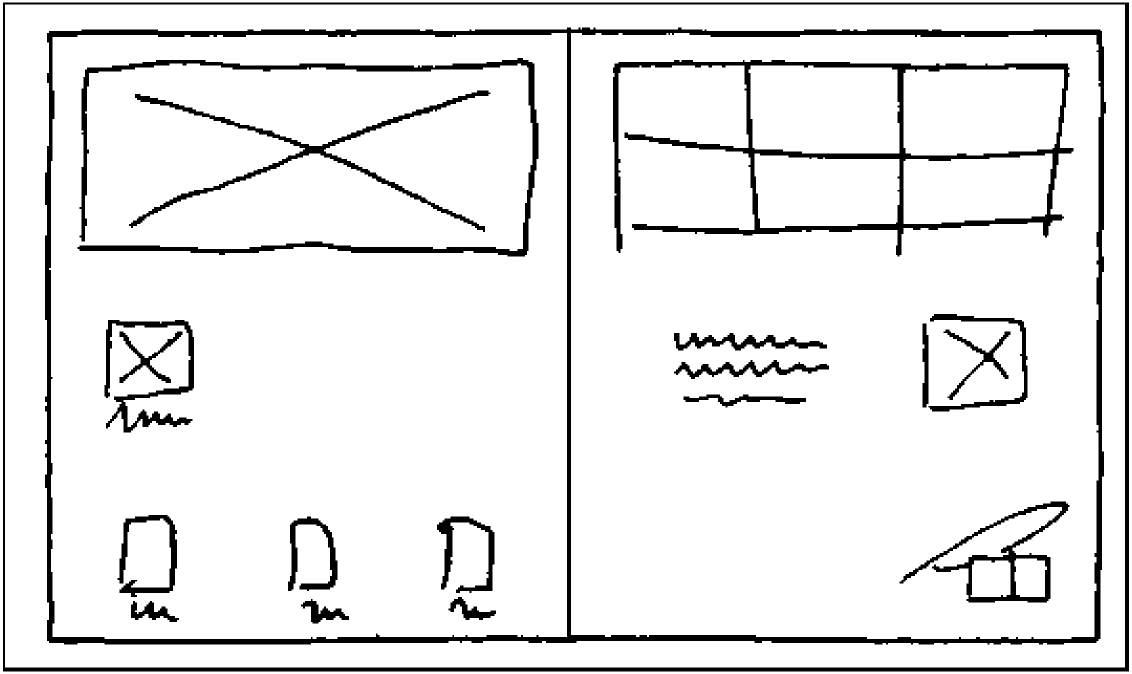
• How much space approximately will each exercise need?

These considerations should result in a first draft or design of the contents of a unit. You should sketch your design in pencil without paying too much attention to precision or scale.

On the next page you will find the draft produced for four pages of a lesson in the revised version of *Garabola.*

Outline the rough presentation of the contents of each lesson
You should identify the basic structure of your book little by little, scribbling down ideas, feeling your way forward, and changing your plan time and time again

exercises, remember that two exercises on an otherwise empty page may look silly, but that six or more may be too many, making it difficult for the reader to find his place and conveying an impression of a dauntingly packed page.



The two pages dedicated to reading consist of:

Left–hand side: A block to introduce the topic; A sentence using the new grapheme; The key word; The syllabic family.

Right–hand side; A table of new words; A text to reinforce what has been learned; A visual reminder of the new grapheme

A dictation of words on the basis of vignettes

The Layout Plan

Now you have your basic structure and can draw up a rough layout for the entire book. This model is known as the “layout plan”.

Once again there is no need to respect the final format of the textbook, a smaller format will do just as well. If necessary refer to the layout plan for *Garabola,* which you will find at the start of chapter 1.

4. The Artwork

You now have an overview of what your book will be like, but the conceptual phase is still not over.

You have still to decide on the artwork, which is crucial so that you can write the text and so that you can request a first estimate from the printer (this is a compulsory part of conceptual work).

Now is the time to decide what sort of illustrations you need (diagrams, photos, etc.) and how they are to be printed (in one or more colours). We suggest the following procedure to ensure that your decisions are well founded.

Graphic Options Open to You

Consider firstly the options open to you to illustrate a textbook; these can be summed up as follows

	Colours		
Type of Illustration	1	2	4
Photos			
Realistic drawings			

Your illustrations must be prepared for printing; for monochrome printing you can choose line photoengraving if your illustrations involve only black lines. If, however, you want to lend some depth to your illustrations you will need shades of grey; this is called halftone gravure, and is more expensive.

When illustrations are to be printed in two colours, the preparation of the colour inks and the screen will often give you good value for money; this procedure is significantly cheaper than 4−colour printing, especially if the screens are produced manually, as is often the case in developing countries. The uninitiated often think of the result as a “colour” illustration, without making a distinction between this and 4−colour printing.

4−colour printing involves separating the colours, and producing three negative films with the positive images printed in magenta, cyan and process yellow, to which black is added to give depth. This procedure is complex and we will not go into details here because we do not consider this a priority for you, it always being an extremely costly operation.

We cannot urge you enough to keep a close watch on costs, and to accord financial considerations the importance they deserve. In our experience, authors, anxious to produce a really worthwhile book, often reject out of hand reasonably priced options, which they associate with mediocrity. Sometimes they produce entire books in colour, and then cannot find anybody to finance them. Sometimes, the authors simply refuse to listen to reason and insist on having at least one page in colour in the book; they consider this a modest and acceptable request without realising that it is not enough to produce the colour drawings, but that they must be processed and printed, and that this can be extremely expensive as we will see in the next section[12].

Sobriety should not necessarily be equated with mediocrity in the field of graphics
Consult your printer again to ensure that your artwork decisions are well founded

Printing Costs

You should also look at the costs of printing per se.

In particular, you should be aware that for 4−colour printing each sheet must go through the presses four times with different elements being printed each time. That means that the printer must prepare his presses four times: the presses must be scrupulously well cleaned each time[13], the new elements to be printed (films transparent, browns rapidly and laps up ink is no good for 4–colour printing. The printer too, must have the skills and equipment required: for colour printing the printing presses must be extremely well regulated, and it is very, very difficult to set them with the precision required so that the blocks or plates match exactly. If they do not match exactly the reproductions of the various colours will be blurred and fuzzy.

If you cannot be sure that your printer can guarantee all these conditions it would be irresponsible to invest in expensive colour printing, the results of which will never justify the scale of the investment.

Don't focus on one single textbook. Take the entire series into account

Long–Term Planning

Finally, even if your budget today allows for four–colour printing, you must be sure that you will have the money tomorrow as well for reprints, which must then also be in colour.

This aspect is particularly important if you are preparing a pilot version. It may be easy enough to finance 3,000 colour books, even if the unit price is very high. In some cases, the need for 4–colour printing will only be seen during the testing phase[16]. In general, however, you should only use colour once you are certain that the revised version, which may involve a large run, can be financed. If you fail to look ahead at this stage you may end up having to redo all the artwork and remodel the original text; this is more than a revision, it really does involve rewriting the entire book[17].

5. Provisional Costing

Until now, you have worked in a state of splendid isolation, as if you were the entire publishing chain.

For the first time now you must leave the confines of your office and make contact with the body which charged you with producing the book and with the printer. You must make the preparations for the manufacturing phase, checking whether or not the physical and graphic features you have decided on are acceptable from a financial viewpoint. The aim of this next phase will be to request a provisional quotation and

Manufacturing Costs

These costs will always be calculated by the printer, who will base his quotation on the four following factors.

Composition

This involves setting the text by computer, making the corrections required after proofreading and the composition and layout of these texts on the basis of detailed instructions.

By this stage you must know whether you will be submitting a typewritten manuscript to the printer and let him typeset it, or, whether, as is becoming increasingly common, you will write the text on a computer and submit the floppy disk to the printer. You must also decide whether or not you intend to set and compose the text yourself, and, if you are using monochrome illustrations without halftones, whether you will produce the imposition scheme or submit the text and illustration separately to the printer to allow him to assemble each page on the basis of your instructions.

The production of textbooks has changed drastically over the last few years, not only in industrialised countries, but also in the developing world. Whereas it was common practice in the 1980s to ignore computer–assisted printing, today it cannot be overlooked. Anyway large–scale textbook production projects all have computer equipment.

A computer only facilitates and enriches your work if you know how to use it properly

If you are in this situation, you must be aware that computers cannot replace the creative process, neither as regards the concept nor as regards the writing and layout of your book. It can, however, facilitate your work, if used properly since it will help you transform your own manuscript into copy, and will allow you to visualise your layout very rapidly. But, if you do not have a good command of the programmes used and are quite unfamiliar with at least the basic principles of typography, you can easily fall into one of two traps – either you will magnify your already crushing workload as authors, or you will not be able to make good use of the many graphic options the computer offers you.

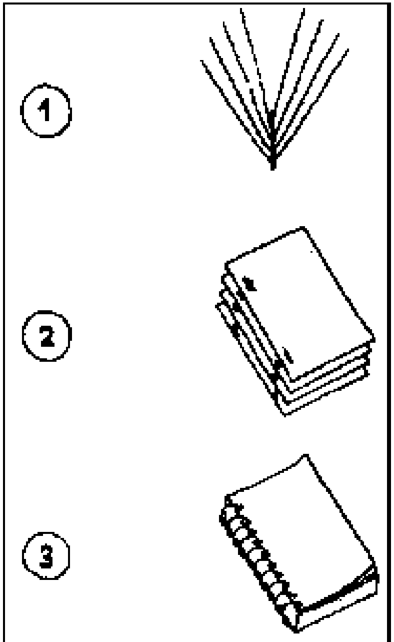
Printing

lay the book open on a table. (Fig. 2)

• Spiral binding is another option. It is the most expensive option, unless you are having a limited run printed and you have the equipment to allow you to insert the spiral binders manually; you could use this option for a pilot run of a few hundred copies. (Fig. 3)

• The pages can also be cut at the spine and then stuck. This is not too expensive and good quality adhesives are available today, but it is not recommended for school textbooks which are often handled roughly and may well start to lose pages rapidly. (Fig. 4)

• The signatures can be sewn with thread and then either sewn or stuck together. Stitching is expensive but it is the firmest option. (Fig. 5)



6. Medium–Term Planning

You have made all the decisions regarding the physical and graphical aspects of your book – you may consider the conceptual phase over.

But, we would recommend that you draw up a medium–term work plan, i.e. up to the distribution of the books to schools, to ensure that the actual writing phase, which is about to start, runs smoothly without any major hiccups.

Make a list of the people who are going to be involved as from now in the development of the book and, finally, plan your activities as carefully as possible.

Actors

You should contact the individuals and bodies listed below at this stage, to ensure that they can provide their inputs on schedule.

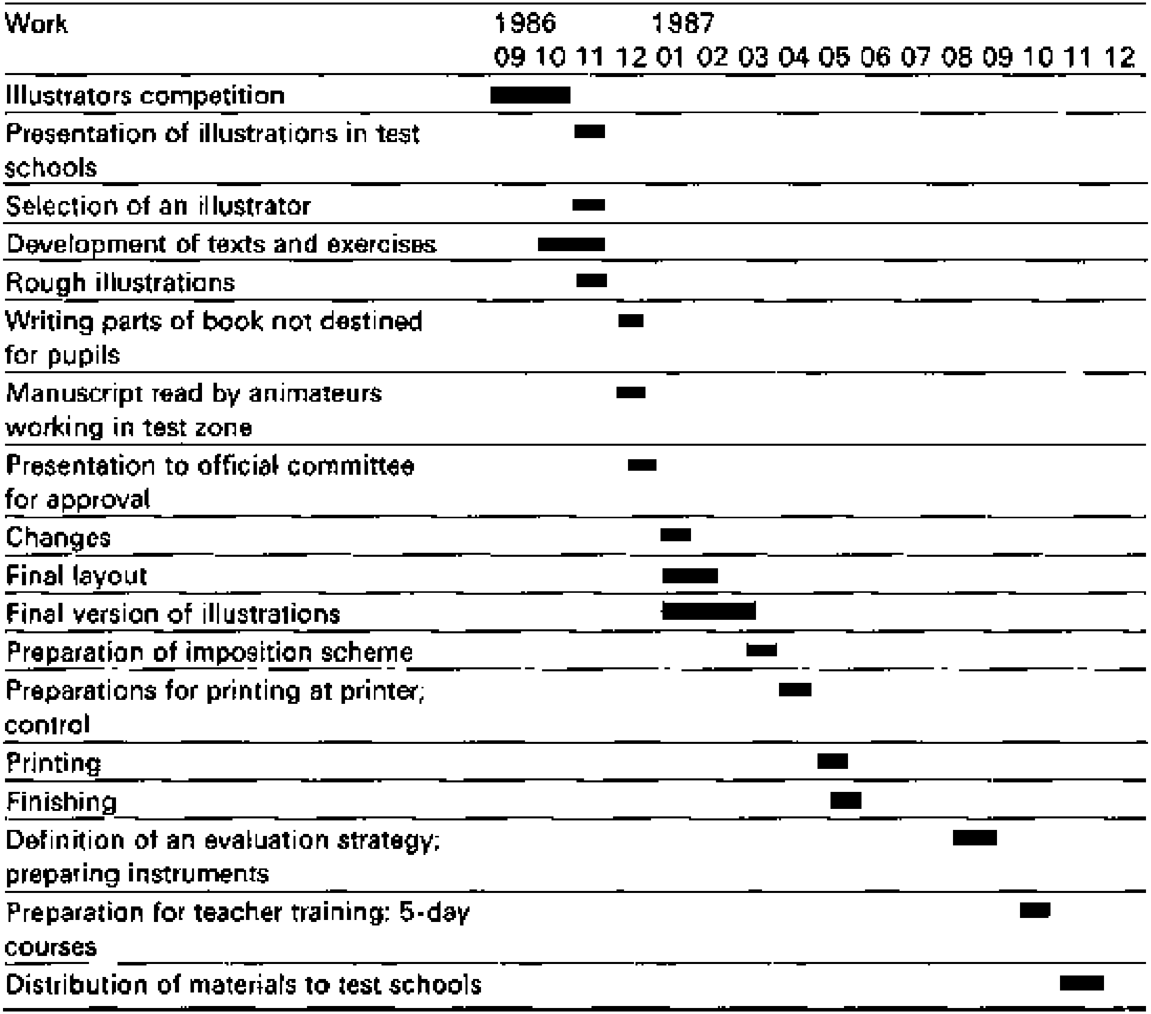
Illustrators and/or photographers

Ideally, these individuals should be part of the team of authors from the start, but in practice they are very often brought in once the first draft of the texts is finished at the earliest.

You must select the people you want now, to ensure that they will be free to work with you when needed. It may take some time to select them. If you are working on the first book in a series, you should perhaps run a competition and then check in the field that the style of the illustrator you have selected corresponds to the preferences of the target group. As you will see from the time schedule for the development of *Garabola* in Table 22, this can take a lot of time.

Resource Persons

These individuals will review your manuscript and help improve it. They will include proof readers to eliminate



Work Schedule for Garabola

Don't take the contents of this table as a model, since working conditions vary from one country to another. Take them only as a frame of reference; in particular, look at the tasks listed and the time–scale reserved for each task and adapt these to bring them into line with your own situation.

This is the time to organise the people who will read and correct your manuscript
Allow at least one year for the development and production of a first textbook

7. In Conclusion

Detailed Documentation

You have now defined the contents and the form of your textbook, thanks to a systematic analysis of numerous factors.

To ensure that the quality of the development phase is as high as that of the conceptual phase, we recommend that you keep detailed records of every decision made. You can use two instruments to this end.

Logbook

You can keep a note of the key ideas in your work on a day–to–day basis in a logbook; you might note the reasons why a certain decision was made, any disadvantages it may entail, the repercussions for the teachers' guide, steps to be taken to put it into practice smoothly, etc.

