Illustrations
Dorsi Germann

Typeset & Layout
Fritzler & Fritzler Satz, Braunschweig

INTRODUCTION

In many countries, where natural science and technology are only now being called on to help solve the problems facing the land, educational planners and educationalists have to decide how to meet this challenge in science teaching at primary and secondary level. Conventional teaching media, which must generally be imported, are beyond the means of the already stretched education budgets and some teaching aids, that look to promising, do little more than confuse pupils, without helping to answer the questions.

Time, and a detailed knowledge of the regional problems will be needed in order to find a promising future solution for each country.

We would like to present one possible solution in the form of this collection of fundamental scientific experiments, requiring few, simple and readily available materials and inputs. Experience in many and varied projects, along with evaluations of the relevant curricula and of the schooling situation in various countries spurred us to take this step.

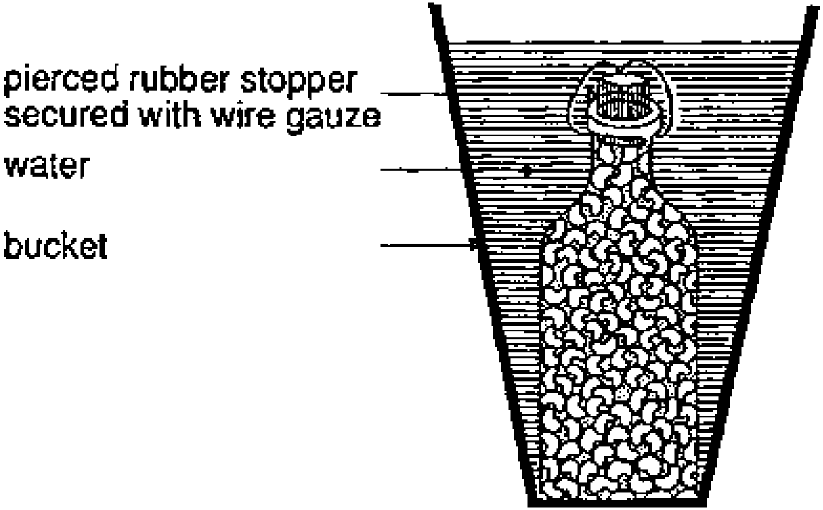
What has emerged is a collection, which we feel is in line with the level of previous methodical and didactic knowledge of the teaching staff, who are often inadequately trained for the tasks they are expected to perform. It provides the information needed for an interesting lesson and is meant to appeal the various intellectual faculties of children. To this end the experiments are described in simple, easy to understand language, and designed in the form of lesson blueprints.

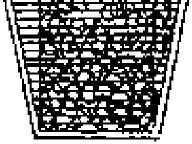
Materials and Apparatus:

bean or pea seeds
a. sand, water, a bottle, a pierced rubber or cork stopper, bucket;
b. gypsum, water, a small cardboard box, a vessel.

Procedure:

a. A bottle is completely filled with either bean or pea seeds and sand. The sand fills the spaces between the seeds. The bottle is tightly sealed with the pierced stopper. The stopper can be secured with wire gauze. The bottle is placed in a bucket filled to the rim with water. The bottle has to be totaly submerged.





Observation:

After a few days the bottle and the plaster block shatter.

Analysis:

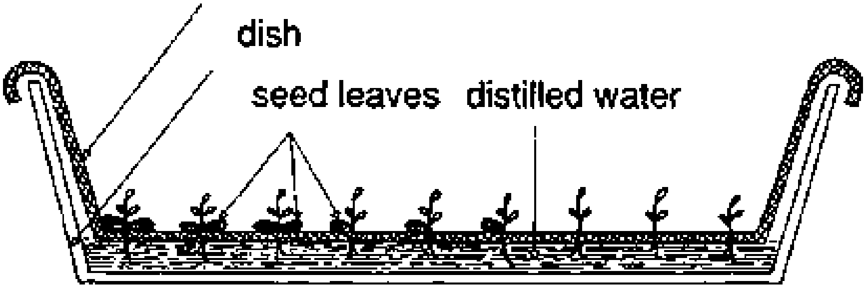
The seeds expand in volume to such a degree that the bottle and the block of gypsum shatter.

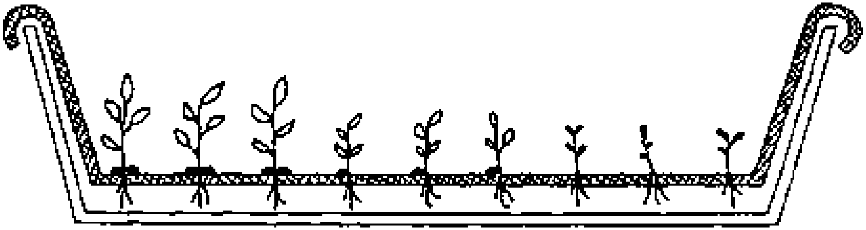
Importance in Nature:

Such power is necessary to push away the ground when the seeds swell in the soil. Otherweise they could not germinate, because they need the intake of water to make the stored nutrients in the seeds usuable.

1.2. THE TASK OF THE SEED LEAVES (COTYLEDONS) OF BEAN OR PEA SEEDLINGS

Main Goal:





Observation:

The seedlings without any seed leaves have not grown.
Those with just one seed leaf have hardly grown.
The seedlings with two seed leaves have grown noticeably.
All of the seed leaves have withered.

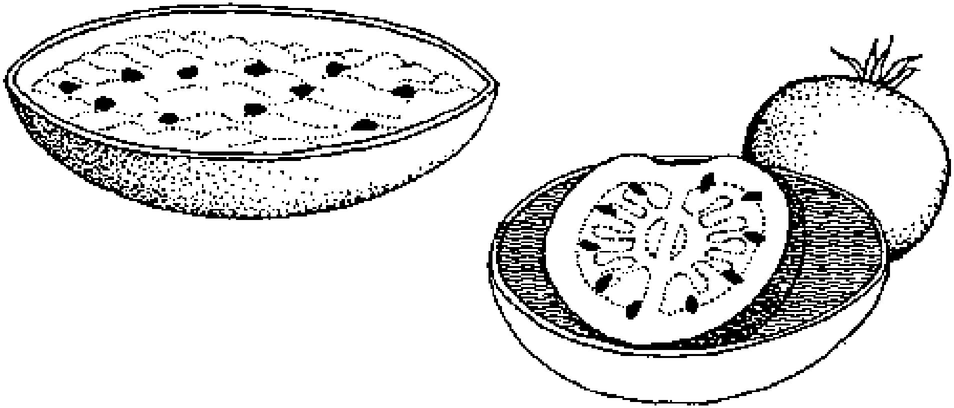
Analysis:

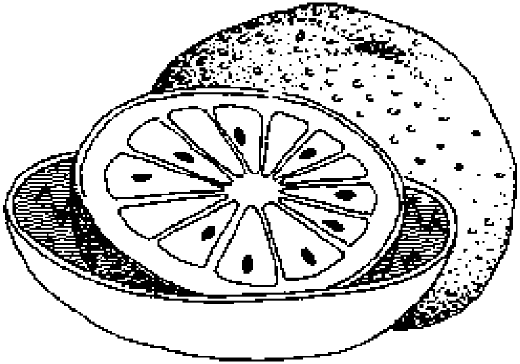
4 round filters, or absorbent paper, or cotton wool
5 round dishes, about 10 cm in diameter (e.g. lids of jam jars)
1 knife water

Procedure:

40 cress plants are soaked for about 10 minutes in one dish filled with water. (The swelling process takes longer if other fruit seeds are used, and some are not capable of germination.)

Meanwhile the moistened filters and the cut parts of the fruits are placed into the other dishes. Ensure that the equipment and your fingers are clean when you cut the fruits and place the parts into the dishes, otherwise you can get blue mould growing on your experiment. If blue mould should grow nevertheless repeat the experiment. The swelled cress seedlings are distributed among the four dishes as shown in the diagram below. They are observed for 4 – 5 days.





1.4. PLANTS DO NOT GROW WITHOUT LIGHT

Main Goal:

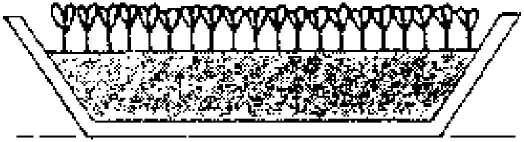
This experiment demonstrates that plants wither without light.

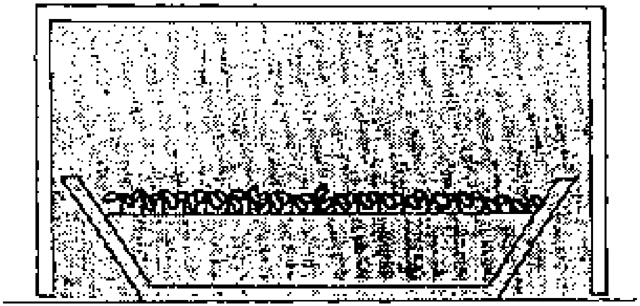
Information:

Plants require light to produce carbohydrates from carbon dioxide and water. (The carbohydrates are decomposed gradually by the metabolism of the plant. During this process,

Observation:

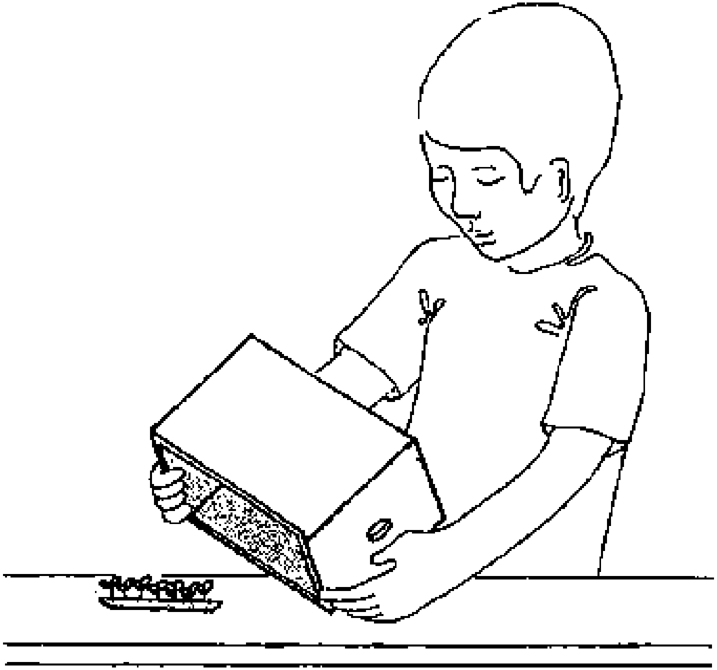
After a few days it can be observed that the leaves of the plants under the cardboard box have turned yellow. The plants do not grow further.





Analysis:

7



Observation:

1.6. PLANTS TRANSPORT WATER

Main Goal:

This experiment shows that plants transport water. There are ony few flowers which are suitable for this experiment.

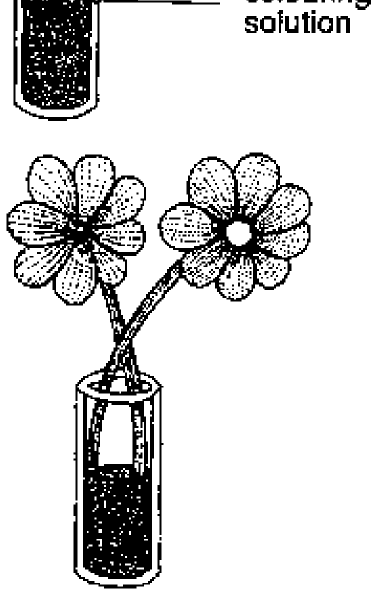
Information:

Plants contain vascular tissue. The xylem (woody tissue of a plant) conducts moisture and mineral salts. The phloem (sieve–tube tissue) serves as a path for the distribution of synthesized food.

Materials and: Apparatus:

white or yellow flowers like sowbread, snowdrop, white lilies, impatiens and other flowers with somewhat hyaline stalks and petals. You can also use small twigs of deciduous trees with very young leaves. It may be necessary to test some plants available in the country where the experiment will be carried out.
water–soluble 1% red or blue colouring
(red or blue ink, acid solution)
1 glass or plastik beaker, approximately 15 cm in height
(depending on the length of the plant stalks)
water
knife

Procedure:



Observation:

The colouring solution can soon be seen in all parts of the plant. The way it moves up the stem can be clearly observed.

Analysis:

Water is conducted into each part of the plant by the **plant's vascular tissue. Thus, a permanent water supply is guaranteed.**

leaves by releasing poisonous gases).

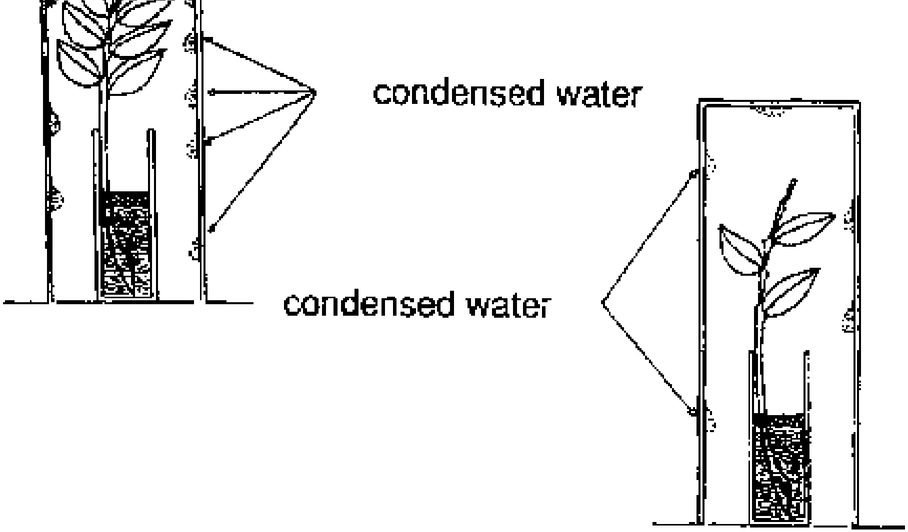
1 glass or plastic beaker (about 10 cm in height)

1 glass only (about 20 – 25 cm in height)

Procedure:

The branch is cut obliquely under water and then placed in the smaller glass or beaker which is filled 2/3 full with water. 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 water rising in the stalk. Then oil is carefully poured into the glass to form a 0.5 cm layer on top of the water.

The larger glass is placed upside down over the apparatus. Place the experiment in cool surroundings This is the only way in which you can see the outcome because the evaporated water will only condense on the walls of the glass if the glass is cool.



Analysis:

The condensation is water, which can only have evaporated via the leaves.

This process is known as transpiration.

The moisture evaporates through tiny holes on the underside of the leaves.

As the number of leaves increases, so too does the transpiration via the leaves.

Addition:

In order to do this, mineral salts and water are indispensable.

Terrestrial plants absorb the mineral salts, which are dissolved in the soil, through their roots.

Materials and Apparatus:

20 beans plants or other plants

2 glass or plastic vessels

2 pieces of wire gauze (or 8 test tubes with flint pebbles to hold the plants)

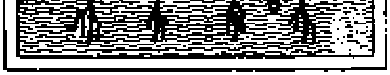
tap water

distilled water

1 bucket loamy soil

Procedure:

Put a small shovel of soil into the bucket and add a large amount of water, so that you can stir the soil. Then fill the two dishes with the water obtained from the soil. This water contains nutrients from the soil. Put the gauze onto the dishes and ten beans on each of them. Make sure that the beans are regularly moistened. Watch the experiment to prevent funghi starting to grow. When the beans are about 5 cm high, replace the soily water from one of the dishes and replace it with distilled water. Rinse off the roots of those ten beans thoroughly but very carefully, **without removing them from the gauze.** Then put those beans into the vessel with distilles water.



Analysis:

Distilled water does not contain mineral salts. Like soil, normal water contains mineral salts. These are necessary for the vital functions of the plants.

1.9. PLANTS PRODUCE OXYGEN

Main Goal:

This experiment demonstrates that a gas, oxygen, is produced during photosynthesis.

Information:

In their green leaves, with the help of sunlight, plants produce glucose and oxygen from carbon dioxide and water. This process is called “photosynthesis”.

Materials and Apparatus:

In different countries there may be other plants which are suitable for this experiment, waterweed (elodea)

glass vessel

Observation:

Gradually the water in the tube is replaced by gas. The glowing chip lights up.

Analysis:

The gas produced by the waterweed could be oxygene or methane. You can exclude methane since, although it is a gas left by anaerobic bacteria in rotting organic matter, it is poisonous to plants.

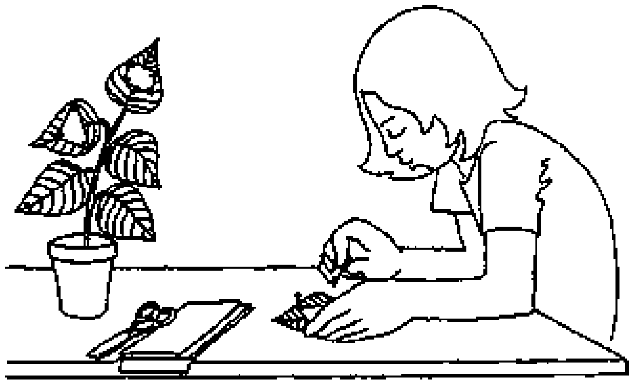
Importance in Nature:

Human beings and animals need oxygen to breathe. That is: We depend on plants producing oxygen, as do all animals. Therefore it is necessary to protect plants and the areas where they grow.
See experiments botany 1.12 und human biology 2.10.

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.

b. The leaves are cut off the plant and the patterns are removed. **Before heating the water put the alcohol aside so that it cannot be inflamed.** Boil the leaves for about five to ten minutes (depending on the hardness of the tissues of the leaves used).

After extinguishing the burner the leaves are dipped into the alcohol until the chlorophyll is almost extracted. This should take about five minutes. Then place the leaves upside down on a plate and drop up to five drops of the iodine solution onto each leave. Rub the solution into the tissue of the leaves with the tip of a small stick. Leave the experiment for about one or two minutes. Then rinse the leave.



Observation:

Where starch is present the iodine will turn to a bluish brown or a deep dark brown. Parts without starch will become only a little bit yellow brown.

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

Potatoes have a high starch content. When iodine–potassium iodide solution is dropped onto a cut potato, the surface turns a black–blue colour immediately.

(The blue–black colouring results from an inclusion of iodine molecules into the twisted arrangement of the starch molecules.)

1.11. THE PRODUCTION OF GASES BY PLANTS UNDER DIFFERENT CONDITIONS

Main Goal:

This experiment demonstrates that the amount of gas produced by plants depends on the amount of carbon dioxide available.

Information:

Plants transform the carbon dioxide from the air or water with water and energy from sunlight into sugar and starch. During this procedure so much oxygene is produced that the plant cannot use it all. This surplus of oxygen escapes from the plant.

Materials and Apparatus:

a glass vessel, e.g. a jam jar
boiled water which has been left to cool down
soda water

Importance in Nature:

With this experiment, botany 1.10 and human biology 2.10 you can explain by yourself the circle of oxygen and carbon dioxide in nature and how animals and human beings depend on plants and vice versa.

1.12. THE TRANSPIRATION OF PLANTS

Main Goal:

This experiment shows that a large account of water evaporates through plant leaves (more than evaporates from an open surface of water).

Information:

Plants transpirate through their leaves.

On the lower side of the leaf there are many small pores, stomata, through which the steam excapes. Only one percent of the surface of the leaf is covered with those stomata, but more water escapes there than from a surface of water as large as the whole surface of a leaf.

Materials and Apparatus:

a big beaker (about a litre), e.g.
a preserving jar a dish measuring about 20 cm in diameter, e.g. a plate
a platform balance with several weights
a bunch of twigs with leaves

Importance in Nature:

Only a little area of the lower surface of the leave is needed to release enough water to enable them to take as many minerals from the soil as necessary. The leaf remains stable in this way. There are only small parts where germs can get into the plant. There is another example of optimal compromises in nature.

1.13. GERMINATING PLANTS IN DIFFERENT CONDITIONS

Main Goal:

This experiment shows that seeds, in this case pea seeds, need air to germinate.

Information:

see analysis.

Materials and Apparatus:

ten pea seeds (other seeds have to be tested)
two dishes with a rim high enough to cover the pea seeds with water
cotton wool or some other such substance to keep the pea seeds moistened

Procedure:

2. HUMAN BIOLOGY

2.1. HEAT RADIATION OF THE HUMAN BODY

Main Goal:

This experiment demonstrates that the human body, like all other substances, emits heat to a colder surrounding.

Information:

The average body temperature of a healthy human being is 37° C. This temperature is maintained by the various metabolic processes (see experiment "HEAT RADIATION").

Materials and Apparatus:

1 thermometer, if possible filled with alcohol rather than mercury

Procedure:

a. With the thermometer, the body temperature is measured under the armpits.

b. Fix the thermometer in a stand (e.g. a small branch in a pot with sand). Put one hand round the lower tip of the thermometer, close to it, but without touching the tip.

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

Practical Use:

Human beings choose their clothing according to the outside temperature. To keep the heat radiation of the body at a low level, the Eskimos in Greenland wear thick furs. In southern warm countries, thin and often lightly coloured clothing is worn. It reflects the radiation of the sun better than dark clothing.

2.2. SENSATION OF WARMTH AND COLD

Main Goal:

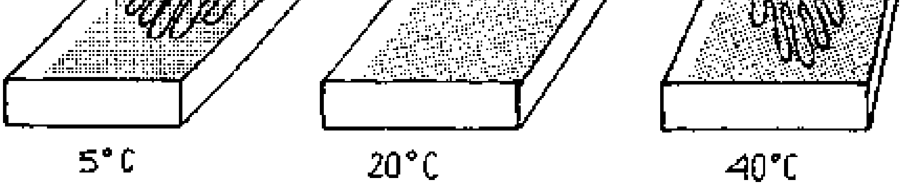
This experiment illustrates that the sense of temperature cannot register temperature in an **absolute way.**

Information:

Covering the skin of a human being are about 250 000 receptors to perceive cold and 30 000 to perceive heat. Temperatures which are too high or too low cause a feeling of pain.

Materials and Apparatus:

1 thermometer



One test person places his left hand into the left–hand dish and the right hand into the right–hand dish. After 5 minutes, both hands are placed simultaneously into the middle dish.

Observation:

The left hand perceives the water in the middle dish to be relatively warm and the right hand perceives it to be relatively cold. After some time the water is perceived as being the same temperature by both hands

Analysis:

Temperatures are perceived with the sense of temperature.

The sense of temperature needs some time to adapt to sudden variations in temperature.

Thus it is only reliable up to a certain point.

Addition:

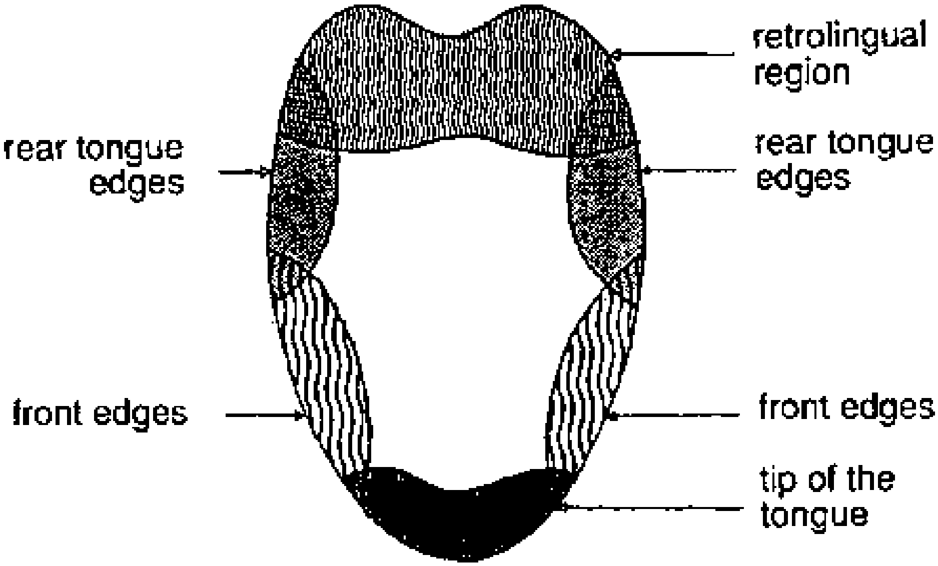
4 cotton buds or wooden spatula
4 flat glass receptacles
1 cloth

Procedure:

Watery solutions of each of the above−mentioned substances and fruits should be prepared.
A test person is blindfolded.

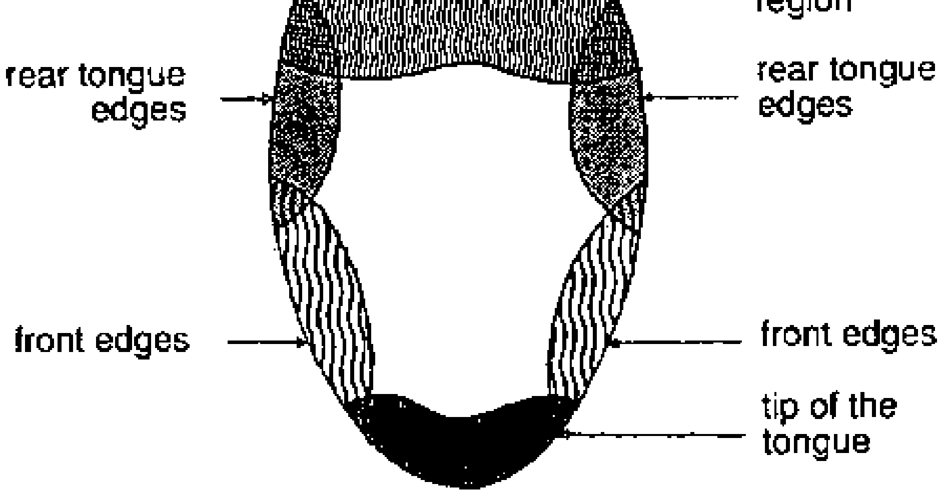
The front edges of the tongue perceive salty substances.

The rear tongue edges perceive sour substances, and bitter ones are tasted in the retrolingual region.



Analysis:

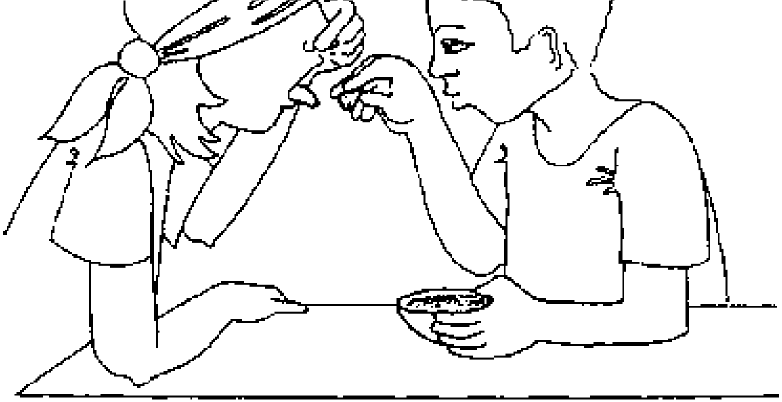
The taste bud areas are shown above in the form of a diagram.
The four different kinds of taste can be perceived <u>best</u> in the above areas.
The tastes overlap at the extremities of each zone.



Materials and Apparatus:

1 apple
1 potato
1 onion
3 spoons
1 grater
3 dishes
1 cloth

Procedure:



Observation:

When the test person holds his/her nose, the sensation of taste is significantly weaker.

Analysis:

There is an interaction between the sensations of **taste and smell.**

Addition:

It is well–known that to a person with a bad cold, food “has no taste”. Refer back to experiment 2.3 and complete your knowledge of tasting a meal.

Observation:

After several minutes the colour changes from dark blue to light brown.

Analysis:

The enzyme ptyalin has catabolized the starch to sugar. Sugar cannot be tested with iodine solution. Therefore the blue colour disappears. This proves that the digestion of food starts in the mouth.

front
(upside-down cage)

back

The string is cut into two pieces. Each of them is made into a noose. The nooses are attached to the opposite edges of the disk exactly in the middle of the drawing. (See diagram below.)

The free ends of the strings bands are firmly held, and then the disk is turned until the two strings are completely twisted. Then pull the ends of the strings in opposite directions. (If you pull too strongly you may tear the strings out of the holes in the cardboard.) The disk rotates rapidly and should be allowed to twist the strings in the other direction by loosing the pull on the strings. Then pull again and so on.

Analysis:

The rapid sequence of images cannot be separated by the eye into single images. The sluggishness of the eye is responsible for this “cinema effect”, which is the melting together of single images into one **animated image. This effect can be produced at a spead of 18 pictures a second. Most films in the cineama and the television work with 24 or 25 pictures a second to avoid any flicker.**

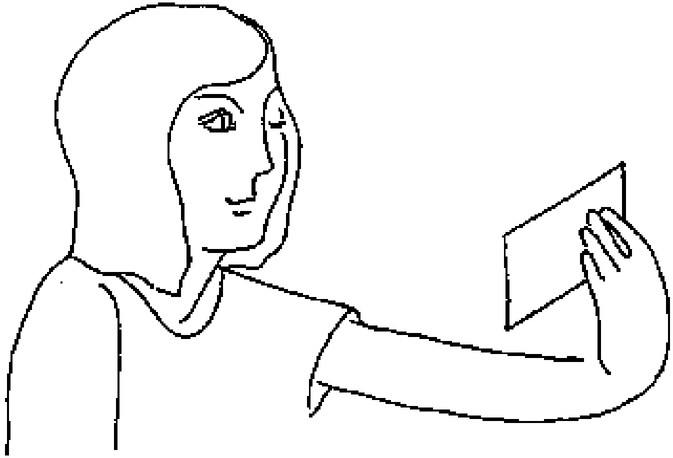
2.7. THE BLIND SPOT

Main Goal:

An experimental demonstration of the blind spot.

Information:

Rods and cones cells which are sensitive to light, are parts of the retina.

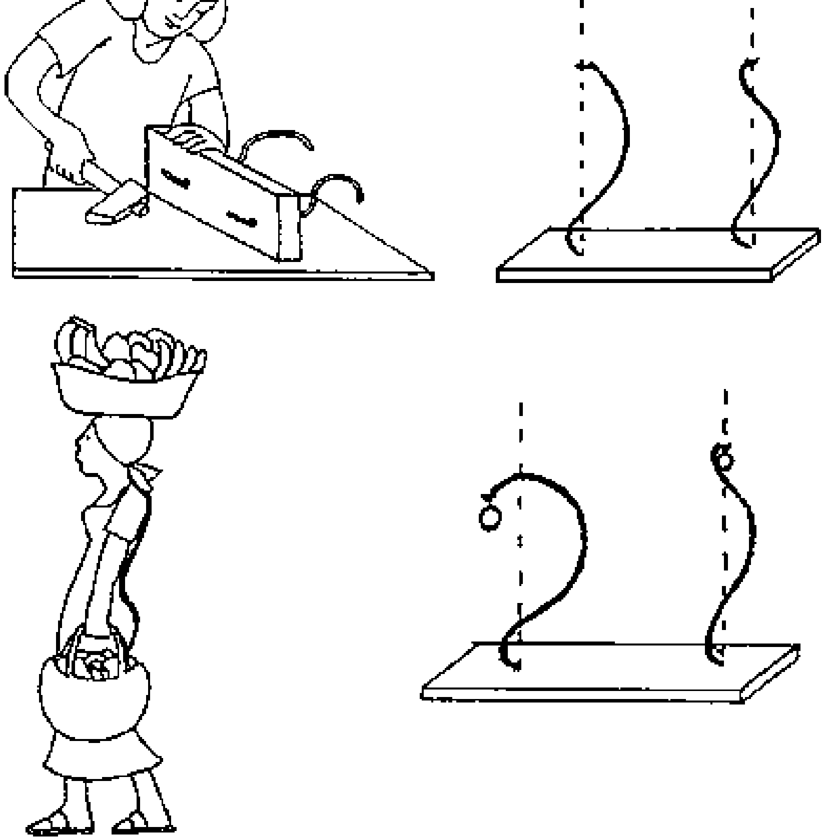


Observation:

The circle “disappears”, when the cardboard is a certain distance from the eye.

Analysis:

Light stimuli, which hit the optic nerve, are not transformed into an image. The spot where the optic nerve emerges is called the “blind spot”.



Identical weights are hung from each spine model.

Observation:

chest (thorax).

Abdominal breathing usually takes place simultaneously with costal respiration.

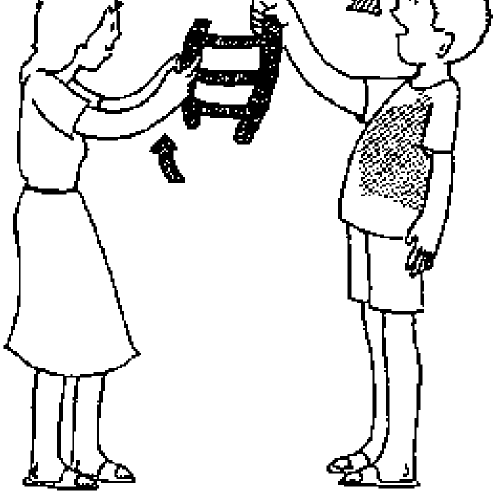
The muscular diaphragm contracts, so that it flattens, presses onto the internal organs, and moves the abdominal wall forward. The lungs follow this expansion. Breathing out provokes the reverse sequence.

Materials and Apparatus:

cardboard (or stiff paper)
scissors
cord, paper clips, rubber bands or blades of grass

Procedure:

A model is made as shown in the following diagram.



Analysis:

Because of the volume expansion, the air pressure in the lungs drops so that it is lower than the external air pressure. A lower pressure is thus formed and the pressure of the external air forces air **into the lungs.**

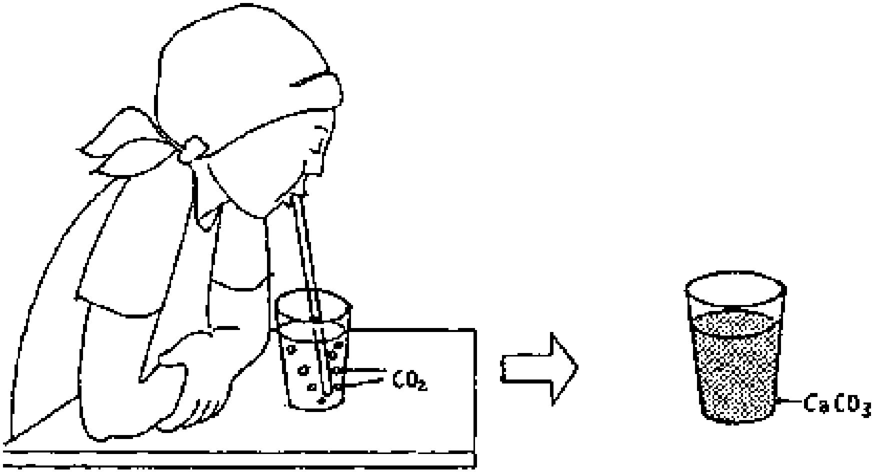
When you breathe out the air zone becomes smaller and the air is pressed out.

Addition:

If you pant you will see quite clearly that the abdominal wall arches forward when you inhale. The chest is hardly lifted. If you place one hand flat on the abdominal wall, you can feel the

Procedure:

If no calcium hydroxide (or barium hydroxide) is available, calcium oxide (or barium oxide) should be dissolved in water. These solutions are filtered until they are completely clear.



Practical Importance:

With the help of sunlight, plants produce carbohydrates and oxygen from carbon dioxide and water.

Oxygen is essential for human beings and animals.

Addition:

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

$Ba(OH)_2 + CO_2$? $BaCO_3 + H_2O$

Leaving limewater or baryta water in direct contact with air does not cause clouding because the carbon dioxide concentration is too low.

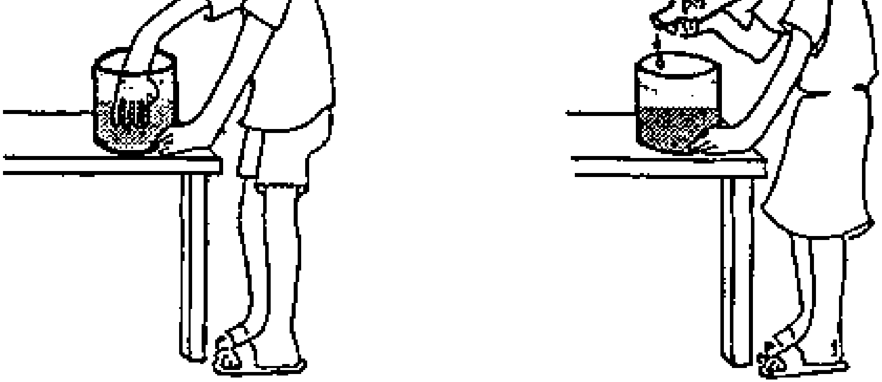
Look up the experiments botany 1.10 and 1.12. Together with the experiment above you can now explain the circle of oxygene and carbon dioxide in nature.

2.11. THE SKIN RELEASES SODIUM CHLORIDE

Main Goal:

This experiment shows that sodium chloride is released by the skin.

Information:



b. Sodium ions can be identified using magnesia sticks and a candle flame. The top of the magnesia stick is moistened with sweat and then held in the candle flame.

Observation:

a. A white precipitate is formed.
b. It can be observed that the flame burns yellow.

In the last centurie British miners became ill, suffering from too little sodium chloride after sweating very strongly. After drinking weak saltwater they recovered. The products left by perspiration are not all waste products. Nature is not perfect. There are optimal compromises everywhere.

2.12. FINGERPRINTS

Main Goal:

This experiment shows that fingerprints are a typical characteristic of each individual.

Information:

Fingerprints are determined by the structure of the lines of the fingertips.

Materials and Apparatus:

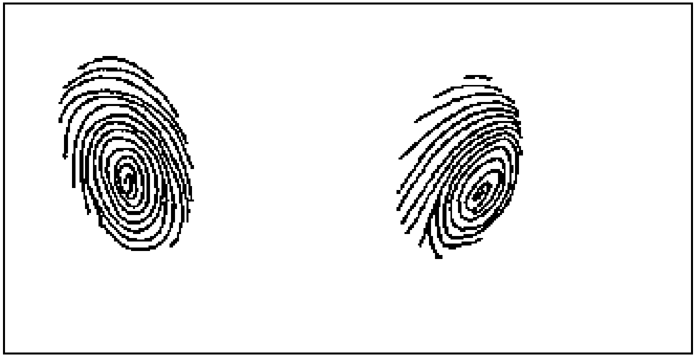
ink or ink pad
white paper

Procedure:

One fingertip is coloured with ink and pressed onto the paper once.

Observation:

A pattern of lines can be seen in black. This pattern is the fingerprint.

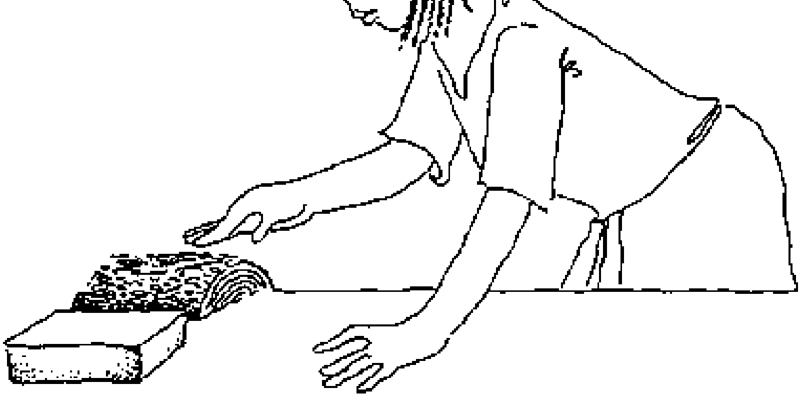


Analysis:

If the fingerprints of different individuals are compared, it can be seen that all of them are different.

Practical Use:

As the fingerprints of every human beings are unique, they are used as an important means of identification in criminology, when they can be used to identify a criminal.



Observation:

Different students will show different abilities to identify the objects they touched while blindfolded. But every one is able to distinguish very different things.

Analysis:

In our finger tips we have many sensory cells for touching far more than e.g. on our back.

The more of these cells there are in any area, the better we can identify different surfaces. The largest number of sensory cells for touching per square millimeter are in the tip of our tongue, but you should not test materials which may not be clean with your tongue.

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 beats you counted.