These notes may be useful when the conceptual work is over and you begin to forget the odd detail.

Pinboard

If suitable for the way you work, you could prepare permanent pinboards to remind you at a glance of the framework for the texts and illustrations you are about to produce.

Keep a careful record of all decisions made during the conceptual phase

[5] In chapter 7 where we will look at the basic concepts of layout, we shall come back to typographical options.

[6] For primary classes in developing countries C. McCullough and C. Chacko suggest significantly larger characters than those proposed by Tinker, i.e.

Grades	Bodies of letters
1	36
2	24
3	18
4	16
5	14

Developing materials for instruction. In: Staiger, R.C. *The teaching of reading,* p. 172. Paris: UNESCO and Lexington: Ginn and Company, 1973.

[7] Cf. Read, A. *A guide to textbook project design and preparation,* op. cit., p. 58.

[8] The paper costs as a percentage of the total production costs are put at the following

for 1,000 copies	28.5%
for 5,000 copies	47.6%
for 10,000 copies	53.5%

In: Smith, D.C. Jr. *Les problèmes économiques de l'édition des livres dans les pays en voie de développement.* Paris: UNESCO, 1977.

[9] The most common paper dimensions in the “A” series (in mm) are as follows:

[14] “4−Colour printing is approximately eight times as expensive as a halftone”, In: Richaudeau, F. *Conception et production des manuels scolaires,* op. cit. p. 214. 1979.

[15] Imposition can be extremely complex, and must always be performed by a specialist. Do not be ashamed of consulting a printer to find out more, if you are only an amateur in this field. Ank make sure that the printer has the knowledge he needs, which is – unfortunately – not always the case.

[16] Colour may be considered unavoidable in a pilot book which aims to upgrade a local language in order to produce a book which will be as attractive to users as textbooks in European languages, which are almost always printed in 4−colour.

[17] In 1979 in the pilot version of a 4−colour Quechua reading book the authors from the German−Peruvian Bilingual Education Project already mentioned chose the key word “puka” (red) to introduce the letter p and illustrated it with a red box. Since the revised version could only be printed in monochrome, this word and the illustration had to be changed, triggering a chain of modifications throughout the book.

Recommended Reading

Layout

DUPLAN, P. AND JAUNEAU, R. *Maquette et mise en page.* Paris: Usine Nouvelle, 1986

GUERY, L. *Précis de mise en page.* Paris: CFPJ, 1988

RICHAUDEAU, F. *Manuel de typographie et de mise en page.* Paris: Retz, 1989

Typographical Legibility

TINKER, M.A. *Legibility of print,* Ames, Iowa: Iowa State University Press, 1963

TINKER, M.A. Bases *for effective reading.* Minneapolis: University of Minnesota, 1965

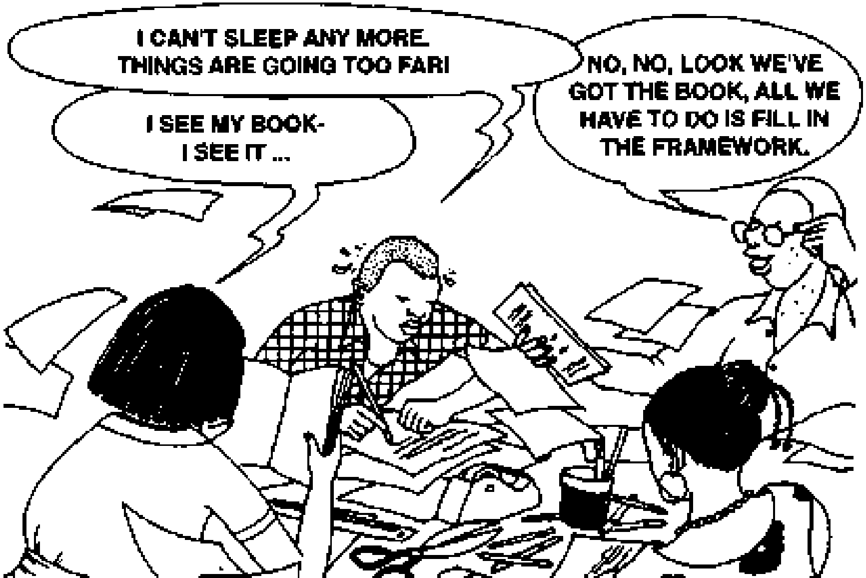
Manufacturing Costs

Teams of authors working in developing countries rarely have the specialist know–how for this phase, but they are always left with the responsibility when the publishing back–up is not forthcoming. Given the fact that few authors will have any back–up from professionals, such as a layout man, most of you will have to acquire a working knowledge of layout and printing techniques and methods. You should consult specialists in your country, especially the printer, and try to put their experience within a systematic framework by reading specialised literature among other things.

The conceptual work should culminate in two documents:

- A detailed work schedule covering the work of the authors and the external inputs required during the writing and manufacturing phases;

- A quotation drawn up by the printer with a view to confirming the decisions made regarding the physical and graphical aspects of the textbook, or to calling into question these decisions.



You must do more than write a text – you must fit text and image together to create a harmonious whole

Plan your writing

1. Overview

The phase you are about to start will seem impossible to structure for some of you, who believe that the texts and exercises will simply come together with time.

However, if you aim to produce high quality material within a given time–scale we recommend that you do not merely wait for inspiration to strike. Forget the romantic image of the literary genius alone in his garret and plan this phase as strictly as possible. By way of reference, we will, as always, give you an overview of the work involved taking the example of the work on *Garabola.*

Writing Garabola

We have selected this textbook as an example because of one particularly interesting feature – since this was their first book, the authors chose to take a systematic approach, trying to avoid any unnecessary delays for the education authorities. The often contradictory goals of quality and keeping to schedule forced the authors to tackle the writing and illustration work in tandem.

We feel that this approach, which is described in detail in Table 23, should not necessarily be taken as a blueprint, but it is interesting and may be useful for teams of authors working under time pressure.

2. Organising the Work

Once you have a general idea about the form your literary and artistic work should take, you can organise the writing work and decide what approach you wish to take.

Planning and Organising Writing Work

The authors started by defining the type of writing work to be performed and how they were to be fitted together. They set quotas in line with the work schedule drawn up at the end of the conceptual phase for the textbook as a whole. They also decided how they proposed to conduct the writing.

Writing the First Version of the Reading Texts

The authors settled down to write the textbook per se, starting with the reading texts.
They adopted a systematic procedure, developing a list of criteria, identifying the topics to be tackled, deciding on the type of texts, writing and producing the artwork for a first unit which was then used as a model for the rest of the textbook, and then writing the other units.
The authors then ran a series of checks on the texts produced.

Organising and Supervising Illustration Work

Since the illustrator had been selected and approached during the conceptual phase, the illustration work could start; he illustrated the reading texts while the authors devised the exercises.[2]
Collaboration between authors and the illustrator took the following form: a contract was drawn up in line with the work to be performed, the contents of the illustrations were stipulated as was their layout on the page, drafts were produced and any changes made, the illustration techniques and instruments were stipulated.
Once the layout had been finalised, the illustrator produced the final versions of the illustrations.

Writing the Exercises

While the illustrator was preparing sketches for the reading texts, the authors started work on the exercises. They established a list of criteria, identified attainment sub–targets, defined the space available for each exercise, selected the type of exercise, developed the exercises, devised the presentation, and ran an internal check. The illustrator produced sketches for the exercises once he had finished those for the reading texts, observing the same procedure.

External Review

Once the manuscript was completed, various people from outside the group of authors reviewed the texts

Writing and illustration work progress in tandem
If you do not have good editorial back−up, this phase will be a busy one

Group and Individual Inputs

You have drawn up your time−frame for the writing phase, and now you can go on to define how you intend to meet the deadlines you have set, defining the interaction of group and individual inputs.

While nobody would question the value of group work, some of you may ask when and how texts should be written by the group as a whole.

You can answer this question by identifying the type of writing demanded by the situation. Here are three possible options, which we have used in the past: analyse them, and decide which one best meets your needs.

Group Writing

Each text is written jointly; the authors formulate the text aloud in the group and then modify it, until they can agree on a version which is written down and considered definitive by everyone in the group.

This procedure has the advantage of preventing individuals from getting caught up in errors and allowing everyone to identify with the final version. On the other hand it may provoke tensions in the group, if you do not listen to those who are not good at formulating their ideas verbally, or who cannot defend them well.

Sometimes group writing will appear unavoidable. When, for instance, you are defining key words and writing key sentences for a first reading book the text is subject to such strict limitations that it is difficult to work individually. In our experience group work, where texts are formulated aloud, provides the best forum for applying pre−defined criteria to the words and texts to be developed.

If you are in this situation, have a look at Table 25, which outlines the criteria to observe when developing texts for a reading book. Read these and adapt them to your own particular situation.

8		Preparation of illustrations for exercises
9	Correcting sketches	
10		Revision of entire manuscript by externals
11	Writing general information pages	
12	Final changes to the manuscript	
13		Preparation of a typewritten copy of the manuscript and production of hand–crafted mock–up
14	Drawing up specifications for textbook	
15	Organisation and moderation of official revision session	

This approach is often favoured by authors who are not used to working as part of a team, who see it as a fair compromise between the individual work they are accustomed to and the inevitable group work.

It does, however, have many disadvantages; the authors, themselves immersed in writing, do not always have the distance and the calm needed to judge the inputs of others fairly, and are reluctant to contradict their colleagues and criticise them. Some texts are thus accepted with reservations and the finished product displays a lack of cohesion and uniformity.

You should only adopt this approach if you have the back–up of a good publisher who has the skill, the distance and the necessary authority to suggest the necessary changes.

Individual Writing and Group Revision

This approach involves every team member tackling the same text at the same time and handing it in without having time to perfect it; the individual inputs are then put up on the board and the group agrees on one text, or at least on a general direction, a basic text which can then be reworked to a greater or lesser degree.

Most key words should be nouns.
For semantic and graphical reasons, only a few verbs (verbs of movement for instance) would be suitable. Adjectives of colour should be used with caution: you must be aware of the type of printing that will be used, not only for the pilot version, but also for the revised version. Avoid adjectives of colour if the textbook is to be printed in monochrome.

Degree of visualisation

Nouns that cannot be illustrated should be discarded. Then, of the nouns that can only be presented visually in a moderately satisfactory way, only the indispensable ones should be retained. Bear in mind that liquids in general are difficult to illustrate, and can lead to interpretation difficulties when you are dealing with young readers who have had little contact with printed materials.

Unequivocal correlation between key word and its illustration

The relation between the word and the illustration should be unequivocal if possible.
In our experience images of people are difficult in this way, so key words such as “people”, “man”, “woman”, “girl” “boy” etc. should be avoided, since the images are subject to more than one interpretation.

This procedure has several advantages. Firstly, the short time allowed for writing prevents each individual from identifying too closely with his own text. Secondly the fact of putting up all the inputs prevents new authors being so awe−stuck by the process of intellectual production that they are paralysed: the writing work unfolds step by step before their eyes in a certain anonymity, which robs it of its mystery. Finally the revision phase, which is often much more extensive than the writing phase, allows all group members to contribute to the final version and identify with it.

We should, however, point out one major disadvantage: if the authors want to retain a high quality they must identify the best texts irrespective of the originator, and the text, once selected, must be re−worked for as long as necessary, while taking care not to jeopardise the group dynamics. This is only possible if the group is made up of individuals who are not only of a high professional calibre, but who are also intellectually honest and extremely patient. In our experience all the charisma of an internal group leader is needed if the work is to run harmoniously over a longer period.

Working Language

Language of Writing

If you are producing a textbook in a language with no written tradition, it is common for only a few team members to be able to write it fluently. In this case, you should agree which language the inputs should be written in before you start to write.

This question is particularly relevant for texts which do not address the children, the technical presentation of the book for instance, and later for the teachers' guide. In the groups we have observed, we have noted two possible approaches to writing texts.

Translation

The inputs are written in the European language common to the entire group, and then translated into the national language in question.

The advantages of this approach are clear: a highly specialised pedagogue can, for instance, write a text on learning to read in English, French or Spanish, which can then be translated into the national language by a colleague who is less well versed in the theory.

It is a procedure with a two–fold risk, however. Firstly, some authors, finding themselves downgraded to resource persons and translators may lose their motivation and give up on the group little by little. Secondly, internal leaders may emerge and introduce a vertical element within the group which will further limit the opportunity for dialogue.

Step by Step Writing in the National Language

In this case, the texts are written step by step, as follows:

- common development of the criteria to be observed (in the European language)
- corresponding texts written (in the national language)
- verification firstly orally and then with the help of translation of certain passages into the European language, to check for congruence, followed by any corrections needed.

upon yourself to conduct as exhaustive a study as possible and to draw up precise criteria.

To take stock of what your work at this level can involve, examine the list of criteria drawn up for reading texts in national languages, presented in Table 26. The list is long, but it is by no means exhaustive and may not be suitable for your particular situation.

Topics

You have identified the main features of the texts to be produced. To be one hundred percent operational, you must now draw up a list of the topics to be tackled.

In our experience, in primary school textbooks projects authors often start by producing a first reading book, in which the topics are defined by key words; this first book thus automatically reflects the everyday world of the pupils. In the textbooks for the following grades, these topics are repeated, for various reasons. Firstly the authors often see the texts as a way of achieving pre–defined language targets, primarily as a good basis for grammar and vocabulary exercises, and do not thus attach a great deal of importance to the selection of the topics. When national–language books are produced, the authors do not always manage to satisfy the contradictory demands of authenticity (as seen in the selection of topics related to the socio–cultural environment of the child) and openness to the outside world. They often opt for the endogenous to the detriment of the exogenous, and stay within the limits of the first book. Finally, most of them quite simply find it difficult to break out of the traditional topic framework of reading books for the primary level.

Two observations should, however, be made: in groups of authors, the selection of topics is rarely the result of systematic considerations, and the difficulty of the selection process is almost always underestimated. We again suggest a step–by–step procedure when you begin to select topics for the higher classes at primary level.

Select topics for reading books on the basis of precise criteria

Official Instructions

First of all check how the curriculum defines the role of the school within society, and see if detailed topics are

To sum up, you have laid down the approach you intend to take, drawn up a list of criteria and identified the topics for your reading texts. You can now start writing the texts.

26. Criteria for Writing a First Reading Book in a National Language[5]	
Texts corresponding to the general attainment target	
	Texts must firstly be in line with the general targets set for reading in the grade in question. Thus, if the pupils are to learn to read and understand the literal sense of short, explicit messages, you should not produce texts that the pupil must complete to understand the meaning.
Texts corresponding to the specific attainment target of the lesson	
	Whenever the lesson has a specific reading target, the texts must meet these specific demands; thus if a new element is to be introduced, such as an upper case letter, the texts must allow for the systematic introduction of this element.
Controlled use of words	
	The words used must be in line with learning needs, i.e. a minimum of new words should be used at the start, and they should be repeated a number of times to imprint them on the memory of the pupil.[6] Elements which the pupil has not yet learned systematically should not be used.[7]
Readability of words	
	The words should not exceed the maximum linguistic readability for pupils; in languages used world–wide the authors can refer to research conducted since the 1940s. In most national languages, special features will determine the readability of words.[8]
Readability of sentences	
	The sentences too should not exceed a maximum level of readability: they should be short and have a simple morphological and syntactic structure. Here too you may find research done for world languages helpful, but in many national languages, the readability of sentences will depend on other criteria. Thus short sentences, used at the beginning of the learning procedure must make for maximum readability without being artificial or excessively simplified – a tall order for

	result that the same topics are presented with increasing levels of difficulty in a spiral from the first to the last book in the series.
Idyllic past and glorified future	
	The texts should reflect today's world, which is often a world in transition. They should avoid any nostalgic descriptions of times gone by – which were rarely idyllic – and should equally avoid glamorising a modern world which is likely to be unknown to the majority of pupils.
Games aspect and topics liable to provoke conflict	
	The texts should firstly look at the universe of the child. It should focus on the happy side of childhood, but should not completely eclipse conflicts and the negative side – conflicts, problems and fears of childhood should be mentioned.
Respecting the environment	
	Religious and political topics should only be broached with great care and social taboos should never be mentioned.
Texts for children and grown–ups	
	The texts should be worthy of the child and the grown–up he will very soon become, because for many children in developing countries, given the rate of absenteeism, it is true to say that adult life begins after one or two years of schooling. In the books, anecdotes, recitations and games should thus alternate from an early stage with recipes and user's instructions, a literary genre with which they are most likely to come into contact in adult life[9].
New fields of use	
	The texts should pay enough attention to the traditional role of the national language (poems, legends, descriptions of daily life, etc.) but should also look at roles more often played by European languages (slogans, puzzles, recipes, posters, invitations, etc.). In other words the national language should emerge from the domestic ghetto to which it is often confined and should be upgraded by bringing it into the domain of modern life, traditionally the realm of the former colonial language.