Then everybody does ten knee bends. After this someone gives a starting signal again and you count the pulse beats again for one minute.

a scarf or shawl to blindfold a person

Procedure:

All students sit in a circle. One of them stands blindfolded in the center of the circle. One student in the circle knocks on something e.g. his chair to produce a noice. The blindfolded student has to point in the direction from which the noise came without turning round.

Another student knocks from a different direction, the blindfolded student points to the source of the second noise.

Repeat the experiment several times.

After ten trials the blindfolded student holds his/her hand over one ear and the experiment is repeated another ten times.

When one listens with only one ear this time lapse can no longer be heard and it becomes more difficult to determine the source of the noise.

2.16. THE SENSITIVITY OF OUR HEARING

Main Goal:

This experiment shows how sensitive our sense of hearing is.

Information:

see analysis

Materials and Apparatus:

nothing

Procedure:

One student stand in front of the classroom with his face to the wall. Another student whispers a number between thirteen and ninety–nine. The first student has to repeat the number.

Try this experiment ten times initially.

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

This test will demonstrate immediately if a student is particularly hard of hearing in one ear.

Hearing difficulties can be caused by many different things and it is always better to consult a doctor immediately.

3. INORGANIC CHEMISTRY

3.1. COMBUSTION ZONES OF A CANDLE FLAME

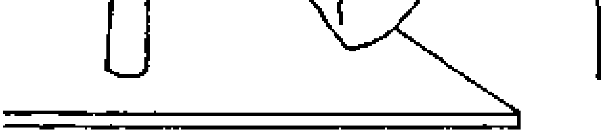
Main Goal:

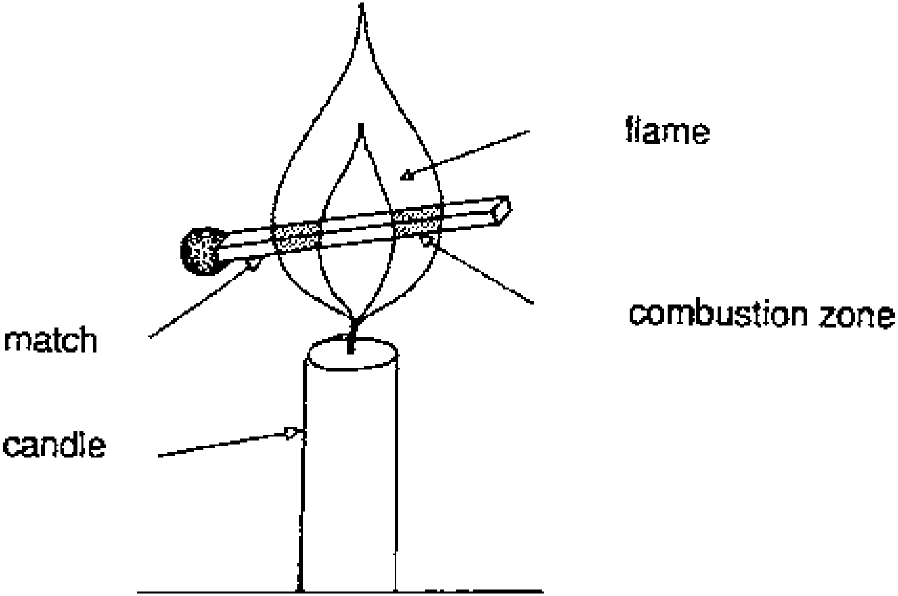
This experiment illustrates that the combustion of the gaseous particles of a candle takes place in the outer, the yellow zones of a flame.

In the following text these particles are called "candle gas".

Information:

The yellow colour of the outer zone of the flame is produced when the soot particles (carbon) light up.





Observation:

a. The part of the match in the yellow zone, is burning.

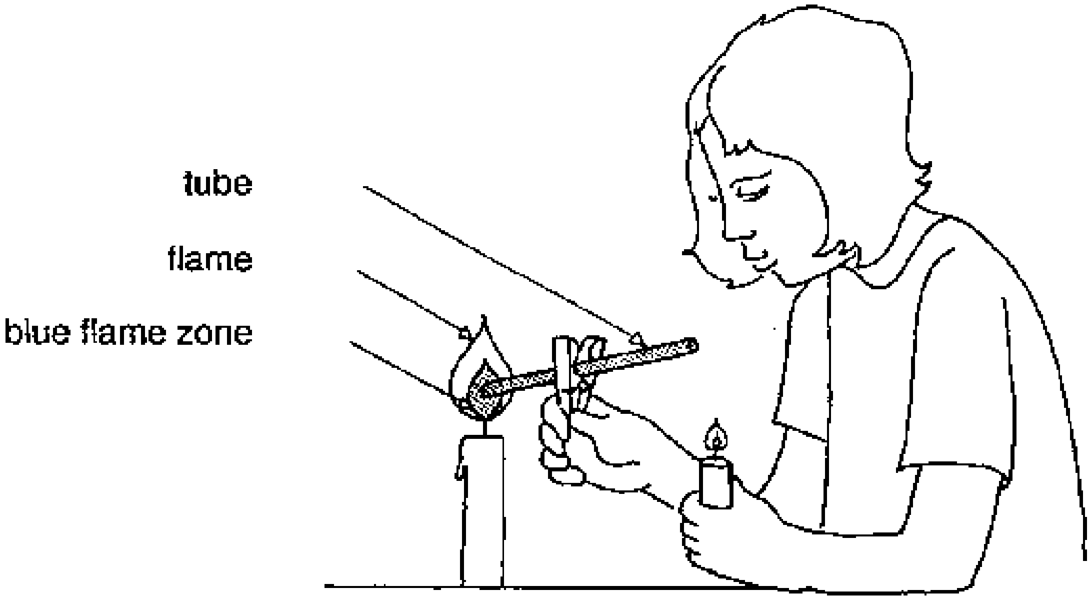
b. The part of the magnesia stick in the yellow zone lights up in **a** yellow–orange colour.

Materials and Apparatus:

2 candles
2 tubes (of metal or glass, e.g. eye dropper)
1 clothes peg

Procedure:

The candle gas of the blue flame zone is passed through the tube (see diagram).



atmospheric oxygen and candle gas mix in the right proportion.

Practical Use:

The candle flame has the same structure as the flame of bunsen or alcohol burners.

The most important properties of these burners can be demonstrated with a candle flame.

3.3. COMBUSTION PRODUCTS OF A CANDLE

Main Goal:

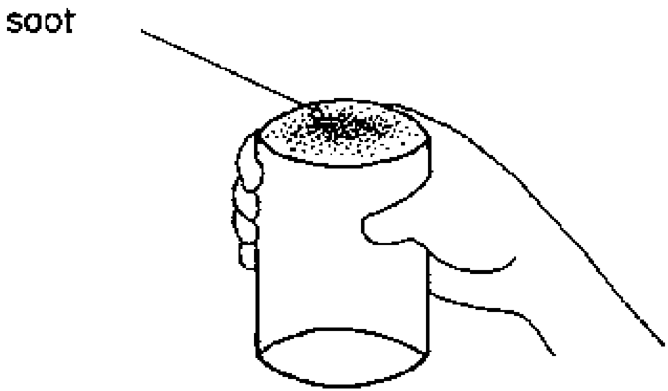
This experiment demonstrates that a candle forms soot (carbon), carbon dioxide and water when it burns.

Information:

The candle substance, natural wax or stearin, consists of the elements carbon, hydrogen and oxygen. Carbon can be identified directly as soot, and indirectly as carbon dioxide.

During combustion water is formed. The presence of water provides indirect evidence of the presence of hydrogen.

Materials and Apparatus:



Observation:

a. Soot settles on the glass vessel.
b. A moist film develops. White copper sulfate turns blue.
c. A white precipitate – calcium carbonate – is formed.

Analysis:

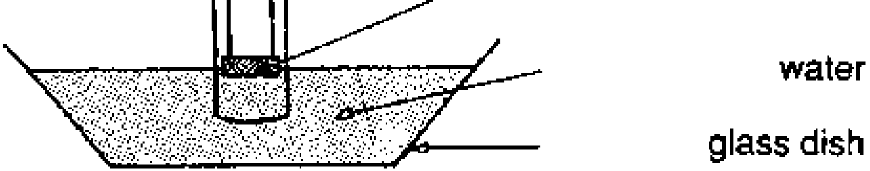
The candle substance burns to form soot (carbon), carbon dioxide, and water. Soot is the product of incomplete combustion of the candle substance.

Procedure:

As shown in the following diagram, apparatus is constructed, with which the oxygen content of air can be approximately determined.

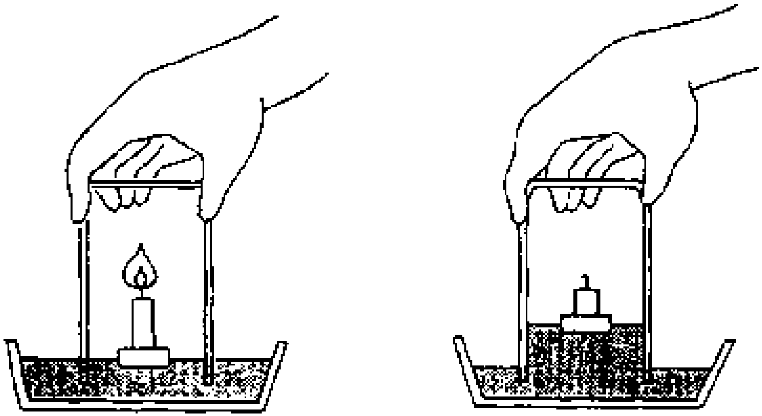
During combustion of the candle, the rising water fills the space left vacant by the air used to form carbon dioxide and water.

(The candle is extinguished before all the oxygen is used. The carbon dioxide formed dissolves in the water.)



Observation:

While the candle light gradually becomes dimmer, the water level in the neon lamp rises. The rising water occupies about one fifth of the air volume which was present at the beginning of the experiment.

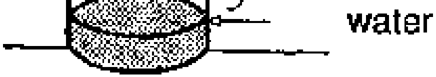


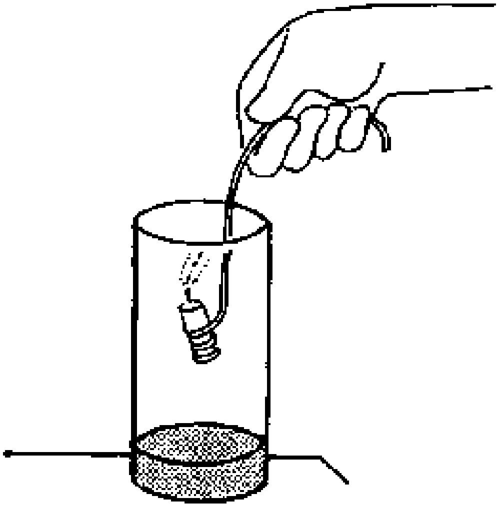
Analysis:

part of a neon lamp (about 30 cm) or a tall glass
small candle – should be light enough to float in water
rubber stopper
glass dish
a covering plate made of wood, glass, or metal
a candle attached to a wire
a stand if available

Procedure:

First the experiment “DETERMINATION OF OXYGEN CONCENTRATION IN THE AIR” is carried out. Then the dish is closed under water with the cover plate and turned upside down.





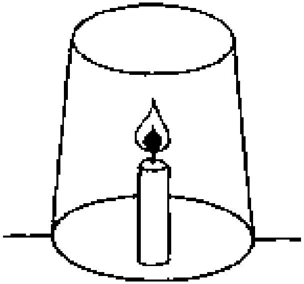
As shown in the diagram below, a burning candle is introduced into the remaining gas.

Observation:

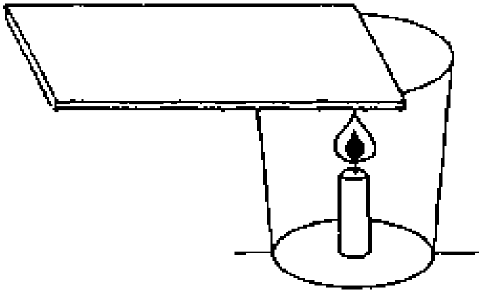
The flame is extinguished.

Analysis:

The remaining gas extinguishes the flame. This gas is called “nitrogen”.



b. A burning candle is placed in an open glass vessel. With the help of the cover plate, the vessel is first half and then completely covered, (see diagram).



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

The component of air which the candle needs for combustion is called “oxygen”.

Practical Use:

The various ways of extinguishing fire all work by preventing the continued supply of oxygen.

Without oxygen combustion does not take place.

Some methods used to extinguish fire include spreading: water, sand, or carbon dioxide over the flames so that oxygen is kept away from them.

3.7. CARBON DIOXIDE AS A FIRE EXTINGUISHER

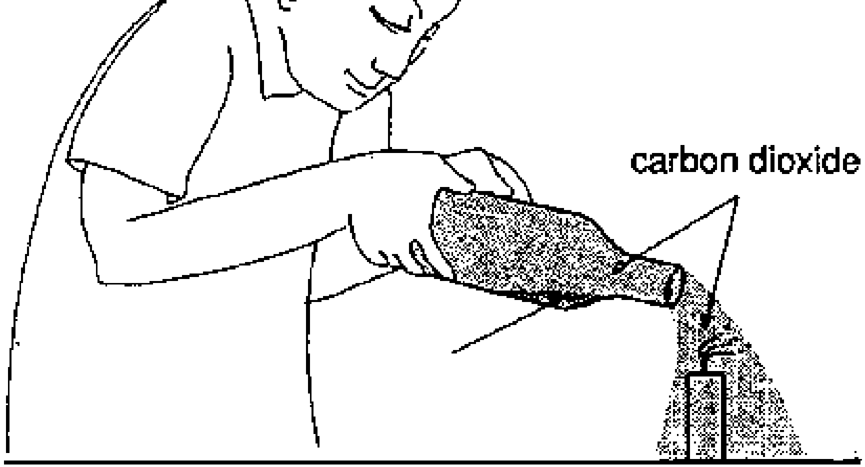
Main Goal:

This experiment demonstrates that a candle or other burning material is extinguished in carbon dioxide.

Information:

As carbon dioxide is heavier than air, it sinks when poured out of a dish.

Materials and Apparatus:



Observation:

The burning candle is extinguished.

Analysis:

A candle is extinguished in an atmosphere of carbon dioxide. Obviously the carbon dioxide is concentrated at the bottom when poured out of the glass dish.

Practical Use:

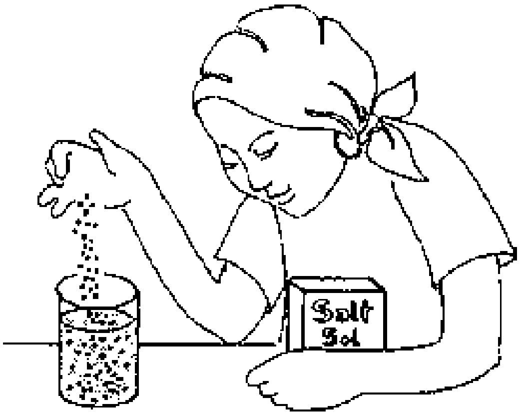
Materials and Apparatus:

sodium chloride (household salt)
flat dishes
1 glass vessel
water

Procedure:

Household salt is added to 50 ml of water (the solvent), until no more salt will dissolve.

Be sure that no solid salt is present anymore in the saline solution.



About 5 ml of the saline solution is poured into each of the glass dishes.

Various substances can be identified from their crystaline form.

Practical Meaning:

Salt is obtained from sea water in some hot countries.

The sea water is channeled into flat basins (salterns).

The sun causes the water to evaporate. The salt, which was dissolved in the sea water, is left as residue. Sea water contains 3% sodium chloride (household salt).

3.9. SALT WATER IS HEAVIER THAN DRINKING WATER

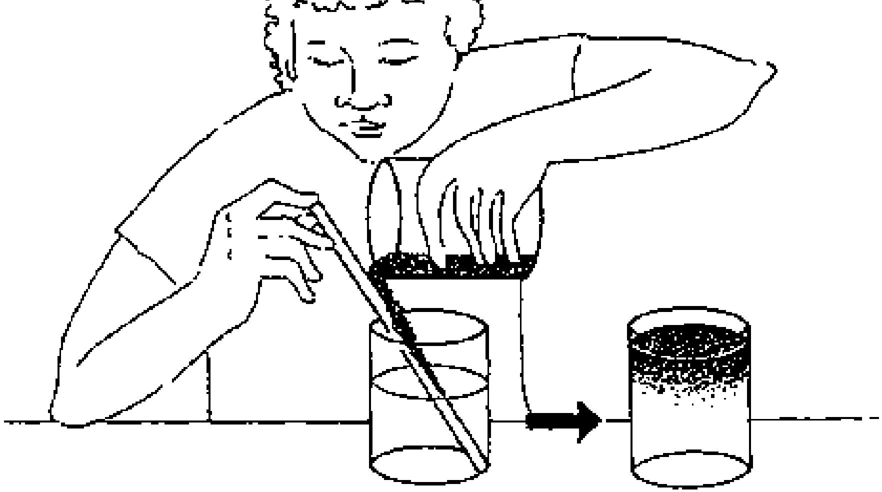
Main Goal:

Solutions always have a density higher than that of the solvent. That is to say that 1 cm^3 solutions has great mass and weights more than 1 cm^3 of the solvent.

Information:

see "Main Goal"

Materials and Apparatus:



Observation:

The coloured salt water sinks to the bottom of the dish.

Analysis:

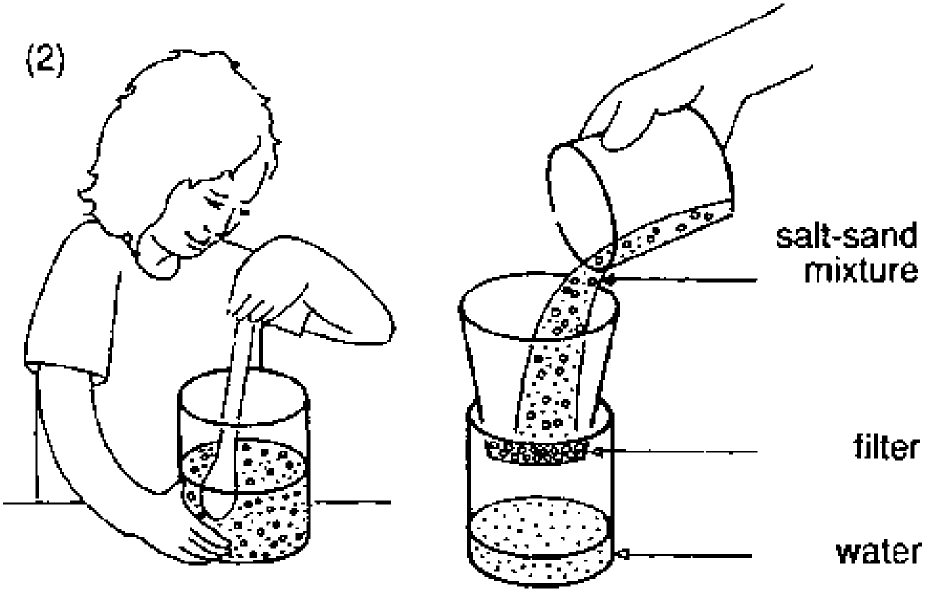
Salt water has a higher density than drinking water. However, drinking water also contains dissolved salts. Therefore, it is heavier than distilled water (completely pure water) without any dissolved salts. Solutions have always a higher density than solvents.

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

(1) The iron cuttings are removed from the mixture with the help of the magnet.

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

(2)



Observation:

The magnet attracts the iron cuttings.

The salt dissolves in water.

The sand does not dissolve but is collected on the filter paper.

water

Procedure:

a. Some dry iron wool is put into the first glass vessel,
b. Some wet iron wool is put into the second glass vessel.

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

3.12. THE IMPORTANCE OF AIR DURING THE PROCESS OF CORROSION

Main Goal:

The experiment demonstrates that air plays a role in the process of corrosion.

Information:

In humid air, iron reacts with oxygen to form rust.

Materials and Apparatus:

iron wool
1 test tube
1 large glass dish
water
sodium chloride

Procedure:

a) The experimental apparatus is constructed as shown in the following diagram and observed for several days.

Observation:

The iron wool has corroded.
Some water has entered the test tube.
The corrosion is faster in the presence of a dissolved salt.

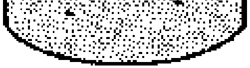
Analysis:

When iron corrodes, a part of the air is used to form rust together with the iron and the water. This proportion of the air is called “oxygen”.

Iron corrodes when water and oxygen are present. Its formation is increased by the presence of a dissolved salt.

Practical Use:

Iron is protected against corrosion by a rust inhibitor (special paint).



The two tins are wrapped in moistened rags and kept wet for some days.

Observation:

Clearly visible rust traces can be seen along the lines of the pattern, whereas the other tin does not show any signs of rust.

Analysis:

Tins are plated with a protective layer, which prevents corrosion.

3.14. INVESTIGATION OF RUST

Main Goal:

The experiment demonstrates that rust is a different material from iron.

Information:

Rust consists of iron oxide (trivalent iron) and iron hydroxides (trivalent iron).

Materials and Apparatus:

Analysis:

Iron is attracted by a magnet; we say it is ferromagnetic.

As rust and iron display completely different properties, they must be two different materials.

Practical Use:

The porosity of rust encourages the continuing reaction with air and humidity until finally the iron parts rust through.

This can be observed in cars. In technology, different methods are used to prevent corrosion, such as plastic covers, metal covers, and rust inhibiting paint.

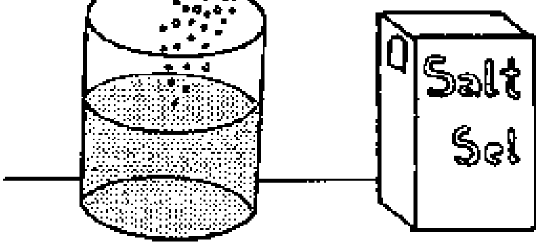
3.15. THE ELECTROLYSIS OF SODIUM CHLORIDE

Main Goal:

This experiment illustrates the principle of electrolysis.

Information:

With the help or direct current, chlorine and hydrogen can be separated from a sodium chloride solution. Chlorine develops as gas at the positive pole (anode) and hydrogen gas at



The two electrodes are attached to the battery and then dipped into the solution.

(An indicator can be added to the solution. In addition, the gases which escape can be collected – see experiment: ELECTROLYSIS OF WATER – and then the detonating gas test can be performed.)

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

At the negative pole (cathode) hydrogen gas is generated and metallic sodium is collected.

(The change of colour indicates an alkali, which is caustic soda solution. Chlorine dissolves well in water and bleaches colours.)

Practical Use:

The electrolysis of sodium chloride is a technique used to produce chlorine.

Chlorine is used as a disinfectant in swimming pools.

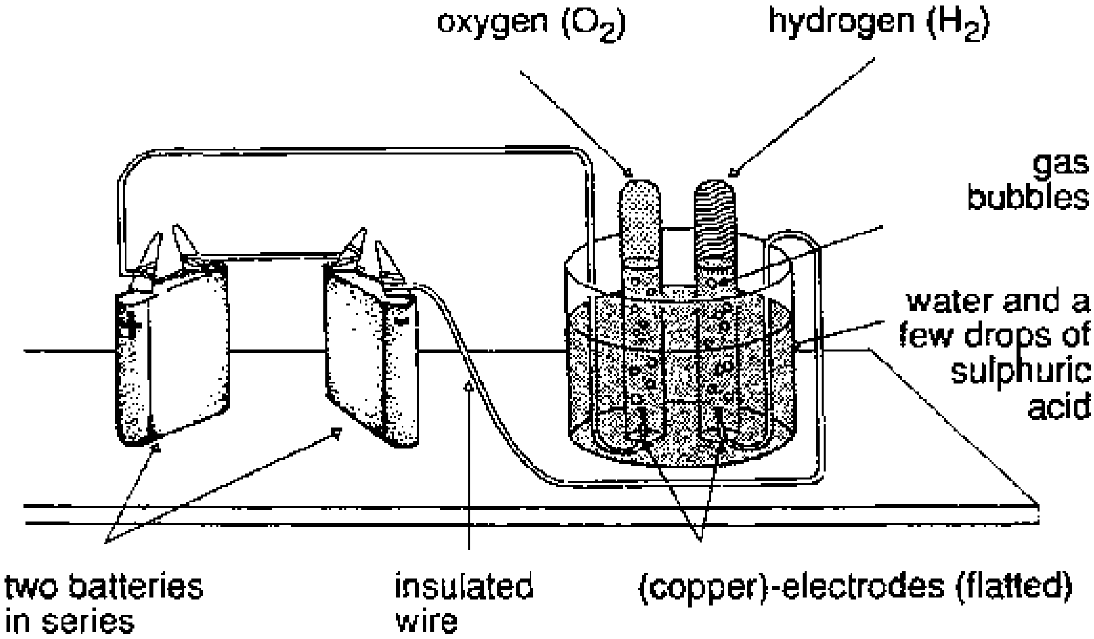
In addition, large quantities of chlorine are used to produce chlorine compounds (e.g., hydrogen chloride (HCl), phosgene ($COCl_2$), chlorinated hydrocarbons (poly vinyl chloride)). Because metal is deposited at the cathode, electrolysis has important industrial applications for manufacturing metal. Aluminium, magnesium, sodium and zinc are often produced in this way.

3.16. THE ELECTROLYSIS OF WATER

Main Goal:

To demonstrate that water is a compound of hydrogen and oxygen.

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



The test tubes are completely filled with the sulphate water, covered with the thumbs and turned upside down over the electrodes.

a. When the apparatus is complete, the electrodes are connected.

b. Shortly before the right test tube (negative pole) is completely filled with gas, **a** candle is lit. The test tube is covered with the thumb after the complete displacement of the water. It is taken out of the water and Kept upside down.

$2\ \mathbf{H_2 + O_2}?\ \mathbf{2\ H_2O}$

Practical Use:

Pure hydrogen is used for autogenous welding or cutting. In cutting or welding torches, oxygen is directed into a hydrogen stream shortly before its combustion.

With a surplus of oxygen, metals can be cut.

With a surplus of hydrogen, metals can be welded.

3.17. THE EXPLODING TIN

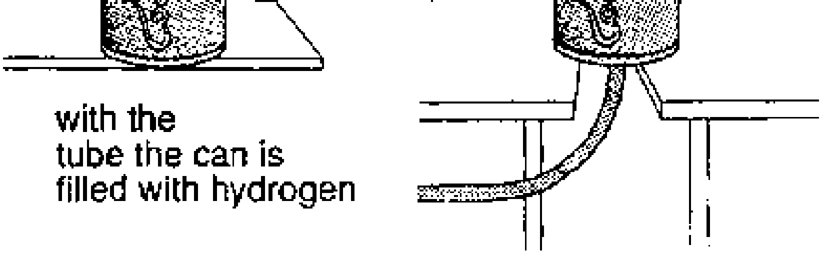
Main Goal:

This experiment demonstrates impressively the danger of a hydrogen–oxygen mixture.

Information:

If a hydrogen–air mixture is ignited, it reacts with a loud explosion, and water is formed. A hydrogen–oxygen mixture with the proportions 2: 1 is dangerous.

Materials and Apparatus:



The adhesive tape is removed, a match is lit, and the flame is held close to the upper hole.

Then move back several steps.

(The experiment is very impressive in a darkened room.

However, one window or door should be left open.)

Observation:

When the gas is ignited, a light explosion can be heard. The hydrogen burns with a blue flame.

A faint whistling sound, can be heard. It becomes louder, and is followed by a loud bang.

The tin is lifted from the table. A faint flame can be seen.

Analysis:

Air seaks into the tin, through the holes in the sides. The air–hydrogen mixture explodes.

Only oxygen and hydrogen produce this reaction, which is known as the “oxyhydrogen gas reaction”.

A 2: 1 hydrogen–oxygen mixture is especially dangerous.

$$\mathbf{2\ H_2 + O_2 ?\ 2\ H_2O}$$

Practical Use:

A high temperature of up to 2000° C is needed to weld iron parts together. This temperature is reached when hydrogen and oxygen reacts.

b. a selection of alkalies (NaOH, KOH, etc.)

a few small dishes

Procedure:

The leaves of the red cabbage are cut into small pieces, placed in boiling water. The corn is also pressed and placed in boiling water.

a. 1 ml of each of the various acids and alkalies are poured into separate dishes, one substance per dish.

b. 2–3 drops of indicator are added to each solution.

Main Goal:

This experiment introduces sulphurous acid and the problem of “acid rain”.

Information:

If sulphur is burned, sulphur dioxide is produced. This gas forms “sulphurous acid” if it is added to water.

Diesel oil and fuel oil both contain sulphur.

This experiment demonstrates that non–metal oxides and water form acids. (Carbon dioxide is also formed.)

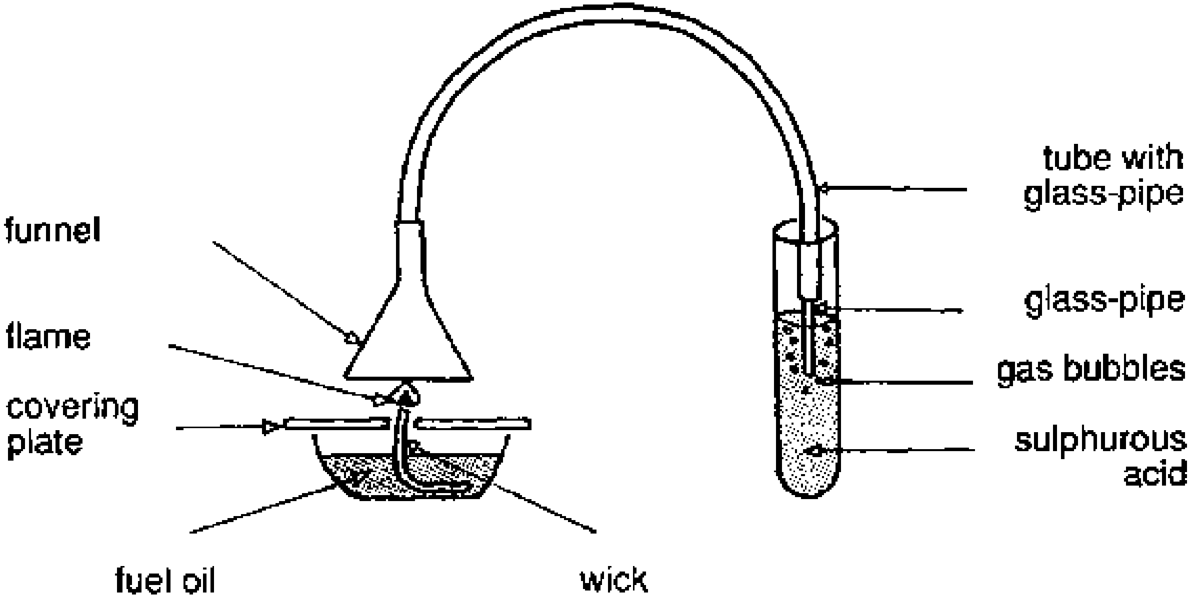
Materials and Apparatus:

Diesel oil or fuel oil

1 wick or cotton thread or rag
1 dish
1 covering plate (metal) with a hole for the wick
1 funnel
1 piece of tubing, with a glass–pipe
1 tall glass vessel (test tube)

water with indicator (fuchsine or litmus solution)

Procedure:



Analysis:

When fuel oil is burnt, the sulphur is oxidized to form sulphur dioxide.

$$S + O_2 ? SO_2$$

Sulphur dioxide can be easily dissolved in water. Sulphurous acid is formed

$$SO_2 + H_2O ? H_2SO_3$$

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 atoms. Each sort has its typical chemical properties. Matter containing one sort of atoms only is called 'element'. Carbon, hydrogen and oxygen are chemical elements. There are just over 100 known elements.

Information:

Carbohydrates contain the elements carbon, hydrogen, and oxygen. Therefore, its **a** compound.

Some examples of saccharides are grape sugar (glucose), cane sugar, starch, and cellulose.

Within the scope of ultimate analysis, carbon is identified as one of the elements of sugar.

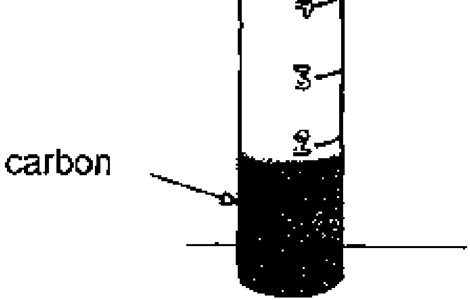
Materials and Apparatus:

glucose or cane sugar
water
about 10 ml of concentrated sulphuric acid
a glass dish which holds about 50 ml or a small beaker

Procedure:

The beaker is filled to a depth of approximately 1 cm with glucose, which is moistened with a few drops of water.

Sulphuric acid is added carefully until the glucose is just covered. (Wear protective goggles.)



Analysis:

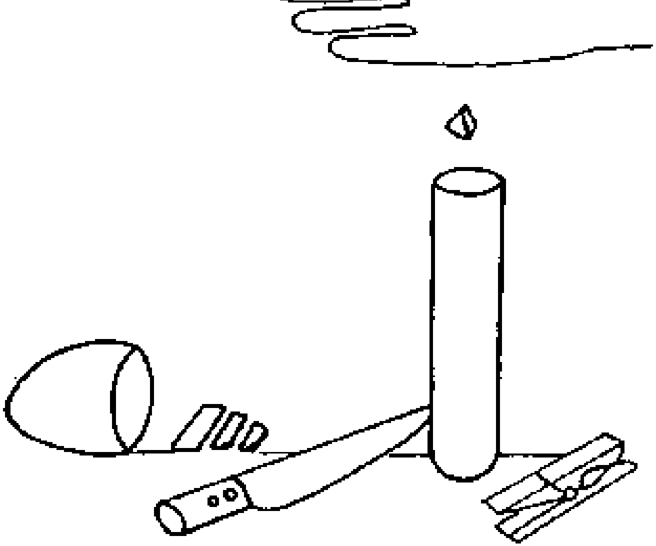
The black substance is carbon.

Concentrated sulphuric acid extracts water from glucose.

Carbon is left as **residue.**

Practical Meaning:

When you burn wood you can observe that it passes a state where it appears black (charcoal). Again, the black substance is carbon.



Observation:

The protein turns black when heated.

The litmus paper changes colour indicating an alkali.

Analysis:

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

Protein contains nitrogen. When chicken protein is heated, ammonium gas is set free. It forms ammonium hydroxide if water is added.

Ammonium hydroxide changes the colour of indicators.

Addition:

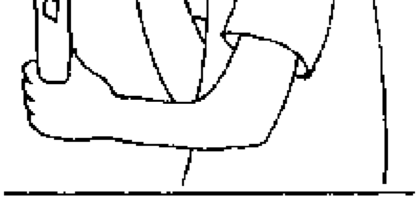
$NH_3 + H_2O$? NH_4OH

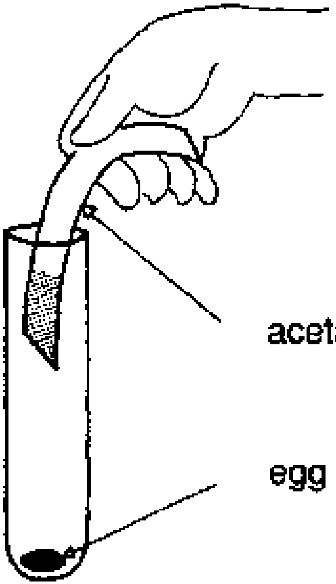
4.3. PROTEIN CONTAINS SULPHUR

Main Goal:

Qualitative ultimate analysis.

Information:





Observation:

The protein turns black when heated.
The white lead acetate turns black.

b. 1 slice of potato

1 cube of bread

Procedure:

a. The potassium iodide is dissolved in distilled water, and then the iodine is added.

b. Some drops of the iodine potassium iodide solution are dropped on a cube of bread and a slice of potato.

Addition:

Starch molecules are coiled in the form of a helix (like a spiral staircase). Iodine molecules accomodate themselves in this starch spiral.

The blue colour is caused by the trapped iodine molecules.

4.5. CARBON DIOXIDE IS PRODUCED DURING THE PROCESS OF FERMENTATION

Main Goal:

The experiment demonstrates alcoholic fermentation.

Information:

The oldest chemical synthesis technique of mankind is fermentation. It is the change which takes place when a saccharine solution is exposed to yeast. The products are alcohol (ethanol), carbon dioxide and heat.

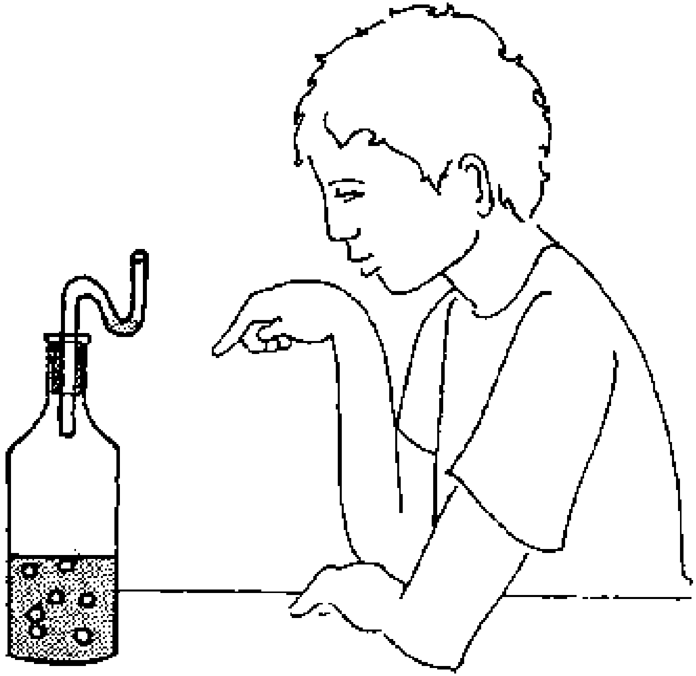
Materials and Apparatus:

freshly pressed apple juice or other fresh fruit juice

yeast (from a bakery)

Observation:

After some time gas bubbles form.
The limewater becomes cloudy.
A white precipitate settles.
The glass vessel becomes warmer.



This experiment demonstrates the processes of melting and solidification taking water as an example. Water appears as liquid, vapor and solid (ice). These three modes of appearance are called phases. The transition from one phase to another one is called 'phase transition'. At the melting point solid water changes phase to liquid water. At the freezing point liquid water becomes solid water.

Information:

The melting point and the freezing point, i.e. temperature at which these changes take place, are identical.

These two phase transitions are hardly dependant on air pressure.

Materials and Apparatus:

a. water

dish
refrigerator

b. ice

glass dish
thermometer

Procedure:

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

Thus it is possible to liquefy a solid substance and solidify a liquid.

The melting point (and the freezing point) for water is 0°C.

Practical Use:

The melting point is one means of identifying a material.

Addition:

The melting point of alcohol is – 114° C, its boiling point is 78° C.

For mercury the corresponding data are – 39° C and 357° C.

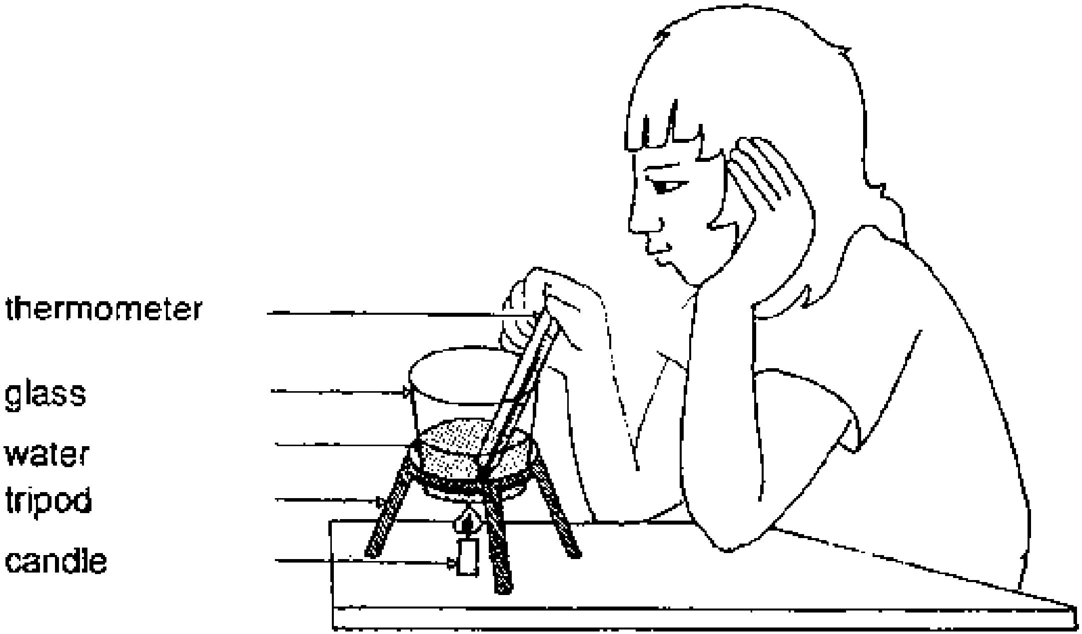
Further thought:

As long as the ice melts, the temperature remains constant (0° C) in spite of the fact that heat is continually being supplied.