Bear in mind that whatever the level involved, the texts and illustrations should always be developed together, following the basic structure.

Development of the Other Units

Taking your lead from this first unit and your basic structure you will now be able to write the texts for the other units without any major difficulties.

> **Revise your textbook, bearing in mind the needs and possibilities of users**
> **Keep a careful record of your reading texts**

We recommend that you compile the following, day by day.

Text File

The texts selected by the group should be filed carefully, in a box file, for instance, and each of them accompanied by a sketch, however rough, of the scenes or items planned; a sketch is always better than instructions alone.

Logbook

We also recommend that you continue to keep the logbook you started during the conceptual phase. Document your work; in particular keep a record of the instructions you plan for the teachers' guide, which you will otherwise forget before you come to produce this guide.

Internal Revision and Changes

The concentration needed during the writing phase is such that it is generally impossible to stand back from the texts and check their quality thoroughly. You should thus wait until all the pupils' texts are finished before conducting a series of internal controls.

guilty of plagiarising. Check that this has not happened with your manuscript: copyright infringement can result in expensive legal action and plagiarism is not the best advertisement for a group of authors.

This point, which is scrupulously observed in industrialised countries, is often ignored in developing countries. We have seen groups of authors, who did not pay attention to this point being tripped up by harsh reality at a later stage. To ensure that what is often nothing more than ignorance does not become a time–bomb ticking away under your work, find out about the basic principles of reserved rights; the books listed at the end of the chapter may be useful.

Do not copy or plagiarise

Social Options

You should also review the social options which you will automatically have selected as you wrote. Analyse the roles which you have attributed to the various protagonists: look at the number of times each of them appears in the texts and sketches, look at the occupations of mothers and fathers, of girls and boys, etc.

Then take a hard look at the social image reflected by the textbook: analyse the role of institutions, first and foremost the school, look at the angle you have taken on authority, be it parents, teachers or village elders; and look again at the way you have responded to certain crucial topics of today, the most important being the protection of the environment.

If you now, in retrospect, see serious imbalances or omissions in the texts, correct them – you still have time. You can either modify them or change graphic elements, which will sometimes be enough to redress the balance of the text–image unit. If, for instance, you wish to upgrade the role of women, and you note that there are fewer women than men in your textbook, you can redress this balance by making women figure more often in illustrations. Be careful in your choice of setting for these illustrations though. If you wish to upgrade the status of women do not show them performing only menial work.

Linguistic Checks

If you are producing a first reading book, you should pay particular importance to linguistic checks. First of all, count the words used in the book, and then look at the average length of these words, classifying them by

We can only repeat that it is extremely difficult to design good exercises, much more difficult than to write texts for reading. The approach we suggest here will certainly not solve all your problems, but we hope that it will allow you to avoid the worst pitfalls and errors.

Choose an easily understood mechanism and an appropriate form of presentation for your exercises

Drawing Up a List of Criteria

As is the case with texts, you should never start designing exercises without first drawing up a list of criteria, which should be as precise as possible. The quality of the exercises in your books will depend firstly on the quality of these criteria. You should thus approach this first step with the rigour and the meticulousness it deserves.

Some criteria are general in nature, and can be applied to any subject and any grade: the exercises for instance must always reflect a clearly defined attainment target. Others, however, will be determined by the particular nature of the material you produce. If you have decided to present exercises in the textbook and have rejected the idea of producing expendable materials such as separate exercise books or cards, one criteria of your exercises will refer to the mechanism: you must reject out of hand all exercises requiring the children to stick things in, fill in gaps, join up, colour in or circle anything – a criteria which sometimes causes authors in developing countries enormous headaches as you will appreciate in the course of your work.

We look in more detail below at the general criteria that should be taken into account for primary–level textbooks in developing countries; as you will realise the list is by no means exhaustive and not all points will be relevant in every set of circumstances.

Examine them, adapt them as well as possible to suit the cultural, linguistic, pedagogical and didactic features which you must respect in your textbook, and supplement them as necessary.

27. Linguistic Checklist for a Manuscript in a National Language	
	In view of the fact that textbooks venture out into the world beyond the school yard, they can be

are in line with official norms where any exist and that these forms are acceptable to the users of the national language, in particular to teachers.

Inventing Words

National languages almost always have a vocabulary that is too limited to meet all cultural and technical requirements. You may thus be forced to invent some words, either resorting to borrowing the term from the former colonial language and adapting it, or neologising, i.e. creating a new term from the roots of the national language itself.

Although the process of creating technical terms is considered obligatory, positive and quite normal in strong languages, it often appears artificial in national languages. The readability of texts, particularly those which describe modern technologies (user's manuals, recipes, etc.) may suffer two weaknesses: newly created words may appear clumsy, and may not be accepted immediately by the reader, or the texts may be too liberally scattered with new, unfamiliar words. It is a good idea then to make a list of these words, to check that they do not already exist in another form, to check that they are correct by circulating the manuscript to have it read and to limit the number of these words used.

Official Language and Variants

Most national languages exist in regional and local variations alongside the one variant that is recognised as more or less official. This situation has repercussions on textbooks since authors are torn between the need to normalise and standardise the language, which means making linguistic choices which will be binding for all users, and the needs of users who may reject the book if they cannot identify sufficiently with the language used.

This is an extremely delicate issue and we can only urge you to be vigilant; list words of limited usage, ask the people who re–read your manuscript for their opinion and be sensitive to the positive and negative feed–back.

Punctuation

Punctuation is a relatively recent development, it is true, but it is now an integral part of written language. What we often forget, however, is that each language has its own punctuation rules. Few national languages have their own punctuation rules with the frequent result that authors are tackled in the exercises.

Let us look at one example, to give you an idea of the practical significance of this recommendation. Let us assume that the general learning objective for writing has been defined in the following terms. “The pupil should be able to copy short texts legibly and correctly from a model in joined–up writing, and should understand the meaning.” You should firstly identify the sub–targets regarding handwriting and those concerning written expression. For handwriting, you could identify the following sub–targets:

• Produce the round part of letters such as **a** or **g** with an anti–clockwise movement;

• Produce the ascenders in letters such as **b** or **h** and the descenders in **g** or **p** on the correct scale;

• Join up the letters within a word correctly

• Leave the space required between words and so on.

Having listed the sub–targets you should decide which ones are indispensable, and list those which could be considered part of the basic structure.

Identify the sub–targets for written comprehension in the same way.

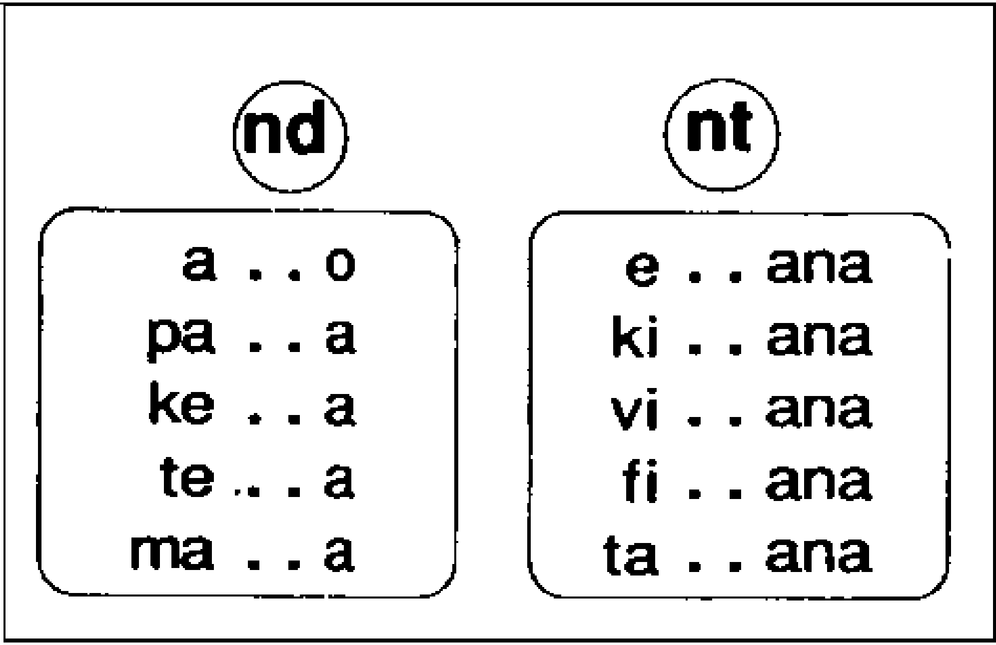
Mechanisms and Presentation

The results of the last step should now allow you to begin devising the exercises. But, you may well ask, where do I start?

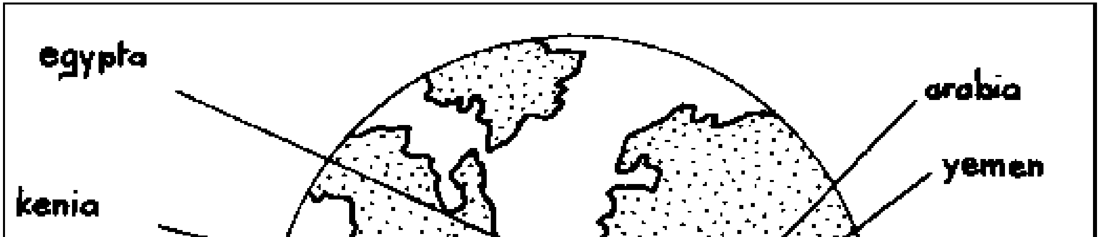
Your first task should be to identify a general direction for the first attainment sub–targets. If you already have some experience in this field you will be able to sketch these out fairly rapidly, and these will become exercises little by little. If, on the other hand, you are new to this work, and feel quite out of your depth we suggest that you look at the sort of exercises printed in recent textbooks. But be careful – you must not under any circumstances copy these exercises. Take them as a starting point by all means, add to them, change

Exercises must correspond to a detailed attainment target	
	This is the starting point for each exercise: every exercise must reflect a specific attainment target. An analysis of school textbooks shows how difficult it is to achieve this. The sole purpose of some exercises appears to be to balance a page aesthetically. Frequently they do not properly reflect the target set, and sometimes they tacitly reflect other targets.
Coherent sequence	
	Exercises must follow on, one from the other, in a logical sequence to allow a logical progression of new elements to be learned.
Adaptation to working conditions	
	The exercises must be in line with the working conditions found during the preliminary investigations, in particular as regards the time–table followed by the majority of the pupils, the average class size and the instruments available in most schools.
Ensuring optimum impact	
	Exercises should illustrate the phenomenon to be taught in an optimum way; it is thus important to identify not only the subject matter, but also the mechanism and the presentation best suited to enable pupils to achieve the target.
Mechanism that is easily understood by the teacher	
	The mechanism of the exercise should be immediately accessible to the teacher; explanations and information should not be needed to inform the teacher in detail about the mechanism, but merely to confirm what he has instinctively understood. This means that innovation must be kept within limits. If a book involves too many innovations there is a chance that teachers will not understand the exercise and will thus reject it, or that they will misunderstand it and use it incorrectly.[13]
Mechanism that pupils can follow	
	The exercises must be in line with the level of maturity and knowledge of the pupils; thus

	with more sophisticated presentations.



Example of function exercises
Transparency of mechanism: making and copying words (Tongavola p. 81)



mechanism does not allow us to illustrate a phenomenon well: you will change it, of course, but this change may trigger a whole chain of repercussions.

You should not then be unduly surprised if you have to resume your work a hundred and one times before you have a final layout: this is more likely to be a sign of the quality of your work than a reflection of mediocrity.

Internal Checks

Designing exercises is almost always a long and extremely arduous task. Once you have completed your first version, try to stand back and run a series of internal checks. We suggest that you pay particular attention to the following aspects.

Subject Matter Check

Check that the exercises do not contain any errors! Force yourself to sit down and do them in their entirety, and if you intend to print the answers in the book or later in the teachers' guide make sure they are correct. These will be the errors that will leap out at every reader later, without their having to go through your product with a fine–tooth comb.

Pedagogical and Didactic Check

Check and see that the natural progression of learning has been respected; sometimes changes are made with the result that the exercises no longer correspond to the original sequence.

Once you have completed these internal checks, you can submit the manuscript to your external correctors. Prepare the manuscript and identify appropriate proof readers.

Graphic Check

Start by looking at the length of each exercise one at a time; make sure that the instructions are not longer than the shortest exercise. If necessary lengthen the exercise – three or four words do not count as a proper exercise! Thin out exercises where the sheer length is off–putting.

5. External Checks

You have produced the pages of text for the pupils, i.e. you have written the texts and sketched the illustrations, and you have produced the exercises, i.e. you have written them and decided on the presentation, and you are doubtless impatient to “see” the textbook, with the finished illustrations and the text printed on a word processor.

But let's not jump the gun. After all the months of working in a vacuum, you no longer have the distance to your product to undertake the final revision, which is so vital. And you have been cut off from the outside world for too long. You can overcome this dual problem, however, by getting experts from outside the group to read your manuscript: this will allow you to check the quality one last time, and to inform the education authorities of the status of your work and start paving the way to ensure that your finished work is well received.

One way to do so is to follow the approach outlined below.

Preparing the Manuscript

Revise your manuscript once again, check that all your changes have been incorporated and that it can be read profitably and without any major difficulty by individuals without publishing experience. Remember that the unfinished nature of the manuscript may unsettle some readers who will then focus all their attention on shortcomings in terms of the form.

Proof Readers

Once your manuscript is ready, identify individuals whose skills and authority make them appropriate proof readers. Select proof readers who can make valuable comments now and can help ensure that your book is well received later; the following people would be suitable.

Subject Specialists

Good specialists in the subject in question, from universities or the ministry will be able to give a well–founded assessment of your work, and identify any fundamental errors which other proof readers will probably not notice.

If you have produced a textbook in a national language, especially if it is a reading book, we recommend that you submit a copy to parents; this will often involve reading them entire passages.

This will have two major advantages for you. Firstly, parents' comments may make for a greater richness and authenticity of the texts[14], particularly if you have distanced yourself from your native tongue and no longer speak it with total ease. Secondly, these information and sensitisation activities will often assure you of the interest and even the support of parents for your activities.

Groups of Children

It can be very interesting to have the manuscript read informally by children of the same age as the target group for which you have just produced the book. These children may be a source of important information, as regards in particular the complexity of the texts and their interests.

Reading Documents

To avoid generating too much confusion on the part of the proof readers who are not accustomed to re-reading manuscripts, you must inform them about your work and stipulate exactly what they are expected to do.

If you have time, you should then draw up two documents: specifications, identical for all proof readers which give a short presentation of the contents and the main physical and graphic features of the book, and an individual list of instructions, specifying the points you would like the individual readers to comment on, in the form of either a list of points to be examined carefully, or a series of detailed questions.

Logistics

If you wish all your efforts to bear fruit you cannot sit back yet. If possible contact your proof readers personally, ensure that they agree to help and define the terms of cooperation, in particular the time they have to read their copy of the manuscript and the date planned for pooling results. Stress that you are interested in constructive criticism rather than unfounded praise.

This phase, which in large publishing companies is the responsibility of the publisher, can mean a great deal

Try to avoid any errors, such as incorrect page numbers in the table of contents, or omissions which will irritate the reader: you should always give the date and place of publishing for instance. And you should exercise great care when you write these texts so that the official information (a foreword signed by the minister for instance) is every bit as convincing as the more technical parts (a presentation of the contents to allow readers to use the book without the teachers' guide if necessary).

And one last recommendation is surely important: do not underestimate the importance of the table of contents. It is not enough to list the units and give the page numbers; give a brief overview of the contents of each unit so that the table of contents is a genuine reference tool for the reader, and, when the layout is performed devote an appropriate length of time to this issue, to find a presentation worthy of your book.

The Cover

Take care also with the text which will be printed on the cover. The two outside cover pages address the purchaser, so give him the information he needs: print the ministry of education's name on the front cover, or at least the name of the publisher, the title, a description of the contents (e.g. reading book with exercises) and the grade for which it is designed. On the back cover you can, if appropriate list the other books in the series and announce the forthcoming titles. The two pages inside the cover should be left blank if possible. Think of the first as an invitation to the reader to concentrate, and the last as a visual curtain closing on the book, which makes white the most appropriate colour. If you are forced by financial constraints to use these pages, leave as much blank page as possible[16].

7. In Conclusion

The End of the Writing Phase

At the end of this phase, nothing is yet definitive. Your manuscript has undergone a first external check, but you can still modify it, add elements and remove others without losing time or entailing any extra costs.

If you need the authorisation of the education authorities to print your book, this is the time to submit the manuscript to them: you can still make any modifications at this stage. Later your choices will be more or less

[7] Here is one example, to demonstrate how important this is. In Malagasy, the negation “tsy” (“not”) does not figure in the first reading book, because it includes the complex grapheme **ts** which is incorporated in the systematic learning programme for the second year. This linguistic restriction proved to be the most irritating when the texts were being written for *Garabola.*

[8] This point is explained in more detail in this chapter in Table 27.

[9] Non–school education must be one of the considerations of authors of textbooks for the lower classes at primary level. See Hummel, C. *School textbooks and lifelong education: an analysis of schoolbooks from three countries.* Hamburg: UNESCO Institute for Education, 1988.

[10] A valuable book to read in this regard is Berthelot, J. *Petit guide a l'intention d'auteurs débutants et de quelques autres,* op. cit. pp. 59–69.

[11] Cf. Huot *Dans la jungle des manuels scolaires,* op. cit. p. 79.

[12] The modernisation of national languages is a long, complex process, which is rarely crowned with success; textbook authors, who may be the first to express an interest in this subject, are sometimes unaware even of the existence of a language planning agency. See also “Textbook writers and language planning”. In Rubins, J. (Ed.) *Language planning processes.* The Hague: Mouton Publishers, 1977.

[13] All innovations must be recognised as such, even where you consider the new methods obvious and incapable of being misunderstood. We will just recount the example of one teacher who was given an exercise book for writing for primary one – something completely new to hear; the letter to be taught was presented in dots to allow pupils to practice by joining up the dots. For several months she taught her pupils to write letters in dots.

[14] Textbook authors are often bilingual, but having undergone their education in a European language they have sometimes lost touch with their native tongue. If this applies to you do try to re–read your manuscript with groups of parents. They are an excellent source of lexical and syntactic information.

[15] When the author is responsible for organising the proofreading phase, this work is almost always a veritable mini project, whatever the type of publication in question. The organisation involved in having this book proof

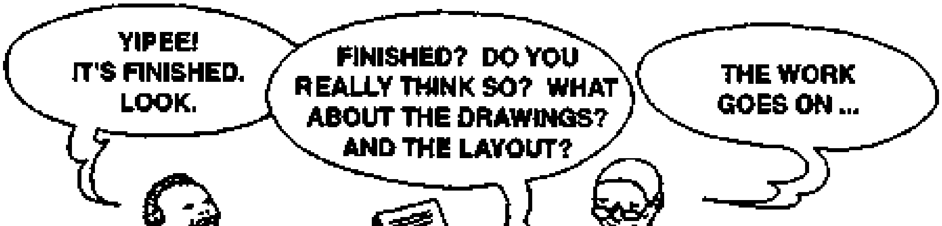
To Sum Up

The systematic concept drawn up for the contents and the physical and graphic aspects of the textbook allows the authors to move smoothly into the actual writing phase.

Among the many tasks of textbook authors, this is often the one they feel least apprehensive about, especially if they have been selected on the basis of their writing skills. This confidence is, however, often based on a misapprehension. Although the writing of texts and exercises is important, writing a textbook is not a purely literary pursuit; it must be accompanied by graphic considerations. It is important to deal with the form and the contents of each page together, such that the products of this phase are not merely texts and exercises, but an entity of words and images linked so coherently that we can speak of a “text–image unit”.

We feel that three points are important to finish off this work, although the complexity of these tasks is often under–estimated. Firstly, a frame of reference and working conditions are needed which give free reign to the literary and artistic talents of authors. Secondly, certain procedures must become automatic, such as checking the position, length, presentation and accompanying illustrations for each piece written. Thirdly, a systematic approach should be taken to writing the texts and devising exercises, involving the following steps: drawing up a list of criteria, producing a model unit, doing the provisional layout, writing the other texts and exercises, performing an internal check, and identifying a group of external proof readers to re–read the manuscript one last time and make their comments.

At the end of this phase it is absolutely imperative that all authors' corrections be completed. This is why we recommend that all teams who must obtain the authorisation of the education authorities before printing their material submit their work at this stage, so that the latter has a chance of suggesting modifications which the authors can incorporate without entailing additional costs or losing time.



In developing countries, the authors themselves generally plan, define and supervise the illustration and layout work. In this chapter you will find a presentation of the work involved, which we hope will be interesting for all of you. You should, however, realise that if you have no training in graphic art, this chapter alone will not enable you to solve all the problems you are bound to encounter.

Try to get some professional back–up, and, whether or not you are successful, make an effort to become familiar with the basic principles of graphic art; read this chapter carefully, consult the books listed at the end and examine the illustrations and layout of recently published textbooks.

A finished manuscript is still far from being a printed book
It's an uphill struggle from the manuscript to the imposition scheme

1. Overview

The preparatory chain involves all operations leading from the manuscript to giving the printer the go–ahead. This authorisation is noted on the final set of proofs, the blueprint, indicating that no more changes will be made and thus giving the printer the go–ahead.

This phase is long and complex, much more so than many authors realise, believing as they do that a completed manuscript is more or less a printed book. To give you an idea of the nature, scope and sequence of the tasks involved, we will proceed as always, starting with an overview. Once again we will take the example of the procedure followed in the Tef'Boky Project, which is laid out in Table 29.

The various tasks we describe here do not differ significantly from those found within large publishers, of course, but some of the steps taken by the project in an attempt to avoid the major pitfalls that beset the production of textbooks in developing countries may be instructive for teams without much publishing experience and for teams only able to ensure sporadic monitoring of the printing work.

29. An Example of the Chain: Garabola
Illustration work

readers and layout men. It revealed the more serious graphic errors, forced the authors to correct some pages or reconsider certain typographic decisions; it also allowed them to identify the odd punctuation or spelling error, and correct it.

Pinboards

Gradually, as the pages of the pasteup guide were finished they were stuck up on a pin board, until the entire book including the cover pages had been pinned up, double page by double page.
This method had the advantage of giving a permanent overview of progress; the authors could find the pages which had not yet been put into their final form and the illustrations that were missing, and were also able to pick up that one last mistake which had slipped through the individual checks, or something in the layout which had to be modified.

Shading

For financial reasons the interior of the reading and writing books produced in the Tef'Boky Project was printed in monochrome. The authors shaded the accompanying illustrations in three shades of grey; this gave depth to the pictures and marked the difference between reading and exercise pages, which have no shading.
The authors themselves indicated how the shading was to be done on photocopies of the originals.

Preparing the job envelope

The authors then prepared a job envelope for the printer. For every page of the textbook they prepared one large envelope containing four documents: the final version of the corrected text with layout, the corresponding original drawings, a photocopy of these drawings with shading instructions and the page layout, as a reference for the assembler.
These precautions were felt to be necessary as a result of the poor communications with the printer, and because the authors were called away to other tasks almost as soon as the job envelope had been submitted to the printer.

Checking the blueprint

In spite of the measures described above the authors asked the printer to prepare one last set of proofs, the blueprint. They checked these, ensuring not only that the montage was correct, but also that there

9	Mounting the make–up on a board and checking texts and layout systematically	
10	Instructing the printer about shading	
11	Preparing the job envelope, with one envelope per page of the textbook, containing all the pertinent documents	
12	Instructing the printer, submitting the job envelope and set–off sheet	
13		Providing the printer with imported inputs
14		Monitoring the progress of work from assembly to printing
15	Checking assembly on the basis of the blueprints	
16		Checking printing quality
17		Checking quality of finishing

2. Illustrations

Now you have an idea of the various steps leading up to the printer receiving a go–ahead, let us go back to stage one.

The illustrations will often be noticed first; make sure they are appropriate

The objective is to have the illustrations that you devised and possibly sketched during the writing phase completed. These may be photographs or drawings, which will then be printed in one or more colours. Within the scope of this publication, for the reasons given in the introduction, we do not propose to go into the

Type and Number of Illustrations

You should then list the main technical features of the illustrations.

First of all, stipulate what type of illustrations are required: perhaps realistic scenes from everyday life, to be drawn in ink with shading which will later be screened and printed in two colours, or text illustrations accompanying the exercises, or models for writing lessons, to be copied in pen. Go through the book page by page with the illustrator and make as detailed a list as possible of the number and format of the drawings to be produced. This will be used as a basis for determining the illustrator's fee.

> **A carefully drawn up contract that is respected by both sides ensures good cooperation with the illustrator**

The Tasks of Those Concerned

Stipulate the respective tasks of the authors and the illustrator at this stage.

At the outset it is essential that the illustrator appreciates that he must put his skills at the service of pedagogical and didactic criteria. He has not been contracted to “express himself” but to translate into images the more or less precise instructions you give him.

You should thus explain to him that together you will produce illustrations which best correspond to the visual decoding ability of the children in question. They must be in line with the average age of the children, with their degree of familiarity with printed materials and with the socio–cultural features of their immediate environment. It is up to you to decide, for example, if you feel it appropriate only to depict people in their entirety, to use unusual perspectives or to resort to caricatures – but the illustration work must always be based on an agreement in principle with the illustrator who is about to join your team. You are thus very much in charge of the illustration work, while the illustrator works within a pre–determined, limited framework and needs the transparency and complementarity of a genuine working group.

This has two important consequences: firstly you will have to determine all the features of the illustrations, and secondly the illustrator must agree to redo illustrations which do not correspond to your instructions. Make this

Graphic Criteria

Once the illustrator has agreed to the terms and conditions, and has signed the contract you can start the illustration work per se, firstly drawing up a list of criteria to be respected.

Never under–estimate the power of the image. Remember that even if the texts in a book can capture the interest of an attentive reader, images do not need his attention or even his interest. They appeal directly to him, triggering an emotive response – attraction or rejection. Take great care then to draw up as precise as possible a list of criteria which will allow you to identify which elements should be given precedence and which should be ruled out to avoid the risk that the textbook will be rejected by readers.

In Table 31 you will find some of the general criteria which guided the illustration of the reading and writing books produced in the Tef'Boky Project. We have only listed the criteria we felt were most interesting for textbook authors in developing countries; read them carefully and see which ones apply in your case.

Sometimes textbook illustrations must attempt to reconcile the irreconcilable

Do not wait passively for the illustrator to submit his drawings – you must guide him

When the authors of the Tef'Boky Project began to draw up a list of criteria for the illustration of their textbooks, they differentiated between criteria which they felt were of universal validity, such as the concordance of text elements and drawings, and those which they felt were specific to developing countries. As you no doubt noted in the Table 31, the latter criteria are particularly difficult to respect since they are always somewhere between two extremes.

31. Main Criteria Observed when Illustrating Garabola and Tongavola	
Realism vs. Idealisation	
	The illustrations must reproduce actual everyday life, removing any element which could be construed as demeaning, i.e. the reality depicted should be idealised while remaining realistic enough for pupils to recognise it immediately and identify with it.

	personification of animals, where extra care is needed. Care should also be taken that the reader, unaccustomed to a critical view of his environment, is not unsettled or insulted.
Childhood and Adulthood	
	Illustrations should be adapted to the children who the book addresses first and foremost; they should also be generally instructive and pertinent for children whose adult life often begins after barely two years schooling.

Identifying Scenes

Once the terms and conditions have been agreed on, and the criteria listed, you can go on to the next stage; starting to work in close cooperation with the illustrator.

To this end you should return to your texts and sketches, and examine them page by page. Start by arranging each drawing as exactly as possible on the page, and determining its dimensions. Then decide which elements must be depicted and which are at the heart of the text and must therefore be emphasised.

We recommend that you take seriously any reservations the illustrator may have. If he has major difficulties illustrating a particular text, look firstly for the reasons in your own work. See in particular if the text allows for an adequate degree of visualisation, and if it doesn't, rewrite it.

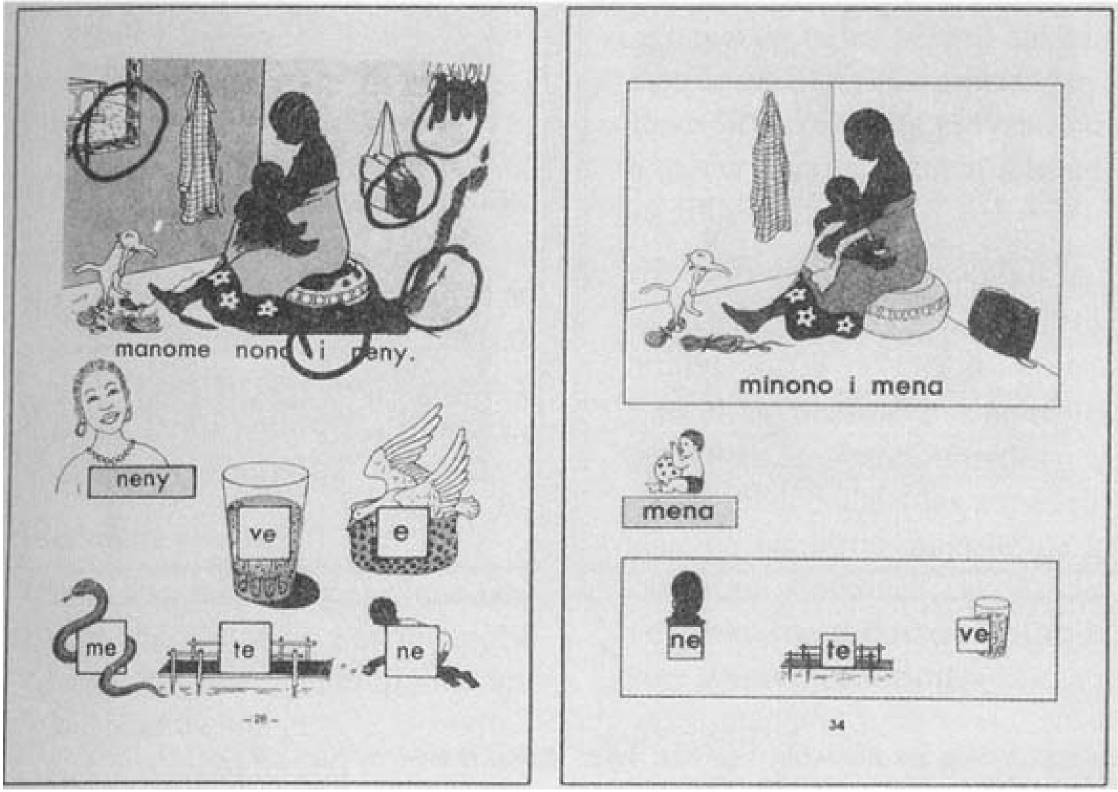
End this phase by ensuring that the illustrator has as precise a dossier of instructions as possible, in the form of notes or sketches, which will enable him to start work.