Why does the temperature not rise?

The water is heated.

The temperature at the boiling point is measured using the thermometer. (The temperature should not be taken at the bottom of the dish).



b. Then the second glass vessel is then held in the gaseous water (steam).

"evaporation" or "volatilization".

b. The transition of a gas to a liquid at a certain temperature (condensation point) is called "condensation".

Practical Use:

Boiling points are a means of identifying substances.

Air is generally loaded with water vapor. If air rises and reaches colder regions, the vapor condenses. Tiny liquid water drops are formed, clouds develop.

Further thought:

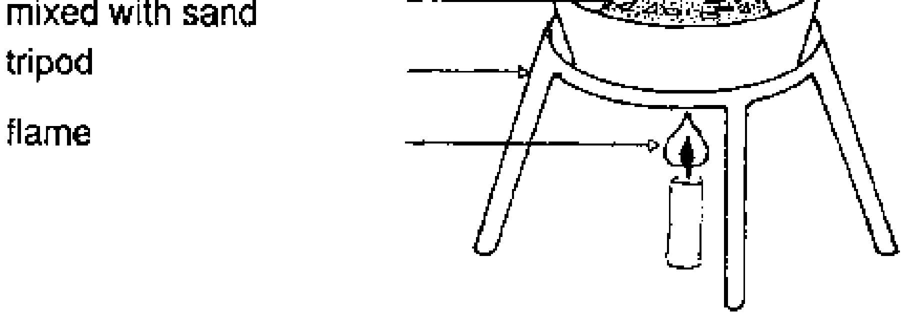
A solid must be heated to melt. A liquid must absorb heat to vaporize. Conversely, what must a gas release to liquefy and a liquid to solidify?

5.3. SUBLIMATION AND RESUBLIMATION

Main Goal:

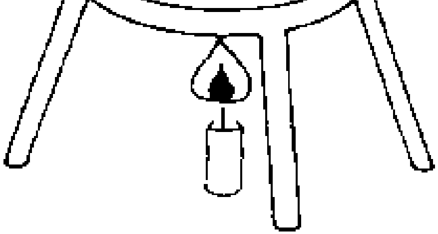
This experiment demonstrates the processes of sublimation and resublimation taking iodine as an example.

Information:



Observation:

Violet vapour appears. The solid iodine becomes a gas without melting. Crystals settle in the glass dish.



Analysis:

This direct transition of a solid substance to a gas is called “sublimation”.

The direct transition of a gas to a solid condition is called “resublimation”.

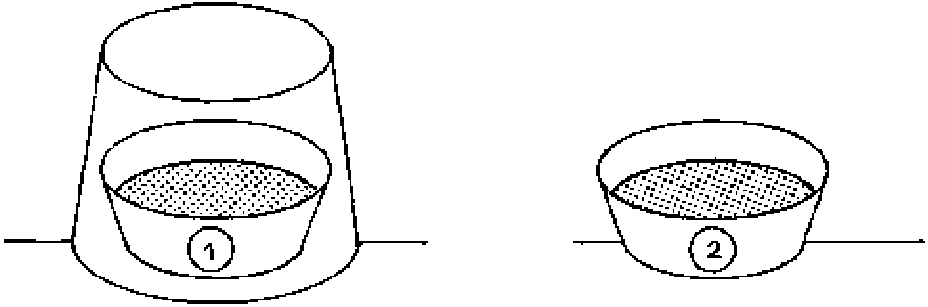
Further thought:

So–called “dry ice” (a solid) consists of carbon dioxid. At the open air it undergoes sublimation, and i.e. it changes phase directly from solid to gas. Why then is dry ice used in picnic cooler?

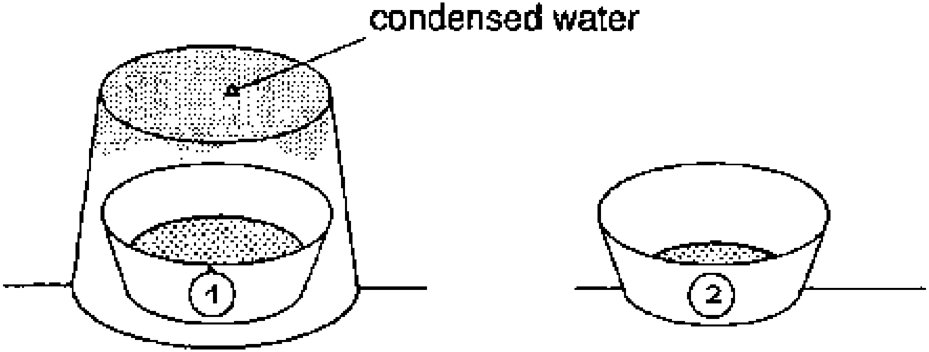
5.4. LAUNDRY DRIES WHEN THE WATER EVAPORATES

Main Goal:

Through the experiment pupils learn why and how liquids evaporate, taking water as an example.



b. The rags are soaked in water. One is dried in the sun and the other one in the shade. The times taken by the rags to dry are compared.



Observation:

a. After a few days (the time depends on the amount of water and the size of the surface) the water in the open dish has completely evaporated. The water in the other dish has only partly

5.5. WATER EVAPORATION – DEPENDANT ON THE SURFACE SIZE

Main Goal:

The experiment demonstrates to what extent the evaporation of water is dependant on the surface size.

Information:

Water also becomes a gas below the boiling point. This process is called evaporation.

(see experiment: LAUDRY DRIES WHEN THE WATER EVAPORATES.)

Materials and Apparatus:

1 glass vessel with a smaller diameter
a tin pan
1 measuring cylinder (scales, measuring vessel)

Procedure:

The same amount of water is placed in each of the three vessels. They are then placed in a sunny spot and observed for several days.

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

Practical Use:

see experiment: LAUNDRY DRIES.

Laundry dries faster when the surface of the washing is made as big as possible.

Further thought:

What is the effect when rubbing alcohol is poured on your back?

5.6. WATER EXPANDS WHEN IT SOLIDIFIES

Main Goal:

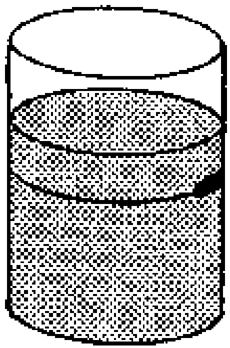
This experiment illustrates the volume expansion of water when it solidifies.

Information:

Water has its greatest density at 4° C. Above and below this temperature, the density decreases.

Observation:

The water is frozen, the jar has shattered, the ice in the tin has reached a higher level than the liquid water before.



Analysis:

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

water

drinking glass

Procedure:

Some ice cubes are placed in a pan with water.

ice cubes
in a pan

pressure ice melts already at – 5° C or even lower temperatures.

With all other substances the melting or the freezing point is increased by an increase in pressure.

Materials and Apparatus

1 ice block

1 boulder or big brick (about 5 kg)

wire about 30 cm long

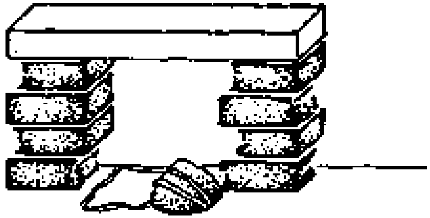
10 normal bricks

Procedure:

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

The experiment takes about half an hour or longer, depending on the thickness of the ice block, and the weight of the weight.

c)



Observation:

The wire moves through the ice block without cutting it into pieces.

Analysis:

The boulder produces pressure along the line of the wire at the upper surface and at the sides of the ice block. The ice melts because of the pressure transmitted to the ice by the wire. Above the wire the ice freezes again. Under increased pressure, water has a lower freezing or melting point.

Practical Meaning:

Ice skating is possible due to the increased pressure which is exerted on the ice through the blade of the ice skate. A water film is created which allows skater to glide.

The movement of glaciers can also be explained by the high pressure which the upper layers of snow or ice exert on the lower ones.

Materials and Apparatus:

1 metal sheet (aluminium or copper)
1 coin

alcohol or gas burner,
a candle a pair of tongs
a pair of pliers

Procedure:

An opening is cut into the metal sheet to allow the coin just to to pass when cold. The coin is heated as shown in the diagram below. (The time required depends on the material of which the coin is made.) After heating, attempt to put the heated coin through the opening in the metal sheet.

Analysis:

The coin expanded when heated.

Metals expand when heated and contract when cooled down.

Practical Use:

The expansion of metals on heating can be observed in the wires of telegraph lines and transmission lines.

During the summer metal wires sag, whereas in winter they tauten again. When metal wires are laid in summer, they should never be tautened.

In winter small gaps between railway tracks can be observed. These close in summer. The length expansion must be taken into consideration to avoid a deformation of the whole track system. Track sections are often welded together today without leaving seams. Iron tyres are fitted on a wooden wheel after having been heated. When they cool down they contract and tighten on the wood.

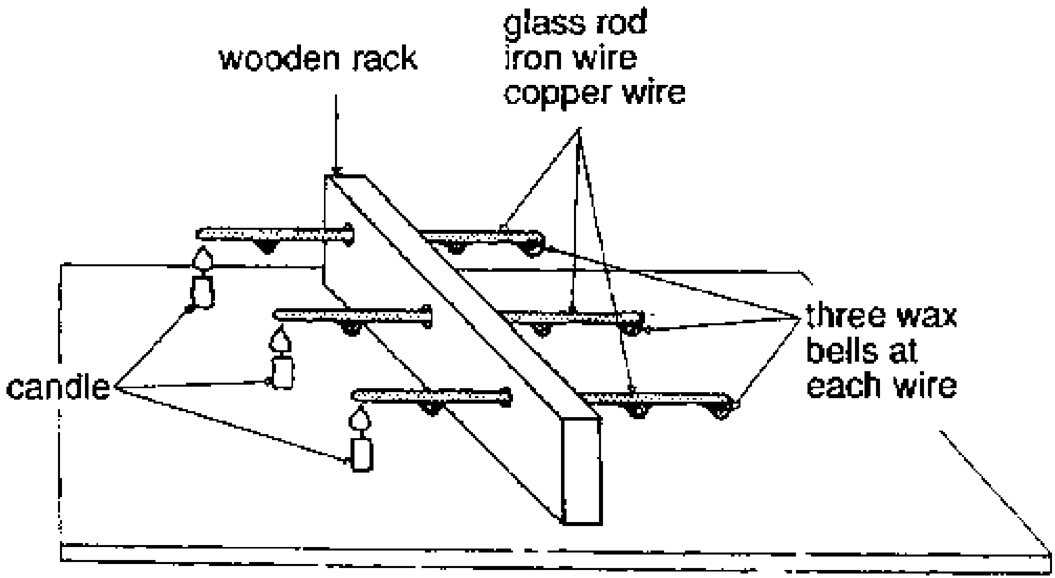
Metal bridges are set into concrete only at one side of the bridge, so that they do not bend when they expand. Bimetals take advantage of various kinds of length expansions of different sorts of metals.

(see experiment: THE PRINCIPLE OF A BIMETAL) *wax*

3 candles

Procedure:

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



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 on the material. There are good, mediocre and bad heat conductors.

Practical Use:

Good heat conductivity is taken advantage of in the household, e.g. with pots.

Wood conducts heat much worse than brick.

A house made of wood only warms up slowly, which means, it stays cool in summer. In winter it cools down more slowly than houses made of brick.

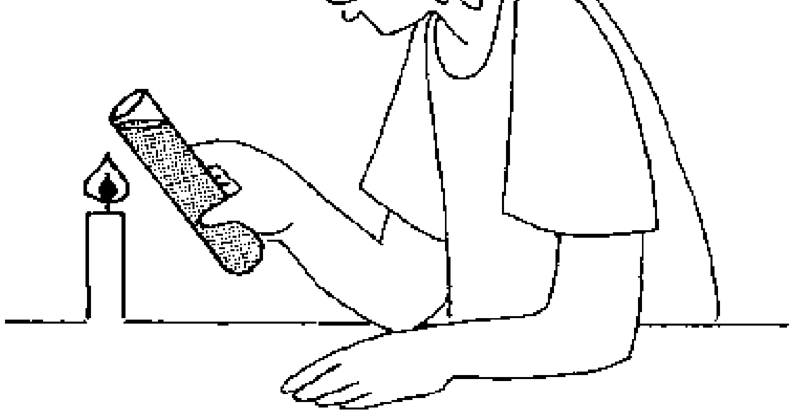
(The thickness of the wall and its construction also have to be taken into consideration.)

It is recognized that houses made of brick are built in such a way that the bricks include a lot of air, since air is a poor thermal conductor.

On Cabor Verde, holes are punched into mud blocks and gypsum blocks with the help of bottles and tins. This procedure saves material and is insulating.

Futher thought:

Why is it difficult to estimate the temperature of things by touching them?



Observation:

The water boils in the upper part of the glass tube.
The bottom of it hardly warms up.

Analysis:

Heated water expands, the density decreases and it becomes leighter (see experiment 6.4). Therefore, it does not sink down.

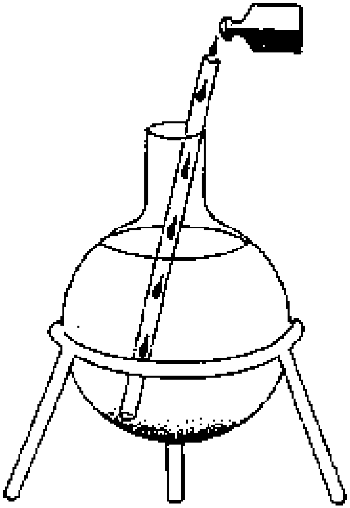
The water at the bottom of the test tube remains rather cold.

Therefore: Water must be a bad heat conductor.

tripod or a similar frame
candle
glass beaker

Procedure:

Ink or another colour is placed at the bottom of the beaker by means of a straw or a glass pipe.



The water is warmed up with the candle at one side of the bottom of the beaker.

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 down–pipe. Today pumps are used to support this cycle.

Furhter thought:

In this experiment not only water is moving! It carries colour and something else. What?

6.5. DENSITY DIFFERENCE BETWEEN WARM AND COLD WATER

Main Goal:

These experiments show that warm water has a lower density than cold water.

Information:

The greatest density of water is at 4° C. Above and below this temperature, the density of water decreases (see experiment: WATER EXPANDS WHEN IT SOLIDIFIES)

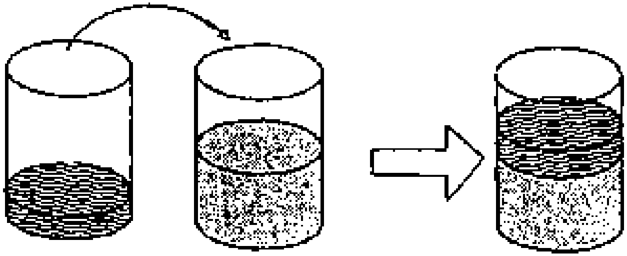
Materials and Apparatus:

a. water heated to about 50° C

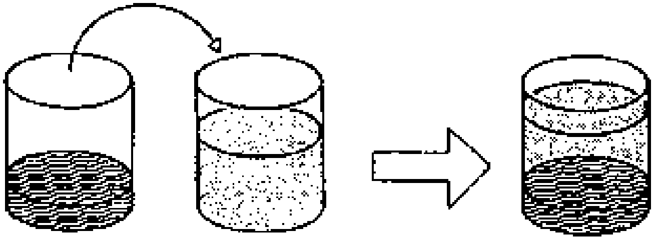
ink
cold water of about 10° C
2 glass dishes

Observation:

a. If added carefully and slowly by means of a glass rod where it ‘slides down’ to the surface of the cold water, the warm water floats on top of the cold water.



b. Added in the same way to warm water, the cold water sinks more down to the bottom and mixes with the hot water.



“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. The thermal energy of the sun is transformed into radiant energy and travels in that form through space. When it strikes an object on earth it is retransformed into thermal energy. This is the energy in the object due to the random motion of its molecules. The object, when it has higher temperature than another body or substance in its environment, can loose part of its thermal energy due to flow of heat to the colder body. Therefore, not heat is transmitted in the radiation process but radiant energy.

(see experiment: DARK MATERIALS COOL DOWN FASTER THAN LIGHT ONES)

Materials and Apparatus:

any kind of heating element
(candle, heater, bunsen burner or burning glass and sunlight)

Procedure:

Hands are held at a distance of about 10 – 20 cm from the heating element.

any specific kind of substance. It needs no medium.

Practical Use:

Every kind of heating element exploits heat radiation (e.g. open fires, ovens, central heating).

With the help of sun collectors, the heat radiation of the sun is harnessed. Sun collectors include, for example black tubes through which water flows.

Further thought:

The composition of the upper atmosphere is changed. It prevents a greater amount of the earth's “heat radiation” from escaping into the space. What are the consequences?

6.7. DARK MATERIALS WARM UP FASTER THAN LIGHT ONES

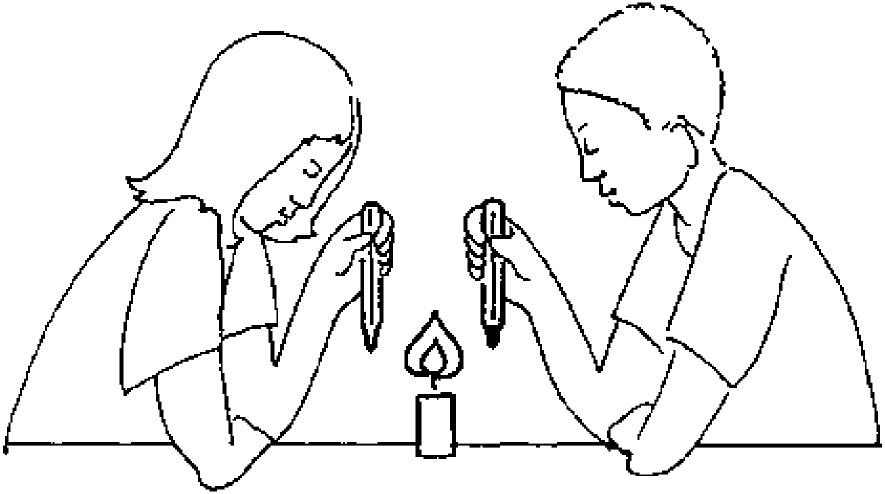
Main Goal:

Investigation of how different kinds of materials react to heat radiation.

Information:

Light materials reflect (from the Latin “reflectare”: to throw back) a greater proportion of heat radiation than dark materials.

Dark ones absorb (from Latin “absorbere”: to suck up) a greater amount of this radiation.



They are held close to some kind of heating unit.

Observation:

After a short time the blackened thermometer indicates a higher temperature than the white one.

Analysis:

Dark materials absorb in the same time and at the same distance from the heat source more heat radiation than light ones. The absorbed heat causes the temperature of the absorbing material to rise.

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

Materials and Apparatus:

2 tins or glasses
2 thermometers

boiling water
a *candle*
soot or black paint
white paint

Procedure:

The outside of the tin is blackened with soot (or with black paint).

The second tin can be painted white although this is not absolutely necessary.

Observation:

The temperature of the black tin drops faster than that of the white one.

Analysis:

Black materials do not retain heat as long as light materials. Black materials emit heat faster than light ones. Thus black materials not only absorb heat better than light ones (see 6.7), but also are better emitters.

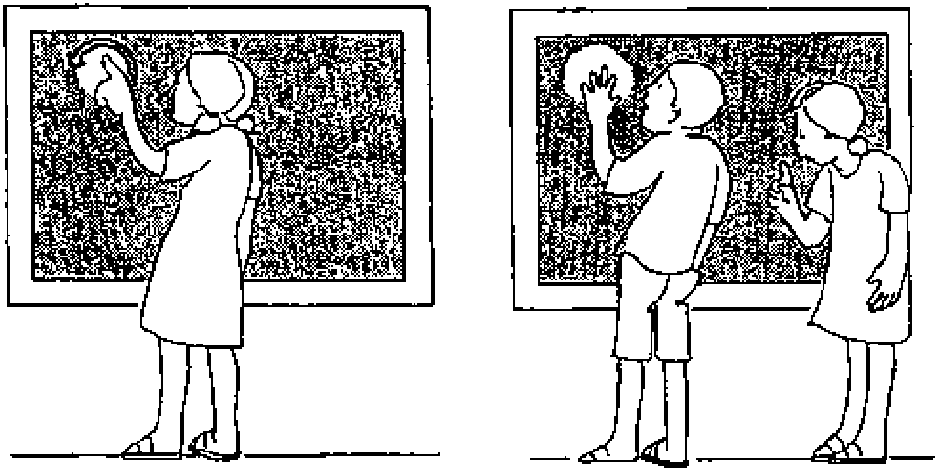
Practical Use:

The rays of the sun warm up the dark soil and water in daytime. The dark ground and the water emit heat so that the air warms up. The same amount of heat warms the water less than the ground, because it needs more heat to increase the temperature of 1 kg water than for 1 kg stone or soil.

At the coast it can be observed that the land warms up faster than the sea under the influence of sun radiations. As the air above the land is warmed up more, it ascends and the cooler air above the water streams onto the land. It is the other way round during the night. We perceive this heat streaming in the air as wind. In the daytime the wind blows from the sea onto the land, and during the night from the land to the sea. The degree of heating depends on the angle at which the sun's rays hit the earth and the water. The steeper the angle at which the sun's rays hit the earth, the stronger is the heating effect. This can be explained by the fact that in this case, more rays hit the ground per square metre.

Procedure:

a. Vigorously rub a small spot on the blackboard with one finger. Immediately afterwards, feel this spot and its surroundings with the ball of the other hand.



b. The piston of an air pump is pulled out about 15 cm. The valve is closed with one finger. Then the piston is vigorously pushed into the cylinder.

This process should be repeated several times.

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

The higher temperature results from the friction of rope and the palms of the hands.

Further thought:

When heat is flowing energy (from hot to cold) and thermal energy is due to random motion of molecules, what then is temperature?

7. AIR

7.1. THE AIR – A BODY

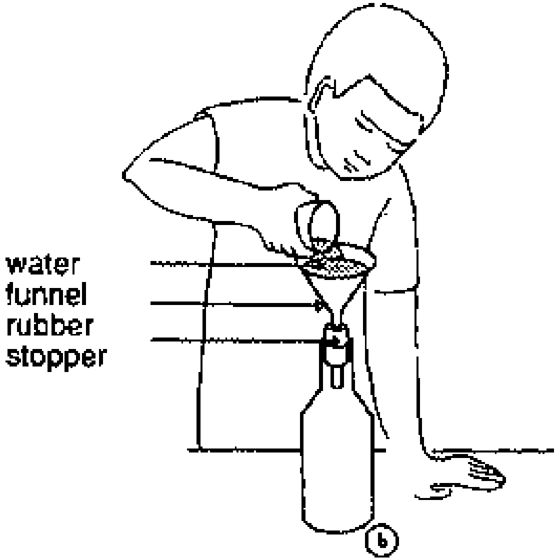
Main Goal:

The experiment demonstrates that air occupies space.

Information:

Air is a mixture of gases whose main components are 78.09% by volume nitrogen, 20.95% by volume oxygen, 0.93% by volume inert gases and 0.03% by volume carbon dioxide.

b. The apparatus is set up as shown in the diagram below. The funnel is filled with water, and then the stopper is eased out a little.



Observation:

a. The water does not completely fill the glass. Part of the glass remains dry (see a).

b. The water flows into the bottle only after the stopper is loosened.

Information:

Air is a mixture of gases. As gases too are bodies, where one body is, no other body can be. If one body wants to occupy the space where another body is situated, this other body must be displaced. Thus, when you occupy a certain space, you dislodge the air from this space. But air as a body, like all other bodies, offer some resistance against your efforts. Sometimes you can feel this drastically.

Materials:

newspapers or large sheets of cardboard

Procedure:

The pupils hold very large newspapers in front of their bodies and run quickly across the school yard or through the classroom. While running, they push the newspaper away from their bodies a few times.

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 displacement.

Further thought:

It is difficult to breathe when snorkeling at a depth of 1 meter. It is practically impossible at a 2–meter depth. Why?

7.3. AIR RESISTANCE

Main Goal:

This experiment demonstrates air resistance.

Information:

Air consists of a mixture of gases. As gases too are bodies they offer resistance against change of their place.

Materials and Apparatus

1 sheet of paper
1 stopwatch, (or someone must count regularly)
2 cardboards of same size and same thickness

Which one hits the ground first?

Observation:

a) The smaller the paper is, the faster it falls to the floor.

b) That one with the edge in front hits first.

Analysis:

The smaller the surface that points in the direction of motion, the less air resistance met. From further experiments it is known that the shape of the falling object also plays a role.

Practical Use:

Parachutists take advantage of air resistance. The round shape of a parachute significantly increases the time of falling compared to a flatter shape.

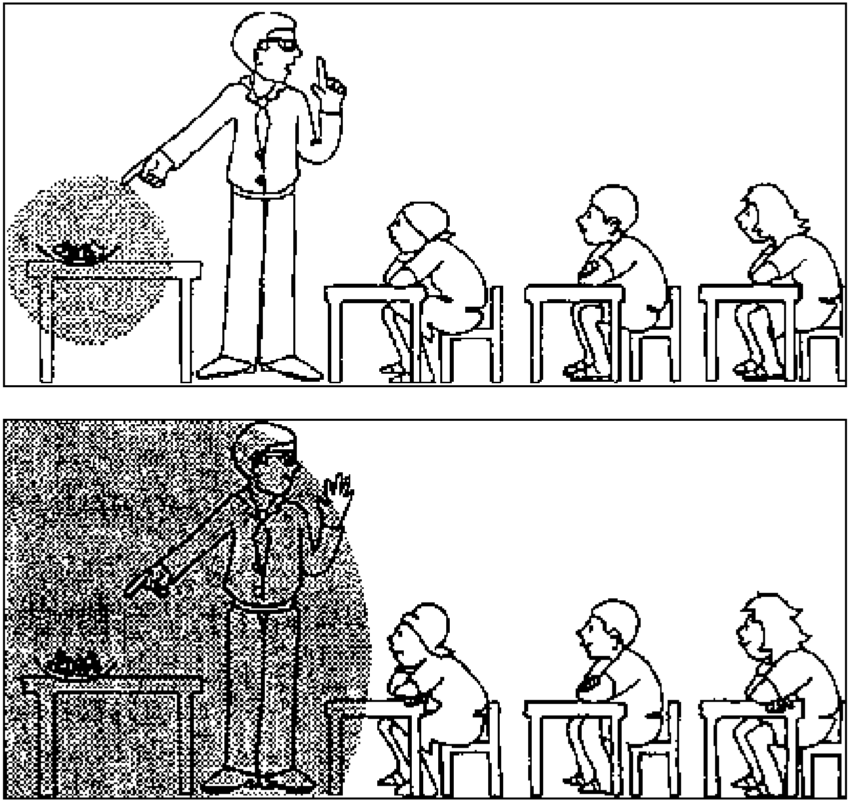
The seeds of plants, which are spread by the wind, are also shaped in such a way that they harness the air resistance.

Addition:

In order to make a parachute, four cords of equal length are fastened to the edges of a square cloth. The ends of the cords are tied together and attached to a moderately heavy

Procedure:

1 – 2 ml of the perfume are placed into the vessel.



7.5. CARBON DIOXIDE IS HEAVIER THAN AIR

Main Goal:

Gases, like solid matter, have different densities.

Information:

When carbon dioxide is produced in **a** vessel, it concentrates first at the bottom of the vessel, as it is heavier than air. Later it completely displaces the air. The carbon dioxide then gradually diffuses evenly. (See experiment: DIFFUSION OF GASES)

Materials and Apparatus:

3 candles
empty bottle, tubing, rubber stopper
Alka Seltzer (or sparkling lemonade)

Procedure:

A glass dish is prepared as shown in the diagram below. Using Alka Seltzer and water, both put into the bottle, carbon dioxide is produced and led into the glass dish. (Or, carbon dioxide from lemonade is conducted through the tubing into the dish. It is also possible to exhale air into the dish through the tube.)

of the dish. The more carbon dioxide is produced, the more air is displaced.

Practical Use:

Where it is impossible to use water to extinguish a fire, carbon dioxide is used, e.g. in power stations or in chemical firms. Carbon dioxide leaves no residues and does not conduct electricity.

Human beings and animals breathe in oxygen and exhale carbon dioxide. Plants produce glucose and oxygen from carbon dioxide and light.

Further thought:

The increase of carbon dioxide concentration in air atmosphere has serious consequences (greenhouse effect).

What would be the best ‘biological’ mean against this effect?

7.6. THE PHENOMENON OF AIR PRESSURE

Main Goal:

This experiment demonstrates the consequences of air pressure.

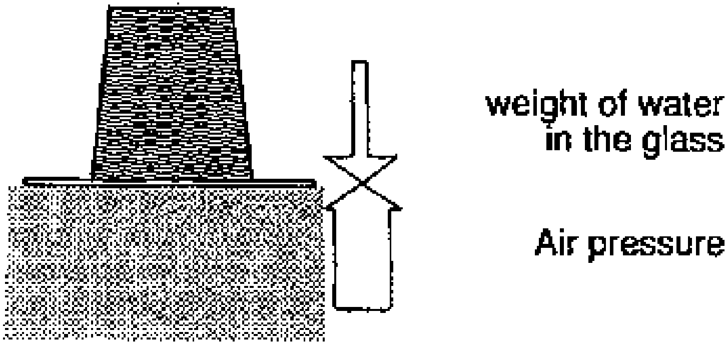
Information:

b) The glass is filled up to the rim with water. Then it is covered with the paper, which is pressed down with the palm of the hand. The paper is held tight until the glass has been turned upside down.

Observation:

a) The can is compressed and damaged.

b) From the glass the water does not run out.
(Warning! After a certain time the paper will be soaked through.)



Analysis:

The air in the can is replaced by water vapour. In contact with cold water vapour condenses. Inside the can is suddenly very low pressure, so that the outer air pressure presses the can.

This experiment demonstrates the practical use of air pressure.

Information:

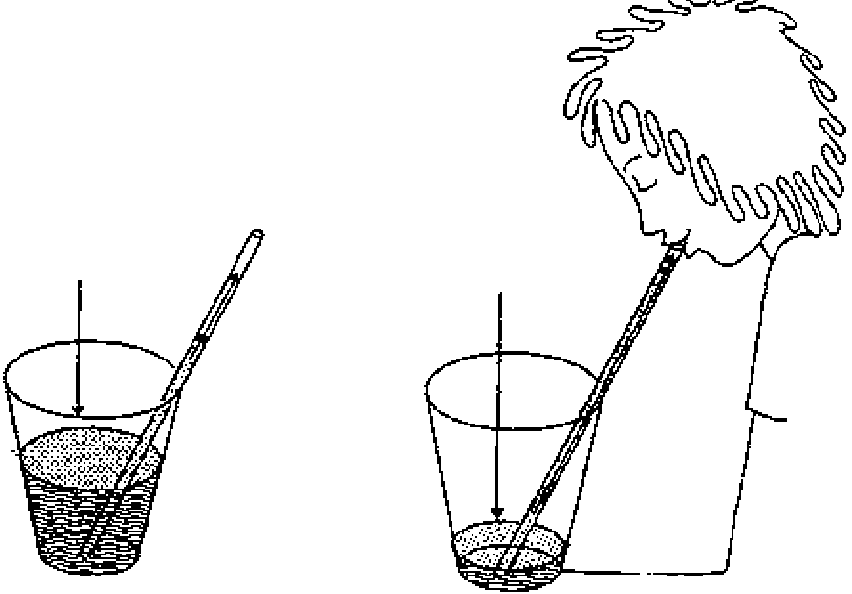
Air pressure is caused by randomly moving atoms or clusters of atoms (molecules) bouncing randomly against other matter.

Materials and Apparatus:

water or a beverage
a drinking straw
glass

Procedure:

Some water is sipped through the straw.



Analysis:

First the air is sucked out of the straw. This creates a space in which the air is rarefied and a space with low pressure is formed.

The ambient air pressure, which is higher, presses on the water surface, forcing the water to rise up the straw. A low pressure region is also formed in the mouth, due to the continual sucking. Therefore the water is always pressed into a space in which the air is rarefied.

Procedure:

The rim of the bottle neck is wetted with some water, and the opening covered with a coin. When the bottle neck is grasped with both hands, the air in the bottle expands due to the transmission of heat from the hands to the bottle and from the bottle to the air in the bottle.

The pressure in the bottle becomes higher than the ambient air pressure, so that the coin is lifted up briefly again and again.

(The glass also expands a little.)

Observation:

The coin “dances” on the bottle neck.

Analysis:

A transfer of heat causes the air in the bottle expand. The pressure increases, lifts the coin, some air escapes and the pressure is reduced for a moment. Then the heat transmission again expands the air, pressure increases and the coin lifts up again, and so on.

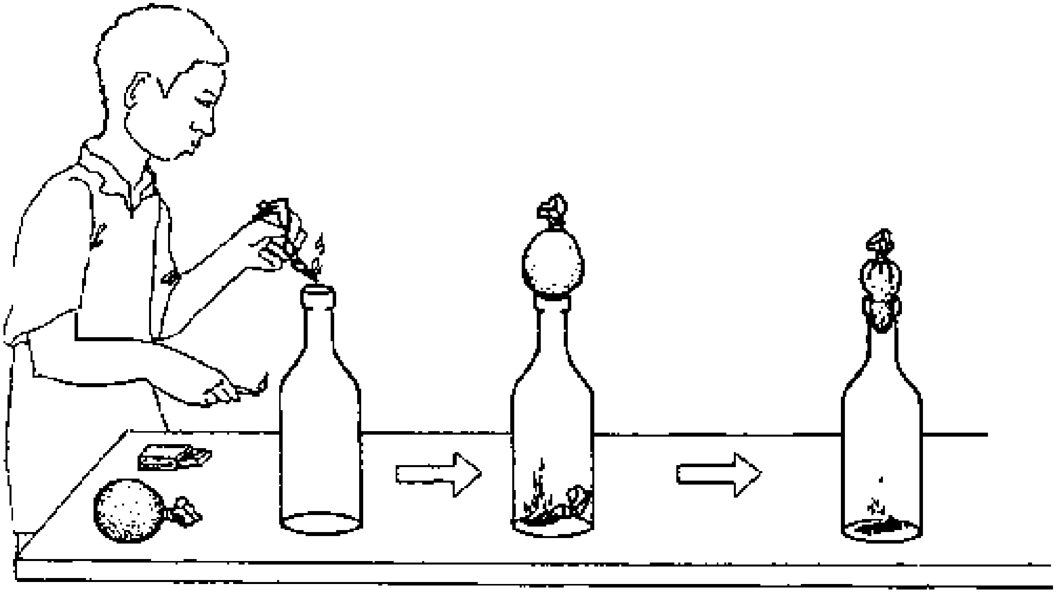
Practical Use:

1 balloon

paper

Procedure:

A piece of paper is set on fire in a bottle. A balloon is then placed onto the neck of the bottle, immediately the paper is burnt.



Observation:

Information:

When heated, gases expand much more than solids and liquids. If the pressure remains constant, ideal gases expand when heated by 1/273 of their volume 0° C for every 1 degree they are heated.

When cooled down, they contract to the same extent. In the following experiment, most of the air is expelled from a glass vessel by heating. When it cools down, the remaining gas is under lower pressure. The external, higher air pressure presses the water into the glass vessel, until a pressure balance is created.

Materials and Apparatus:

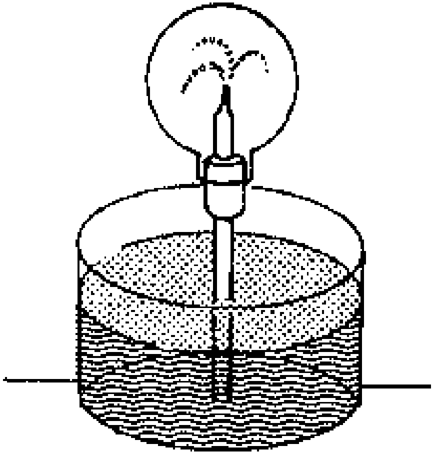
glass pipe, 20 cm long, which is pointed at one end
pierced stopper (rubber or cork)
glass flask or bottle made of clear glass
glass dish
burner (alcohol or gas burner or a candle)
water (may be coloured with water soluble eosin or ink)

Procedure:

The apparatus is set up as shown in the diagram below. The flask is held at the neck and carefully heated from the side. When there are only a few gas bubbles escaping from the flask, the burner is set aside. The dish is held vertically in such a way that the end of the glass pipe is always submerged.

Observation:

When the glass pipe is first heated a large number of gas bubbles escape. The number of gas bubbles decreases gradually. Some time after the burner is removed, water shoots into the flask.



Analysis:

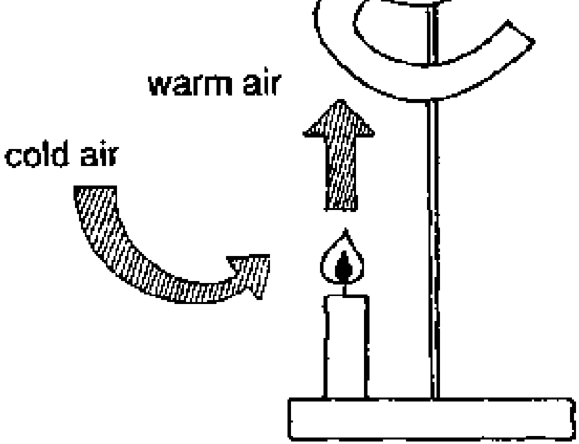
Materials and Apparatus:

thick wire about 20 – 30 cm long
wooden board
a streamer made of thin cardboard
a candle

Procedure:

A spiral shaped streamer is cut out of cardboard.

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



Observation:

The streamer starts rotating.

Analysis:

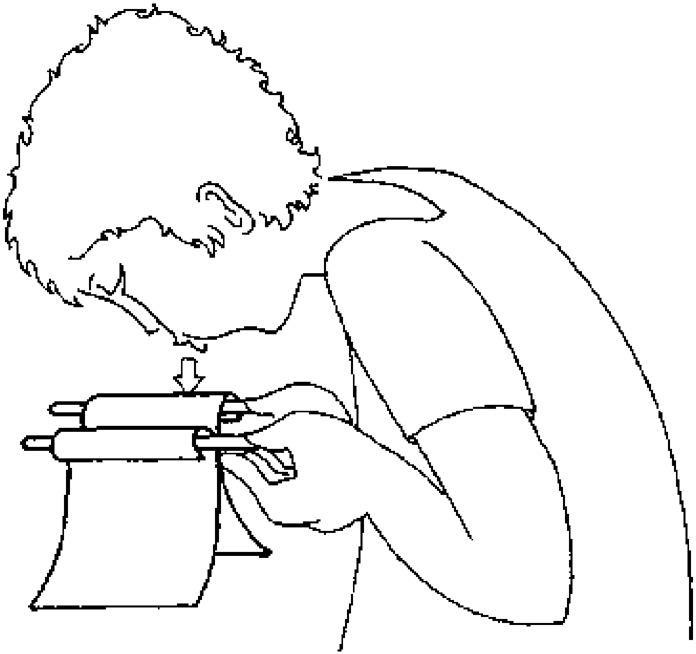
The candle warms the surrounding air. The warm air ascends and causes the streamer to rotate. Cold air flows in to replace the ascending warm air, is also heated, and the process continues.

Practical Meaning:

Procedure:

The paper is placed round the wooden rods as shown in the diagram.

Air is blown, alternately lightly and strongly, between the two sheets.



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

The faster the pace of the streaming (the more strongly the air is blown), the lower the pressure in the flow. The normal outer air pressure pushes the sheets together.

Practical Use:

This paradox (it is called paradox because its against our intuition) is harnessed in water jet pumps and in the construction of aeroplane wings.

Further thought:

What is the consequence of this effect with respect to the roofs of houses in case of a strong storm?

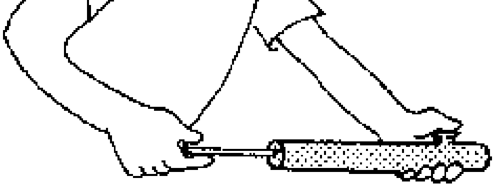
7.13. THE BOYLE–MARIOTTE LAW

Main Goal:

This experiment demonstrates the relationship between the volume and pressure of gases.

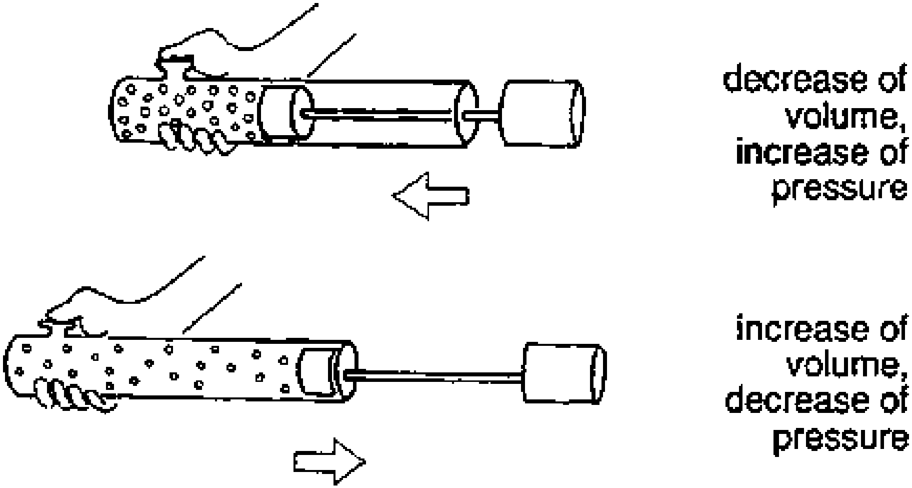
Information:

If the pressure exerted on a closed gas volume is increased, the volume decreases.



Procedure:

The piston of the air pump is pulled out of the cylinder, and then the valve opening is sealed with one finger. The piston is then pressed as far as possible into the cylinder.



Observation:

Main Goal:

This experiment demonstrates the phenomenon of repulsion.

Information:

Air which escapes from an narrow orifice produces a repulsion.

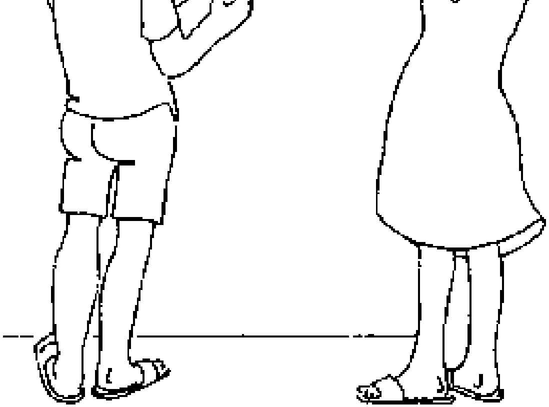
Two forces always come into play: one in the direction of the streaming, the other in the opposite direction.

Materials:

1 balloon

Procedure:

The ballon is completely blown up.



Observation:

The balloon moves around jerkily. First it flies upwards, and then it moves uncontrolled through the room. The excaping air hisses.

Analysis:

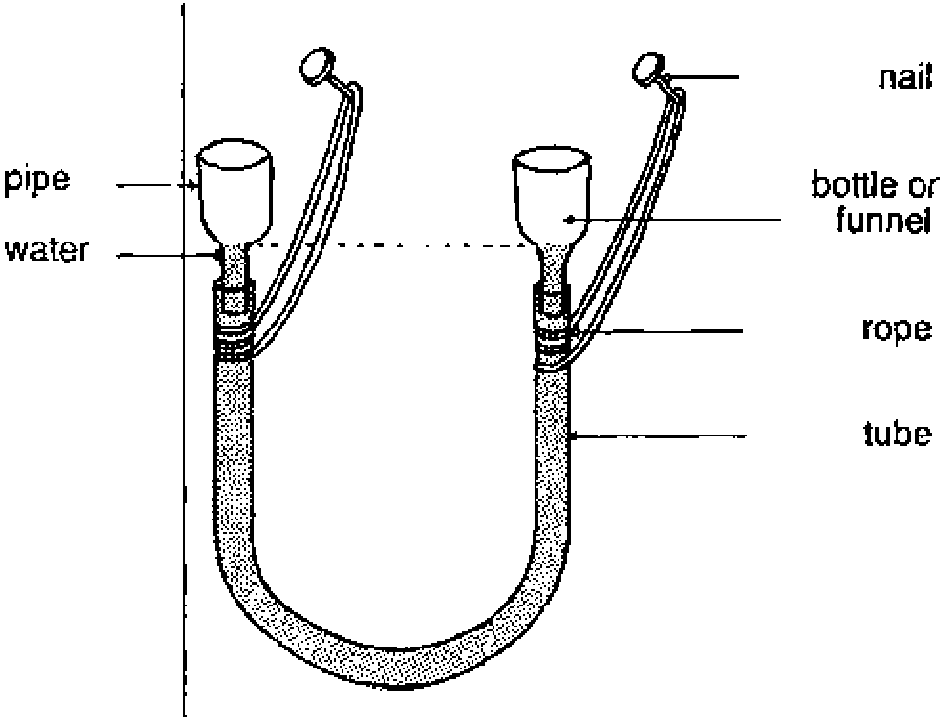
The balloon moves because of the repulsion, in the opposite direction to the excaping air. One force in the direction of streaming. This force stems from the tension of the rubber of the balloon. It pushes the air through the orifice. On the other hand: the air pushes back and causes the balloon to move in the opposite direction. The two forces are equally strong.

Practical Use:

rope
water

Procedure:

As demonstrated in the following diagram, the principle of a water–pipeline is illustrated.



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.

Practical Use:

The principle of joint vessels is used in floodgates. Ships are lifted or lowered onto an adequate water level with the help of water which flows in and out.

Further practical applications: Roman water pipes, wells, irrigation plants.

Further thought:

This experiment contains implicitly a method to keep a gas volume constant when the temperature rises.

How does it work?

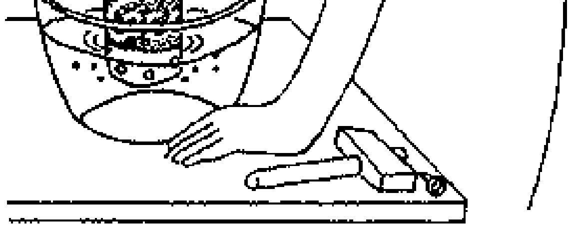
8.2. THE PRINCIPLE OF A WELL

Main Goal:

This experiment demonstrates the working mechanism of joint vessels

(see experiment: MODEL OF A WATER–PIPE)

Information:



As demonstrated in the diagram below, the tin is dipped into the water.

adjustes itself after a short time.

Analysis:

The well which is represented by the tin, and the ground water surface represented by the water surface in the vessel are joint vessels. In joint vessels the water surfaces always adjust to each other.

Further thought:

What is the maximum height to which water could be drink through a straw?

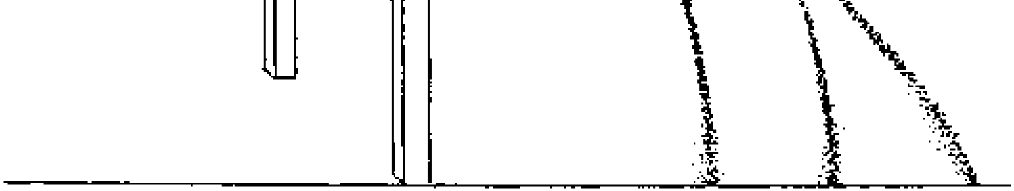
8.3. THE SIDE–PRESSURE OF A WATER–COLUMN

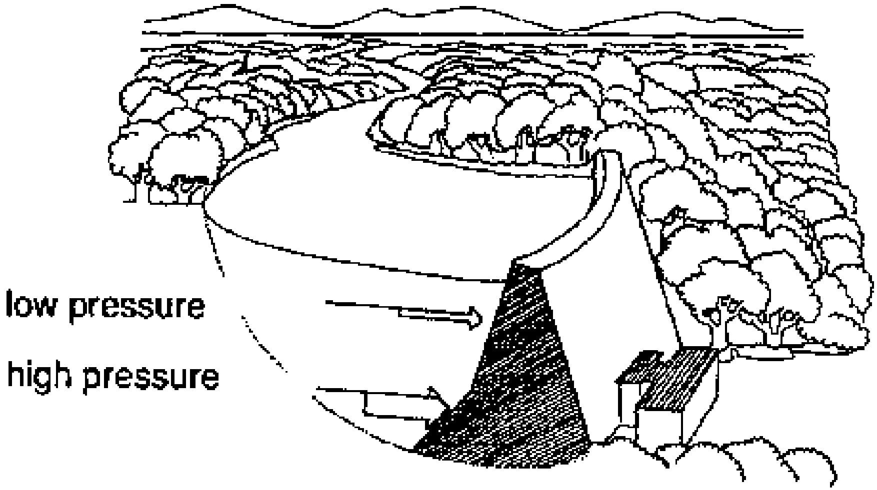
Main Goal:

This experiment demonstrates the pressure increase from the top to the bottom of a water column.

Information:

The pressure of a liquid onto the bottom and sides of a liquid column depends exclusively on its height. The pressure increases towards the bottom. A water–column of 10 m exercises a pressure of 1 atmosphere (about 1.013 bar) onto the bottom.





Observation:

see diagram

Analysis:

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.)

Materials and Apparatus:

stone
measuring cylinder (measuring flask)
water

Procedure:

The measuring cylinder is half filled with water. The water level is exactly read before and after inserting the stone.

Take care that no water splashes out of the cylinder when the stone is inserted.

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

Analysis:

The stone displaces just as much water as it needs to settle in the cylinder.

The water that has been at the place where the stone is now situated had no other choice than to rise and to settle above the stone. Thus, the water level rises.

The amount of water (the volume) has not changed.

The difference between the two readings is a measure of the volume of the stone.

Further thought:

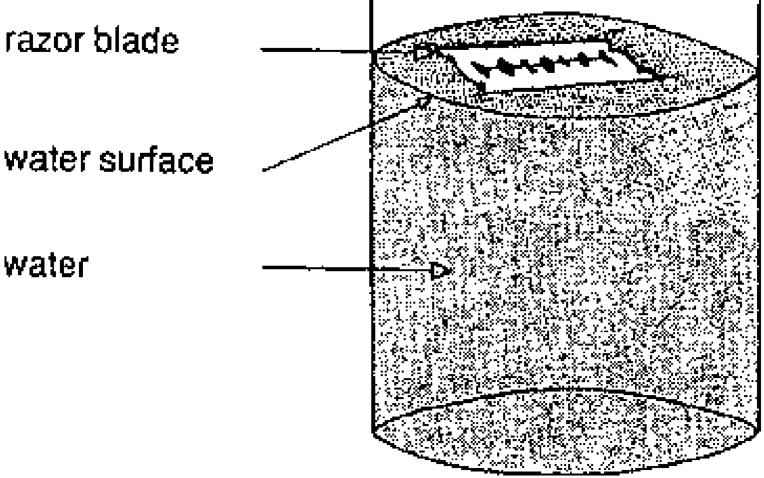
This method functions because the rock (or other solid bodies) doesn't change its volume when submerged in water.

What's about your body when you are submerged? Does the method work too?

8.5. A RAZOR BLADE FLOATS ON TOP OF WATER

Main Goal:

This experiment illustrates the phenomenon of surface tension.



b. An attempt is made to place the razor blade on the water surface on one of the cutting edges.

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

This characteristic of liquids is called “surface tension”.

Examples:

Insects which run over the water surface can be observed, e.g. the water–runner. Further examples of surface tension are rain drops or dew drops.

Further thought:

Why do rain drops have a spherical shape?

8.6. WATER HAS A SKIN

Main Goal:

This experiment demonstrates the phenomenon of surface tension.

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

Materials and Apparatus:

waxed paper
pipette (drinking–straw)

Observation:

Small drops are really spherical. If pushed together, bigger drops are formed that are more tear–shaped.

Analysis:

The high surface tension of water is responsible for the holding together of this “surface skin”.

The surface tension tends to form the smallest possible surface surrounding the volume of water. 1 sphere has the smallest possible surface.

Addition:

If some drops of soap solution or some small grains of a detergent are added to the “heap of water”, it dissolves at once. The surface tension of water is reduced.

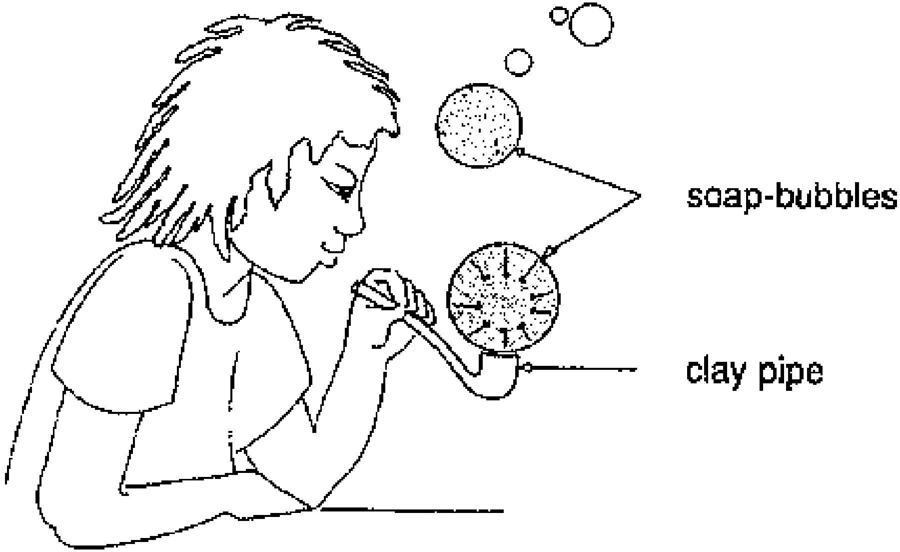
Practical Meaning

The reduction of the surface tension of water is achieved with detergents to increase the wetting ability of dishes or clothing.

Procedure:

a. Soap–bubbles are blown with a clay pipe.

The mouthpiece is then released and observed.



b. As demonstrated in the diagram below, a wetted loop of yarn is placed onto the soap skin. This skin is pricked in the centre of the yarn loop.

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

Analysis:

a. Round soap–bubbles develop due to surface tension, which presses the air out of the soap–bubble, so that its surface size decreases. The surface tension tends to minimize the surface area.

b. The surface tension is responsible for the yarn loop being torn apart. The remaining soap skin has minimum size when the yarn has a circular shape.

The surface tension of different liquids varies.

Water has a very high surface tension, so that it is not possible to form a "water bubble" in analog to the "soap–bubble".

Further thought:

The surface tension of hot water is smaller than that one of cold water. Why?

8.8. WATER ASCENDS IN SOIL

Main Goal:

This experiment illustrates the phenomenon of capillary action. (Latin: suction effect of very thin tubes)

Procedure:

The chalk is dipped 10 cm into the ink–solution.

After 10 minutes, the piece of chalk is broken into two, at the point to which the coloured solution has climbed.

Analysis:

This observation is called "capillary action" or the suction effect of hair–like tubes.

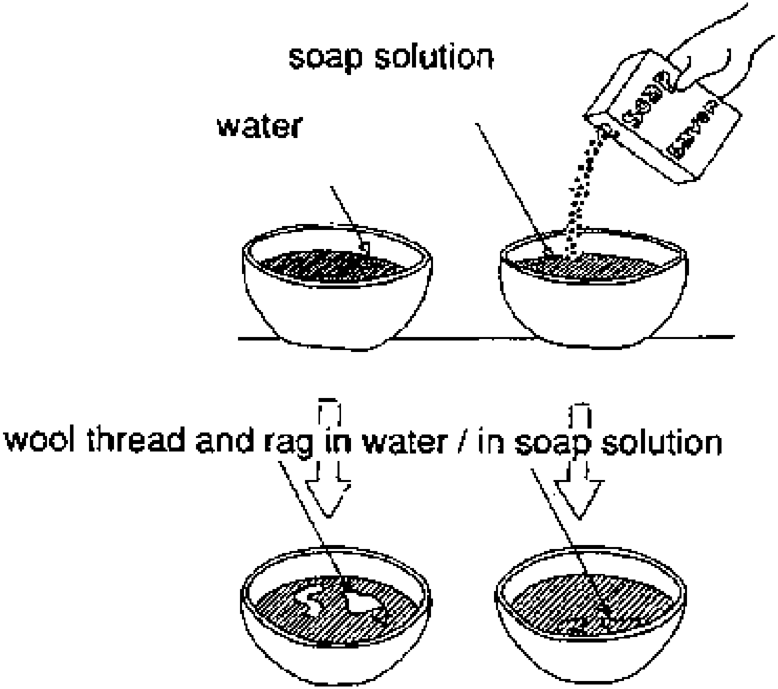
Practical Meaning:

Ground water climbs up in soil because of capillary action. So the roots of plants are continually supported with water even in dry seasons. (Capillary tubes are formed when the soil sags and rainwater flows slowly in thin streams through the soil.)

Usually the water climbs up to the earth's surface, where it evaporates. When farmers hoe the ground, they make the capillaries wider and the water does not go up. Thus, they hinder this process, as the capillary effect is reduced. Therefore, the water loss of the soil is reduced for some time. Furthermore, the soil surface is loosened and the area of surface is increased.

Further thought:

Why is oil soaked upward in a lamp wick when one end hang in oil?



Observation:

The wool thread and rag sink ralatively quickly into the detergent solution. The rag sinks much more slowly into pure water, whereas the wool thread hardly sinks or does not sink at all.

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.

Fruit and vegetable stains are destroyed by bleach. The experiments demonstrate the perfusion of soot and grease by detergents.

Materials and Apparatus:

a. 2 glass dishes (test tubes)

soot (activated carbon or wood charcoal)

b. 2 glass dishes (test tubes)

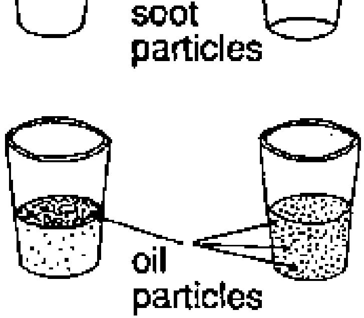
oil (salad oil, engine oil)
detergent solution
(about 1 teaspoon of detergent in a big vessel of water)

c. 2 funnels

2 paper filters
2 glass dishes

Procedure:

a. One glass dish is half filled with water;
a second is half filled with detergent solution.



Observation:

a. The soot particles in the detergent solution are distributed, whereas those in water recollect on its surface. The soot particles in the detergent solution are hardly retained by the paper filters.

b. The oil in the detergent solution in distributed in very small particles, whereas it forms a layer on top of the water.

Analysis:

Detergents cause oil and soot to be well distributed in water. Oil drops and soot particles are distributed and thus kept floating.

Thus, the dirt particles are prevented from being deposited on the fabric cloth again. In the first case of the soot particles in a detergent solution, a **suspension is formed. In the case of detergent solution and oil, a suspension is formed.**

In technology, cogwheels serve to transmit rotary motions.

The simplest kind of gear transmissions consists of a driving gear, an output gear, one crank, two spindles, and two bearings. A gear transmission transmits two unchanging rotary motions, motions into slowness, into speed, in opposed motions and motions into other revolving planes.

If there is a transmission to speed up, the bigger of the two cogwheels is the driving gear and the smaller one is the output gear.

Materials and Apparatus:

firm corrugated board
screws
wire
knife or pair of scissors
coloured pencil

Procedure:

Two cogwheels – one with 20 and the other with 40 cogs are made of the corrugated board. The screws serve as spindles and simultaneously as fastening devices on a sheet of corrugated board. A crank – made of wire – is fastened to the bigger cogwheel.

One cog of each gear is coloured, to determine the number of rotations.

The bigger cogwheel is driven by the smaller one.

driving gear output gear

Observation:

Driving gear and output gear rotate in opposite directions. The output gear turns twice as fast as the driving gear.

Analysis:

If a rotary motion is transmitted from a bigger driving gear onto a smaller output gear, the number of rotations of the smaller cogwheel is greater.

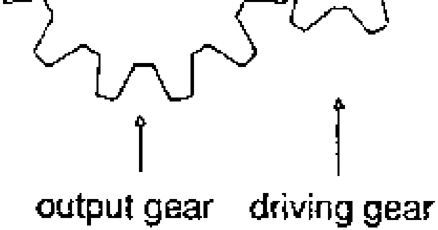
The quotient of the number of rotations is called transmission. It is coputed by the proportion between the two cogwheel radii or between the proportion of the cogs of the single gears.

$$\mathbf{u} = \mathbf{r_1/r_2} = \mathbf{z_1/z_2}$$

u: transmission
r: radius of a gear
z: number of cogs

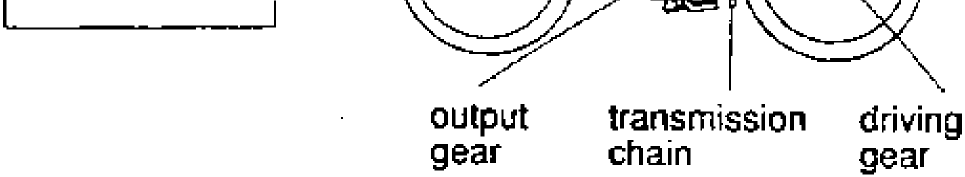
Practical Use:

One of the numerous examples of such a transmission is the gear mechanism of a grinding machine. The grindstone (as working element) is connected over a spindle to a smaller output gear, which speeds up. With bicycles, the motion is transmitted over the chain.



Observation:

Driving gear and output gear turn into the opposite directions. The driving gear turns double as fast as the output gear.



Analysis:

If a rotary motion is transmitted from a smaller driving gear onto a bigger output gear, the number of rotations of the bigger cogwheel is smaller. The quotient of the number of rotations is called transmission. It is computed by the proportion between the two cogwheel radii or by the proportion between the cogs of each gear.

$$\mathbf{u = r_1/r_2 = z_1/z_2}$$

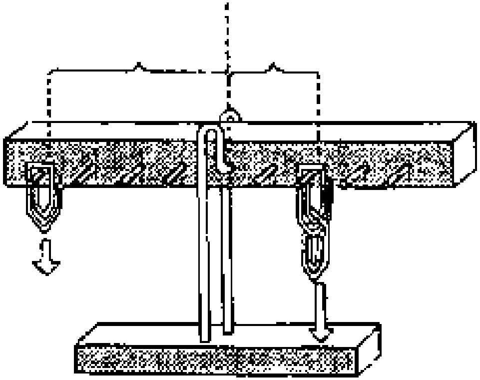
u: transmission
r: radius of a gear
z: number of cogs

Practical Use:

A vivid example of a transmission to slow down is the gear mechanism of a bread–slicing machine. The knife as working element is connected to a big output gear which undergoes a transmission into slowness by a smaller driving gear.

styrofoam (or soft wood)
thin iron nails
paper clips metal rings which are similarly heavy
(if existing: weights)
pencil, ruler
firm, thin wire
knife

distance between attacking force and the fulcrum



Procedure:

As shown in the drawing 1, a two–armed lever is constructed.

The axle bearing has to enclose the axis in such a way that the lever can freely rotate. However, it should not be too loose. It is favourable to pierce the styrofoam with the wire, which serves as axis and rack. Perhaps the wire should be heated before hand. The weights, e.g. paper clips or metal rings are fastened in different amounts at different distances from the fulcrum.

Practical Use:

Examples of two−armed levers include: beam scales, scissors, pliers, and railway−signals.

Further thought:

What must be done in the situation of drawing 2 when the seesaw is to be balanced? There are two possibilities.

9.4. MODEL OF A SIMPLE CABLE WINCH

Main Goal:

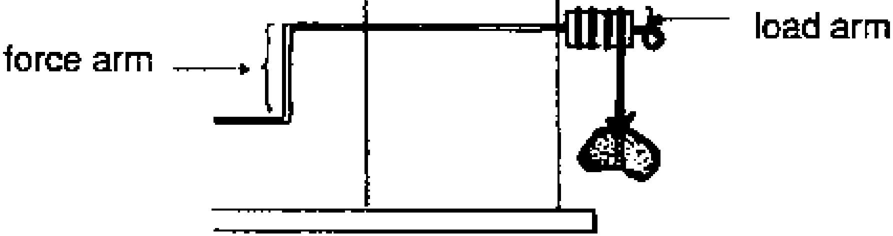
Younger pupils learn that loads can be moved more easily with the help of a cable winch. Older pupils trace the cable winch back to a two−armed lever.

Information:

With the help of a cable winch, loads can be lifted vertically, or pulled closer horizontally more efficiently, i.e. with less effort.

Simple cable winches consist of a cable drum, the cable, and the friction drive. The friction drive can be moved by hand as well as by a motor.

(see experiment: A SEESAW − A TWO−ARMED LEVER)



Observation:

The stone can be lifted more easily with the cable winch.

Further thought:

We save force with cable winches or levers.
Do we get this for granted or do we have somehow to pay for?

9.5. INERTIA

Main Goal:

The experiment illustrates well–known observations, from which the law of inertia can be derived.

Information:

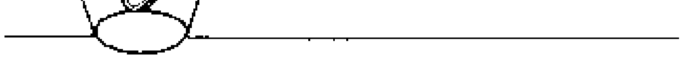
Inertia describes the property of all bodies to counteract a change in motion. That's what experience teaches us.

The heavier a body is, the more inertia it exerts.

It is more difficult to put a heavy body from a position of rest into motion than a light one.

More force is needed to stop a heavy body than to stop a lighter body.

Materials and Apparatus:



Observation:

The coin falls into the glass. It does not join the movement of the paper.

Analysis:

If stationary bodies try to remain in a position of rest, then, once in motion, they should also try to remain in motion. They should resist to change their state of actual motion. This is, in fact, the case.

Practical Use:

these principles can be observed with vehicles – cars, buses, trains, aeroplanes. If they suddenly stop, the passengers fall forward. If these vehicles start quickly, the passengers are pressed into their seats.

It is very dangerous to jump on or off a moving train, as our body hardly can balance the sudden change in motion.

Illusionists take advantage of the law of inertia, when they pull a table cloth off a set table as quickly as a flash of lightning. With a little everybody can do this too.

Further thought:

Materials and Apparatus:

2 brushes or brooms
marbles or peas
sand

Procedure:

a. As shown in the diagram, the two brushes are placed on top of each other.

b. The upper brush is moved to the right side.

c. The marbles are rolled over a smooth and a sandy (rough) ground. Their initial speed should be nearly the same.

Observation:

a. The bristels grip one another.

certain depth of tread patterns, so that the car does not skid on a wet road.

The brakes should not be wet or oily, because this would greatly reduce the breaking action (friction).

A nail or a screw stays in a wall or in wood because of frictional forces.

Further thought:

When we walk, has this also to do with friction?

9.7. A HEAVER – A ONE–ARMED LEVER

Main Goal:

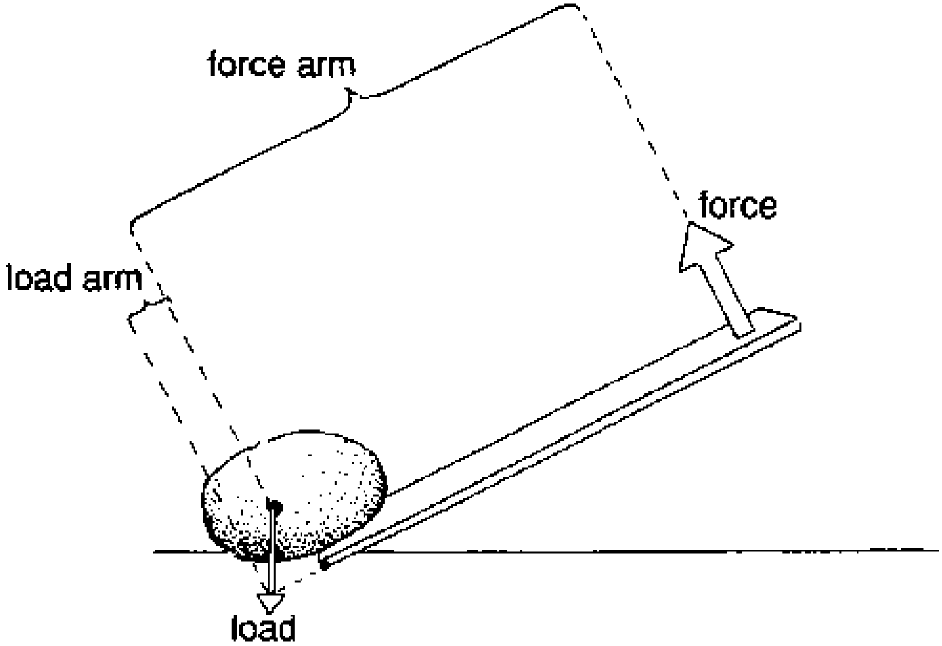
With a one–armed lever, it can be demonstrated that a weight can be lifted more easily, the longer the force arm of the lever.

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 one–armed lever lies at its end.

Load arm and force arm of a one–armed lever are resting on the top of one another. Thus, the two forces attack the same side of the lever.



Observation:

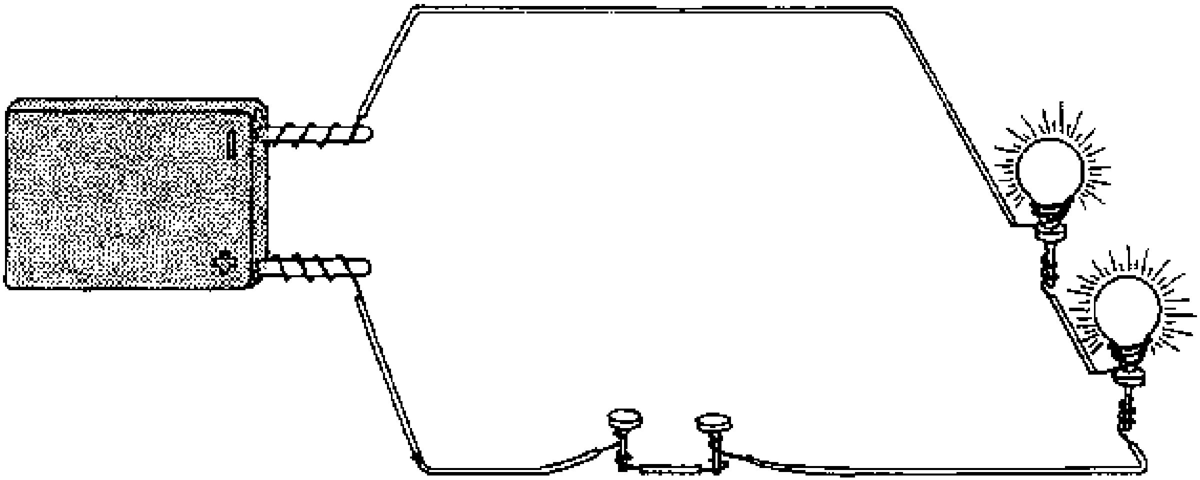
The longer the lever, the greater the distance between the fulcrum and the end of the heaver, and the less force is needed to lift the stone.

Analysis:

N. B.

The experiments performed with batteries, can also be performed with a transformer.

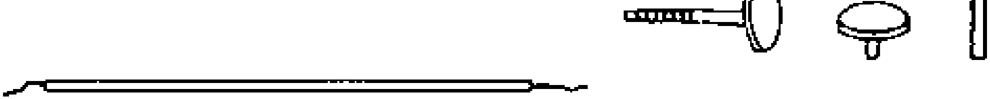
(Batteries pollute the environment and are expensive)



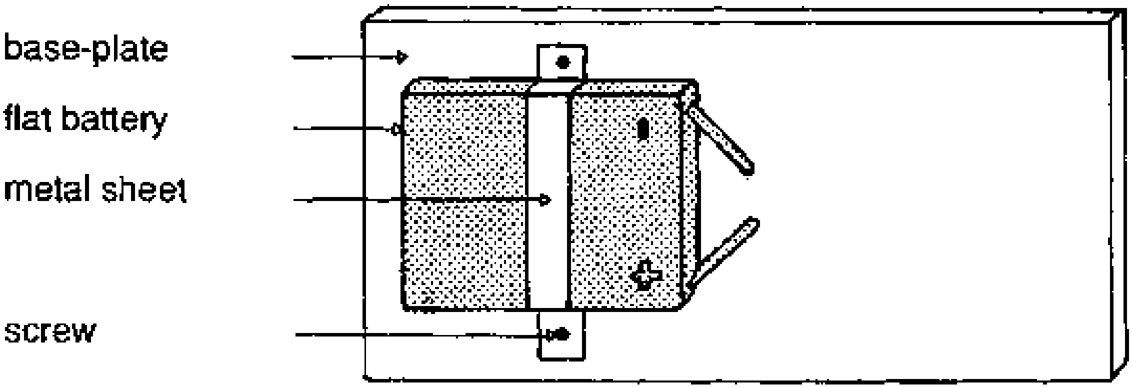
SUGGESTIONS FOR "SCIENCE OF ELECTRICITY"

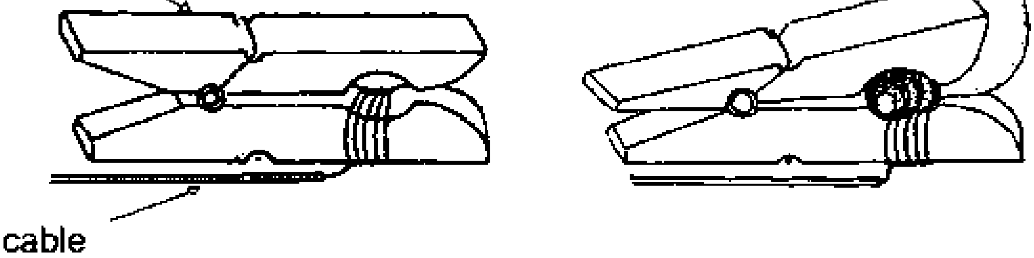
a. MATERIALS

batteries	:	flat and round batteries
small light bulbs	:	e.g. from flashlights
metal sheet	:	thin, made of copper, aluminium, or iron

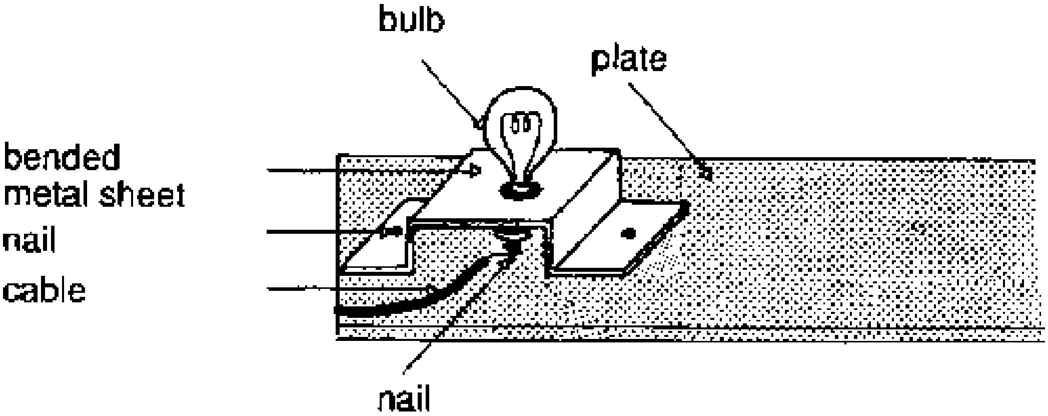


b) Suggestions for the base–plate

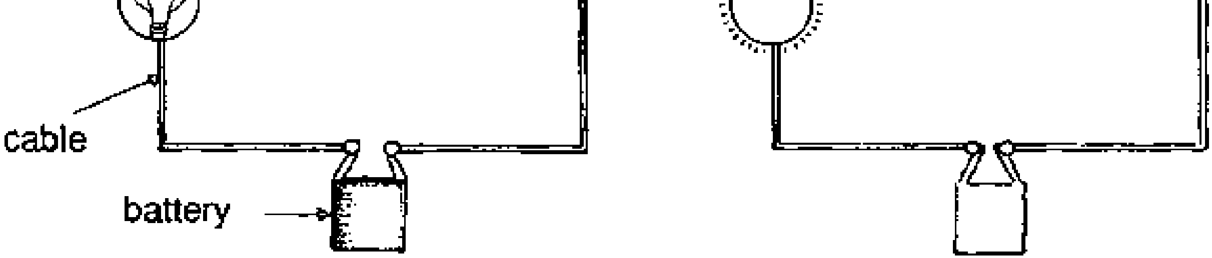




Clothes peg used as clamp



d) Suggestions for the switches



slide-switch: off

on

10.1. A JET OF WATER IS DEFLECTED

Main Goal:

The following experiment demonstrates static electricity, which can be found when a non–conductor is charged due to friction.

Information:

Various non–conductors, e.g. rubber, glass, plastic, can be charged electrically by rubbing them with a woollen leather or nylon cloths.

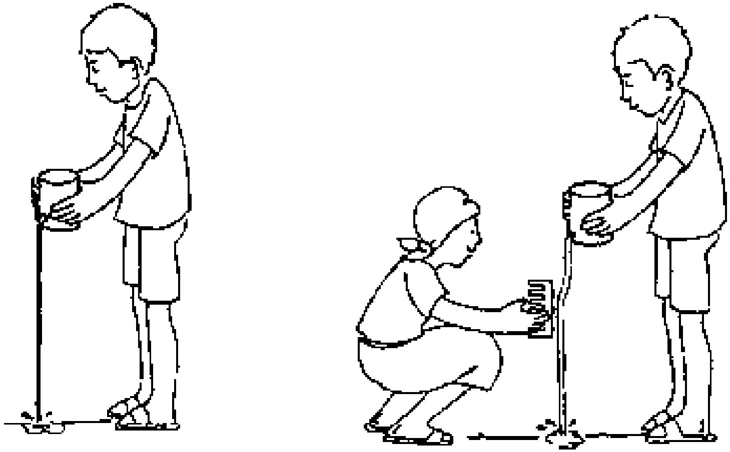
Friction causes an electron surplus or deficiency, depending on the material, (The material, used to rub the non–conductor takes on the opposite electric charge.)

This specific charge is retained for a short period, so that the influence – electrical attraction

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

c. The comb is rubbed vigorously with a woollen cloth and then brought close to a thin jet of water.

d. Inflate two balloons, rub them at your woolen pullover and try to get hot balloons close together.



Observation:

a. The sheeting or bags repel each other. They do not touch.
b. A crackle can be heard. In a darkened room sparks can be seen.
c. The jet of water is attracted by the comb.

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 voltage (in volts V) across the circuit.

Thus power = current × voltage,
in units watts = amperes × volts.

A simple circuit can be demonstrated with the help of a battery and a small light bulb.

Materials and Apparatus:

battery (about 4.5 V)
small light bulb (about 2.2 V)

Procedure:

The circuit is closed as illustrated in the diagram below.

Practical Use:

see “Main Goal”.

Further thought:

The electric current that flows in the circuit consists of electrons. Where do they originate?

10.3. THE PRINCIPLE OF A FLASHLIGHT

Main Goal:

This experiment demonstrates that switches can close and interrupt circuits.

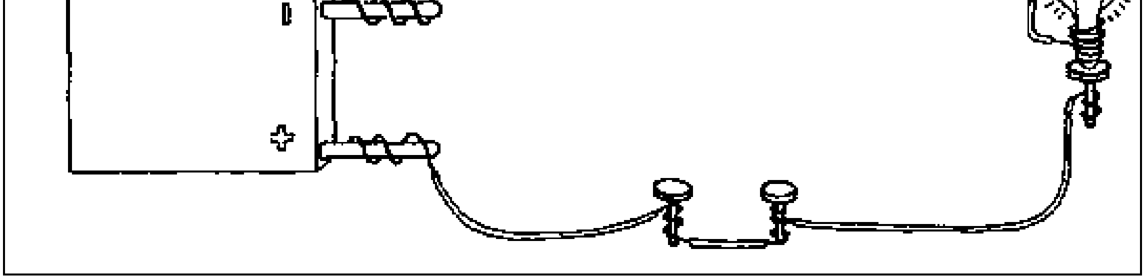
Information:

Switches connect contacts. Those which are known from the household and engineering include slide switches, rotary switches and button switches.

Materials and Apparatus:

see suggestions “SCIENCE OF ELECTRICITY”

Procedure:



Observation:

The bulb lights up if the switch is connected with the two drawing–pins. The bulb lights off when the switch is ‘opened’.

Analysis:

Switches can close or interrupt circuits.

They connect or interrupt two conducting parts of a circuit.

There is no current when the switch is off.

Wood or cardboard seem not to be able to conduct electric current.