Correcting Drafts

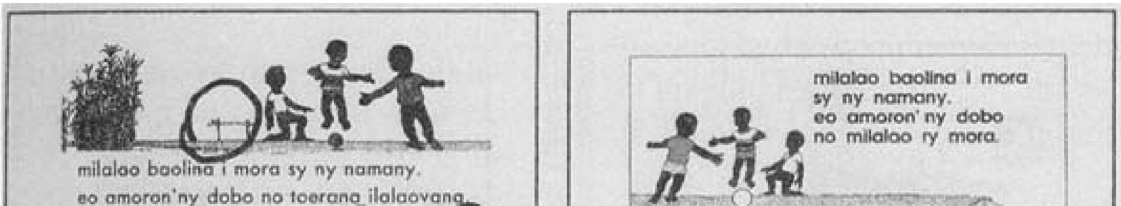
Although illustrators generally go off by themselves initially to produce their first sketches and familiarise themselves with the book, it is important for them to re–establish contact with you rapidly. During this phase you should intervene at least twice in the following way.

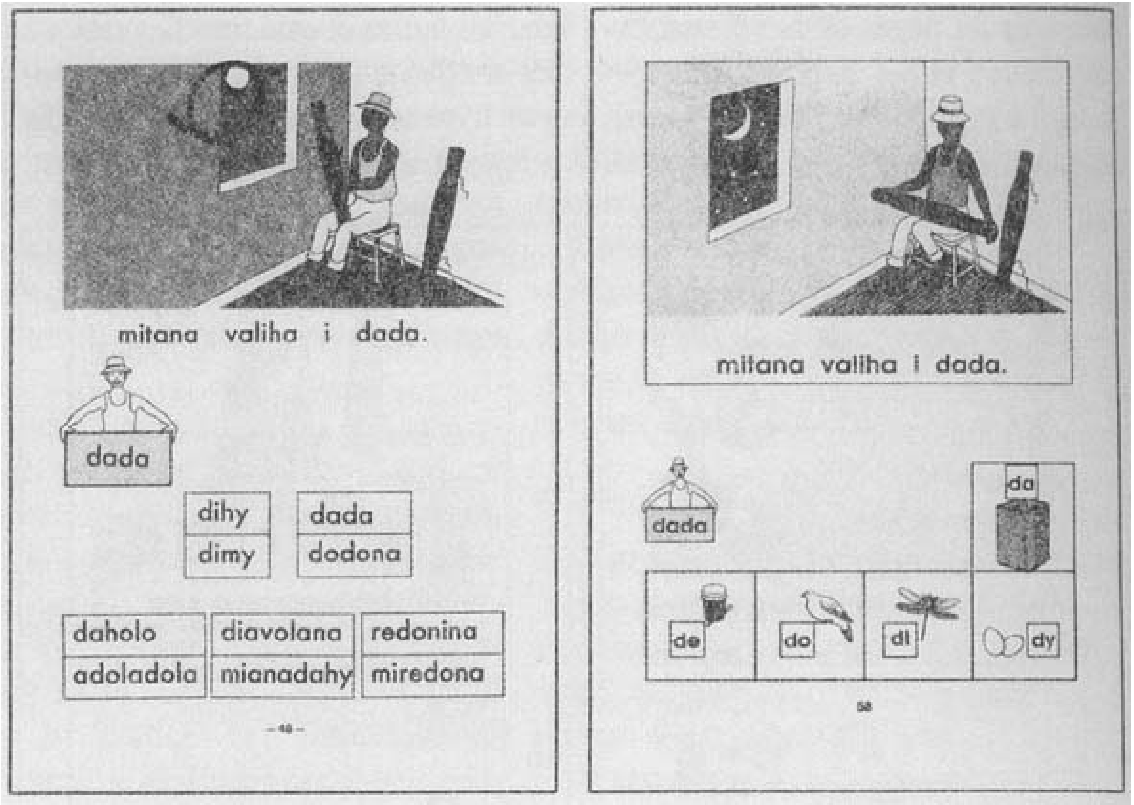
Initial Instructions

To ensure that the illustrator is on the right lines, you must insist that he show you his first drafts. Examine

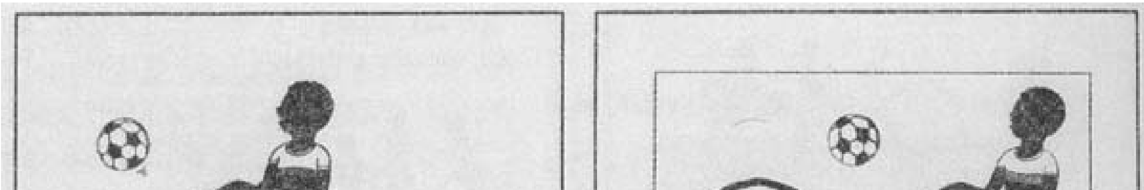


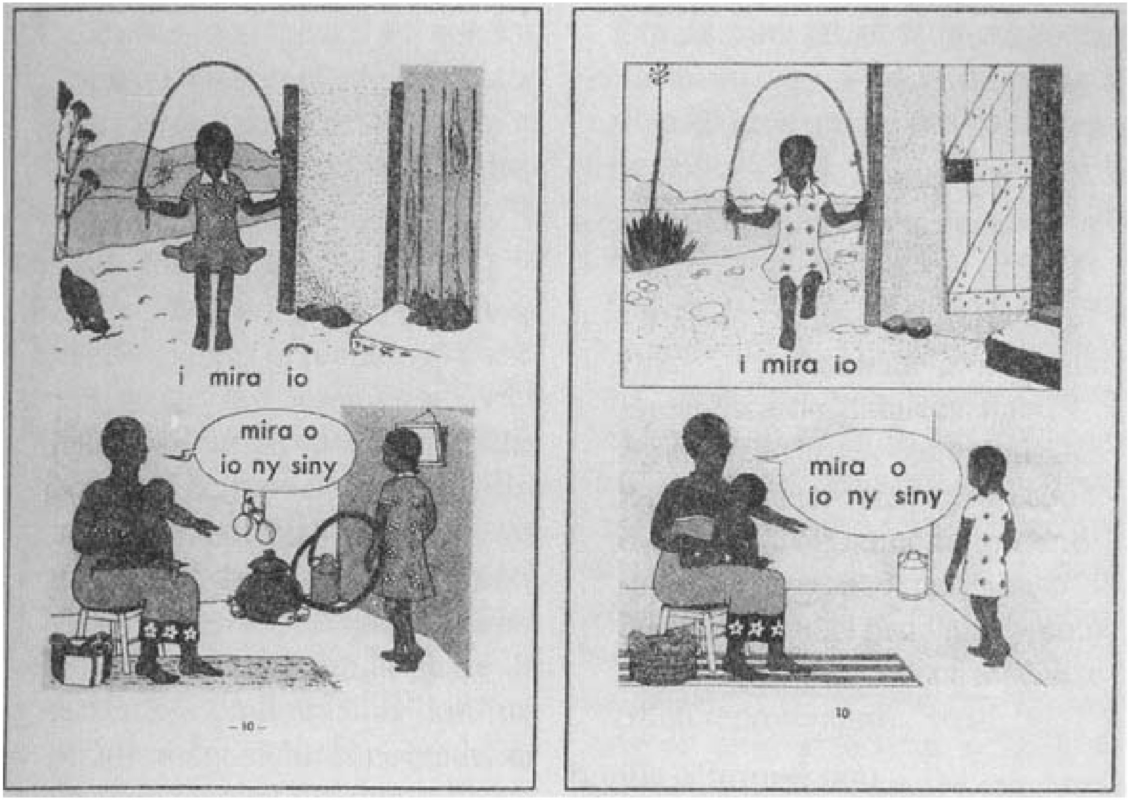
1. Remove secondary elements which obscure the relation between the text and the image.



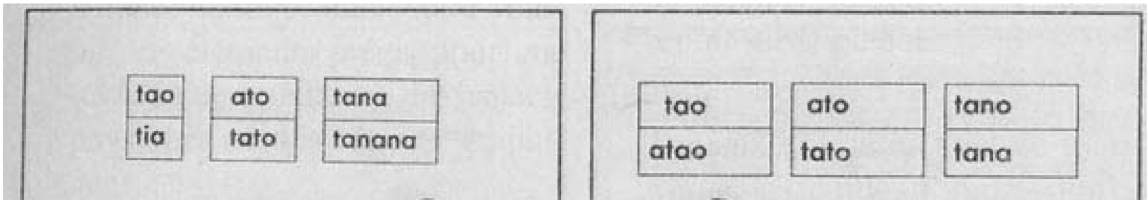


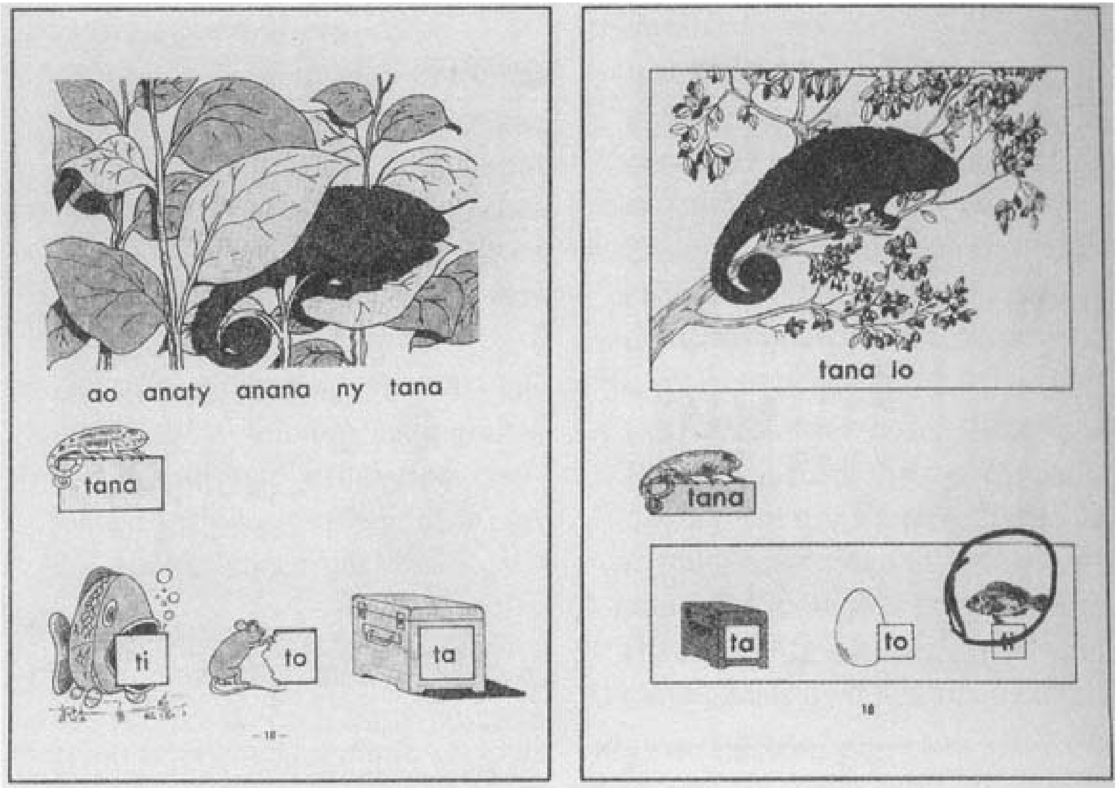
3. Select elements which make the object depicted as easily recognisable as possible.



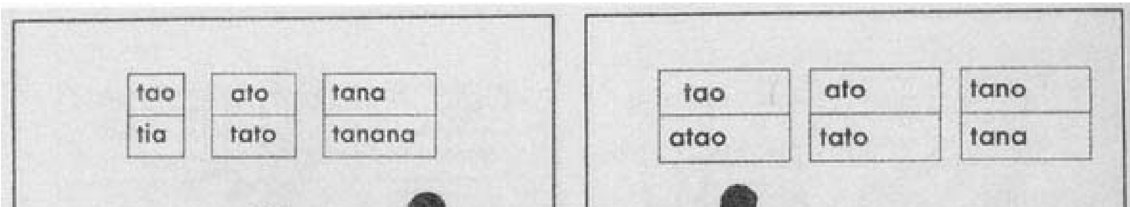


5. Outline elements that are central to the text.





7. Check the exactness of specific elements[5]



canson, etc.).

All originals should be kept carefully; simply note the page on which the drawing is to be printed, and make a photocopy before filing the original. If it is not modified in any way, it should be submitted to the printer at a later date in this state.

3. Layout

During the conceptual phase you will have laid down a fundamental visual structure for your book, which you will have developed in more and more detail during the various stages involved in writing and illustration. But the fruits of your labour are not yet ready to be published. If we can make a comparison with the world of haute couture you now have the fabric to make your dress and you have an idea what form the dress should take. But you still have to cut, sew and finish the garment.

During this phase you will "tailor" the page, deciding on the stencil, putting it together with the typeface you choose and finishing it by checking the arrangement of the elements on the page.

We cannot claim to present the fundamental principles of layout in a book like this; the field is much too wide. We will thus look only at what is essential for an author of textbooks, who alongside his many other roles finds himself responsible for the layout of his book, although he cannot claim to be a professional in this field. If you find yourself in this situation, proceed as follows.

Margins

Your first concern must be to decide on the margins.

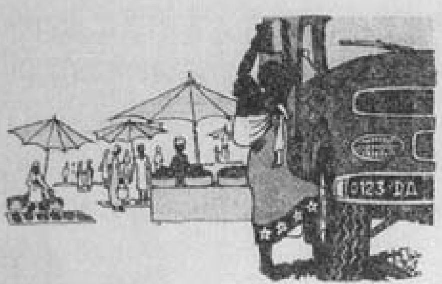
All printed materials have four margins, at the top, bottom, left and right hand edges of the page. Margins give a book its particular style, and you should aim to find the proportions which will give the best possible balance and coherence.

The size of the margins can be set professionally; layout artists today still set the margins on the basis of

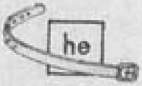
If the contents of your book are relatively heterogeneous, as is the case in a reading and writing book, for instance, the layout is bound to be complex. Nevertheless you should not position the various elements instinctively. Arrange them as though they were on a sort of invisible grid. In view of the fact that the reader will be confronted by two pages of the book at a time, you should design your grid for even and uneven pages.

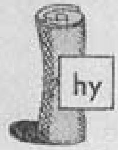
Start by familiarising yourself with the concept of a grid. Just look at the first page of your daily newspaper, and you will see that the text is divided into a certain number of columns, within which and across which the headlines and illustrations are spread; these columns are repeated on the following pages and give the newspaper its identity.

The grid for your textbook will never be as complicated as a newspaper grid, but you should have one to help you impose a certain discipline on your page and thus enhance the impact. The positioning of the various elements on this grid will not always be identical and rigorous; it will be a flexible distribution which may from time to time break with the basic structure without ever completely obscuring it and this will thus retain the attention of the reader without irritating him by introducing too many changes. On the opposite page you will find one example.



manatatao harona i neny.