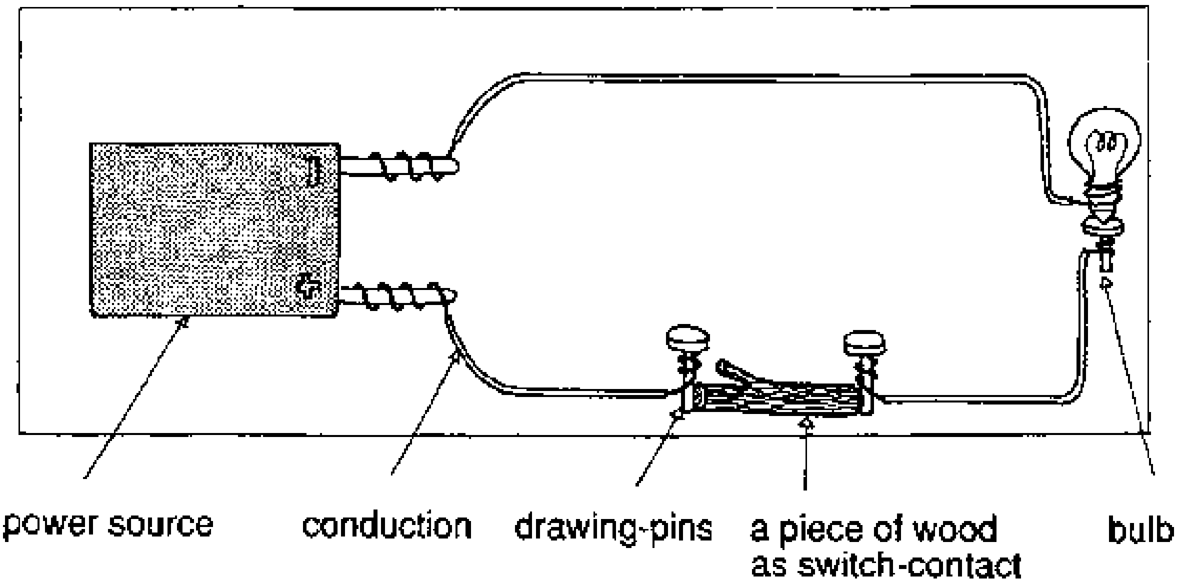
Practical Use:

see “Main Goal”.

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

Procedure:

A circuit is set up as shown in the following diagram.
The materials to be tested are connected up between the two iron nails.
A material conducts electricity when the bulb lights up.



coal	+	
paper clip	+	
coin	+	
nail	+	
cigarette paper (metal foil)	+	
water		**0**
wet wood		**0**

Analysis:

It depends on the material, how good or bad current is conducted.

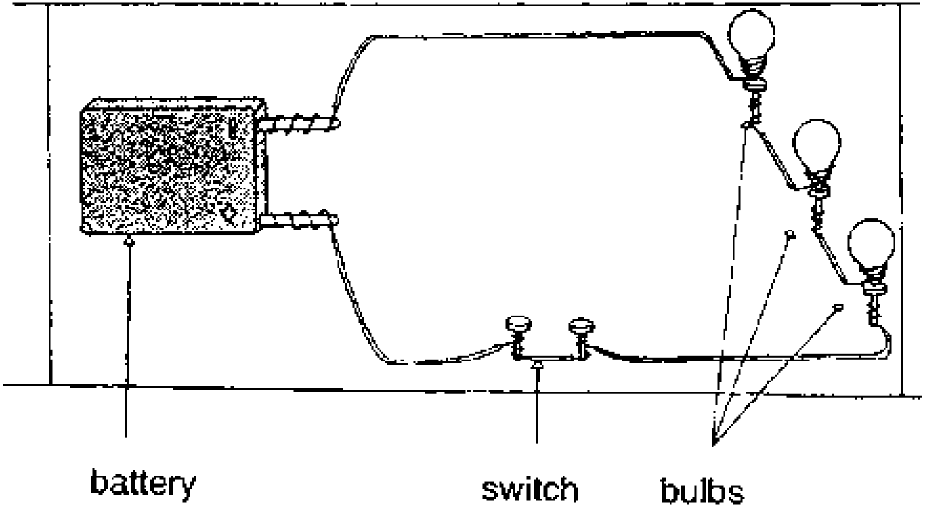
Practical Use:

Materials which conduct current are insulated with materials which are very bad conductors. Thus, a voltage drop, short circuit, and electro–cution are prevented.

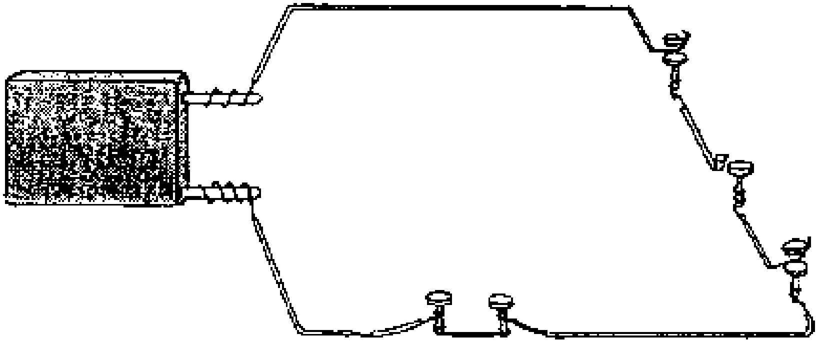
Further thought:

Sometimes not good conduction is required, but good non–conduction. So, what kind of material is used as isolators?

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



b. When the switch is closed one of the small bulbs are unscrewed then another and so on.



10.6. PARALLEL CONNECTION

Main Goal:

This example teaches younger pupils the principle of parallel connection. The observations made are not analysed in detail.

Older pupils learn Ohm's law in combination with Kirchhoff's law.

Information:

If two bulbs – resistors – are connected in parallel circuits, they shine with equal intensity. This is due to the fact that two or more separate circuits exist.

To calculate the current at each resistor, Ohm's law is used.

Materials and Apparatus:

See suggestions – "SCIENCE OF ELECTRICITY"

Procedure:

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

a. The small bulbs are connected in parallel circuits.

b. When the switch is closed, the small bulbs are alternatingly unscrewed.

In all households, outlets and switches are connected in parallel circuits. The electricity meter is placed in the non–branching part of the electric power supply system. The complete amount of electric current used, runs through the meter (1st law of Kirchhoff).

Because the voltage is standard (220 V or 110 V), power (= voltage × current) times the time for which the power is used in the household is what we have to pay for:

power × time = electrical energy

The electrical energy is measured in wattseconds (ws) or kilowatthours (kwh).

Further thought:

What happens when the circuit is interrupted, e.g. at the point 1, or 2, or 3 in the drawing?

10.7. ELECTRICAL CURRENT PRODUCES HEAT

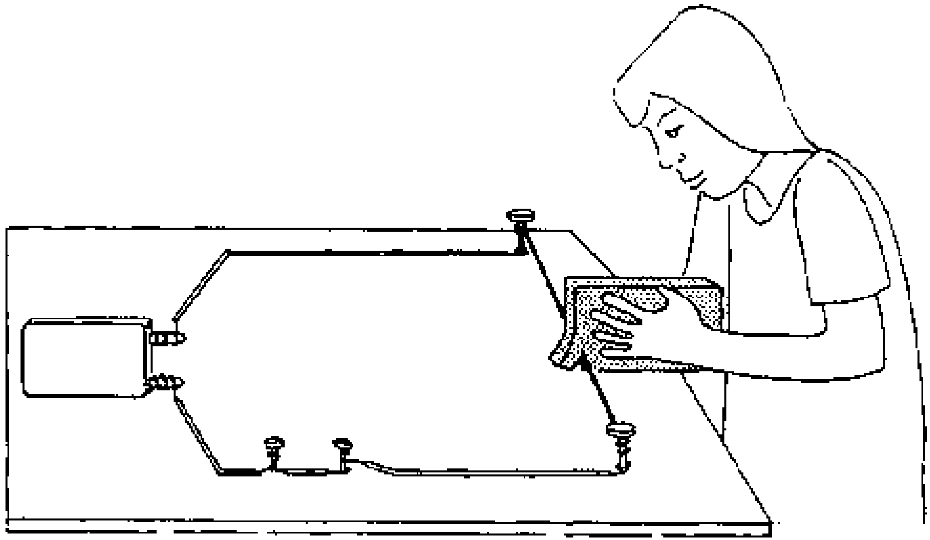
Main Goal:

This experiment demonstrates that electrical energy can be transformed into heat.

Information:

If electricity flows through a conductor, the conductor is heated. Depending on the material of which the conductor is made on the voltage, and on the current, the conductor is heated more battery switch heating-wire (resistor)

When the heating wire is red glowing, it can cut the styrofoam or singe the wood.



Observation:

The heating wire becomes hot, so that it cuts the styrofoam or singes the wood.

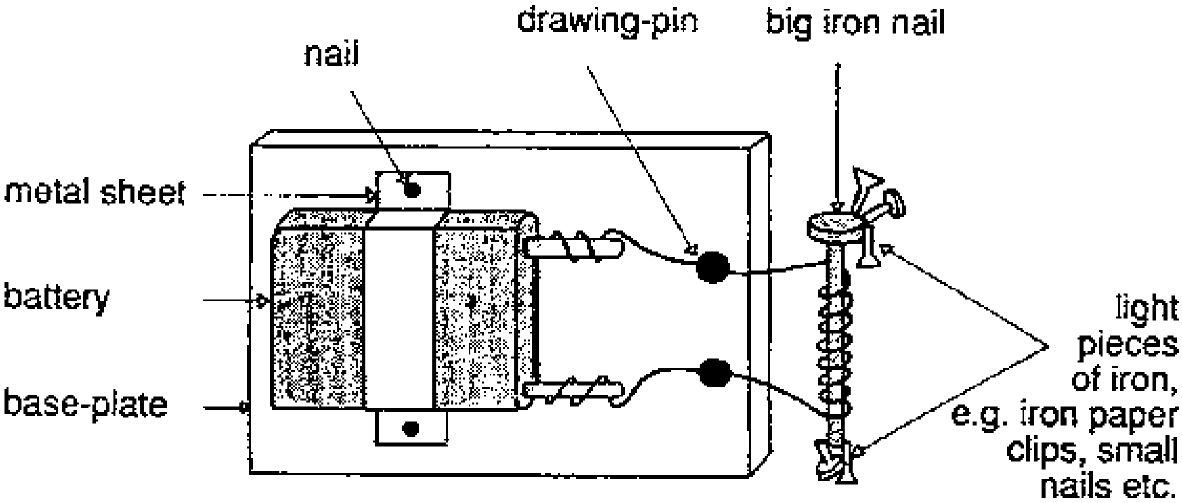
Analysis:

Materials and Apparatus:

see suggestions – "SCIENCE OF ELECTRICITY"
iron nail
light pieces of iron

Procedure:

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



Some experiments which can be performed:

– The current–carrying coil attracts the lighter pieces.

– The attraction is increased with the addition of the iron core.

– The attraction is increased or decreased.

– Small current means little attraction, large current strong attraction.

Analysis:

A coil with an iron core is called an electromagnet. Its attractive power is greater, the higher the number of coil windings and the larger the current An electromagnet looses almost all its effect when switched off. No current, no magnetic effect.

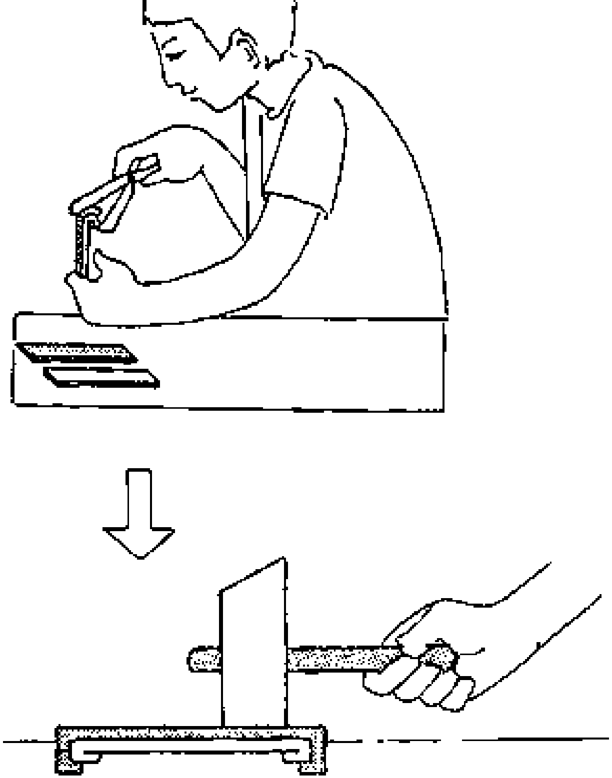
Practical Use:

With the help of an electromagnet, iron pieces are transported and sifted out from other metals.

Electromagnets are also used in many electrical appliances. They either close a circuit, as a bell, or interrupt the circuit, as in an electric fuse.

Further thought:

A permanent magnet (e.g. a horse shoe magnet) has a magnetic North–Pole and a magnetic South–Pole. What’s about poles of an electro magnet?



The strips are then hammered flat.

Practical Use:

Bimetallic strips are used wherever it is necessary to interrupt an electrical contact at a specific temperature.

The circuit is interrupted, when the bimetallic strip is twisted.

Thus, bimetallic strips serve in thermostats. They are used in irons, ovens, electrical fuses, refrigerators, etc.

Further thought:

How would you construct a switch (e.g. a thermostat) by the help of a bimetallic strip?

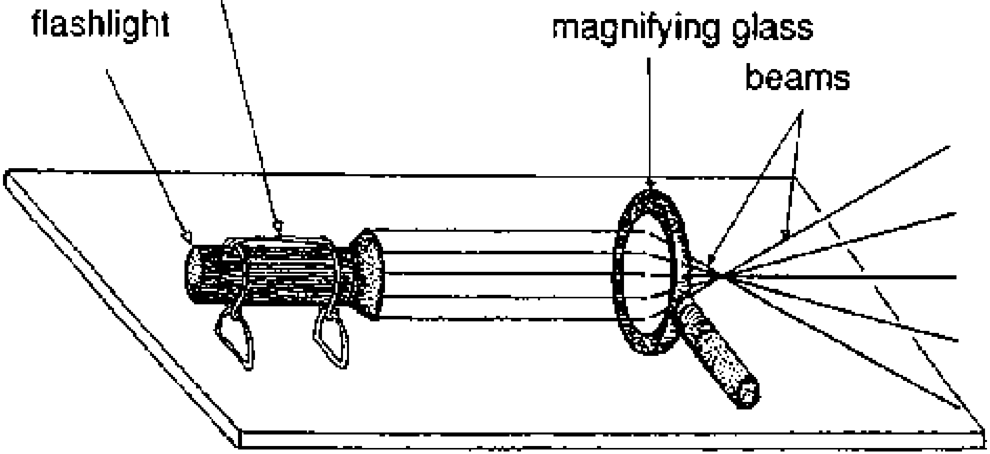
11. OPTICS

11.1. A CONVEX LENS

Main Goal:

This experiment shows the course of the rays of a convex lens or condensing lens.

Information:



flashlight
magnifying glass
beams

The point is called the focal point.

It is situated on the optical axis.

The distance from the lens centre to the focal point is called the focal length (f).

Practical Use:

Convex lenses are used to correct long–sightedness and in microscopes, cameras, binoculars, etc.

The lens of the human eye is a convex lens.

Further thought:

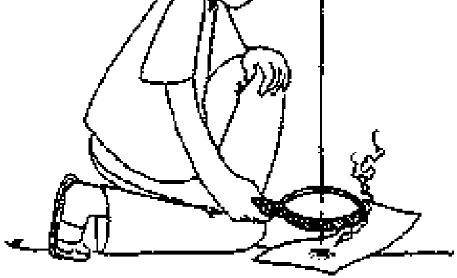
Optical lenses normally are made of glass. Can one obtain the same effect (focusing of parallel light in one point) with lenses of other material?

11.2. THE BURNING GLASS

Main Goal:

The experiment demonstrates that a convex lens works as burning glass.

Information:



Observation:

The light can be seen as one small spot on the sheet of paper.

Here the paper starts to burn.

Analysis:

A convex lens can be used as a “burning glass”.

At the focal point, the sun’s rays and the energy carried by these rays are collected. Here, the energy concentration or energy density is so high that paper can be set on fire.

Further thought:

Why can you not get the same effect with a flash light as light source?

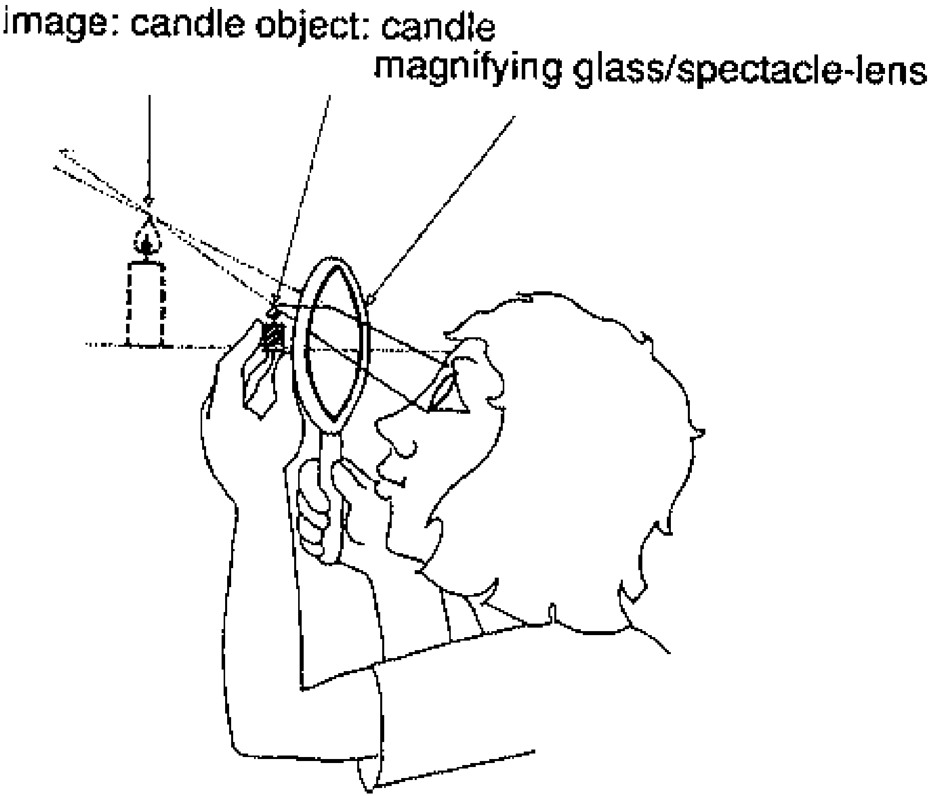


image: candle object: candle
magnifying glass/spectacle-lens

A convex lens is needed by people who are longsighted.

The eyeball of a long–sighted eye is flattened. Thus, without a convex lens, the incoming rays meet “behind” the retina. The lens corrects this defect.

Further thought:

Within glass light has a lower velocity than in air. Therefore, light going through the middle of the lens, where the glass is thicker, looses more time than light going through the glass at the edge. Is this fact of importance for the image forming?

11.4. REAL IMAGES WITH CONVEX LENSES

Main Goal:

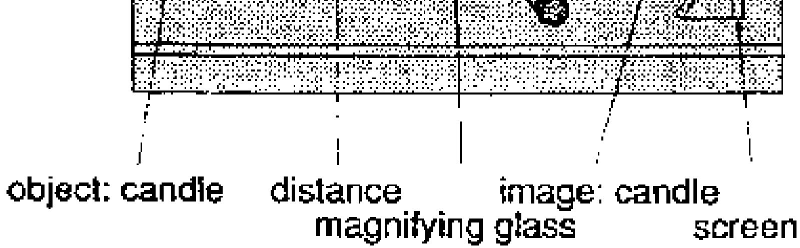
Through this experiment, images created by a convex lens are observed.

Information:

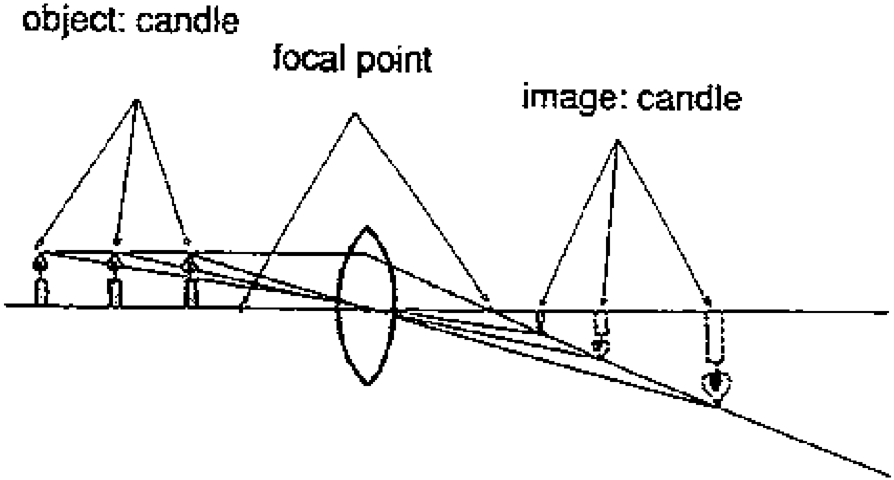
Convex lenses create images, which can be projected on a screen. They are called real images and appear upside down on the screen.

If an object is moved towards **a** convex lens, its real image moves further away from the lens and becomes larger.

If the object is located at the focal point, no real image is formed.



Using the measuring rod, the distance from the candle to the lens, the distance from the image to the lens, the object size and the image size are measured.



Observation:

Information:

Diverging lenses are thinner in the middle than at the rim.

Rays parallel to an axis are refracted by an concave lens in such a way that they are refracted off the optical axis.

If the rays are followed backwards, it seems as if they all come from one point. This point is called the “virtual focus” or “point of divergence”.

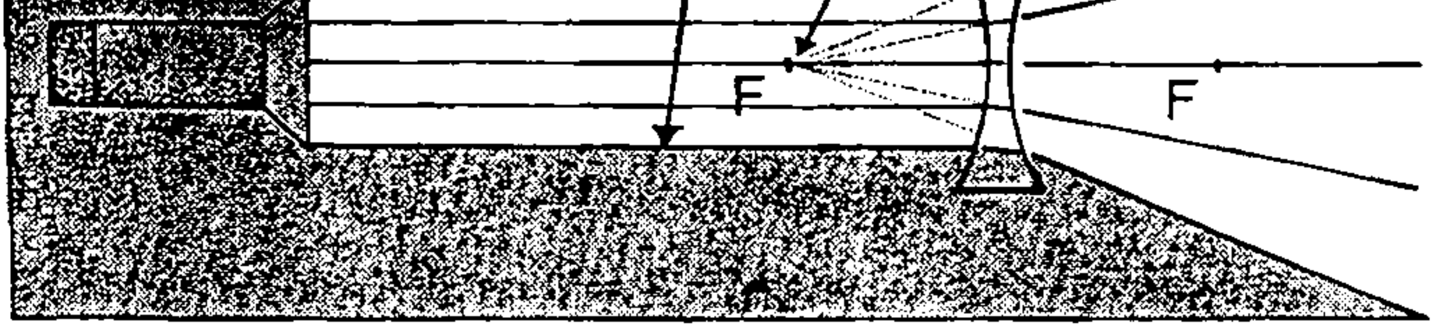
The centre ray remains at the centre. No real image is created.

Materials and Apparatus:

concave lens –
(one spectacle–lens for short–sighted people)
flashlight (or maybe a candle)
rack made of wire for the flashlight

Procedure:

The apparatus is set up as shown in the following diagram. The room is darkened and the ray path is made visible by means of cigarrette smoke or chalk dust.



Observation:

Behind the lens, the light of the lamp is diverging in a way that makes them appear to come from a single point in front of the lens.

Analysis:

Lenses which deviate light in such a way that it is spread out or diverges are called concave (or negative) lenses.

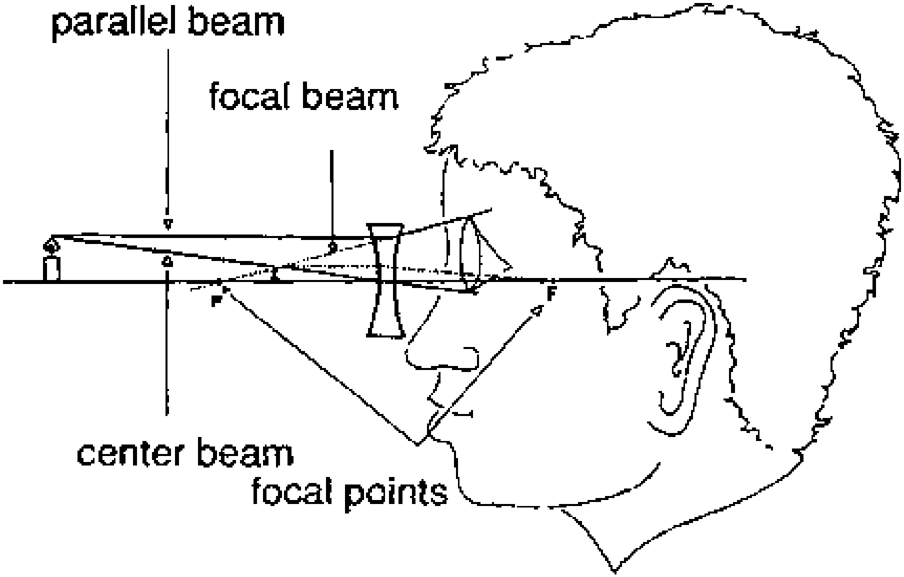
If the refracted rays are followed backwards, it seems as if they all come from one point.

This point is called the virtual focus or point of divergence.

Practical Use:

Procedure:

The burning candle is placed at some distance from the lens. The candle is observed through the lens.



Observation:

An upright image is observed, smaller than the actual candle.

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

If the object is moved away from the pinhole diaphragm, the size of the image is reduced.

If the object is moved towards the pinhole diaphragm, the image is enlarged.

A small pinhole creates a clearer image but is weaker in light intensity than a bigger pinhole.

The image is created by rays coming from every point of the object. A small number of those rays arrive at the diaphragm opening. These finally focus onto the screen as several light spots. All of these spots together form the image.

Materials and Apparatus:

candle
cardboard box (shoe or cigar box)
translucent paper, waxed paper
pieces of cardboard
pair of scissors
glue

Procedure:

One of the two small side–walls of the cardboard box is replaced by translucent paper. That's the screen where the image appears.

A hole of 4 mm diameter is cut into the other small side–wall.

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

Analysis:

If good optical images are desired, the aperture, light intensity, and distance of the object from the aperture have to be coordinated.

Practical Use:

In a camera a condensing lens is placed in front of the diaphragm (see experiments on condensing lenses). This provides better light exposure. The size of an opening can be changed using a mechanism called iris diaphragm.

The human eye lets light penetrate through the pupil. The pupil becomes smaller or larger depending on the intensity of the light. Upside–down, scaled–down images are produced on the retina.

Further thought:

Our optical perception system delivers upside–down–images, but we ‘see’ things upright. Isn’t that a contradiction?

BIMETAL	:	Two different metals which are closely connected to each other
BOILING	:	A rapid state of evaporation which takes place within the liquid well as at the surface.
CAPILLARITY	:	The rise of a liquid in a fine hollow tube or in narrow space due to surface tension.
CARBOHYDRATE	:	Organic compounds of carbon, hydrogen, and oxygen with the general formula $C_n(H_2O)_m$, e.g. all kinds of sugar, starch, and cellulose.
CATALYZER	:	A substance which induces or accelerates a chemical process, however, is not affected by the reaction.
CATHODE	:	katodos – Greek: the way downwards It is the electrode which is connected to the negative pole of a voltage source. (Emits electrones and gives off negative ions.)

expand when heated. It is an alloy made of 60% copper and 40% nickel.

CONVECTION : convehere – Latin: to bring together
The transmission of heat or electricity by the mass movement of the heated or electrified particles as in air, gas, or liquid currents.

CONVERGING LENSE : A lens that is thicker in the middle than at the edges and refrects parallel rays of light passing through it to a focus.

COTELYDON : kotyle – Greek: cup
The seed–leaf, primary or first leaf of an embryonic sporophyte. They are part of the plant embryo in the seed. Those of peas and beans serve as food storage organs for the seedling.

CRYSTAL : Regular arrangements of atoms, ions or molecules in a pattern as in solid grains, sugar, salt, etc.. The regular arrangements determine the shape of the matter.

DENSITY : The mass (amount of matter) per unit of volume (space into which the matter is packed)

density = m/v

ENERGY	:	A state of a body or a system of bodies that – among other characteristics – enables the body or the system to do work.
ENZYME	:	zymes – Greek: leaven en – Greek: in Any of various complex organic substances, originating from living cells, and capable of producing by catalytic action certain chemical changes.
EROSION	:	erodere – Latin: to gnaw off The process by which the surface of the earth is worn away by the action of water, glaciers, wind, waves etc..
EVAPORATION	:	Change of state at a surface of a liquid as it passes to vapor.
FERMENTATION	:	fermentare – Latin: to cause to rise The breakdown of complex molecules in organic compounds, caused by the influence of organisms; such as yeast or bacteria or enzymes.
FORCE	:	Any influence that can cause a body to be accelerated.

MAGNETISM	:	The property or quality or condition of a magnetic field.
MASS	:	Quantity of matter in a body. Becomes manifest due to a body's inertia and/or due to the property of being attracted by another mass in its environment (heaviness).
MELTING	:	Change of state from the solid to the liquid form.
MIXTURE	:	An aggregate of two or more substances which are not chemically united and exist in no fixed proportion and do not lose their individual characteristics.
MOLECULE	:	The smallest particle of any substance that has all its chemical properties. Atoms combine to form molecules.
MONOSACCHARIDE	:	A carbohydrate not decomposable by hydrolysis; simple sugar such as glucose, fructose, etc..
OSMOSIS	:	osmos – Greek: an impulse, a pushing The tendency of a fluid to pass through a semipermeable membrane into a solution of lower concentration, so as to equalize

POLYSACCHARIDE : polys – Greek: many
saccharum – Latin: sugar
Any of a group of carbohydrates that decomposes by hydrolysis into more than three molecules of monosaccharides. For instance cellulose, starch, etc..

POWER : Time rate of work:

$$power = \frac{work}{time}$$

PRESSURE : Ratio of the amount of force per area over which that force is distibuted.

$$pressure = \frac{force}{area}$$

PURE SUBSTANCE : It is a substance which cannot be further separated on the basis of physical processes.

RADIANT ENERGY : Energy that travels in the form of electromagnetic waves through space without needing a medium. When it meets an absorber it is transformed into thermal energy. On the other hand, the thermal energy of a radiating body is transformed, at the instant of behave similar a stretched rubber membrane.

THERMAL ENERGY	:	Internal energy a body possesses due to the random motion of its molecules. The faster the motion, the higher the thermal energy of the body.
VASCULAR TISSUE	:	Specially modified plant–cells, usually consisting of either tradual or sieve cells, for circulation of sap.
VELOCITY	:	Speed of a body but with specification of its direction of motion.
WORK	:	Product of the force extended and the distance through which the force acts.
XYLEM	:	xylon – Greek: wood Lignified portion of vascular bundle, which is found all over the plant. Its purpose is to transport mineral salts and water sucked up over the roots.

GTZ

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag–Hammarskjöld–Weg 1+2 · D6236 Eschborn 1 · Telefon (0 6196) 79–0 · Telex 407 501–0 gtz d

Editing Coordinators:

J.B.A. Mihigo, Mzumbe Book/Project
Manfred Schiess, Rastatt, Germany

This workshop project was sponsored by:

– Ministry of Education and Culture, Tanzania
– Ministry of Education and Culture, Hessen, Germany
– Goethe–Institüt, Dar es Salaam

This low–priced edition for Tanzania is sponsored by:

– Canadian Organization For Development Through Education (CODE)
– Partnership Furtherance With the Third World (APDW), Karlsruhe, Germany

Editorial committee:

J.M. Waryoba, A.S. Mrutu, B.W. Faustine, M.J. Mbuji,
J.M. Sekulu, J.B.A. Mihigo, G. Emmanuel, B. Enjiku,
I. Tabaro, D. Pietz, M. Schiess

The editors thank Dr. W. Kemp, C. and G. Stieghorst for their valuable comments and help in proof–reading.

Special Technical assistance was sponsored by:

Busanji Wilson Faustine
Kilakala Secondary School

Charles Philemon
Jangwani Secondary School

T.J. Msami
Weruweru Secondary School

M.J. Mbuji
Minaki Secondary School

U.S. Mohamed
Usagara Secondary School

J.D.K. Bulemo
Azania Secondary School

Pastory B. Rwamwasi
Pugu Secondary School

Bonus P. Ndimbo
Songea Boys Secondary School

Raphael R. Malisa
Old Moshi Secondary School

H. Mgonja
Same Secondary School

Foreword

Children come to school with rich knowledge about their environment. They gained this knowledge through observation and imitation. For example, they know how to construct toy cars by perfectly applying the physical laws. They also know how to carry a heavy load on the head and how to lift a heavy stone. They can do all this without studying Physics. Through such learning by doing they absorb easily the knowledge needed to solve everyday problems.

Science and Physics for that matter is borne in the nature around us. Scientists observe, explain and formulate the results into abstract laws for further investigation of other problems. We are all born with the ability to be investigators, however, we have to learn how to do it. This learning should start with phenomena the child is familiar with and not with abstract definitions what science is.

The rich practical knowledge of the students can be used as a springboard for teaching science not only to beginners by getting the pupils to have a critical look at and ask analytical questions about their environment. This requires a practical approach in teaching. By this approach students learn to be investigators by finding the applied principles in the things around them. Students should learn to see the daily environment with the eyes of an analytical scientist. This makes them also aware of the resources to be found in their country.

Physics as a natural science deals with the investigation of matter. However, the investigation of matter can be done by using a practical approach only.

Children are eager to talk or ask questions about things they are familiar with rather than about abstract theoretical knowledge taken from books.

Furthermore, the teaching of science with locally available materials makes learning by doing accessible, even when conditions for teaching are not conducive.

This is the message of this book. It shows that the most common materials are often sufficient for stimulating experimental lessons. Experimenting is a difficult job for a less experienced teacher. However it can also be

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 there is no need to repeat them here. The reader will welcome the ideas on how to modernize his teaching since this book provides him not only with the "how to do it" but also with the "what to do" information.

Going through this book, the reader will find that many traditional experiments can be performed as handy experiments too. They are more illustrative and more appealing to students than "black box experiments" with sophisticated equipment. They encourage the students' creativity to invent other experiments and stimulate their natural curiosity to understand the physics behind the experiments.

The suggestions of this source book are stimulants to modern teaching and learning, i.e. *teaching and learning by doing.* They should be supplemented with the teachers' own ideas, students' ideas and ideas from other sources. This source book is a result of a workshop which drew participants from Uganda, Kenya, Germany and Tanzania.

We acknowledge with gratitude the professional, technical and financial assistance of all who have contributed to publish this source book particularly to the Ministry of Culture of the State of Hessen (Germany) and the Goethe–Institute for sponsoring the workshop.

Last but not least, we thank Morogoro Secondary School for hosting the workshop from which the source book resulted.

A.S. NDEKI
Chairman of the Executive Committee
Mzumbe Book Project

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 development by improving the daily life of the people.

An experiment has several important phases which we have usually outlined in this source book. The symbols are as follows:

P: The *procedure:* what and how to perform the experiment and/or how to build the apparatus.

Q: *Questions* which the investigator may ask himself or a teacher may ask his students in order to guide them to the proper observations and explanations.

At this stage the dedicated investigator or student should stop reading and try to answer the questions himself after carrying out the experiment. If he/she has the self–discipline needed to do this, he/she will certainly gain a lot.

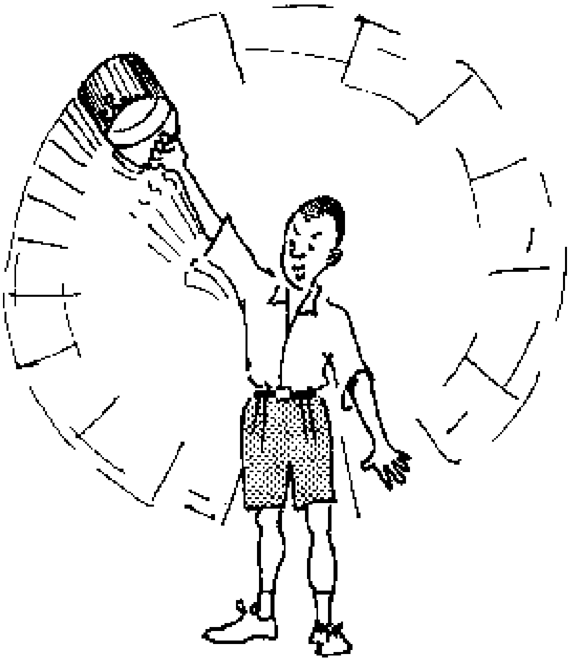
O: The *observations* are described here. So you may check *after* you have made your own observations if you did not miss an important point.

E: The *explanation* of the observations is outlined here. Physics always aims for explaining observations. Only if he can explain his observation, the scientist usually will be able to predict the outcome of other experiments. This leads to the knowledge of the laws of physics. Then he/she may also become creative enough to apply a certain physical law in a machine or an apparatus which he/she invents. This way development takes place.

A: Some *applications* of the phenomenon under investigation in the respective experiment may be given here. Thus, the interested student will easily recognise and appreciate the close relationship between Physics and Technology. The latter cannot exist without the former.

We warmly welcome your criticism, suggestions and opinions about this book. Please, fill in the questionnaire at the end of this volume and send it to us. Please write to us to improve future editions of this book:

1. What is Physics?



1.1 What is Physics?

environment. Let the pupils enjoy physics. This sourcebook shows how this can be achieved.

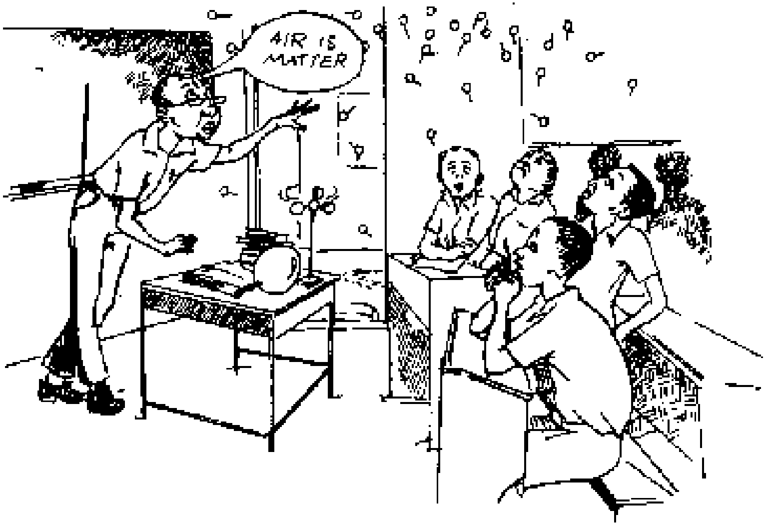
1.2 Laboratory Techniques

Imagine you would buy different kinds and different quantities of meat. The butcher will have to weigh and then calculate the price for each kind of meat and produce the total bill. Thus, measuring and the collection of data happen nearly everyday in our life.

The tailor takes the measurements of his customer and of the material needed for a suit. The milkman measures the volume of the milk sold. The technician measures with a calliper the diameter of a screw and even at school the time of each period is measured. Especially in engineering precise measurements are

There are plenty of meaningful experiments. For these, see chapter 3.

1.4 Matter

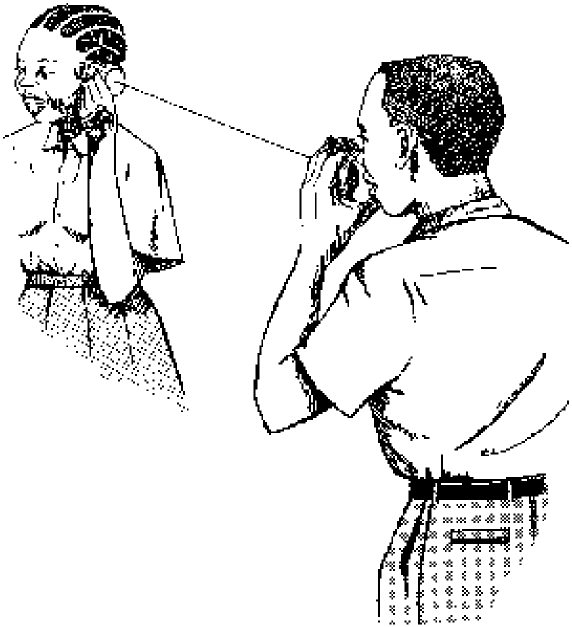


A chair can be touched. Water in a bucket also. But air? Can you imagine that while you are reading these lines your nose is punched more than 100 billion times by air molecules?

The environment around us, whether in solid, liquid or gaseous state is made up of billions of tiny particles which are either molecules or atoms. These particles which constitute air are so tiny, that we cannot see them even by a powerful microscope. However, the students can be given an idea of the particle structure of matter by indirect evidence.

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 do not require a lot of equipment and which are not time consuming in their preparation and performance? See chapter 5.

1.6 Wave Motion

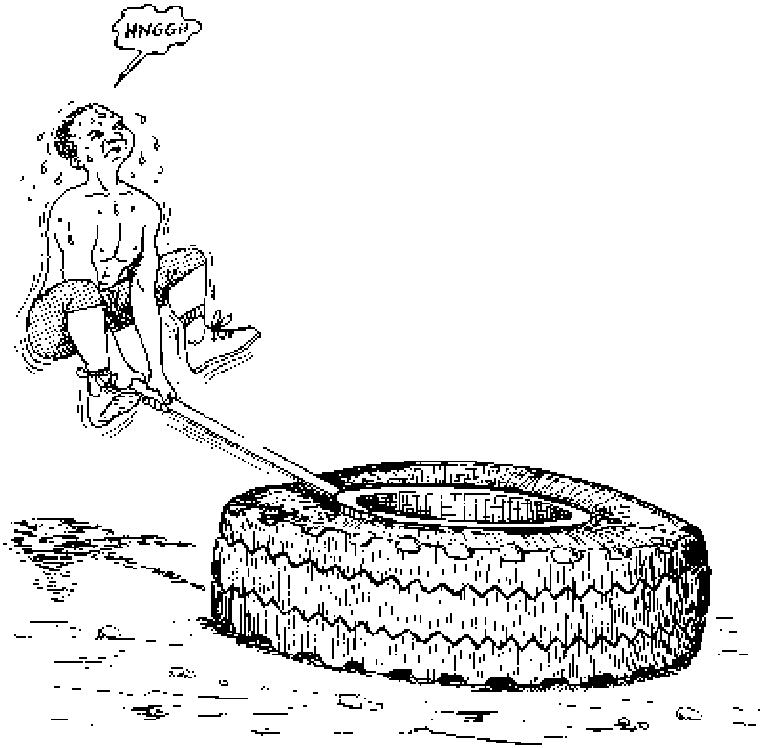


Communication through spoken words has to do with the transport of waves. Telephone and radio are well known. But do we think about waves when we hear a music band, when a craw is croaking or when children are playing with a string telephone?

When we hear about optics, the optician, eye glasses and lenses come into our mind. But that is not all what optics is about. Optics is also about the reflection of an image in a mirror or in a water puddle. The water surface is like a mirror. The image to be seen is inverted and it seems to be as far behind the water surface as the object is in front of it. Perhaps there are no curved mirrors at your school to teach about concave and convex mirrors. No problem. Take a polished spherical spoon and you will be able to perform an interesting lesson. If you have no equipment for an introduction to the principles of how lenses work, this is no problem too. Take a fused and water filled transparent bulb and you can be sure about the admiration of your students about your creativity in teaching physics by doing. Certainly not all themes can be taught by simple qualitative hand experiments only. But you may be astonished to see how many there are for eye catching demonstrations. For details, see chapter 7.

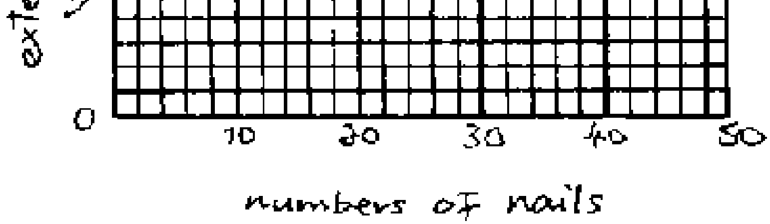
1.8 Electricity and Magnetism

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 wanted? Only look on chapter 8.



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. They should be introduced to the basic measurements of mass, distance and time. They should be trained in recording and in graphical analysis of data.

2.1.1 Data on Weighing



A rubber band is fixed at one end and is attached both to a wire hook at the other end (which serves as a pointer) and a small plastic bag (e.g. for wrapping groundnuts). Fill the bag with nails in succesive small numbers (which you count) or other objects of similar weights. Let the pupils measure the extension of the rubber band, each time they add more nails, record the readings and ask them to draw a graph (see the figure).

2.1.2 Data on Distance

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 experiment several times in each case with the tyre allowed to roll a few more turns. The distance is calculated in each case and a graph is drawn.

2.1.3 Data on Time

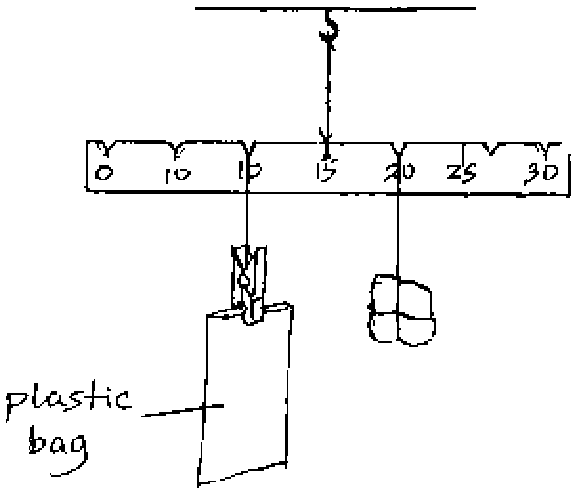
shown. Repeat the experiment by horizontally displacing the nut by 10 cm and 15 cm consecutively. Try to find out the length of a pendulum which happens to oscillate just 60 times in one minute.

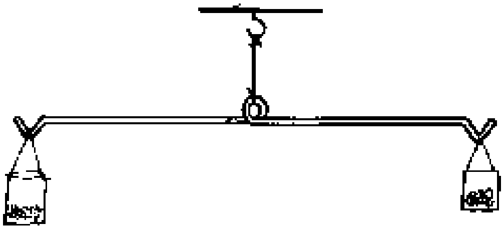
2.1.4 Data on Velocity

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 timekeeper stops his watch.

Pupils record the time taken for each case and figure out the respective velocities.

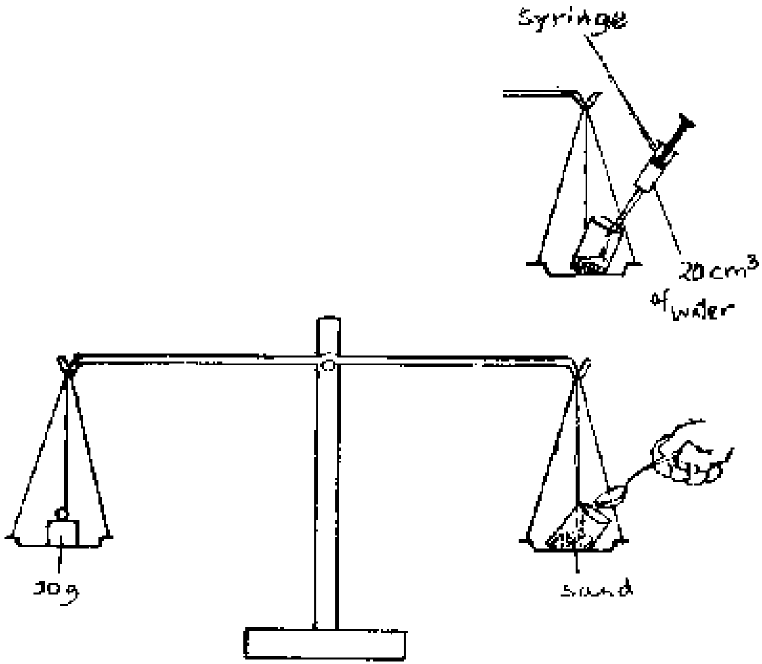
2.1.5 Simple Beam Balances



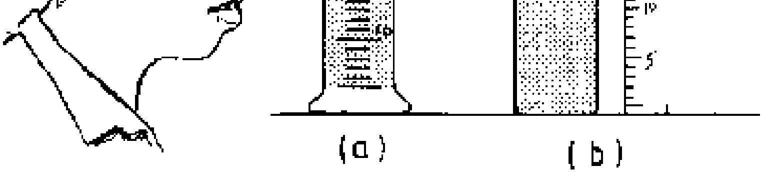


Drill a hole through a clothes peg below the spring for a wire or nail to pass through. Fix a wire right in the spring as a balance beam, and another one in the mouth of the peg as a pointer. (The shorter the pointer, the more sensitive the balance). Fit the arrangement in a wide mouth glass bottle or a plastic bottle marked with a scale.

2.1.7 Weights

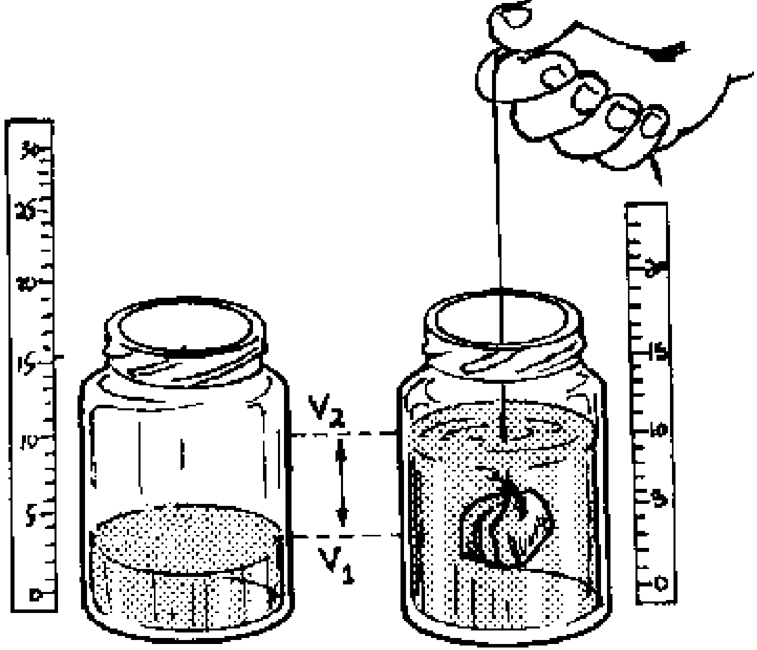


(a) Fill small plastic bags with sand or small stones and compare them with standard weights. Label and seal the bags with a small flame.



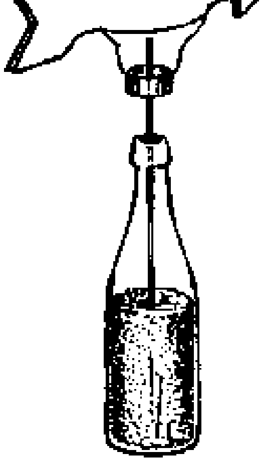
The volume of liquids can be measured by accurately reading the meniscus (a). The principle can be taught with a transparent bottle and a ruler (b).

2.1.10 Measuring Different Densities



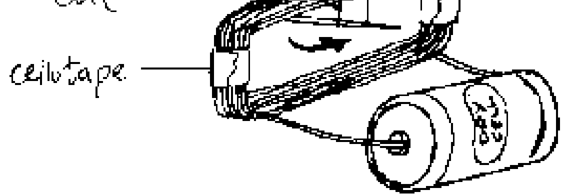
The volume of an irregular body (stone) can be measured by hanging it on a thin thread and dipping it completely in a measuring cylinder containing water. The difference in the volumes of the water read before and after completely submerging the irregular body is its volume. Only the principle is shown here.

2.1.12 Measuring Long Distances



Take an opened fused bulb (for opening see appendix), place a piece of stiff wire so that the bulb turns with low friction on the tip of the wire. Fix two paper arrows folded around the bulb. Dip the wire in a sand filled bottle as a support. The device works excellently.

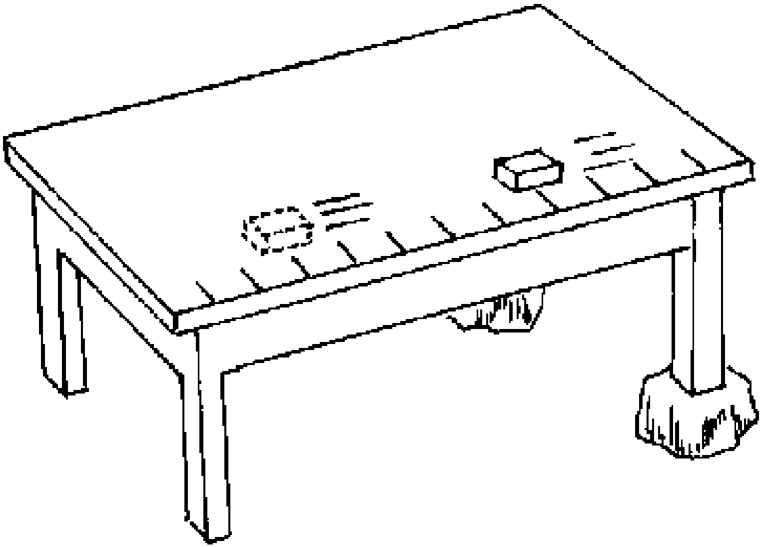
2.1.14 Wind Speed



Wrap about 10 turns or more of insulated wire (from a used motor coil or as used for electric bells) round a match–box in order to get the required shape of the coil. Suspend a magnetised steel needle (or a magnetised piece of a bicycle spoke) with a thin thread inside the coil. You can magnetise the needle with a magnet (taken from the loudspeaker of an old radio) by moving it along for about 30 times always in the same direction. When a current flows through the coil, it deflects the needle. A change of the poles changes the deflection.

3. Basic Mechanics

3.1.1 Uniform Motion



P: Place chalk marks along the long side of a smooth table or plank at an equal distance of 10 cm. Then tilt it so that a matchbox loaded with a stone will just not start to move. Then give the box a little push so that it will move.

Q: Does it need always the same time from one mark to the next?

O: If not, change the inclination of the table or plank until it does.

E: If so, this is a *uniform* rectilinear motion: the velocity is constant, there is no change in velocity, thus the acceleration is zero.

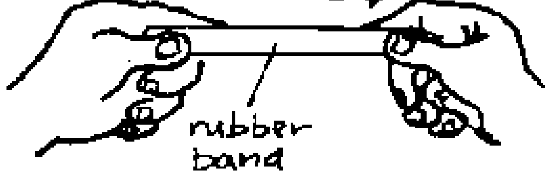
A: Where do such motions occur in daily life? – For example, a stone falling down; a bus accelerating after the stop; a bus breaking before a stop.

3.2 Forces

What is a force? *A force is a push or a pull on a body.* It can be recognised by its effects on a body which are:

Change in velocity of a body (accelerating, breaking, changing the direction of the movement); Deformation of a body (changing its shape or size).

3.2.1 The Effects of Forces



P: Show the effects of forces by pushing, pulling, lifting, turning a stone; by stretching a rubber band.

Q: How can you group these effects of force?

E: Pushing, pulling, lifting, turning *change the velocity of a body.* – Compressing and stretching *change the shape or size of a body.*

A force changes the velocity or the shape of a body.

3.2.2 Making a Newton Balance

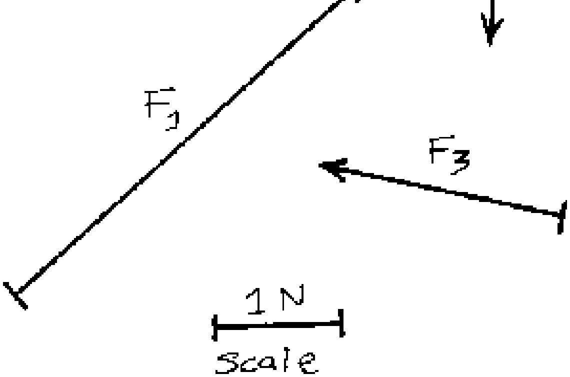
Forces are measured with a Newton balance.

P: Take a strip of card board or a wooden lath. Using incisions or a nail fix a rubber band on it. (The stronger the rubber band, the larger the force you can measure.) Attach one paper clip as a pointer as shown in the figure. Then fix some paper clips as a hook at the bottom end of the rubber band.

Now *calibrate* the balance in *newtons* using either a standard set of weights (e.g. borrowed from the lab of a well equipped school) or another Newton balance: a weighing piece of 1 g mass has a weight of 0.01 N; one of 10 g mass has a weight of 0.1 N; one of 100 g mass has a weight of 1 N and so on. Draw marks accordingly on the scale of the balance.

H: Never apply such a big force that the pointer does not go back to the zero mark when the force ceases.

3.2.3 Direction of Forces



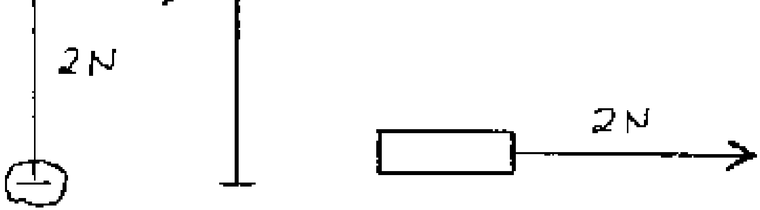
Quantities which have both direction and magnitude are called vectors.

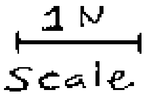
Thus, for example, force, displacement, velocity and acceleration are vectors.

Vectors are drawn as arrows whose length gives the magnitude.

Draw some forces like those in the above figure and a scale on the blackboard and ask the students to give the direction and magnitude of these forces.

3.2.5 Measuring Forces



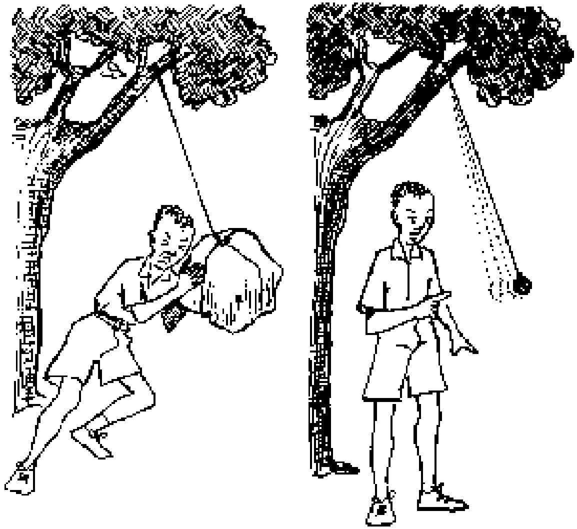


P: Ask the students to draw all the forces which you have measured in experiment 3.2.5 as vectors in their notebook.

3.3 Weight and Mass

The *weight* of a body is the pull of the earth on it. Thus, weight is a *force* measured in newtons. It is a *vector* directed to the centre of the earth. It is measured by the Newton (spring) balance.

The *mass* of a body is a measure for the quantity of matter in that body. Thus, it is a *scalar* which *stays everywhere the same* while the weight of body will decrease when its distance to the centre of the earth increases. It is measured by the beam balance.



P: (a) Suspend a large and a small stone using long pieces of string (e.g. from a branch of a tree). Try to push the two stones. Then try to stop them.

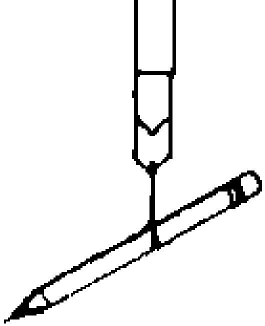
Q: Which stone is harder to push? Which is harder to stop?

P: (b) Take a ball and a stone or brick of similar size. Throw both.

Q: Which is harder to throw?

O: (a) The larger stone is harder to push and to stop than the small stone.

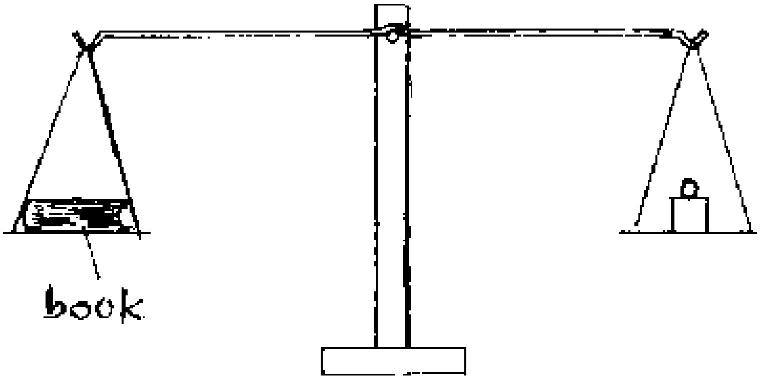
(b) The stone or brick is harder to throw than the ball.



Since weight is a force, it is measured by the Newton (or spring) balance.

P: Take a Newton balance (see p. 15) and measure the weight of a pencil, a book, etc. in newtons.

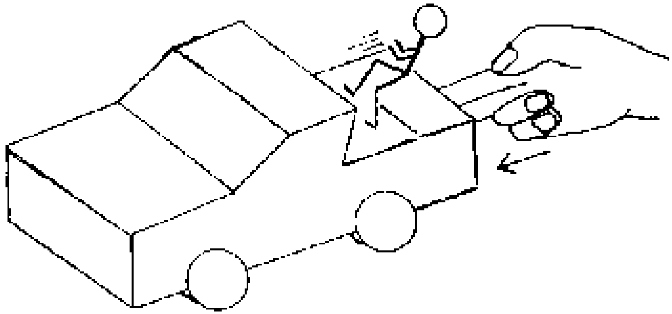
3.3.4 Mass is Measured by the Beam Balance



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 that it leaves the table, see the figure.

Q: What happens? How do you explain this?

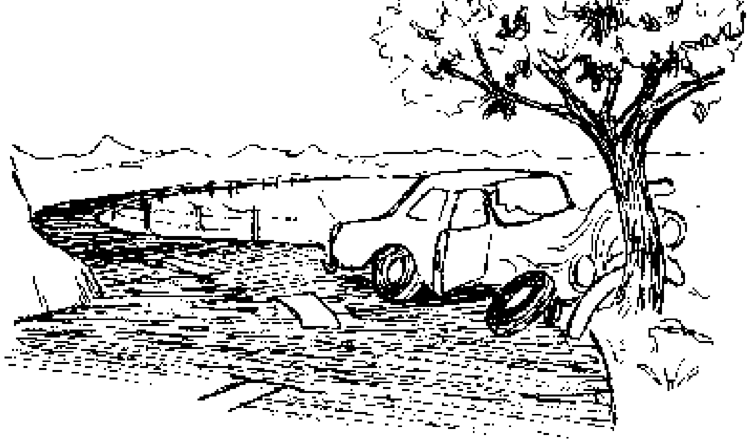
3.3.6 The Standing Passenger in the Pick–up



P: Take a toy pick–up or a box (representing a pick–up) and place a *freely standing* passenger (made of card or wood) in it. Strongly accelerate the pick–up. Make it turn a corner. Finally slop the pick–up suddenly.

Q: What happens to the standing passenger in each case? Why?

3.3.7 Kicking a Brick



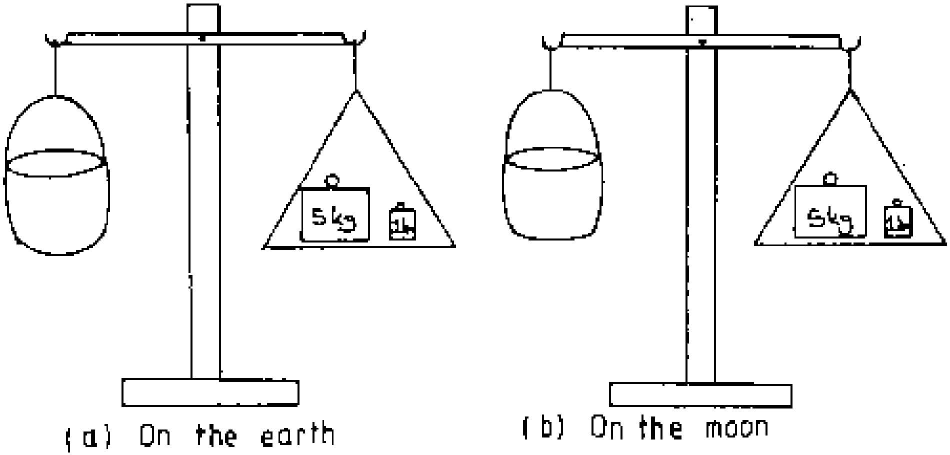
P: Make a display chart of the figure.

Q: Why did this car get so badly damaged?

E: The big mass of the car has great inertia. Thus, a great force exerted by the tree was needed to stop it suddenly. This force deformed the car.

3.3.9 The Weight Changes

3.3.10 The Mass Stays the Same



P: Make a display chart of the figure.

Q: Why is the mass of the bucket of sand the same on the earth and on the moon?

E: The quantity of matter of the bucket has not changed, hence its mass has not changed.

3.4 Centre of Gravity and Stability

This section deals with the moment of a force, the centre of gravity (centre of mass) and stability.

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 near the top (see figure). Mark six 3 cm spaces on each side of this middle point *(fulcrum).* Suspend this balance e.g. from the back of a chair and balance it by cutting off a little from the heavier side. Tie pieces of thread of about 20 cm length into loops about 7 cm long to support the weights. Use e.g. *equal* clothes–pegs as weights and balance them in many ways (see fig.).

Multiply weight x distance (from the fulcrum) for each side of the balanced beam.

Q: Prepare a table for several weights and distances from the fulcrum.

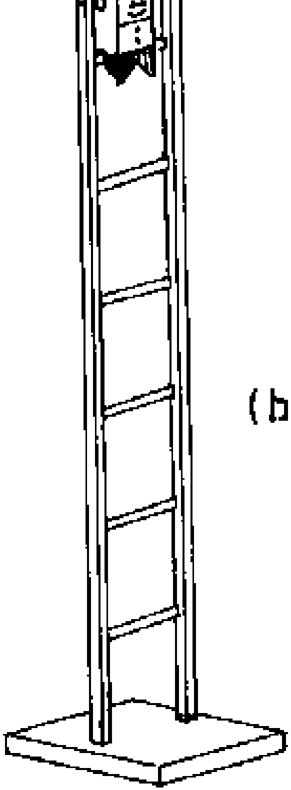
E: A force acting at a distance from a fulcrum has a *turning* effect which is called *moment* or torque. It can be calculated:

Moment = force x perpendicular distance (from the force to the fulcrum)

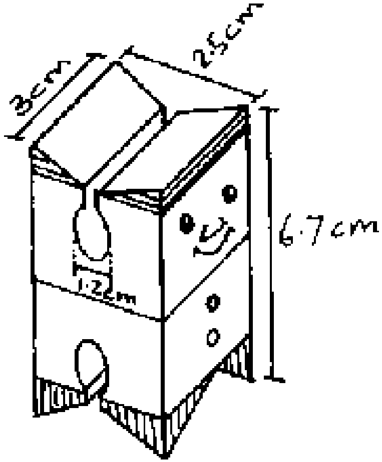
Our table shows that *the clockwise moment must be equal to the anti–clockwise moment in order to achieve equilibrium.*

A: The beam balance (see p. 10), the roman steelyard and other levers (see section 3.10).

3.4.2 Centre of Gravity (COG)



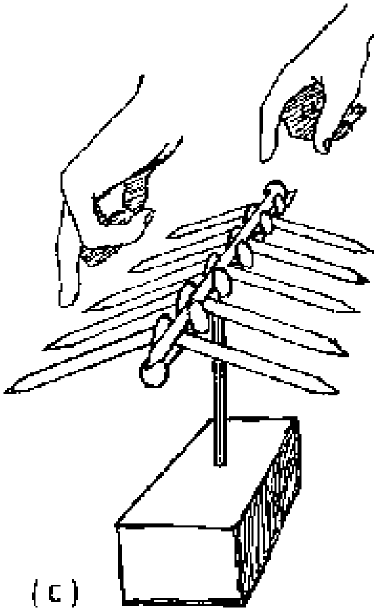
(b)



P: Ask a carpenter to make the funny jumper according to fig.(a) and (b). Place the jumper *feet down* on the uppermost step of the ladder.

Q: What happens? Why?

(b)



(c)

P: Give the students 2 inch nails (see fig.(a)) and ask them to balance them all on top of the nail which was fixed on the piece of wood. In doing this, the nails must neither be bent nor glued together etc.

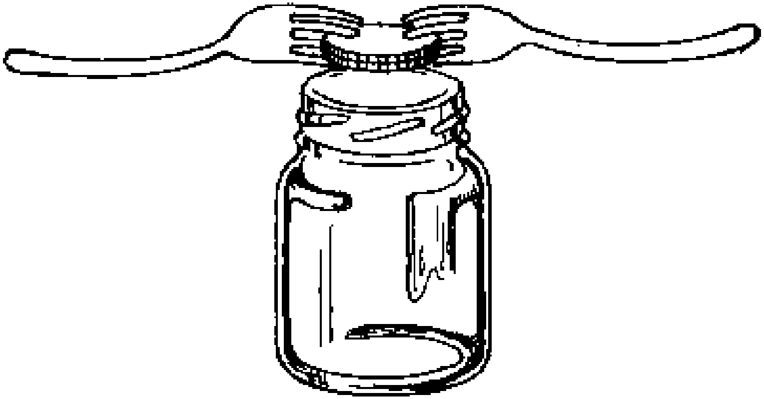
This may be a challenging riddle for the students!

E: This riddle can be solved by arranging the nails according to fig.(b) when lying on the table. Then lift this arrangement carefully to the top of the first nail and balance it there. The COG is now lower than the

P: Construct a candle balance as shown in the figure.

Q: What happens? Why?

3.4.7 Balancing Coins



P: Take two coins and attach two forks to them as shown in the figure. Balance this arrangement on the rim of a jam glass.

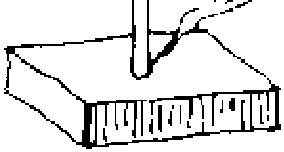
3.5 The Force of Friction

The force of friction always opposes motion. Friction may be reduced by lubrication. Rolling friction is less than sliding friction. The rougher a surface, the greater the force of friction.

Friction plays an important role in daily life. Without friction we would be unable to start walking.

Any woven material would decompose because it is held together by friction of the threads only. However, we have to reduce friction in the bearings of moving parts of vehicles and other machines in order to save fuel.

3.5.1 Friction Produces Heat



(b)

P: Rub your hands.

Turn a stick very quickly between your hands and press its tip onto a piece of wood.

Q: What do you feel on your hands?

What do you observe on the piece of wood?

How do you explain this?

O: The hands become warm, the piece of wood starts smoking and finally burning.

E: Friction produces heat which can light wood if great enough.

A: Lighting a fire without matches.

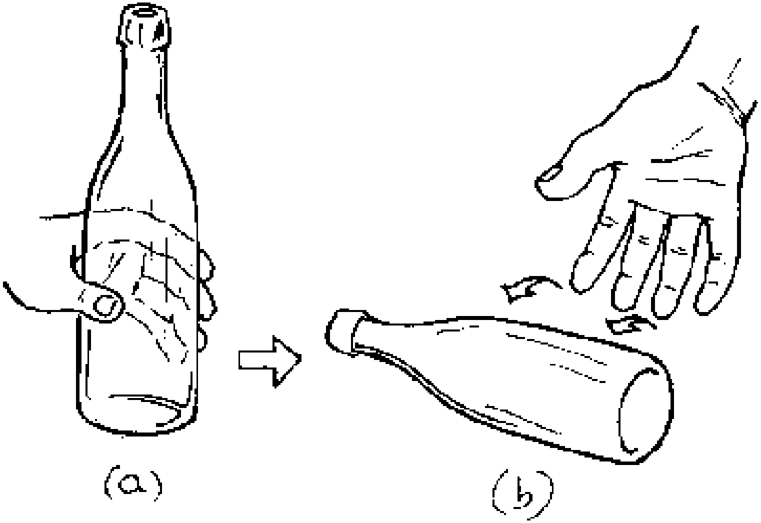
3.5.2 Friction and the Kind of Surface

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

O: It is harder to pull the book on the cloth than on the bare surface of the table.

E: The rougher the surfaces are which slide on each other, the greater the force of friction is. The "mountains" and "valleys" of the surfaces tooth and hence cause the force of friction, see figure (c).

3.5.3 Lubrication



P: Slide a bottle or tin and roll it.

Q: How are the forces of friction in each case?

3.5.5 Rolling Friction

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

Q: Why does the car *not* move even though the wheels turn?

E: There is not enough friction between the tyres and the road to get the car moving.

3.6 Density

The density of a substance tells us which mass the unit volume of that substance has got. Thus, it is defined as follows:

$$\text{Density} = \text{mass} + \text{volume.}$$

For any pure substance the density is constant at constant temperature and pressure.

Hence, density may be used to identify substances.

3.6.1 The Density of a Solid

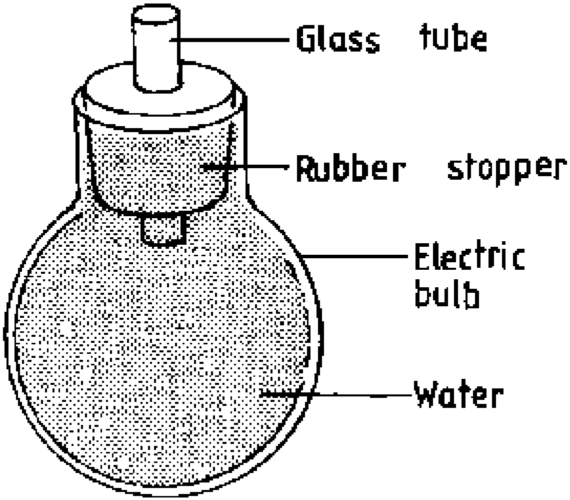
(Of course, the mass could be measured using a beam balance.)

Assume that the volume of the water displaced by the stone is 20 cm^3. Then the density of the stone is

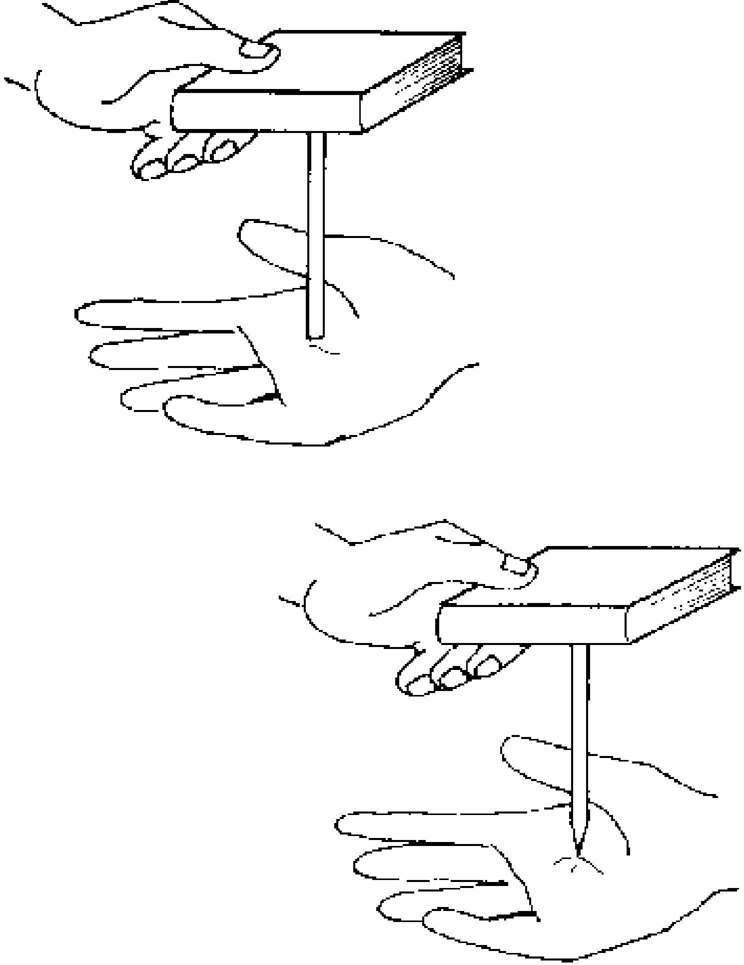
$$50 \text{ g} \div 20 \text{ cm}^3 = 2.5 \text{ g/cm}^3$$

A: The determination of density can help to identify a certain substance, e.g. to answer the question: "Is a certain ring really made of gold?"

3.6.2 The Density of a Liquid



P: Prepare a density bottle from a worn out electric bulb fitted with a rubber stopper. Weigh the bulb with its stopper in air, then weigh it when filled with water and then when filled with liquid A, whose density is required. Determine the respective masses. You may use the beam balance described on p. 10.

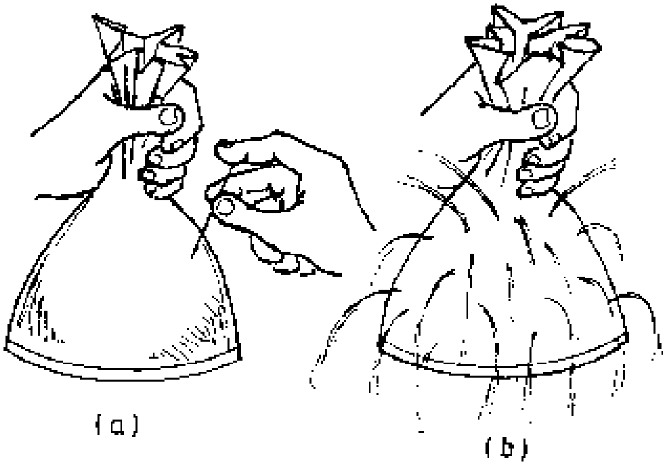


Q: How does the pressure change with the depth of the water? Why?

O: The water shoots the faster out of a hole, the greater the depth of that hole from the surface of the water in the tin.

E: The increasing speed of the water from the top to the bottom holes shows that the water pressure increases with the depth of the water. This is so because the weight of the water on top of a certain water particle acts on that particle causing pressure.

3.7.3 Carrying a Load on the Head



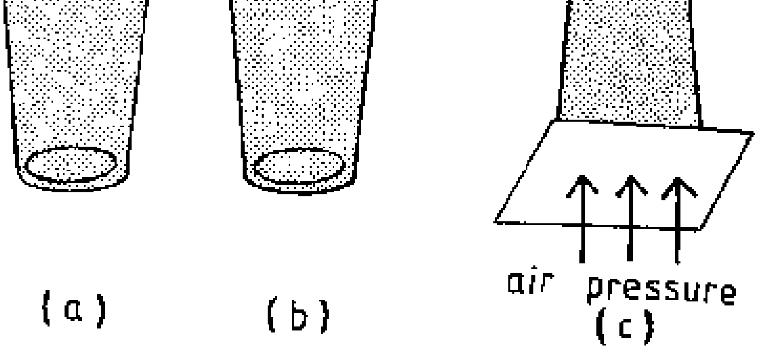
P: Pinch some small holes into a plastic bag using a needle. Fill it with water and squeeze the bag gently.

Q: In which directions does the pressure of the water act? Why?

O: The pressure acts in all directions.

E: The particles of a liquid can easily move behind each other while those of a solid are in fixed positions (see chapter 4.2).

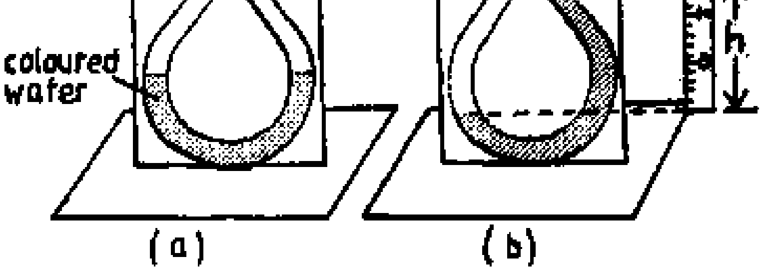
3.7.5 Air Pressure: The Crashing Can



P: Fill a drinking glass up to the rim with water. Then push a smooth card or a sheet of smooth plastic from the side to close the glass so that no air bubbles are included. Then turn the glass upside down.