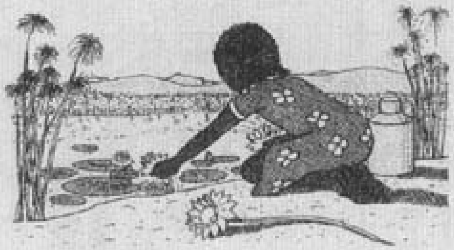


hena	loha	lehilahy	harona
hanina	aloha	vehivavy	harena

- iny eny misy olona.
- lehilahy sa vehivavy ?
- vehivavy. i neny.
- inona iny lolohaviny iny ?
- harona.
- harona misy inona ?
- misy hanina.
- hanina inona avy ?
- hena sy anana ary ovy.

tena	ilany	sarona	manina
hena	ihany	harona	hanina

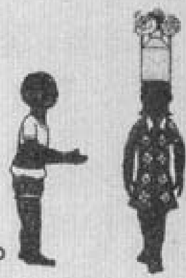
- iny eny i neny.



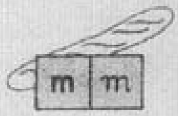
mioty tatamo i mira.

tatamo

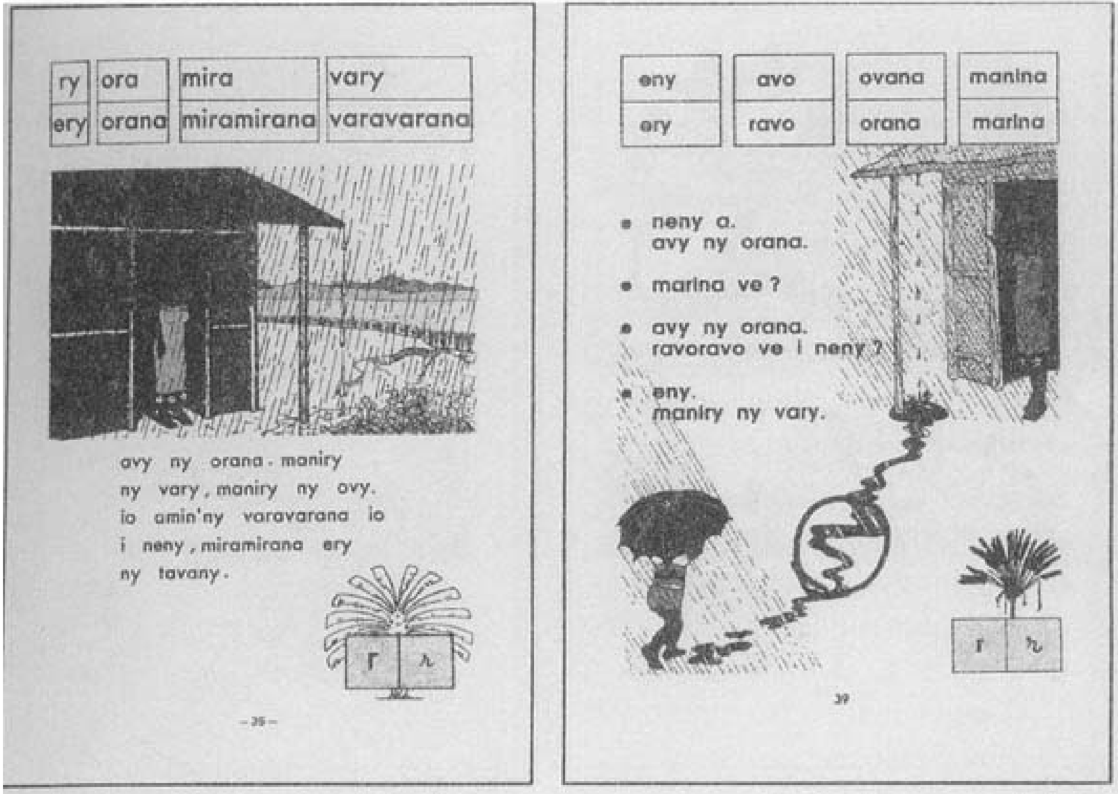
manana	manao	mitoto
maninona	namanao	mitatao



- mira o maninona ianao
- mitatao siny
- inona no ao anaty siny
- tatamo
- omeo tatamo ny namanao



manana	maninona	mitoto
namana	manonona	mitatao



ry	ora	mira	vary
ery	orana	miramirana	varavarana

avy ny orana. maniry
ny vary, maniry ny ovy.
io amin'ny varavarana io
i neny, miramirana ery
ny tavany.

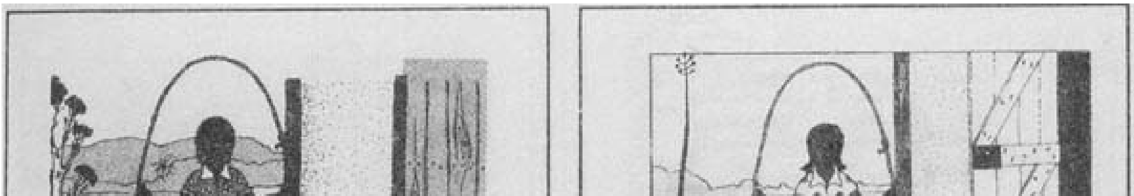
– 38 –

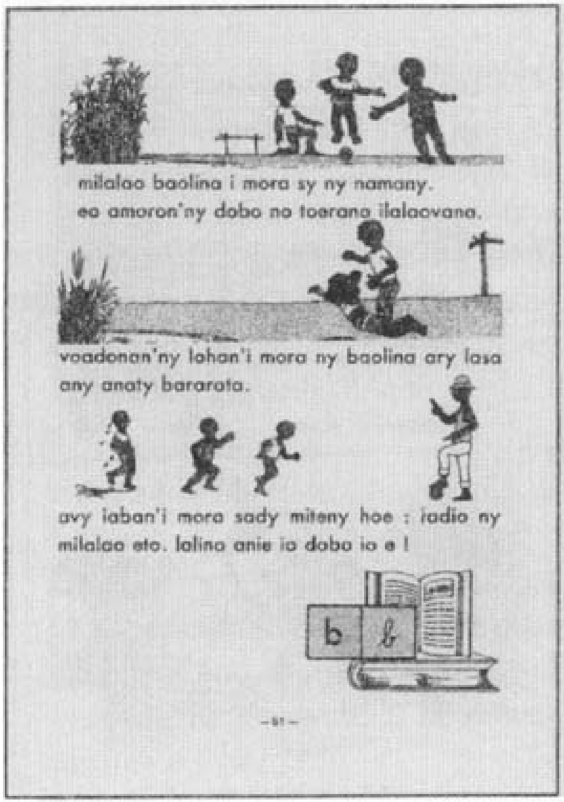
eny	avo	ovana	manina
ery	ravo	orana	marina

- neny a.
  avy ny orana.
- marina ve ?
- avy ny orana.
  ravoravo ve i neny ?
- eny.
  maniry ny vary.

39

3. Avoid monotony and break with the basic structure, but ensure that it is still identifiable as such.

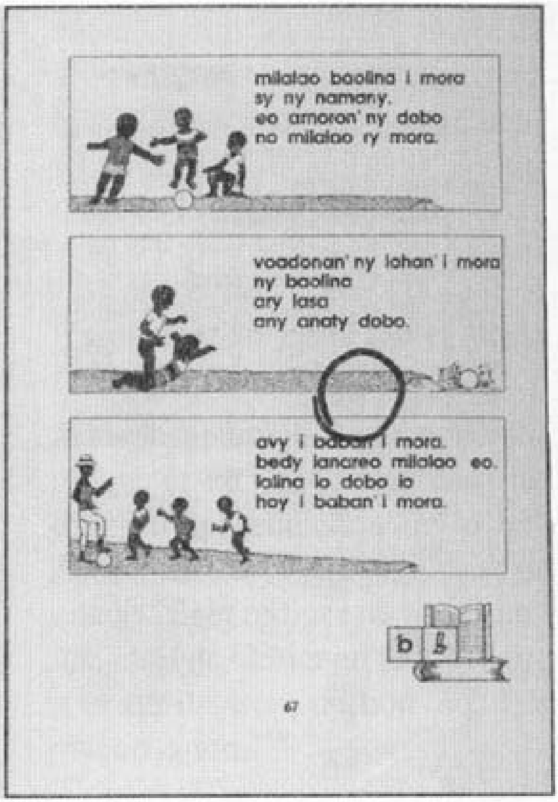




milalao baolina i mora sy ny namany.
eo amoron'ny dobo na toerana ilalaovana.

voadonan'ny lohan'i mora ny baolina ary lasa any anaty bararata.

avy iaban'i mora sady miteny hoe : iadio ny milalao eto. lolino anie io dobo io e !



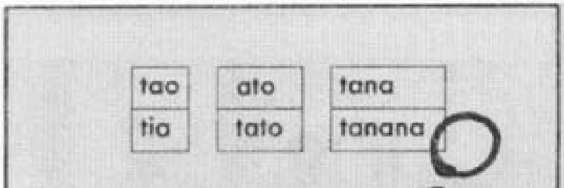
milalao baolina i mora
sy ny namany.
eo amoron' ny dobo
no milalao ry mora.

voadonan' ny lohan' i mora
ny baolina
ary lasa
any anaty dobo.

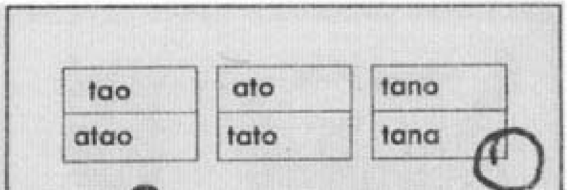
avy i baban' i mora.
bedy lanareo milalao eo.
lolina io dobo io
hoy i baban' i mora.

67

5. Bring text and image close together while respecting the requirements of both.

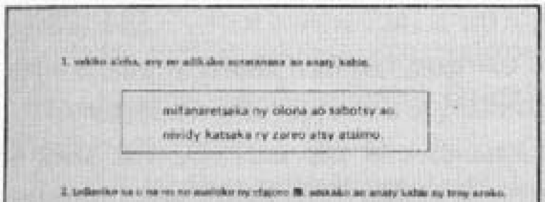


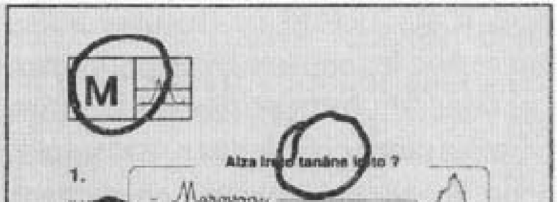
tao	ato	tana
tia	tato	tanana



tao	ato	tana
atao	tato	tana

7. Balance the dimensions of the various illustrations on a page.





Compare the two and think about the principles behind the changes; they probably apply to your book too. Most changes are indicated by a circle.

> **Arrange the elements on the page according to a grid, which need not be unduly complex – two columns are perfectly adequate**
>
> **Practice identifying basic layout principles if you have no recourse to a professional layout man**
>
> **There is no sure–fire recipe for good layout: rigour and imagination are equally necessary**
>
> **Moderation is always called for in layout for primary school textbooks**
>
> **The layout must bring out the essential elements**
>
> **The layout concerns all the elements on a page; don't forget to examine the drawings, texts and blank spaces on each page**

4. Typography

By deciding on the precise margins and identifying the exact arrangement of the elements on a page, you have drawn up a plan for your book. You must now decide on the typographical features of the texts and exercises.

In a publishing house, this work would be performed by a professional graphic artist. If you are forced to make the typographical decisions you should firstly be aware that this is an extremely wide field, where research has been conducted for centuries, and about which more is being written today than ever before. It is a field that we cannot hope to do justice within the scope of this book any more than we could for the layout.

To avoid repeating information that you will find in any specialised literature, we have decided not to dwell on

• level and hierarchy of texts

Decisions at Character Level

Once you have drawn up your list, turn your attention firstly to six aspects concerning the characters you plan to use. The information below should help you make your decision.

Class

Today, you can print a multitude of different characters. They have been classified many times over[8]; one of the most widely used is Maximilian Vox's classification, which distinguishes eleven groups of characters[9].

For a first reading book you should select the best class to help pupils learn to read and write. Straight–line characters are good for this and are found in most textbooks which address grade–one pupils. First of all the characters look like a simplified form of cursive style, and, unlike the characters used for other classes, they have no serifs (short lines drawn at right angles or obliquely across the ends of stems and arms of letters), which are not found in cursive style either. This means that the pupils need not discount any elements when they write most of these letters in cursive style. They simply have a shape to complete. These characters are also of more or less equal weight of type throughout, and since the days of the heavy down strokes and light up–strokes are over, they are thus more like the style of writing actually taught.

As of the second grade, the pupils should be able to read texts written in characters with and without serifs. In the books for second grade upwards you should thus select a different class of characters.

Lower case characters with serif

Lower case letters without serif

Every family has three founts: roman characters, in which the axis is vertical, italics which are inclined and cursive style in which the letters are joined up as they are in handwriting[10].

> **There are no fewer than 12 aspects to be taken into account when deciding on the typography**
>
> **Typography is important in all printed materials, but for a first reading book it is absolutely critical**

The first form is best suited for pupils who are learning to read, while the second is reminiscent of handwriting, but should not be taken as a model for the first graders.

Category

Should you use upper or lower case letters?

In some languages, such as German, it is imperative that children learn both lower and upper case letters from the start, since upper case letters have a specific grammatical role, such as to denote nouns. In a first reading book you may, in some languages, be able to avoid using upper case letters. If you are forced to introduce both, use the same technique to introduce the upper case letters as you have already employed for the lower case – use characters with straight lines and no serif.

Here are two examples to illustrate this difference.

Upper case with serif

GARABOLA

Upper case without serif

GARABOLA

Garabola (extra-light)
Garabola (light)
Garabola (medium)
Garabola (bold)
Garabola (extra-bold)

For a first reading book you should select normal characters for a continuous text and bold letters for headings as well as for free–standing letters, symbols and words.

Decisions at Text Level

Once you have decided how to deal with the characters you can come to the text, and look at the following aspects.

Character Spacing

The space left between letters within one word ought to be chosen for maximum readability, neither too large as can sometimes happen when texts are written in columns, nor too small.

This point is important when you are working on a reading book. If you have used straight–line characters, you will notice that the absence of serif makes it difficult for beginners to read certain combinations of letters; narrow letters, such as **l**, **t** and **j** are difficult to identify when they are followed by an **i** with automatic spacing.

To help solve this problem, you should widen the space between characters slightly. By way of illustration here is one word written with automatic spacing and one with slightly wider spacing.

Garabola
G a r a b o l a

Word Spacing

Garabola is a reading and writing book for first-grade pupils in Madagascar's primary schools. It is written in Malagasy, printed in monochrome and stapled.

Garabola is a reading and writing book for first-grade pupils in Madagascar's primary schools. It is written in Malagasy, printed in monochrome and stapled.

Garabola is a reading and writing book for first-grade pupils in Madagascar's primary schools. It is written in Malagasy, printed in monochrome and stapled.

Paragraphs

In texts which address experienced readers, the start of a new paragraph is marked by different line spacing, by indentation of the first line of the paragraph or by a first line which starts further to the left than the body of the text.

In a first reading book the start of every new paragraph should be clearly indicated, if necessary by double line spacing.

Once again use this book to familiarise yourself with the possible ways of indicating the start of a new paragraph.

Line Length and Justification

The length of the line again should ensure good readability; when the characters used are small, the line must not be too long so that the reader can find the start of the next line without difficulty.

It is possible to allocate spaces between words to make a line a predetermined length or width; then we say that the text is justified or aligned at the right and left–hand sides. This is not recommended for a first reading book where words would be stretched out to avoid hyphenating them, which in turn would not make for good readability.

For a first book, unjustified or ragged–right settings are generally preferred, i.e. the left hand edge of the text

There is no better way to avoid errors of this sort than to re–read the text, draw up a detailed table of contents and compare it with the body of the text as often as necessary.

Additional Visual Aids

In a school textbook the hierarchy of texts is sometimes such that it is not enough to alternate between characters of different sizes and weights; additional visual aids may be necessary.

These should be used to the extent appropriate and necessary; excessive or inappropriate use of additional aids will only confuse the reader. The aids we outline below have a place in a reading book.

Boxes and Lines

To underline the separation of two distinct parts of a page, or to draw attention to one element or emphasise the unity of one exercise, you can use a box or a fine line.

You will see from this book how we have used these aids. You will find a certain number of boxes, most of which have only horizontal lines. We have used lines with circumspection, but you will find them, for instance separating pieces of information in tables or separating the body of the text from the running head on each page.

Shading

To underline an element or a distinguish between different levels of text, a slight grey or coloured shading can be used. You should only attempt this if the assembly and printing conditions are good. Nothing looks worse than letters which are to be emphasised that are badly printed or badly shaded. Once again look at the use we have made of shading in this book.

Pictograms

In a first reading book one is tempted to use symbols which it is felt will be easier for the children to decode. Thus slates are used to indicate a written exercise instead of a heading, while silhouettes are used to represent the speakers, dispensing with inverted commas. But again avoid overkill – keep the use of

You have submitted your manuscript to a keyboard operator. Before doing so you checked to make sure that there were no spelling errors in the manuscript, that no more corrections had to be made to the text, that the length of the text was in line with the layout requirements and that the punctuation had not been forgotten.

The first set of proofs you get back will surprise you; you will not always recognise the manuscript that you have slaved over for so many months... which is just as well, because it gives you a certain distance to the text and allows you to spot composition errors better.

In general the first set of proofs contains only the typewritten text in continuous form, without any concessions being made to the layout. Your corrections must thus meet the following criteria.

Clarity

Use a red pen to append your corrections and write as legibly as possible.

This recommendation always applies, but it is all the more important when you have a manuscript in a national language which the keyboard operator does not necessarily speak or write well. Form every letter with great care if you want to avoid the keyboard operator making more errors as he or she corrects the first set, which will only add to the number of times you have to proofread.

The groups of authors which we have had the opportunity of observing have always corrected by hand, indicating in the margin when a letter or word must be changed, added or removed, a paragraph inserted or two syllables joined up. They either rewrote the entire word or gave detailed instructions as to the changes to be made, and these instructions were generally understood without difficulty by the keyboard operator. You too can adopt this procedure, but you must be careful that your instructions and corrections are always clear.

Official systems of proof correction marks do exist. They are used by professional proof readers and can be found in most books on layout and typography; you can refer to these works if you wish to upgrade your work – but check first that the keyboard operator is familiar with them, or far from enhancing the results you may face a disaster.

Precision

The proofs that you have re–read and corrected should now be submitted once more to the keyboard operator, who will not only incorporate your corrections, but will then do the layout. He will follow your instructions as regards the characters and text features, and will then submit to you another set of proofs which you will once again have to re–read and correct. You must pay particular attention to the following aspects at this stage.

Spelling

Re–read the proofs one last time. No effort can be too great to locate a missing point or a spelling error in a text designed for beginners. You will be held responsible for all mistakes – and this is the sort of mistake your readers will be quick to note.

Split Words

Generally, when the text is arranged in columns some words will be split at the end of the line – check that this has been done correctly.

For languages in world–wide use you will find computer programmes which hyphenate words automatically. When you are working in a national language for which there is no such programme, pay particular attention to this point.

Hierarchy of Texts

If you plan to use different characters, or different sizes and weights of characters check that your instructions have been properly followed, in particular that the hierarchy of texts has been properly respected. Paragraphs must be treated uniformly.

A heading in the same size of characters as the normal text, a word which has not been printed in bold print as planned, or one paragraph which is indented while all others are not – all these errors will make your book less readable and thus reduce the quality of the finished product.

Graphics Dossier

In our experience, many groups of authors are tempted not to finish their work in an attempt to accelerate the printing work. They submit an incomplete job envelope and think that they will complete it afterwards.

But, once the printer has the job envelope, those concerned with the development stage almost automatically consider their work over.

It is then very onerous to complete the work properly, because it is difficult to find every missing element: the illustrator appears to have vanished off the face of the earth, the photocompositor has other urgent work to finish or it is impossible to consult all the authors, since the group has been disbanded or sent elsewhere.

It is thus imperative to go through the job envelope one last time while all the actors are still present and correct. You should focus, in particular, on the two following aspects.

Complete Development

All the many elements of the book should now have been duly prepared; you should not find the four cover pages are missing, or find that one page has vanished or that you are suddenly missing a text or graphic element on any of these pages.

For many years, we spread out the dossier on a desk, leafing through the pages one after another, which meant that we never had a complete vision of the dossier as a whole. Now, however, we believe that the best way to ensure that nothing is missing is to stick up a photocopy of your entire model on pinboards. This allows both authors and outsiders literally to take a stroll through the book. We have found that the physical distance this gives you allows you to note certain omissions and even to find (more!) typing or spelling errors which can still be corrected at the last minute.

We would thus urge you to adopt this procedure, and not to be content until every member of your team has examined the book page by page and signed each page on the pinboard.

Complete Job Envelope

Secondly, check that all the original documents have been put together and all the necessary instructions given to allow the printer to produce the books without difficulty. You should then examine your textbook page

We would just like to draw your attention to one last point: you should never make author corrections on the blueprint. Do not give in to the temptation to improve your text at this stage – it is too late. What can happen, of course, is that you spot another typing error, which you must, of course, correct. This is, however, the absolute exception, and if you have read this book attentively we will not have to explain why.

6. In Conclusion

Calculating the Sales Price of the Book

The production of textbooks in developing countries is a long process and requires the attention of the authors throughout. Once the process is launched the authors rarely have time to stand back and evaluate the price of the operation.

There is, however, so much at stake that you must gauge the viability of the exercise. An examination of the costs should allow those concerned to better manage their work in future: authors and publishers thus have a good basis on which to determine the physical and graphic aspects of a series of books, and on the best way to produce them, or the final version, where you have been working on a pilot version.

This work should be performed by specialists who will take into account the following[11].

Printing and production costs

At the end of the conceptual phase you had a provisional quotation drawn up for the production of your book, based on approximate figures. You now have the precise figures, since the printer has been able to update and modify his prices. You can thus take the figures in his final quotation.

Development costs

These costs include all costs incurred from the preliminary research phase until the job envelope is submitted to the printer, i.e. all the costs of preparing the manuscript, the graphics dossier and the layout work.

[4] If, however, you are forced to deal with the legal side of things look at the question of authors' rights and royalties, and be sure and consult the books recommended here.

[5] The pupils are expected to recognise not just any old fish but the "tilapia" which is well known in Madagascar, which is why the changes had to be made.

[6] Layout problems are not new: in the thirteenth century the French architect Villard de Honnecourt proposed a model which divided the page harmoniously; today research is still being conducted; some of the most interesting includes the work of J. Tschichold and R. Rosarivo, which you will find in the books on layout listed at the end of this chapter.

[7] Most of the changes to the illustrations and the layout of *Garabola* were made by Marina Dinkier, a professional graphic artist. These modifications significantly improved the final version. Cf. Dinkier, M. *Mise en page et préparation pour l'impression.* Internal paper, Tef'Boky Project, 1990.

[8] The major classifications are the work of Thibaudeau (1921), Vox (1952), Novarese (1964), Jacno (1978) and Alessandrini (1980). They are based on various perspectives (historical, aesthetic, geographical, etc.).

[9] In this classification the two last groups (Gothic and non–Latin characters) are not generally particularly relevant for textbook authors.

[10] If the textbook is to give examples of handwriting, you should bear in mind that computer programmes which can reproduce writing of this sort are expensive and rarely meet all your requirements. It is often a good idea to have examples illustrated by hand.

[11] We refer you to the costing grids proposed by F. Richaudeau in *Conception et production des manuels scolaires,* op. cit., pp. 215–239.

Recommended Reading

Preparation and Re–Reading Copy

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To Sum Up

All the work we have described until now, has been geared to producing the raw material of the textbook. To make it publishable, you must now polish it and put it into its final form. To put it more plainly, you must have the illustration and the layout work done.

At this level everything is still open: a good manuscript can become a good book, but it can also be made into a monotonous, abstruse or obscure book. The illustrations and the layout of a book give the contents their contours, which will promote or block learning. You should thus illustrate the texts in a functional way. Do not decorate. Create references which will help the reader without trying his patience. Establish a rigorous and transparent structure for your book which will not bore readers.

This work demands unique expertise, an expertise which not all authors of textbooks in developing countries possess – sometimes they are not even aware of how important it is. Given the fact that few of them will have recourse to a professional and that there are few long–term training courses, they should try to train on the job, by

- demanding sporadic support from technicians on the spot, and in particular from the printer
- using specialised reference works on layout in particular
- acquiring certain mechanisms as they read, so that they register not only the contents but also the graphic features of printed materials.

This phase is over when the job envelope has been submitted to the printer. It should be so well prepared that contacts with the assembly man and the printer are kept to a minimum.

Even if the author's work is now finished, it is vital that the work performed be recapitulated and costed. Specialists should always calculate the price of the book, taking into account not only the development and

The fruit of so much work will now ripen rapidly as far as you are concerned, for the printer's deadline will bear no relation to the time you have spent up to now. The printing is generally the shortest step in the entire chain, assuming that the authors have made all the necessary preparations.

The joy and pride you will feel the first time you take your book in your hands and flick through it will almost inevitably be slightly dampened. You will be disappointed that the margins are so narrow and that you didn't notice before, that the grey of the shading is too dark or because at this stage you find a typing error in a prominent position, quite inexplicably in view of the care with which you compiled the manuscript and the model.

It is undoubtedly true that errors of this sort detract from the quality of the book, and may discourage authors, but they are minor details, even if people rush to point them out to you. The most important thing is that the book exists and that it is of an acceptable quality. By producing this book in such difficult circumstances you have blazed a trail for other publications of even better quality. In view of the urgent demand for textbooks in many developing countries, and the production conditions commonly encountered, minor shortcomings such as those mentioned above are relatively unimportant.

The publication of a book always marks the end of a long and intensive period of work. Given the book situation and the scarcity of experienced textbook authors, it is to be hoped that the skills thus acquired will be shared; that all those who toiled to make their contribution to a quality publication will continue in this line of work.

But, do not fall into the trap of thinking that your training is complete after the first book. You will never have learned everything there is to know, and the quality of your work will always depend on the diversity and solidity of your training. Every book you work on will be a challenge in its own way, and you will have to find individual, tailor–made solutions in each case. Your products will gradually improve the more experience you have and the more you learn. Keep in touch with professionals in the world of publishing, gather your own documentation, examine the contents and form of other printed materials, in particular textbooks, to try to help improve the efficiency of schools in your country.

Annexe: Evaluation

1. Overview

One of the main difficulties which you will face in your evaluation work is bound to be the logistics. In some cases, you will already be involved in other work, like drawing up your next book, and in others the education authorities will exert a lot of pressure on you to produce the final version as rapidly as possible[1].

Whatever the specific constraints you will almost always be working under time pressure, which means that you must plan the evaluation activities meticulously to ensure that you achieve the quality required within the given time–frame.

Evaluation is a major task which will often take an entire year. To give you an idea of the scope and the complexity of this phase we will sum up the major steps taken in the Tef'Boky Project to evaluate the first version of *Garabola.*

Evaluation Work for Garabola

Aspects, Strategy, Instruments

October 1988

Once production work on the *Garabola* set (reading book, writing book and teachers' guide) was completed, the authors were quick to set up an evaluation system so that the evaluation could start at the beginning of the academic year. They drew up a list of the aspects to be examined, and then decided on a strategy and the research instruments that they would need to give them the information they required.

This was one of the most labour–intensive phases of the entire project, involving the following tasks in addition to the evaluation per se:

- designing and organising a system to distribute the *Garabola* materials to the schools in the test zone

- designing, organising, realising and evaluating the presentation of pilot materials to the 40 teachers concerned

January 1989

The third instrument was a classroom observation grid, allowing the evaluators to look at the way *Garabola* was used over a one–week period; the authors themselves thus spent one week at the schools at the start of the second term.

Critical Examination of the Material

January 1989

At the same time the *Garabola* set was sent to various individuals for a critical examination. It was accompanied by a form letter, inviting the recipients to make their comments and suggestions.

This action brought absolutely no results; not one single comment filtered back to the authors. It may be safe to assume that personalised questions would have had better results.

Second Test Series

March–June 1989

The last evaluation instrument consisted of tests to gauge reading and writing progress. Preliminary tests were firstly run in two rural schools after which the instrument was modified. To give a comparative analysis of the year–end results the tests were run in 20 of the schools in the test zone and 20 control schools. The working conditions in this control group were comparable to those in the test schools, but they did not use *Garabola.* The evaluation team, duly instructed, ran the tests; the team members took advantage of this field visit to gather documents, first and foremost writing exercise books and gather information, such as the rate of attendance at the schools and the physical state of the books – all data which will help make for a complete evaluation.

Processing and Interpreting Results

July–August–September 1989

appropriate. If on the other hand they are clearly negative, you must examine these aspects in great detail and be ready to make far–reaching changes[3].

And bear in mind that the education authorities are bound to attach great importance to the test results. Their first questions are unlikely to concern the aesthetic qualities, the suitability or even the solidity of the book, but whether or not it produces results.

Shortcomings of the Content Matter and the Form

The tests should give you an idea as to whether or not your material works; these general pointers will not, however, tell you what need not be changed and what should be modified on each page.

Before you can revise your material page by page with full knowledge of the facts you will need an instrument which will allow you to examine every aspect in detail.

Let us assume that you have been working on reading and writing materials: you should then look at the topics chosen, the linguistic and pedagogical aspects of the texts, the characteristics of the illustrations and the layout of the pupils' materials as well as the contents and presentation of the teachers' guide, rather than focusing only on the learning method used.

The results should enable you to revise your materials advisedly, on the basis of the reaction of users.

Repercussions on Attitudes to School

In many countries school rolls are dropping[4], a development which is attributed to several different factors.

Although it is true that the rate of growth of school rolls in a country depends primarily on the household income, it is also linked to learning conditions. It can thus often be instructive to see if the introduction of the new material coincided with a drop in pupil absences or not.

Robustness of the Book

Although it is relatively unimportant if a pilot book looses pages or rips easily after one year of use, the revised

32. Identification of Evaluation Instruments		
Aspects–Indicators–Instruments		
Effectiveness of Material		
	School results	
		Attainment tests
		Verification of the rate of learning (in teacher's lesson plan for instance)
		Daily self–evaluation grid
		Classroom observation
Shortcomings of material		
	Teaching process	
		Daily self–evaluation grid
		Classroom observation
		Voluntarily kept log–book
	Learning process	
		Daily self–evaluation grid
		Classroom observation
		Analysis of pupils' exercise books
Repercussions of the materials		
	Parents' attitude	

In general, the existence of pilot materials in itself reassures the education authorities enough to stop them exerting undue pressure on authors to prepare a final version.

But if financial assistance has been pledged for printing and distribution, it is not unusual for time–limits to be set for the revision phase. In this case you will have to see how you can respect the deadlines without compromising the quality of materials which will then be used for several years in the schools of your country.

Human, Physical and Financial Resources

This is the second aspect to be examined when you come to plan your evaluation activities.