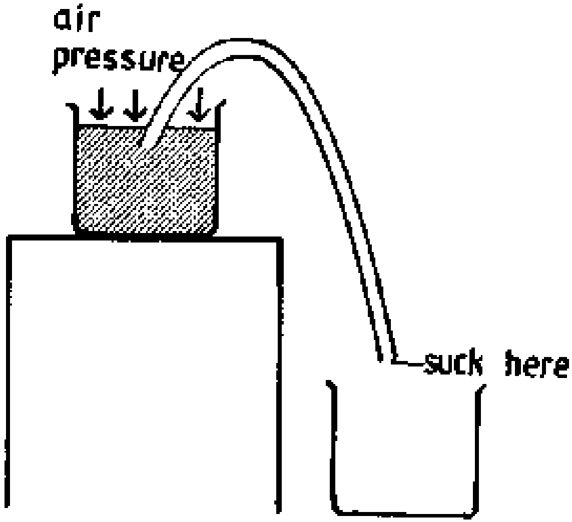
Q: Why will the card not fall off?

3.7.7 A Barometer



P: Make a manometer according to the figure. Use it to measure the water pressure at various depths of the tin of experiment 3.7.2, see p.26.

3.7.9 The Siphon



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.

Q: Which stroke is easier, the inward or outward one? Why? Explain what happens in these strokes.

O: The outward stroke is easier than the inward.

E: *Inward stroke* (see fig. b): The air in region A will be compressed, and in turn it will press the leather washer against the barrel to make it air tight. Consequently air will be forced into the tube.

Outward stroke (see fig. c): The air in A decreases in pressure. Atmospheric air from B pushes the leather washer inwards and hence enters region A.

3.7.12 The Force Pump

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

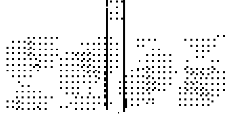
Q: Explain how the force pump works using the display chart.

E: *Outward stroke* (see fig. a). When the piston is raised, the liquid pressure in the barrel becomes less than the air pressure. Hence, the air pressure opens valve A and pushes the liquid up into the barrel. It closes valve B.

Inward stroke (see fig. b). When the piston is lowered, valve A closes and valve B opens because of the higher pressure of the liquid in the barrel. Consequently the liquid is forced through valve B to the outlet.

A: Force pumps are used to pump water from shallow wells in villages. Since the air pressure pushes the water up, the maximum depth from which the water can be lifted is less than 10 m

3.7.13 The Lift Pump



{b}

P: Ask the students to draw a display chart of the lift pump (see the above figure).

Q: Explain how the lift pump works using the display chart.

E: *Outward stroke* (see fig. a): The rising piston pushes the water on its upper side out of the outlet since valve B (on the piston) is closed. At the same time the air pressure pushes the water through the open valve A up the barrel.

Inward stroke (see fig. b): When the piston goes down, valve B opens and water flows from below to the top of the piston, while valve A is closed.

A: The lift pump is used to raise liquids from containers, e.g. tanks of kerosene etc.

3.7.14 The Hydraulic Press

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

Q: Explain – using the display chart – how the hydraulic press works.

E: A hydraulic press consists of a container which has one end wider than the other. Load and effort pistons are fitted in its ends respectively. Note that the load piston has a larger surface area than the effort piston.

When the effort piston is forced downwards, the pressure of the liquid, e.g. oil, is transmitted equally in all directions in the whole liquid.

Therefore, the pressure at the load piston is the same as that one at the effort piston. Yet, since force = pressure x area and the area of the load piston is greater than that of the effort piston, the force at the load piston is greater than that at the effort piston. Thus, *small effort will raise a big bad.* However, the distance moved by the effort will be larger than that moved by the load.

A: Hydraulic systems are used in brakes, pressing bales of cotton, lifting heavy loads (e.g. vehicles in garages), etc.

3.8 Archimedes' Principle and the Law of Floatation

Archimedes' principle states that the *upthrust* (buoyancy) of a body immersed in a liquid is *equal to the weight of the liquid displaced* by the body. When a body *floats* then *the weight of the liquid displaced is equal to the weight of the body* (Law of floatation).

3.8.1 Upthrust

(c) Immerse the stone fully into the water (without touching the bottom of the cylinder) and record the reading of the spring balance. Record the reading of the water level too.

Q: How much is the volume of the stone? What is the weight of the water displaced, if 1 cm^3 of water weighs 0.01 N? By how much did the weight of the stone decrease when it was immersed in the water? What can you conclude about the upthrust?

O: For example, let the weight be 0.2 N. You observe that the decrease in weight when the stone is immersed is also 0.2 N, which is equal to the upthrust.

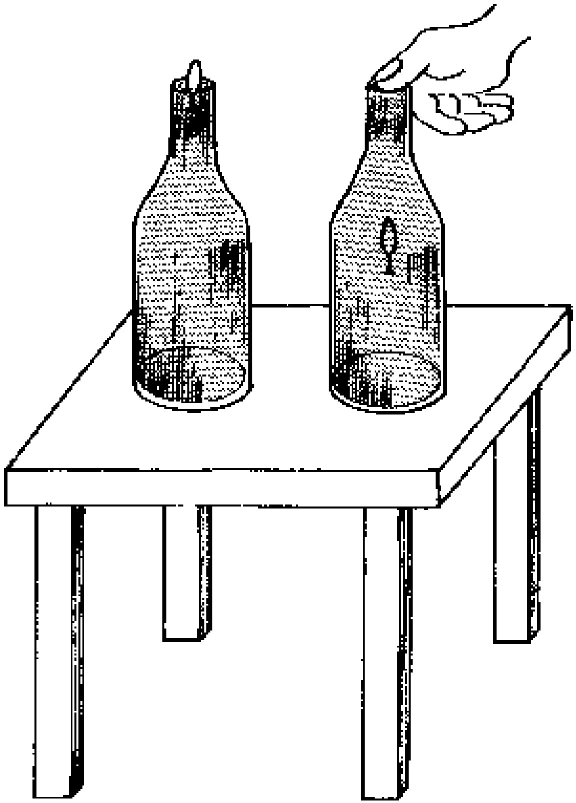
E: Thus, you have verified *Archimedes' principle.*

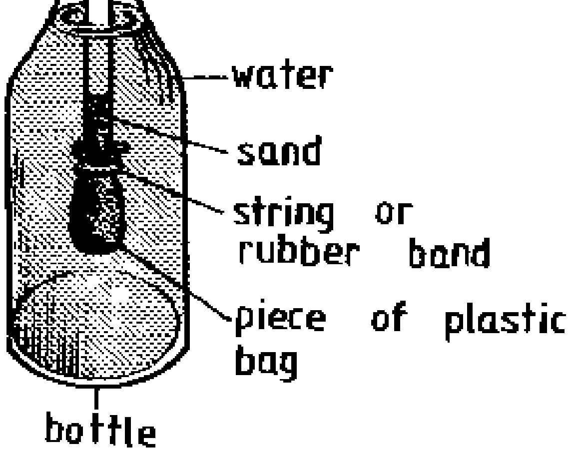
3.8.2 The Law of Floatation

overflow will also be 0.05 N.

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

3.8.3 The Cartesian Diver





P: Prepare a hydrometer by using a drinking straw. Close one end of the straw by wrapping it with a piece of a plastic bag water–tight using a rubber band or a thread.

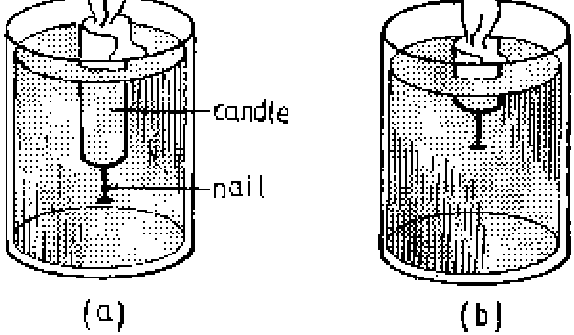
Fill clean sand into it until it floats in a vertical position in fresh water. Mark the water level on the straw. Label it 1.0 (since water has a density of 1.0 g/cm^3). Take the distance of this mark from the bottom of the straw to be x cm. Now you may put marks for liquids with other densities by calculating their distance 1 cm from the bottom of the straw by using the formula:

$$1 = x \div \text{(density of liquid)}$$

For example, if x = 9.4 cm, you calculate the position of the mark for a density of 0.9 g/cm^3:

$$1 = 9.4 \text{ cm} \div 0.9 = 10.4 \text{ cm}$$

i.e. you place the 0.9g/cm^3 mark at the distance of 10.4 cm from the bottom of the straw, and so on. Place marks from 0.6 to 1.2 g/cm^3.



P: Put a nail into the bottom end of a candle so that the candle just floats with its top a bit above the surface of the water.

Light the candle and watch it as it burns up.

Q: Why does the candle continue to float even though it constantly loses weight as it burns up?

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

3.9.1 Work Done by Lifting

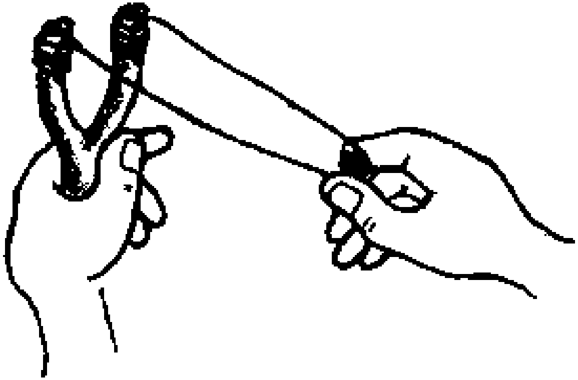
P: Raise a block of wood from the table using a Newton balance (see p. 15). Read the balance when you lift the block at *constant* velocity, not when starting or stopping. Compare this force with the weight of the block. Measure the vertical distance the block is raised.

Q: Calculate the work done when the block was raised by the vertical distance h.

E: The force which lifts the block at constant velocity is equal to its weight in magnitude but has the opposite direction. Thus, the *work done by lifting* is

Work done = weight x vertical distance

3.9.2 Work Done by Friction



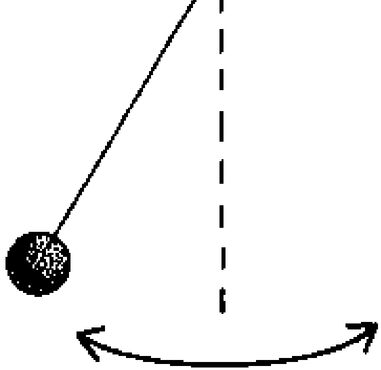
P: Tie a rubber band to the ends of a branched stick. Place a stone in the middle of the rubber band and stretch the band by pulling the stone towards you. Then release it.

H: Be very careful that nobody will be hit by the stone!

Q: What do you observe?

What kind of energy does the stretched rubber band, what the flying stone possess?

3.9.4 The Principle of a Steam Engine

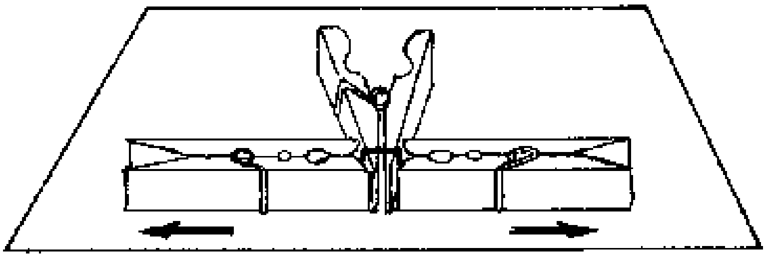


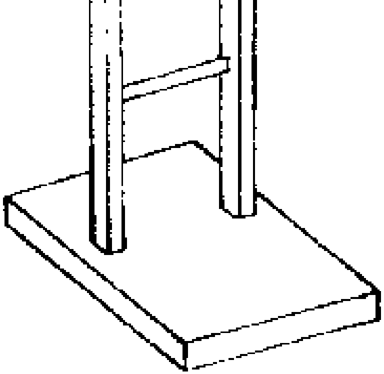
P: Suspend a stone on a long string. Displace it sidewards.

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

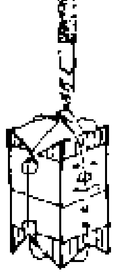
E: When the pendulum is displaced sidewards by your hand, *chemical energy* of your food is changed into *potential energy* of the pendulum. When the pendulum swings back, it converts the latter into *kinetic energy* which is changed again into *potential energy* on the other side of the oscillation and so on.

3.9.6 Potential Energy in a Clothes–Peg





(a)



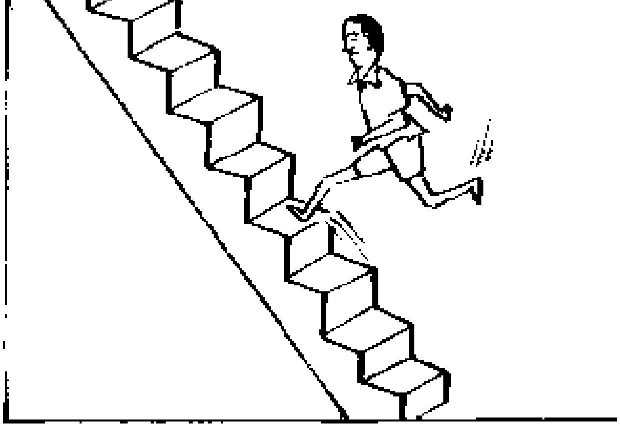
(b)

P: Set up the funny jumper (see p.21). Weigh the jumper using a Newton balance.

Q: Calculate the potential energy of the jumper when it is on the uppermost step of the ladder. Where does this energy go when it jumps down step by step?

E: The *potential energy* of the jumper is equal to its weight times the height of the uppermost step above ground. As the jumper jumps down, this energy is converted into *kinetic energy* (energy of motion) which in turn is converted into *heat* by friction.

3.9.8 Power



P: Measure the vertical height above ground of the first floor of a storey building. Run up to that floor as fast as you can while your friend times you with a watch. Take your weight (probably in a hospital).

Q: Calculate your maximum power.

E: Using your weight and the height of the first floor above ground, first calculate the potential energy (PE) of your body when it is on the first floor:

$$PE = \text{weight} \times \text{height}$$

This is the energy which you had to give out in order to raise your body to that height.

Now calculate your power by dividing that energy by the time (in seconds) you needed for running up.

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

Q: Do you feel the mechanical advantage? Derive a simple formula for MA (assuming there is no friction) using moments of forces (see p.20).

O: The effort is less than the load but the distance moved by the effort (d.e.) is longer than the distance moved by the load (d.l.).

E: Taking moments of forces (see fig. b) we obtain (neglecting friction):

$$L \times 1 = E \times e$$

A:

$$\frac{L}{E} = \frac{e}{l}$$

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 the mass of load.

H: The whole system should be suspended freely in air and it must be balanced *horizontally* in each step.

A: Used in weighing cotton, bags of coffee etc.

3.10.3 The Single Pulley

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.

Q: What is the MA of the simple pulley? What is the advantage of it?

E: A single pulley has an MA of 1, i.e. the effort is as big as the load is (including friction it is even bigger). Yet, the advantage is that the pulley *changes the direction* of the force. You can easier lift a heavy load by pulling downwards (assisted by your weight) than by pulling upwards.

3.10.4 The Two Pulley System

The two pulley system is the simplest *block and tackle* which gives a real MA when used to lift heavy loads.

P: Connect two single pulleys as shown in the above figure. Use this system to lift the same load as in experiment 3.10.3. Measure the effort using a Newton balance.

Q: What do you feel when lifting the load directly and when using this pulley system? How is the MA now (if you neglect friction and the weight of the lower pulley)? How far does the effort move, when the load moves, e.g. a distance of 20 cm?

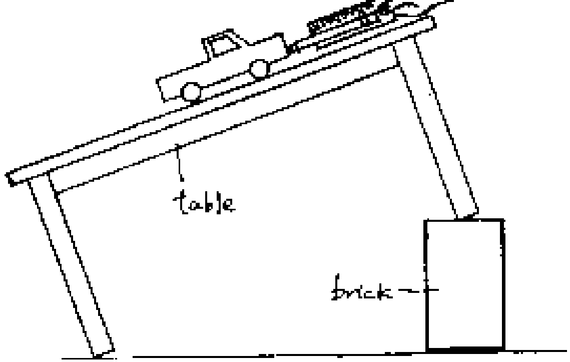
O: It is easier to lift the load using this system: the effort is smaller.

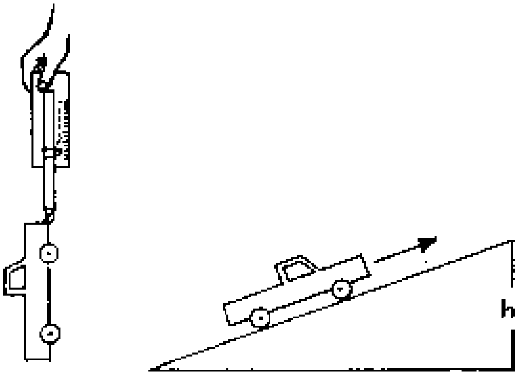
E: Neglecting friction and the weight of the lower pulley, the MA will be 2, i.e. the load is twice the effort. However, in practice it is less due to the factors mentioned.

The effort moves 40 cm when the load moves 20 cm.

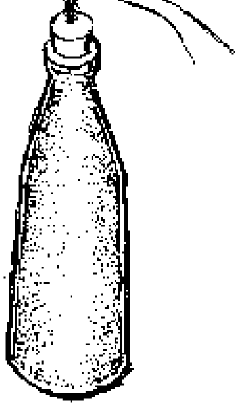
A: Cranes (e.g. in harbours) use (even more complex) pulley systems to lift very heavy loads.

3.10.5 A Riddle





P: Tilt a smooth table by placing bricks underneath its legs on one end of the table (see fig. a). Ask students to bring their toy cars.



P: Pierce a seed and a small fruit with wires. Join an opened bulb (see appendix) to a bottle filled with sand using a wire. Join the three wires so that they allow rotation. The seed, fruit and bulb represent moon, earth and sun respectively. The bulb may be lit using a torch bulb and battery.

E: The model can be used to show the movement of the earth and the moon around the sun and earth respectively. It can also show the eclipse of the moon and the sun, when the earth shades the moon or the moon shades a part of the earth respectively.

3.11.2 Centripetal Force

Due to its inertia a body will move along a straight line when *no* force acts on it. What force keeps the planets on their circular paths?

P: Tie a ball or stone to a thread and whirl it around as shown in the above figure.

Q: What force keeps the stone on its circular track?

E: There acts a force along the thread (which you feel in your hand) called the *centripetal force* which forces the stone to the circular path. Thus, a centripetal force must also act on each planet to keep it on its circular path.

3.11.3 Demonstrating the Solar System

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

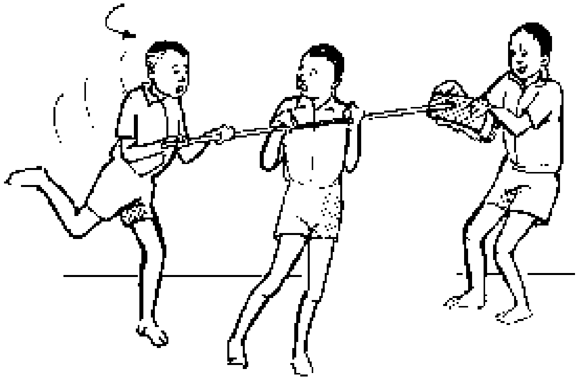
Planet	Distance in millions of km from sun
Mercury	58
Venus	107
Earth	149
Mars	227
Jupiter	773
Saturn	1418
Uranus	2853
Neptune	4469
Pluto	5866

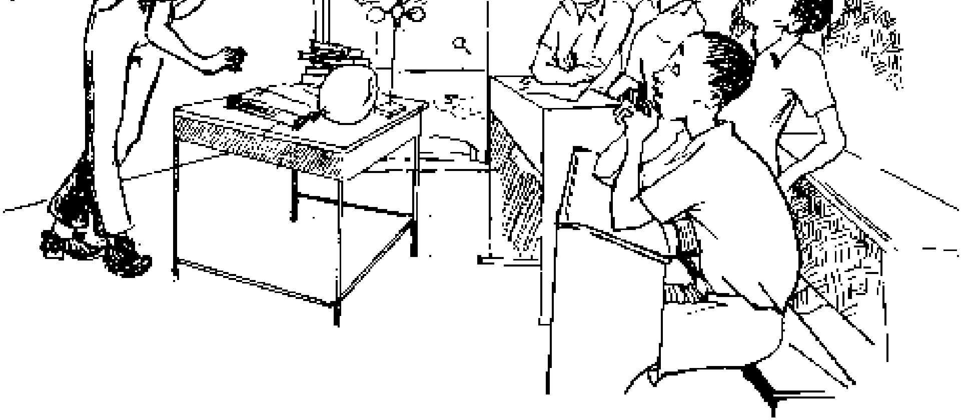
3.11.4 Gravitational Force

force = centripetal force

How do we call the force which acts as the centripetal force for the planets? Obviously, the planets are not tied to the sun by a string as the stone in experiment 3.11.2 is tied to your hand.

There must be a force acting through the empty space tying the planets to the sun. This force is the pull of the mass of the sun on the mass of the respective planet. It is a force of attraction between the two masses which we call *gravitational force.* Thus, the gravitational force between the sun and a planet acts as centripetal force (always directed towards the sun) to keep the planet in its circular path. (You can feel the gravitational force of the earth causing the *weight* of a body on the earth. Due to this gravitational pull of the earth, e.g. a stone falls down to the earth where released.)





4.1 The Particle Model of Matter

Matter is anything which occupies space and has mass. It consists of very *small* particles called atoms or molecules which take part in chemical reactions. The particles possess kinetic energy. Therefore they are in constant vibration. The energy content increases with the increase in temperature. Hence, the motion of the particles increases with the temperature. Forces exist which hold the particles strongly together in *solids,* while they can easily move past each other in *liquids* and *gases.*

4.1.1 Salt is Made of Particles

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

Take a small amount of boiled water and taste it.

Put salt (or sugar) crystals into the water and shake. What happens? Taste again.

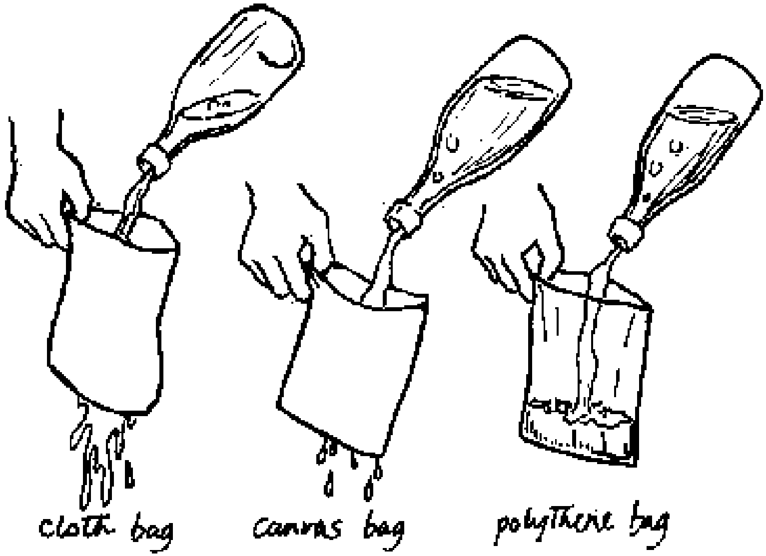
Q: Describe and explain your observations.

O: Salt crystals are often of cubical shape. They are quite hard.

The crystals dissolve in water. The solution tastes like salt (or sugar).

E: Sugar or salt in water exists as very tiny invisible particles that can be identified by tasting.

4.1.2 Water is Made up of Particles

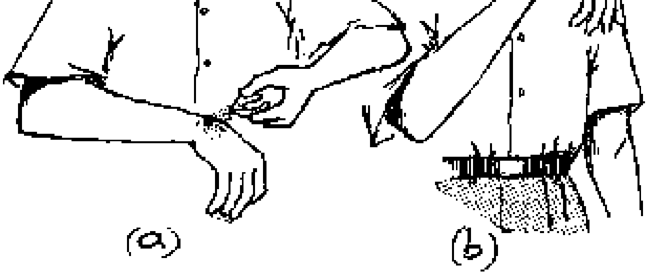


P: Make bags from cotton cloth, canvas cloth and polythene sheet Fill water into the bags.

Q: What do you observe?

E: Water passes through cotton and canvas but not through polythene. This is because polythene has too small pores to allow water particles to pass through.

4.1.4 Feeling Particles



P: Let a student squeeze an orange peel.

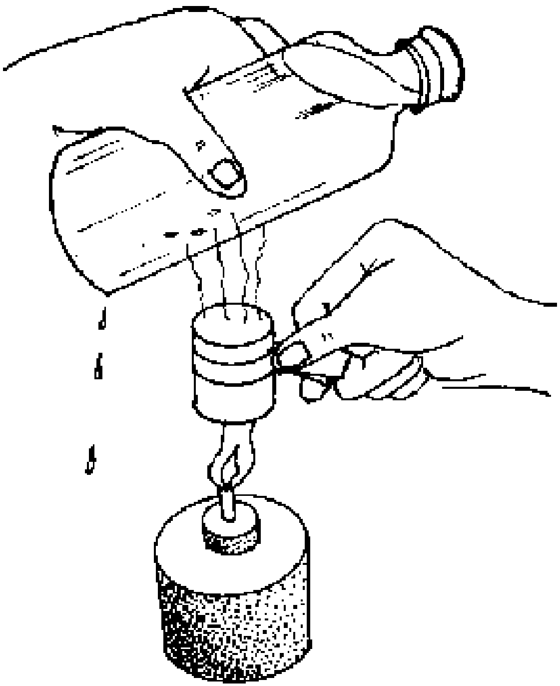
Q: What can he sense?

E: He smells the orange, because invisibly tiny particles from the orange peel spread by diffusion to his nose.

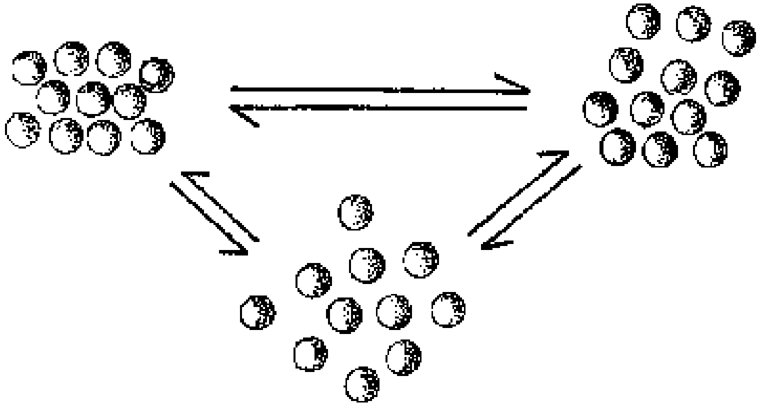
4.1.6 Weighing Particles

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 in the volume which equal masses of the same substance occupy.

4.2.1 Changes of State



P: Heat pieces of candle wax carefully in a spoon or in a tin and hold a glass filled with cold water above it.



P: The three states of matter can be explained by simple models as shown in the figures above.

Q: What do the pictures represent?

E: Very close pupils or balls represent the particles in the *solid* state. Farther apart pupils or balls represent the particles in the *liquid* state. They move past each other. Fast and randomly moving pupils or balls represent the particles in the *gaseous* state.

4.3 Motion of Particles

Particles are in random motion. However, they cannot be seen. How do we get to know about their motion? The existence of the molecular motion can be deduced by indirect evidence through observation of *diffusion.*

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

E: This spreading out is due to the motion of the particles of potassium manganate(VII).

This process is called *diffusion.*

H: This is a slow process. Therefore allow the jar to stand for same days.

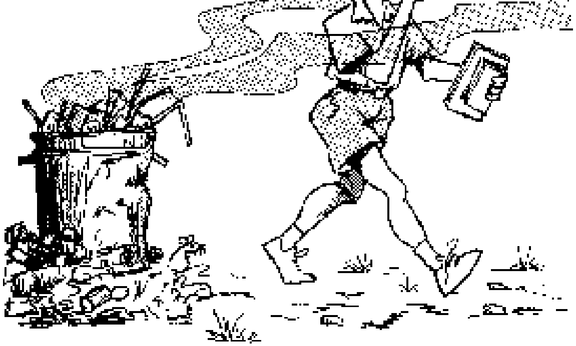
4.3.2 A Model on Motion

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

Q: Which activity corresponds to which state of matter?

E: The movement of particles in *solids* is small and hence the particles are in a fixed order. In *liquids* the particles move past each other and have lost the stiff order. In *gases* the particles move very fast and randomly. They have now no order at all anymore. Hence, the observations in (a), (b) and (c) represent solid, liquid and gaseous state respectively.

4.3.3 Diffusion in Daily Life

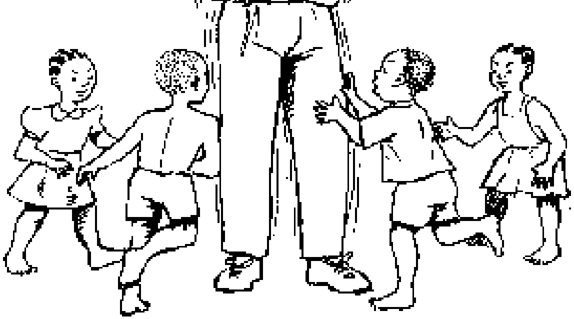


P: Pass near a polluted area (e.g. latrine, burning heaps of litter, a filling station).

Q: What do you smell?

E: Many hazardeous substances spread to the environment by *diffusion.* (Hazardeous substances in any state of matter in our environment mean *pollution.*)

4.3.5 Brownian Motion



Imagine there would be standing a tall adult person around whom small children are in a continuous random movement. The tall person would be punched permanently by the children and hence would be jerkily moved.

4.4 Cohesion and Adhesion

There are two types of *forces between particles.* Forces between particles of the same material are called *cohesive forces* while those between particles of different materials are called *adhesive forces.* Cohesive forces hold the molecules in a water drop together. Nevertheless they are weak, so that the molecules can be easily separated, for example, when we jump into water or when it is heated. Paints and all kinds of glues are based on the effects of adhesive forces.

4.4.1 Exploring Cohesion and Adhesion

P: Drip water on a clean glass sheet (a).

Q: What happens?

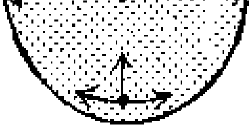
P: Place a second glass sheet on the wet first sheet and try to lift it, see fig.(b).

Q: What do you notice?

E: (a) Water spreads to form a patch on the first glass surface because *adhesive forces* attract water molecules to the glass surface.

(b) A strong force is applied to separate the two glass sheets because the adhesive forces between glass and water are large.

4.4.2 Water Drops from the Tap



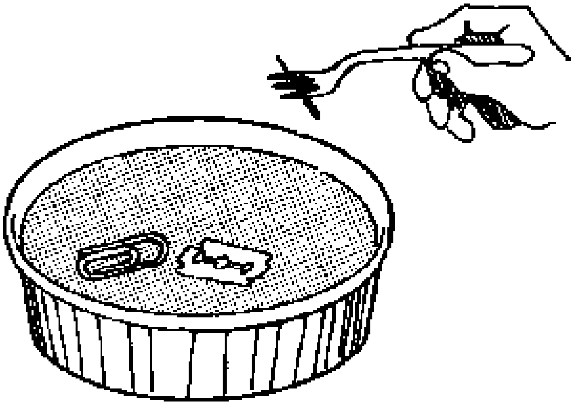
P: Let a thin stream of water flow from a water tap.

Q: What happens?

O: The water stream grows thinner and thinner as it moves further down and finally breaks to form drops.

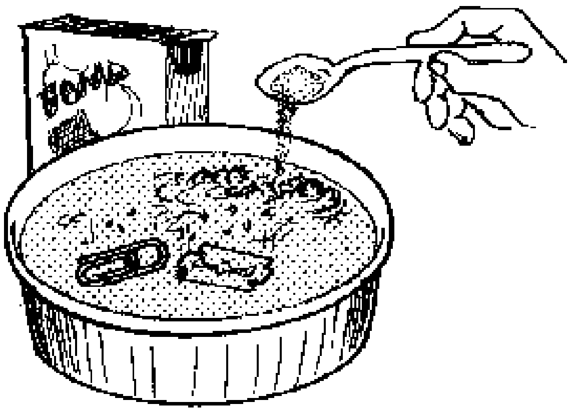
E: Considerably strong *cohesive forces* exist as the stream starts to flow, but as the stream grows thinner the cohesive forces are overcome by the accelerating force of gravity and hence the stream is breaking down to drops. The molecules of the resulting drops are still held together by cohesive forces.

4.4.3 Surface Forces



the water particles.

4.4.5 Affecting Surface Tension

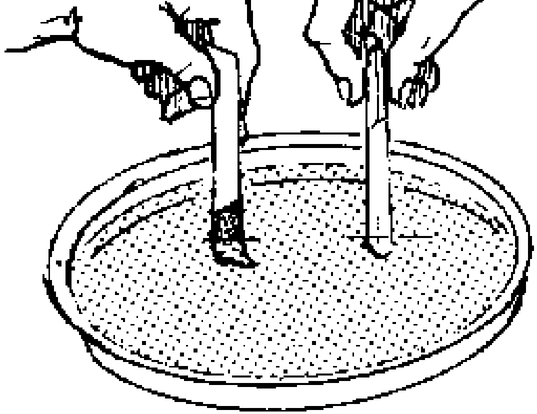


P: Repeat experiment 4.4.3 using detergent or soap solution instead of water.

Q: What do you observe?

E: Soap lowers the *surface tension* of water and therefore the bodies sink.

4.4.6 Capillary Rise



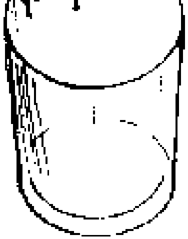
P: Hang a strip of newspaper and place a chalk–stick in a vessel containing water. Leave the arrangement for some time and measure the capillary rise in each with a ruler.

Q: Explain the causes of the differences in capillary rise.

E: Due to smaller capillaries water rises faster in the chalk–stick than in the paper.

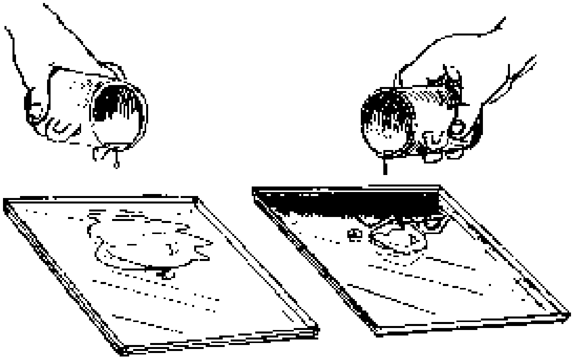
H: Test other substances too.

4.4.8 Automatic Irrigation



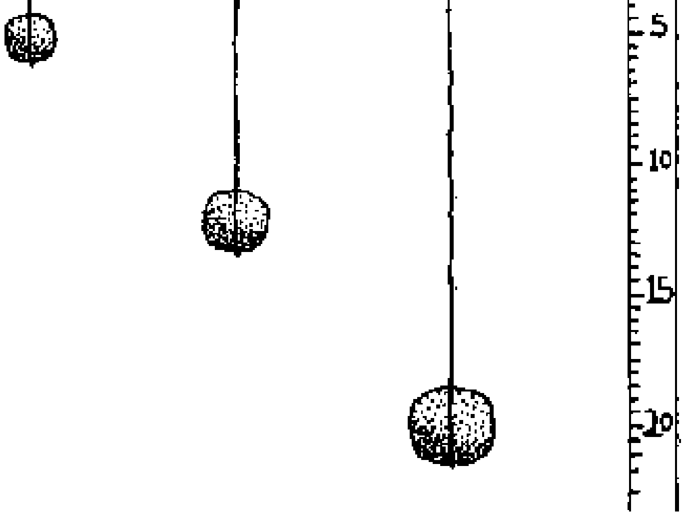
E: When *adhesive forces* are greater than *cohesive forces,* drops of water can be made to move down along an inclined thread.

4.4.10 Weak Adhesion



P: Put a few drops of water on a clear glass surface (a) and on a sooty or greasy surface (b).

Q: What do you observe?



P: Attach various masses (e.g. 1 g, 2 g, 3 g) to a rubber band or a spring and measure the extension for each mass attached. Remove the masses in succession and record the corresponding readings.

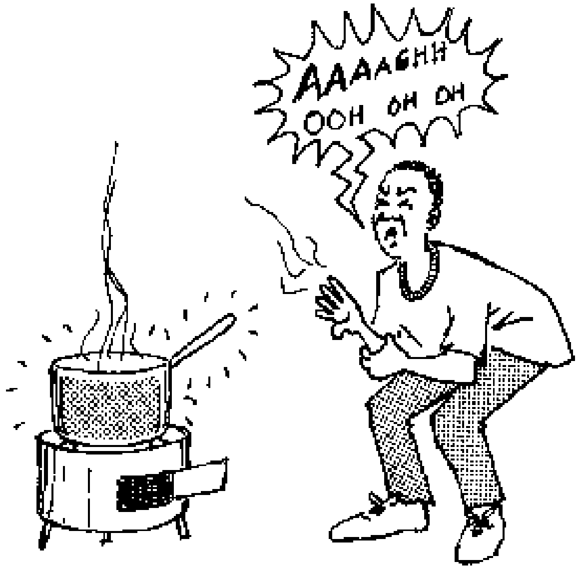
Q: What happens when the masses are removed one after the other?

Plot a graph of extension (y–axis) against mass (x–axis).

E: The graph obtained shows that the extension is proportional to the mass which is *Hooke's Law.*

4.5.2 Viscosity in Liquids

5. Thermal Physics



5.1 Thermal Energy and Temperature

Thermal energy is a form of energy which can easily be produced by converting other forms of energy. Thermal energy is commonly called *heat.* The quantity of heat absorbed by a body generally causes an increase in its temperature. The *upper fixed point* of a thermometer is the temperature of the steam of pure certain distance or up a staircase.

Q: Which forms of energy are converted to thermal energy in each case?

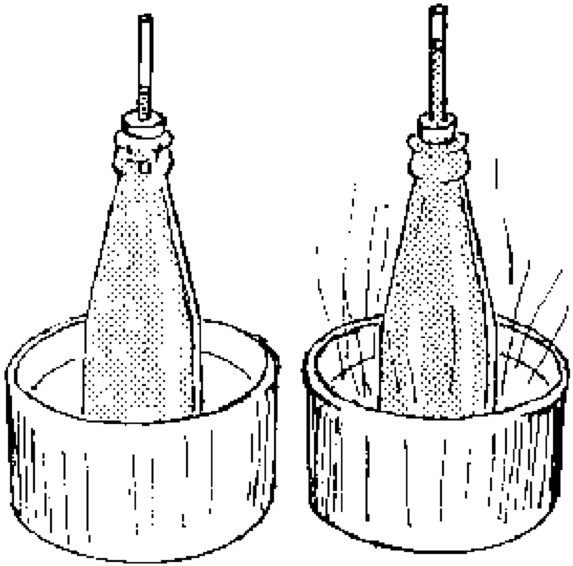
E: (a) A match stick burns converting *chemical energy* into *thermal energy.*

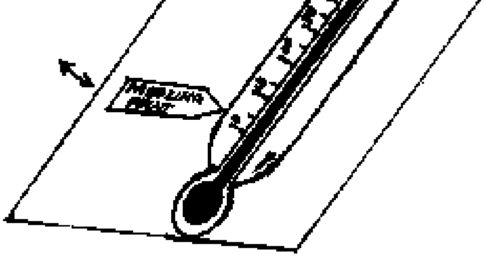
(b) An electric bulb gets heated because *electric energy* is converted to *thermal energy.*

(c) The hands get hot, because *mechanical energy* is converted to thermal energy.

(d) We feel hot, because our body converts the *chemical energy* of the food partially to *thermal energy.*

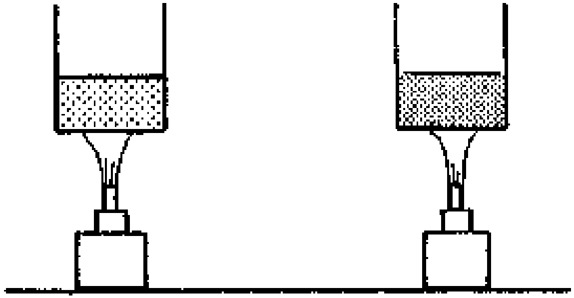
5.1.2 Principle of a Thermometer





P: Draw a large diagram (a display chart) of a thermometer on a paper (paper from cement bags is suitable). Cut out paper arrows for indicating the characteristic fixed points for water and other substances. The pupils can be asked to indicate (using the arrows) the appropriate fixed points on the diagram.