If you refer back to the experience in the Tef'Boky Project as presented earlier in this chapter, you will see that the authors delegated the responsibility for numerous tasks to a so–called evaluation group.

If you do not have this sort of back–up, and if your technical and financial resources are limited, plan your activities accordingly. Distinguish between what is desirable and what is possible, as you did during the preliminary research phase.

Scope of the Work

Time and special skills are always needed to develop instruments, but in developing countries, where research conditions are more complex than in industrialised countries, you will have to examine the entire evaluation phase, to avoid planning activities which are not feasible with the available resources.

In particular, no instruments should be used in the field without first undertaking a series of well–targeted preparatory measures.

It is, however, difficult to foresee all the work which instrument x or y will entail. To give you an idea of the scope of the work that lies ahead we list below the activities which we feel are indispensable to obtain significant results, if you opt for a comparative analysis of school results. Analyse these and draw your own conclusions for your specific circumstances.

Work Involved in a Comparative Analysis

• Select at least two schools, which correspond to the criteria laid down for the schools selected for the final test and administrative steps to allow you to run a preliminary test there

• Issue detailed instructions to those in charge of running the preliminary tests

• Conduct the preliminary tests

• Process results systematically and interpret these

• Make any modifications to the tests or the instructions given to those in charge

• Prepare a sufficient number of the final version of the tests.

Holding the Tests

• Plan the tests (e.g. identify those responsible for running the tests, available transport, sources of financing; draw up a schedule for holding tests school by school)

• Take necessary administrative steps and inform each school in writing when the tests will be held and what they will involve

• Issue instructions to those responsible for running the tests

• Make effective preparations for the field visit

• Conduct evaluation work in the field

• File immediately and systematically the tests and all other documentation collected in the schools on this occasion.

Systematic Processing and Interpretation of Results

[2] With *Garabola* first–grade pupils learn only 21 letters of the alphabet, whereas the current curriculum also provides for pupils learning 13 of the complex graphemes in Malagasy. It was thus particularly important to inform the education authorities about the results obtained in reading and writing.

[3] In the Tef'Boky Project the learning progress tests revealed that the writing exercise book was inappropriate given the current educational context in Madagascar. This led the authors to modify the make–up of the materials designed to teach writing in grade one of primary school. Cf. Chapter 4.

[4] "Although the rate of increase in enrolment declined at all levels of education, the drop was most pronounced at the first level, where it fell from 8.4 percent (approximately 2.9 million additional pupils each year) between 1970 and 1980 to 2.9 percent (approximately 1.4 million additional pupils each year) between 1980 and 1983." In: World Bank "Education in Sub–Saharan Africa" p. 28.

[5] The evaluation work is described in its entirety in KOMAREK K. Dossiers II, 1993.

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In the traditional publishing chain the author is responsible for providing texts.

In general these will be texts which address pupils (reading texts, exercises, captions for photographs or illustrations) and teachers (preface, presentation, table of contents, instructions and information on the cover of the textbook, as well as the entire teachers' guide and complementary didactic materials).

When the author does not have a good publishing structure behind him he may also have to assume certain editorial responsibilities, of a financial, technical, graphical and commercial nature.

Authorisation to Print

Authorisation issued by the education authorities to the authors to go ahead and have a given textbook printed.

Body Size

The size of a type character.

The size is expressed in points; by way of example the main body of the text of this book is printed in 10 point characters, while the chapter headings are printed in 22 point.

Character Count

Calculation of the number of characters and spaces in a text manuscript which allows one to calculate the approximate length of the text after typesetting and the number of pages in the book.

Character Spacing

The blank space between two characters within the same word.

The character spacing in a text may be normal, condensed or wide, and this choice has repercussions on the typographical readability of the text.

Devising all texts to be included in a textbook.

For a reading book, this phase involves choosing and/or defining the attainment targets, identifying the subject matter to be covered, the mandatory steps to be respected and the arrangement of this subject matter within the book.

In developing countries the difficulties are increased by the fact that textbooks ought to correspond to the official curricula, while the work involved leads authors to examine or reconsider targets which deviate too much from the reality in the schools of the country, otherwise the product may be totally inappropriate before it is even printed.

During this phase it is important for authors to be able to judge how much leeway they have to move away from the official guidelines.

Devising the Form

Devising the physical aspects (format, number of pages, binding) and graphic features (type, number and size of illustrations, rough layout, type of printing) of a book.

It is crucial that the form be devised before the writing and illustration phases so that the texts and exercises can be produced to fit a pre–defined framework. The important of this work is, however, rarely appreciated by teams of publishers–authors, which accounts for the "home–made" appearance of some of their products, which is totally disproportionate to the high costs.

Distribution of Textbooks

Important link in the publishing chain. In many developing countries the distribution of textbooks to rural areas where the majority of the school population live is difficult, and thus often constitutes an education project in it own right.

Documentation Specialist

Person put in charge by the publisher of finding all the documents to accompany the texts of a book, and of

They are not, on their own, enough to allow you to revise a pilot textbook and must be supplemented by other instruments (classroom observation, attainment tests, etc.).

Exercise Book

Didactic material considered appropriate or even indispensable for some subjects, such as learning to write. Exercise books are always expensive because they can only be used once.

Any decision based on the assumption that a set of materials must include an exercise book should be reviewed with great care by authors in developing countries.

Exercise–Image Unit

The contents and the form of an exercise.

In a good exercise, the contents and form will complement one another; the form can be a text–illustration, or may present the underlying mechanism of an exercise.

It is always a major challenge for textbook authors to develop exercises which allow for a strict progression of learning, ensure an agreeable visual effect and make the underlying mechanism transparent for teachers and pupils alike.

Feasibility Study

Study which precedes a textbook project and focuses not only on the demand for textbooks but also looks at the conditions in which the book is to be developed, produced and distributed.

No textbook project should be launched before a feasibility study has been conducted. Otherwise it is imperative for the preliminary research phase to include a study on the environment in which the books will be used.

Film

Order and classification of the different parts of a text.

When there is little publishing back–up the authors themselves will have to check the organisation of their texts, clearly indicating the level of titles and text blocks to ensure that the photocompositor can process them accordingly.

In a partly theoretical work, like a teachers' guide, the hierarchy of the texts is often particularly complicated to establish.

Imposition

Setting out the pages of the book on the sheet so that once the sheet is folded the pages will appear in the correct order.

Careful imposition can keep cost down by putting pages with colour illustrations together on one or two sheets thus limiting the number of sheets to be printed in two or four colours.

Initial Quotation

An estimate of the costs of printing and finishing a textbook, which the printer can draw up at the end of the conceptual phase. The initial quotation allows authors to compare the physical and graphic features they have planned with the budget available.

Innovation

Intentional transformation of an education system with a view to achieving the existing objectives or defining new, more appropriate objectives.

In a textbook project innovation is at the centre of all action and it is not easy to have it accepted. It concerns first and foremost the education authorities: the conception and execution of a project demands expertise and attitudes which are not always encouraged within a bureaucracy.

Innovation involves all those who are indirectly affected by the book: the curriculum unit, teacher training unit,

Language of Instruction

Language used as a medium of instruction.

Sometimes this is the mother tongue of the pupils, and sometimes it is another language of which they have a more or less good command.

During the feasibility phase of a textbook project it is absolutely crucial to determine which is the language of instruction.

Language Taught

A language which the pupils must learn as a subject in its own right. In most developing countries, pupils must learn a European language in their first few years of school.

During the conceptual phase of the textbook the authors must determine the grade as from which pupils learn this language and the amount of time accorded to it, so that they can determine how much time is left to learn the mother tongue.

Layout

Arrangement of the blocks of text and graphic elements on a page.

An examination of primary school text–books produced forty years ago shows that the layout is the one element which has evolved most in the course of time and which is thus the clearest sign of modernity. Today there can be no doubt that good layout is not a luxury but a necessity for a textbook. But it must play second fiddle to pedagogical and didactic demands, and it must stay within the limits of what is acceptable to the target group.

The layout of a textbook emerges little by little parallel to the content matter. It is still vague during the conceptual phase, becomes more definite during the writing phase and takes on its finished form just before the book is printed. It is up to the authors to ensure that it performs its primary task – to help learners.

Loan

The act of one language borrowing an element from another language.

By extension, a loan word is a word used in a given language that has been borrowed from another language.

Manuscript

Hand–written document. By extension text written by authors and submitted to the publishing unit after typing.

National Language

The mother tongue of a social group which is generally dominated socially or politically by another group, which speaks a different language.

Most national languages have a difficult and hotly contested entry into schools. While recognising that they allow pupils to better assimilate knowledge, their detractors point out that they are not properly normalised and standardised.

Authors working on textbooks in national languages where this is the case should check the congruence of the alphabet, see that spelling and punctuation rules are respected and enrich the language by creating the technical and scientific terms they need.

Nationwide Introduction

Phase in the production of textbooks in developing countries.

In the typical production cycle, authors will produce a textbook which is then tested, evaluated and revised before a large run is printed and distributed to the various parts of the country for widespread introduction.

Non–Text Information or General Information

Texts which accompany the contents of a book.

Pagination

The sequence of page numbers of a printed book.

Paper Wastage

Paper wasted due to a disharmony between the format of the book on the one hand and that of the sheets of paper and printing presses on the other.

Paper wastage should always be kept to an absolute minimum; in developing countries where the price of the paper may account for one–third or even half of the total costs of producing the book, this is all the more important.

Passed for Press

Authorisation issued by the publisher or the publisher–authors to the printer to expose the plates and print.

The blueprints must be signed to confirm that the assembly and the imposition are correct and that the work is ready for engraving.

Pedagogical Specifications

List of the most important pedagogical and didactic aspects to be taken into account in the materials to be produced.

In large publishing houses the Publishing Manager draws up the pedagogical specifications, which then constitute a detailed frame of reference for the authors.

In developing countries, this is rarely the case. It is almost always the authors themselves who draw up the pedagogical specifications on the basis of an in–depth analysis of the status quo.

Pilot Textbook

Each of the tasks performed by a printer to transform an imposition scheme into a finished product is either performed on the instructions of the publisher (e.g. purchase of paper, or choice of binding) or supervised by the latter (e.g. reading proofs before signing them ready for press, or checking the blueprints before marking them ready to engrave).

The printer should never be forced to take on tasks that are the responsibility of authors (correcting or completing texts) or of the illustrator (completing a page with illustrations), layout person or graphic artist (making typographical choices and deciding on layout).

Printing

Major link in the publishing chain.

Printing is not the sole responsibility of the publisher or the authors. But, during the conceptual phase it is up to them to ensure that the printing conditions are such that the work they plan can be effected at a later date (no 4–colour printing if the machines are not sufficiently precise, for instance). During the printing phase they are also responsible for checking that the results correspond to the terms of the contract with the printer.

Proof Reader

Individual whose skills and/or status is such that they can give textbook authors valuable suggestions or encouragement.

No publication should be printed until it has been screened by a number of proof readers. Time and energy are needed, however, to organise this phase, and textbook authors would do well to consider it a mini project in its own right.

Proofs

Provisional print–out of a text that has been set and composed by computer. Proofs must be re–read and corrected.

Publisher

When textbooks are being produced in a national language, a few more specialists are required. Teams of authors must often call on the services of anthropologists, sociologists, statisticians, linguists and/or experts in the teaching of a second language.

Ream

Package of 500 sheets of paper of the same format.

Recto

The right–hand page of an open book where the book has an odd number of pages. It is the page that one tends to see flicking through a book. The title of a book should always start recto, as should the chapters as far as possible.

Research Institute

Research or teaching centre which may be private or public.

In textbook projects for primary level it is a good idea to seek the support of universities and teacher training colleges, so that the workload of the authors can be lightened by delegating some research work and incorporating existing structures in a common project in this way.

In practice, however, the gulf that generally separates these bodies often makes cooperation an uncomfortable affair.

Resource Person

Individual who gives the authors detailed information, generally of a socio–cultural or socio–linguistic nature.

The resource person cannot be considered an author; he provides the information, but plays no part in devising or developing the textbook.

Revised Textbook

Signature

A collection of at least four pages, and more often 16 or 32 pages which are printed together on one large sheet of paper. The sheet is then folded several times so that the pages are in the correct order. A book is generally made up of several signatures.

Speaking and Listening

Sub–discipline of the “mother tongue”, in addition to reading and writing.

Survey Report

Document presenting the main results of preliminary research regarding the development of textbooks.

The survey report is not indispensable for authors who are able to start the conceptual phase on the basis of the data they have gathered, but it is important for the education authorities.

To prepare the ground for the new textbook, authors are recommended to prepare a survey report, or have this done, and to present it to the relevant authorities.

Teachers' Guide

Reference book for teachers.

The teachers' guide should always be part of a set of didactic materials; in some cases it can even replace the pupils' textbook.

The teachers' guide must offer teachers with a low level of professional training a supplement to their training and a sort of “script” with detailed instructions on how to conduct day–to–day lessons in a given subject.

The guide is the ideal vehicle for teaching innovations in developing countries, unlike industrialised countries, where innovation generally originates from research institutes and is circulated in specialised technical journals.

Textbook projects involve either one phase in the publishing chain, such as large–scale production and distribution of existing books, or the entire chain from the feasibility study to testing, large–scale production, distribution and teacher training.

These projects demand human resources, technical inputs and funds and are often supported by bilateral or multilateral assistance.

Text Exercise

Exercise consisting solely of text, with no concrete or abstract illustration (diagrams, frames, etc.).

Text–Illustration Exercise

Exercise which is made up of a text and a graphics part.

In reading books for primary level these are useful to teach pupils to compose, complete or change words and sentences. There should always be at least one text–illustration exercise to lighten the extreme dullness of text exercises.

Text–Image Unit

The contents and form of a text.

In textbooks which address the primary level, and particularly in reading books, authors must not only devise and write good texts. They must constantly be alert to ensure that their texts lend themselves to illustration.

The interaction of the form and the substance allows the authors to achieve this best.

Time–Table

Official learning time.

Where several different time–tables exist side by side for pupils of the same grade, the authors' work is made

Word Card

Piece of card on which one word is printed. Word cards are commonly used by teachers to help pupils make up and change sentences. They are useful for pupils learning to read.

Word cards are only suitable for use by individual pupils when good storage facilities are available in the classroom.

Word Spacing

Blank space left between two words in a sentence.

Word spacing may be normal, condensed or expanded and the choice will have an impact on the typographical readability and the aesthetic quality of a text.

Back Cover

Since 1960 the DSE, in cooperation with national and international partner organizations, has given advanced professional training to more than 100,000 specialists and executive personnel from more than 140 countries. An increasing part of the programmes takes place in the developing countries, the rest in Germany.

The DSE makes its contribution to development cooperation on the basis of guidelines of the Federal government's development policy. The institutional contribution donor is the Federal Ministry for Economic Cooperation and Development (BMZ).

The DSE was founded by the Federal and Land governments in 1959 on the initiative of the political parties represented in the German Bundestag as a foundation under civil law. Its main seat is Berlin, and its other locations are Bonn, Bad Honnef, Mannheim, Feldafing, Zschortau, and Magdeburg.

Code Europe was established in Oxford as a UK charitable organization in May 1993 as part of the international CODE network which includes CODE affiliates in Canada, USA, and ten countries in Africa (Ethiopia, Ghana, Kenya, Mali, Malawi, Mozambique, Senegal, Tanzania, Zambia and Zimbabwe), and two in the Caribbean (Belize and Guyana). The overall CODE programme includes book distribution, library development, and support for indigenous publishing industries. As part of the worldwide CODE network, it represents the overall organization in Europe, and develops and manages projects in partnership with organizations in the developing countries. CODE Europe's *Partners in African Publishing Programme* aims to increase collaboration between publishers and organizations in Europe and Africa.

ISBN 0 9528651 0 6