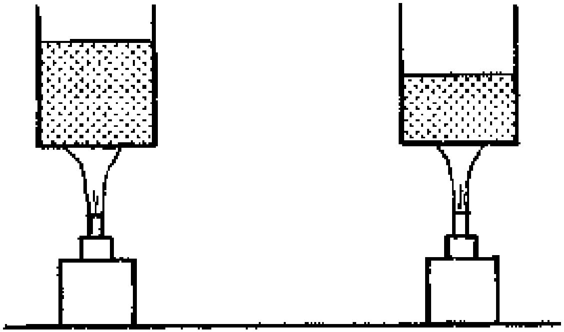
5.1.4 Specific Heat Capacity of Liquids



P: Heat equal masses of different liquids (e.g. water and oil) in two identical containers using a "kibatari" (kerosine lamp) for the same length of time.

Q: What difference in temperature can you feel with your finger?

5.1.5 Thermal Energy

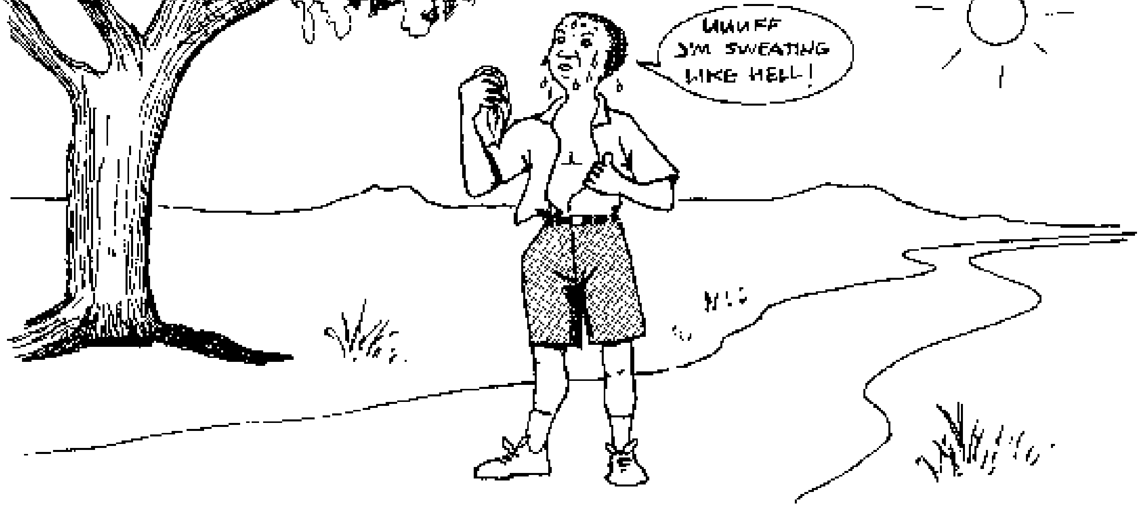


P: Heat different quantities of water using a "kibatari" (kerosine lamp) in two identical containers (e.g. tin cans) for the same length of time. Dip your finger into the two containers of water.

Q: What differences in temperature can you feel?

E: The temperature of the smaller quantity of water is higher, because it received more thermal energy per gram of its mass than the larger quantity. So for the same heat input the temperature rise of the smaller quantity of water will be greater.

5.1.6 Application of Specific Heat Capacity



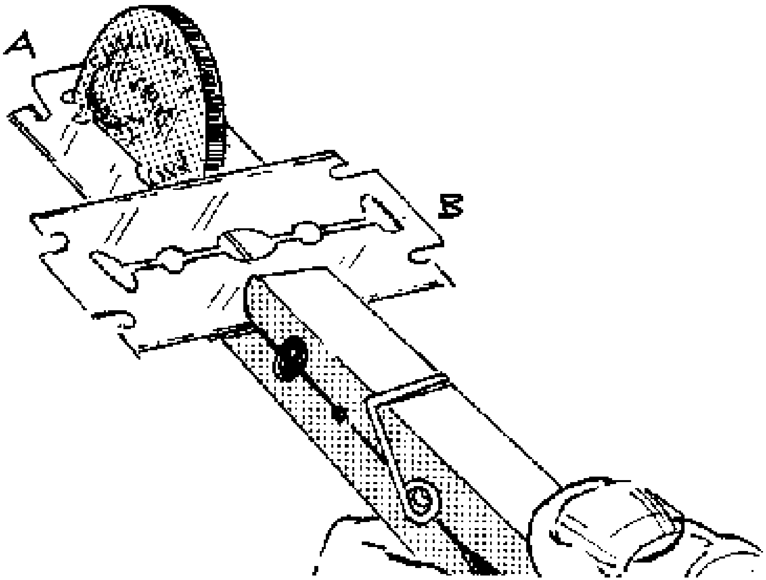
5.2 Thermal Expansion

Solids, liquids and gases expand when heated and contract when cooled. Expansion and contraction occur in all directions. The kinetic theory explanation is, that the particles vibrate with large amplitudes when heated, forcing each other a little further apart. Cooling reduces the amplitude of vibration and brings the particles closer together. *Water* has an anomalous expansion. Its highest density is at 4°C. Therefore in cold regions water at this temperature always sinks to the bottom of lakes. This is why in cold regions the water at the bottom of the lakes does not freeze.

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 diameter or a bicycle spoke can be used for the metal rod.

5.2.2 A Simple Model for Explaining Expansion

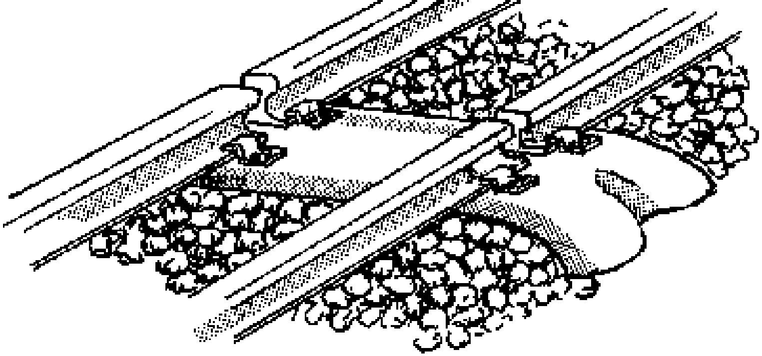
5.2.3 Expansion of a Coin



P: Place a coin into the slit of a razor blade A. Slide a second blade B so that the coin just passes through the slit. Firmly clamp the blades together with pegs or clips. Now remove the coin and heat it in a flame and try to pass it through the slit again.

Q: What happens?

E: The coin does not pass through, because it has expanded due to heating.

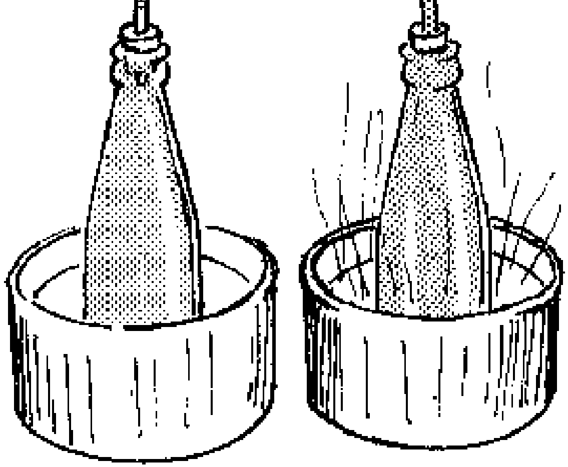


Steel railway lines have gaps at the end of each length of rail. Clicks can be heard as the wheels go over them.

Q: Why are the gaps necessary?

E: The gaps are needed to allow the rails to expand without bending during hot days. The gaps are called *expansion gaps.*

5.2.6 Bimetal Principle

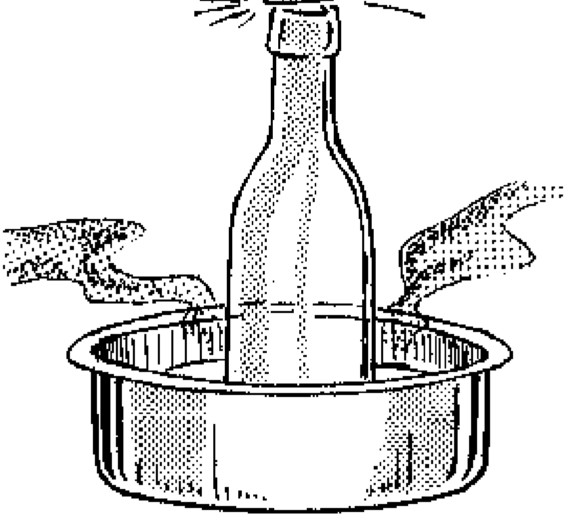


P: Fill a bottle up to the rim with coloured water. Tightly fix a cork bearing a transparent plastic tube (an empty ball point pen tube). Place the bottle into hot water.

Q: What happens?

E: The liquid rises along the tube, because it is heated by the hot water and expands along the tube.

5.2.8 Allowing for Liquid Expansion



P: Wet the rim of a bottle with water and cover it with a coin (e.g. a shilling coin). Place the bottle into a hot water bath.

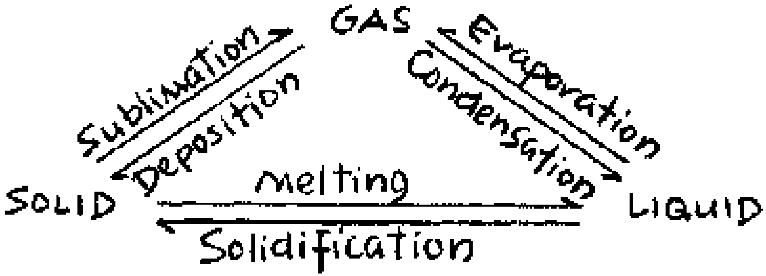
Q: What happens to the coin after a short time?

E: The coin vibrates opening and closing the bottle. This is because when the air inside the bottle expands, it pushes up the coin and when the air escapes, the pressure inside drops and the atmospheric pressure pushes down the coin.

2. 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.

5.3 Changes of State

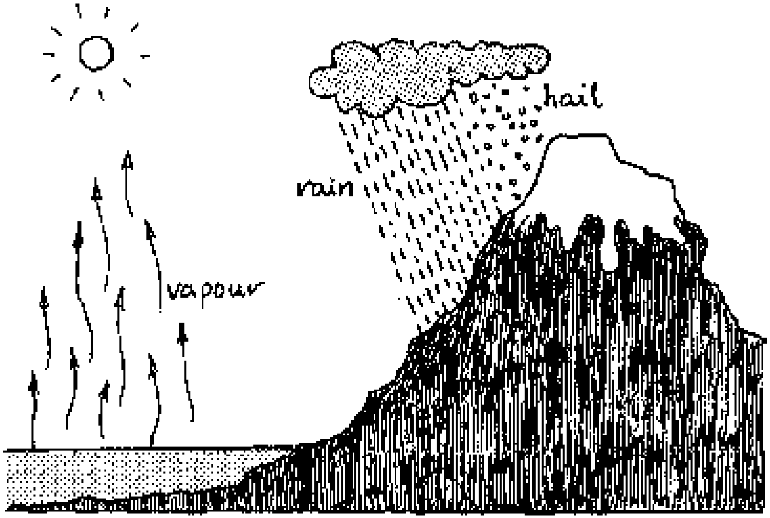
There are three states of matter, *solid, liquid* and *gas.* Matter can be converted from one state to another:



Every pure substance has *characteristic fixed points* at which one state changes into another one. That depends on the temperature. The water cycle in the atmosphere illustrates the change of state of water.

5.3.1 Changes of State of Water

5.3.2 Rain and Hailstone Formation



P: Rainfall is a common occurence all over the country and sometimes the rain is accompanied by hailstones which destroy our crops.

Q: Can you explain how rain and hailstones are formed?

E: The sun heats the sea and lakes. The water evaporates and rises up in the air. The vapour cools and condenses into water droplets forming a part of the clouds. At higher altitudes where temperatures are very low, bigger drops of water are formed which fall as rain. At times bigger drops of water turn into ice (solid) and fall as hailstones.

P: A boy plunges himself into a pool of water and then gets out.

Q: Explain the change of the temperature of his body.

E: He feels very cold (chilly) because the evaporation of water from his body absorbs heat from his skin making him feel cold. This explains why we feel very cold when we stand in a draught of air after sweating.

P: Touch the blackboard with a wet hand.

Q: Observe the trace for some minutes.

P: In many houses water is kept in fired clay pots *(chungu).* Water pots have very tiny pores through which minute amounts of water ooze out.

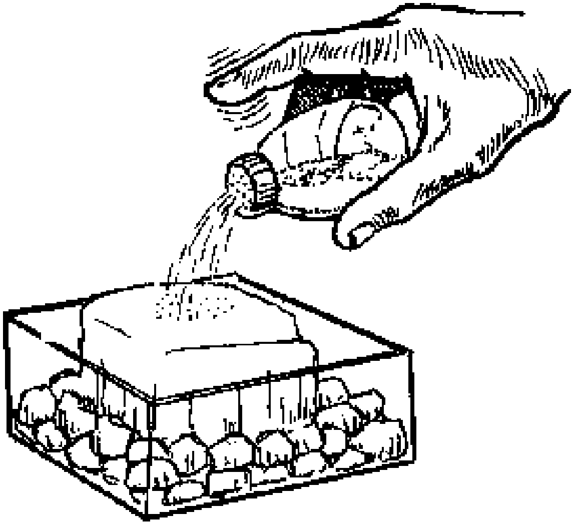
Q: Explain how water is cooled in these clay pots.

E: Some water passes through the tiny pores and evaporates. The energy needed for the evaporation is taken from the pot and water and hence the water cools down.

5.3.6 The Refrigerator

E: Some urban households have got refrigerators. In the refrigerator a special liquid is circulated through a pipe. In one portion of the pipe the liquid evaporates at a low pressure. The energy for the evaporation is taken from the pipe which cools the inner part of the refrigerator. In the pipe at the back the vapour condenses to a liquid under high pressure, thus giving out heat. Therefore cooling fins on the outside have to transmit this heat to the air.

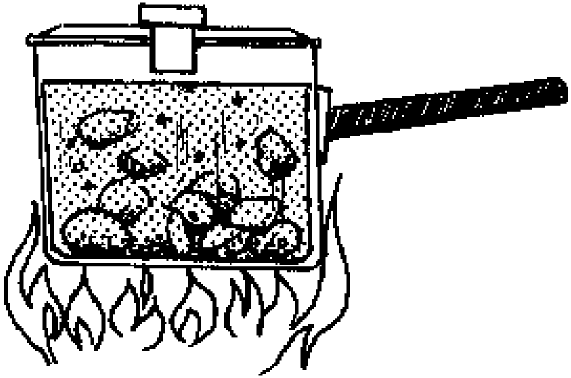
5.3.7 Pressure and Melting Point



P: Place some pieces of ice in a glass container and sprinkle some salt on the ice. Stir the mixture and measure the temperature.

Q: What do you observe?

E: The ice pieces melt at a lower temperature than 0°C. *Impurities* (e.g. salt) *lower the melting point of ice.*



P: Demonstrate how a pressure cooker works.

Q: Explain how it helps to save energy costs.

E: Under the high pressure in such a pot the water boils at a higher temperature of about 120°C. At this temperature food like beans need only about one hour (instead of 3 hours in a normal pot) to cook and become soft. Therefore the pressure cooker uses less fuel to cook and hence saves fuel.

5.4 Transfer of Thermal Energy

Heat can be transfered in three ways:

> *Conduction* of heat is the transfer of heat through a material from one point to another, whenever there is a temperature difference between the two points.

Heat conduction is likened to a football being passed from one player to another just as heat passes from one molecule to another in conduction of heat as shown in figure (a).

Convection is likened to a football being taken by one player from one point of the playground to another one just as heat in a gas or liquid is transported by a particle from one point to another in convection of heat as in figure (b).

Radiation is likened to a football being kicked by one player from one point at the playground to another one without the use of intervening players just as heat is transmitted from a hot object to another without any medium by radiation of heat as in figure (c).

5.4.2 Candle Flame and Heat Transfer

P: (a) Light a candle and demonstrate three ways of heat transfer by a simple hand experiment.

(b) *Conduction:* Stick one end of a nail into the flame.

Q: What do you feel?

(c) Convection: Place your hand at a distance above the flame.

Q: What do you feel?

(d) Radiation: Place your hand at the same distance on the side of the flame.

Q: What do you feel?

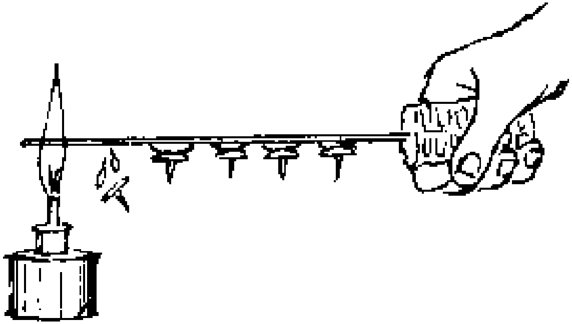
O: In each case heat is transmitted to your hand.

P: To check the *amount of heat transfered per unit time* by convection and radiation, hold a new match stick above and on the side of the flame and find out how long it takes to ignite the match stick in each case.

H: Any burner can be used instead of the candle. Non–luminous flames will produce the best results.

5.4.3 Solids as Conductors

5.4.4 Conduction by a Metal Rod



P: Fix several small stones with molten candle wax along a metal rod at a regular interval. Heat one end of the rod.

Q: What do you observe?

E: The stones will fall off one after another starting from the end being heated, because heat is conducted slowly along the rod from the heated end.

5.4.5 Liquids as Conductors

P: Fill a round flask or opened bulb (see appendix) up to the neck with water. Sprinkle a pinch of fine saw dust on the water. Heat one side of the flask only.

Q: What do you observe in the flask?

E: You will see a *convection current* being formed in the flask. The warm water rises and the cooler water sinks down to the bottom as seen by the movement of the saw dust.

5.4.7 Breeze as a Convection Current

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 land to the sea. The general effect is that the breeze from the sea keeps the daytime temperature on the land lower than expected from the hot sun, whereas the breeze from the land makes the night temperatures cooler than expected.

5.4.8 Good and Bad Radiators

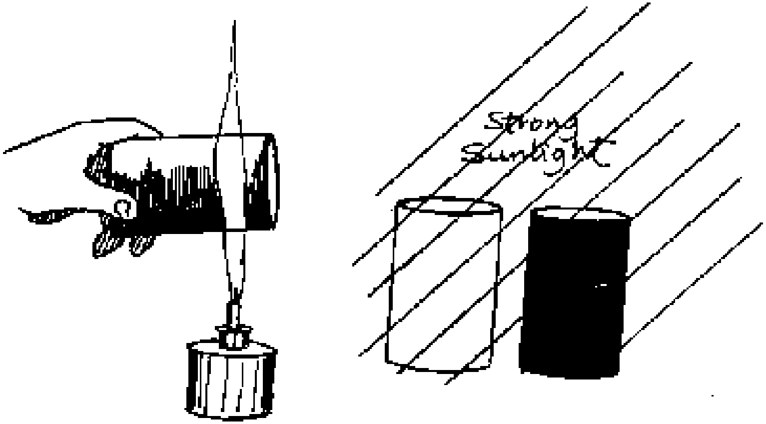
P: Paint one half of the outside of an open can black and leave the other half shiny (see figure (a)). Place a wooden stick near each side of the can. Stick a small stone with candle wax on each stick. Heat the bottom of the can.

Q: What do you observe?

E: The candle wax opposite the blackened surface begins to melt earlier than the wax opposite the shiny surface. This shows that *a black surface is a better radiator than a shiny surface.*

H: Soot and black shoe polish will do for the black paint.

5.4.9 Good and Bad Heat Absorbers



P: The thermos flask is a double walled glass bottle with a vacuum between the walls. Both the inner and outer surfaces of the walls are silvered so that they are shiny.

Q: How does the flask keep hot tea hot or cold water cold?

E: A vacuum is a bad conductor of heat and does not allow convection of heat The vacuum prevents heat loss or gain by conduction and convection. The silvery walls reduce heat absorption and heat loss by radiation.

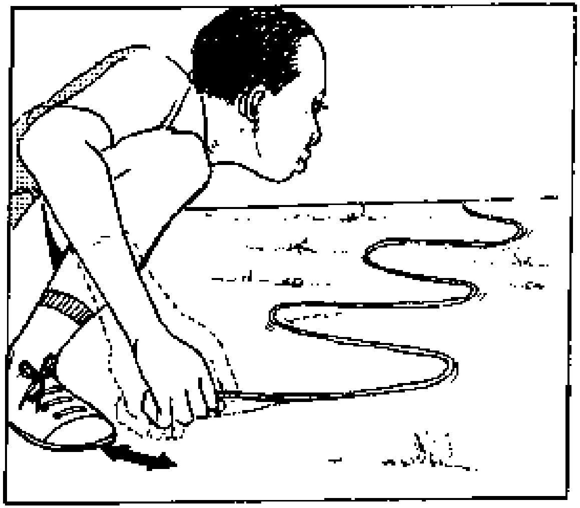
6. Wave Motion

direction of the propagation of the waves.

Only *energy is transported by a wave.* The oscillating particles of the medium, which transmits the wave, do *not* travel with the wave.

The *frequency* gives the *number of oscillations per unit time.*

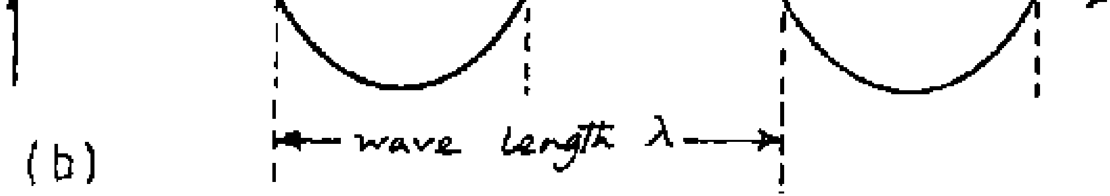
6.1.1 Transverse Wave Using a Rope



P: Take a piece of rope of about 6 m length. Hold it at one end and jerk it sideways.

Q: What do you observe? Draw a sketch.

E: The disturbance produced by jerking travels along the rope making *crests* and *troughs.* The jerking of the

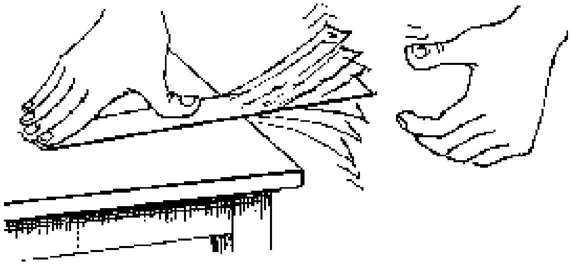


P: Take an empty tin opened at one end. Make a small hole at the other end using a sharp nail. Suspend it using a string so that the bored end faces downwards. By gluing or pinning prepare a 30 x 200 cm sheet of an old newspaper. Fill the suspended tin with coloured water (e.g. using ink) or fine sand (dry). Pull the tin to one side and leave it to oscillate freely. While it is oscillating steadily, pull the paper under the tin with *constant velocity.*

Q: What do you observe? Draw a sketch.

E: When the tin is pulled sidewards, it tries to go back to the equilibrium position and overshoots. As it oscillates the jet from the tin draws a sinus trace on the paper passing underneath it. The resulting trace shows a *transverse wave.*

6.1.3 Sound from a Ruler



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 to oscillate. Make sure that the displacement is not more than 10°. Record the time for 20 oscillations and find the frequency. (Frequency = number of oscillations ÷ time taken). Change the stone to a heavier one and repeat the procedure. Change the length of the thread to 100 cm and repeat the procedure.

Q: What do you find?

E: The frequency is independent of the mass, but depends on the length of the thread.

6.1.5 A Longitudinal Pendulum

Q: What do you observe?

E: The frequency is independent of the mass but depends on the length.

6.1.6 Sound Vibrations

P: Cover one end of an open tin with a membrane (paper). Fasten it using a string. Spread fine dry sand on the membrane. Speak a soft and a loud sound from the bottom into the tin while your friend is watching the sand.

Q: What does he/she observe?

O: The louder the sound, the larger the amplitude of the vibrations.

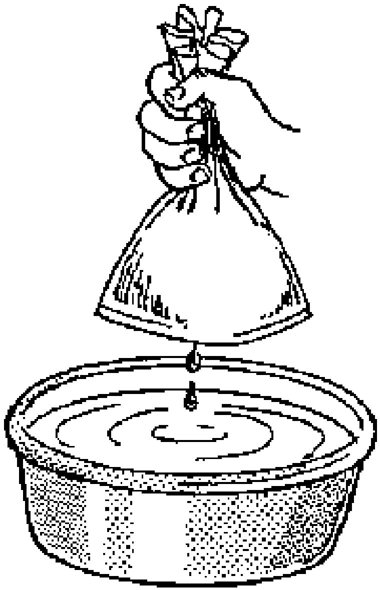
E: The air underneath the membrane has been disturbed by the sound waves which in turn disturb the membrane and make it vibrate. This experiment shows that sound travels as a vibration.

6.1.7 Knocking a Water Tank

C: 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.

A: This can be used to check the presence of liquids in tanks or larger containers.

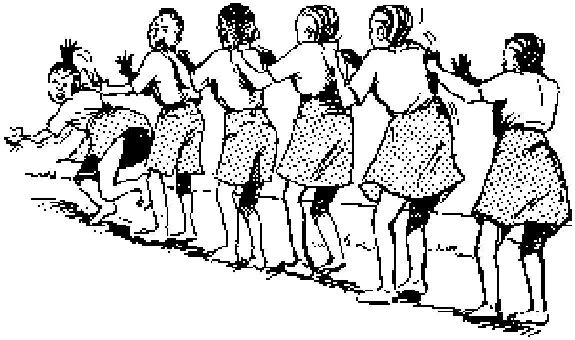
6.1.8 Waves on a Water Surface



P: Allow the surface of coloured water in a bucket to come to rest. (Ink can be used to colour the water.) Fill a plastic bag with water and make a small hole at its bottom. Raise the bag so that drops of water fall on the surface of the coloured water.

Q: What do you observe?

6.1.10 Transfer of Energy



P: Line up a group of students and ask each student to place his/her hands on the shoulder of the student in front with the elbows kept bent. Tell the last student to push forward.

Q: What do you observe when one after the other student pushes?

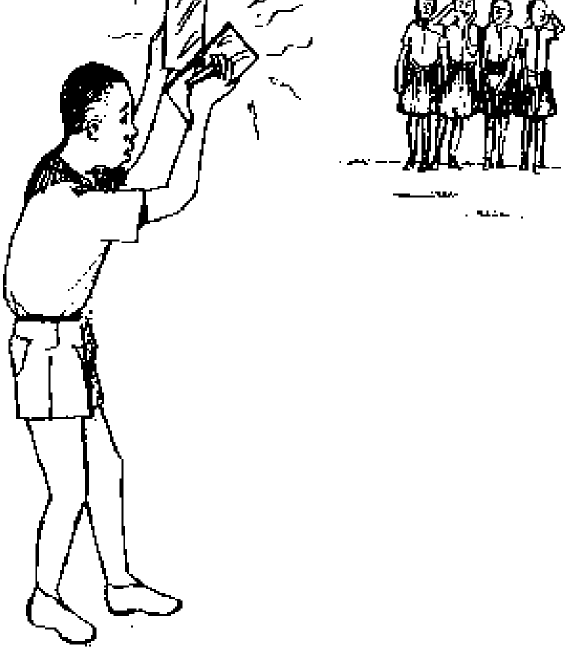
O: A longitudinal wave moves through the queue.

6.2 Propagation of Waves

Sound does not travel through a vacuum but it requires a *medium* for its propagation. Denser media are better transmitters of sound than less dense media.

Thus, sound travels faster and better in water, wood or strings of various materials than in air.

6.2.1 The String Telephone

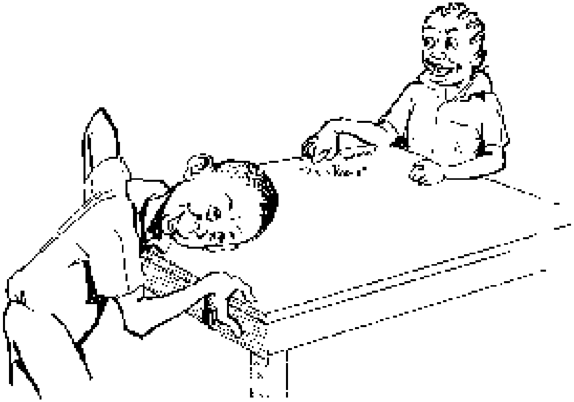


P: One student is standing about 100 m from the class and making sound by clapping two metal pieces (two lids) together.

Q: What do you hear?

O: You will hear a sound. The sound you hear has been transmitted from the source to you by air as a medium.

6.2.3 Sound in a String



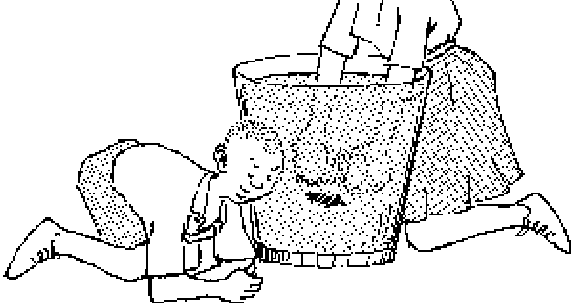
P: Place your ear against one edge of a table while your fiend is knocking the opposite edge slightly. Repeat the experiment by scratching the table slightly. Listen to the sound through air and the sound through the table.

Q: Describe what you hear.

O: The sound travelling through the table is heard more distinctly than when heard through the air.

E: Hence sound travels better in wood than in air.

6.2.5 Sound in Metal



P: Fill a plastic bucket with water. Take two stones and knock them against each other *in the water,* while another person has put his/her ear close to the bucket.

Q: What does he/she hear?

O: He/she will hear the sound coming through the water more loudly.

E: Sound travels better in water than in air.

6.3 Reflection of Waves

When a travelling wave meets a smooth barrier it is reflected. When a wave is reflected, the angle of incidence is equal to *the angle of reflection.*

When a wave is constantly reflected the same way back as it comes to the obstacle (e.g. a wave reflected on the fixed end of a string), a *standing wave* is produced.

Reflected sound is called an *echo.* Ships use *echo–sounding* to determine the depth of the ocean.

O: Parallel waves move across the dish and rebound from the barrier.

E: This behaviour is known as *reflection of waves.* When the angle of inclination of the barrier is changed, the angle of reflection remains the same as the angle of incidence. The barrier is acting as a reflector just as a mirror is a reflector of light.

6.3.2 Reflection of Sound Waves

(b)

P: You and your friend should stand on both sides of a wall beside an opened door. Ask your friend to whisper into a cone and listen through the other cone, see figure (a).

Q: Do you hear anything?

O: No sound is heard.

P: Repeat the above procedure while holding a smooth cardboard as shown in figure (b). Change the position of the smooth cardboard.

Q: What do you hear?

O: Distinct sound is heard. This is because the whispered sound has been reflected by the smooth cardboard towards the listener.

6.3.3 Reflection in a Rope

(b)

P: Tie a rope of about 4 metres length on a fixed bar of a window as shown in the diagram. Hit the rope by a stick.

Q: What do you observe?

P: Repeat the procedure above by jerking the rope up and down.

Q: What do you observe now?

O: (a) An impulse travels along the rope and comes back.

E: When the impulse hits the fixed end of the rope, it bounces off and comes back again as shown by the dotted line in the diagram. The reflected impulse has the same shape as the incident impulse, but is inverted, see figure (a). ? Thus, when a wave is reflected on the fixed end of the rope, a *standing wave* is produced, see figure (b).

6.3.4 Reflection in a Hose Pipe

(b)

P: Stand near a tall building and call out loudly, see figure (a).

Q: What do you hear?

O: After a short time, the call is heard again.

E: The sound waves have been reflected from the wall of the building. The reflected sound which is heard is called an *echo.*

A: Echoes are used by bats in (ultra sound) navigation. Also echoes are used to determine shoals of fish and the depth of oceans, a phenomenon called *echo–sounding* see figure (b).

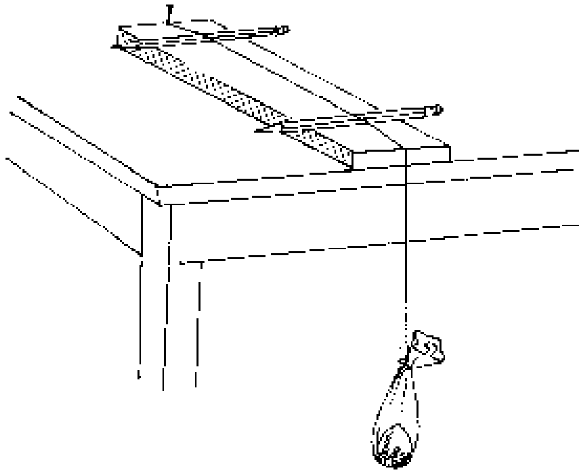
6.3.6 Reflection of Sound Waves

observer.

6.4 Music and Musical Instruments

The human voice is produced by the vibration of the vocal cords. Changes in tension and length produce changes in pitch or tone of the voice. *The less the length and the higher the tension of a cord, the higher the pitch of the tone produced.* The same principle is used to produce music with a *guitar* or a *violin.* The *marimba* and the *xylophone* use sticks or bars of various length or thickness to produce tones of different pitch. The *flute,* the *bottle orchestra* and the *organ* use air columns of various length.

6.4.1 Sonometer (One – String Guitar)



P: Place a soft board on a table. Fix a string with a nail to one end of the soft board. Tie the heavy mass of a stone to the other end of the thread so that the mass hangs below the edge of the table. Insert two pencils

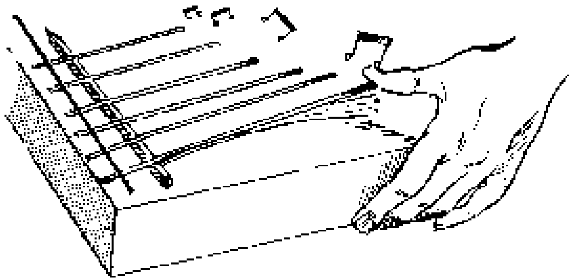
P: Take four equal bottles. Leave the first bottle empty. Fill the second bottle a quarter of its volume, the third a half, and the fourth three quarters of its volume with water and blow into the bottles one after another and listen to the tones produced.

Q: Do you notice any difference in sound?

O: The shorter the air column the higher the tones.

A: The organ (used in some churches); the flute.

6.4.3 Marimba

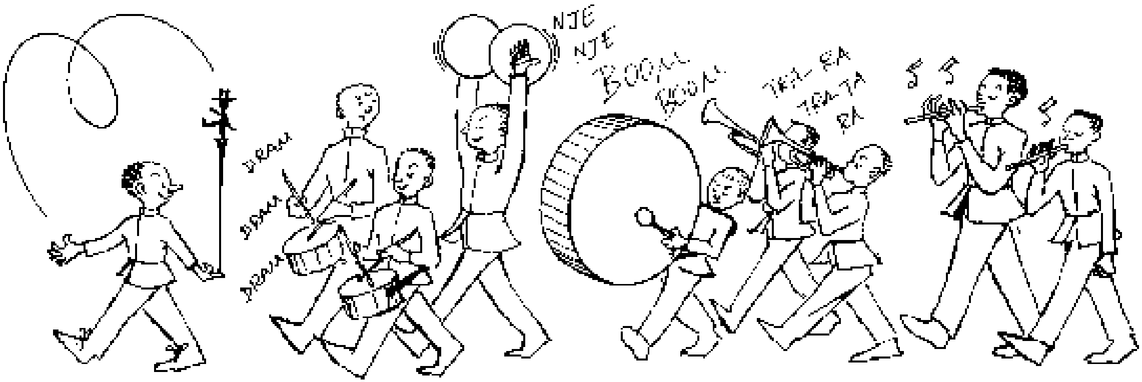


P: Cut bicycle spokes into different lengths. Arrange them on a piece of wood and fix them to it by putting another spoke across them as shown in the figure. Lift the fixed spokes by inserting a pencil under them to raise the free ends of the spokes off the wood. Pluck the free ends one after another and listen to the tones produced.

O: Different tones are produced by the flute as you remove fingers from different holes.

The pitch of the tones depends on the distance of the first open hole from the mouthpiece, i.e. the closer the hole is to the mouth–piece, the higher the tone produced.

E: Thus, the tone produced is determined by the vibration of air in the column between the mouth–piece and the first uncovered hole.



6.4.5 The Violin

6.4.6 The Xylophone

P: Make a wooden box with the bottom and the top side open. Take timber bars of different types and thickness. Drill four holes into each bar and pass two strings to hold all the bars together on the top of the open box. Beat the bars in turn by using two sticks.

Q: What do you hear?

7.1 Nature and Propagation of Light

Light is the energy which is given off by very hot bodies in the form of electromagnetic waves and makes objects visible to our eyes. Light travels in straight lines. Thus, we may use *ray diagrams* in order to explain the *formation of the image in the pinhole camera* or the *formation of shadows* of an object.

7.1.1 Light Travels in Straight Lines

Record your observations.

Displace anyone of the cards so that the holes are not in alignment.

Q: What do you observe? How can you explain this?

E: The light can be seen from end C only if all the three holes are in line. Displacing any of the cards obscures the ray of light and hence you cannot see the ray as you look from card C.

Hence *light travels in the straight lines.*

Figure (b) shows the same arrangement as figure (a) using symbols which are like the cross–section of the actual apparatus. We call such a figure a *ray diagram.*

7.1.2 The Pinhole Camera

(b)

The pinhole camera is a camera made by using a tin or box with a pinhole at one end.

P: Roll a piece of manila card to make a cylinder. Glue a circular piece of card on one open end of the cylinder and puncture a hole at its centre using a pin. Make a second cylinder which fits tightly into the first cylinder. Cover one end of the second cylinder with a plain paper. The paper acts as a screen for the image which will be formed. Close the other end of this cylinder with a card. At the centre of the card produce a hole of about 2 cm diameter. Through this hole you will observe the image. The card prevents light to enter from this side because the image may be too dim to be seen, if light enters from the side of the observer.

7.1.3 Using a Pinhole Camera

(c) Move the camera slowly away from the candle, and observe what happens to the image.

(d) Make the hole wider. Observe the image.

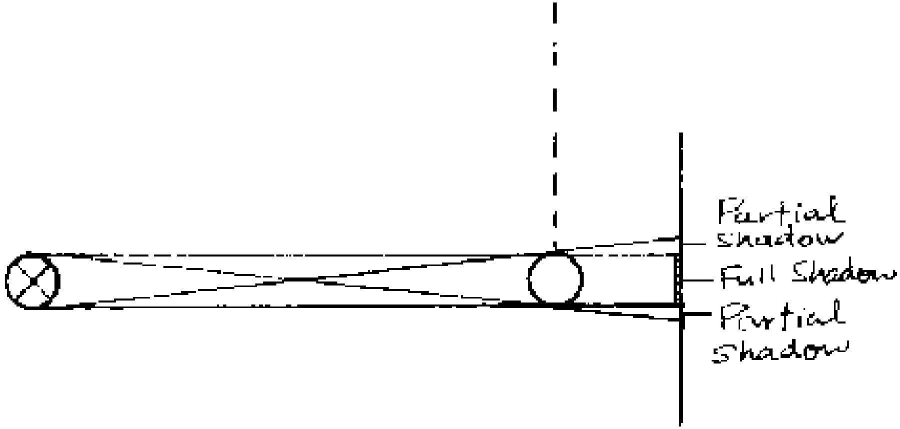
E: (a) The cone of rays reaching the pinhole from the object (candle) decreases with the distance of the hole from the object. Thus, the image becomes smaller and less bright. It is always an *inversed and real image. An image is real if it can be caught by a screen, since the rays really meet in the various point of the image.*

(b) When the distance between screen and pinhole is increased the image on the screen becomes larger and more blurred.

(c) The image becomes larger and more blurred when the object is closer to the hole and becomes smaller and sharper when the object recedes.

(d) When the hole is made larger the image on the screen becomes larger and more blurred. Generally, *an optical image is sharp when all the rays, coming from one point of the object* to the screen, *meet at one point of the image.* If the rays, coming from one point of the object to the screen, hit several points of the screen, the image is blurred.

7.1.4 Shadows Using one Light Source



P: Hold a pencil between a source of light (e.g. candle) and a white paper. Observe the shadow formed on the paper (screen).

Gradually move the pencil closer to the screen and observe the change in the shadow.

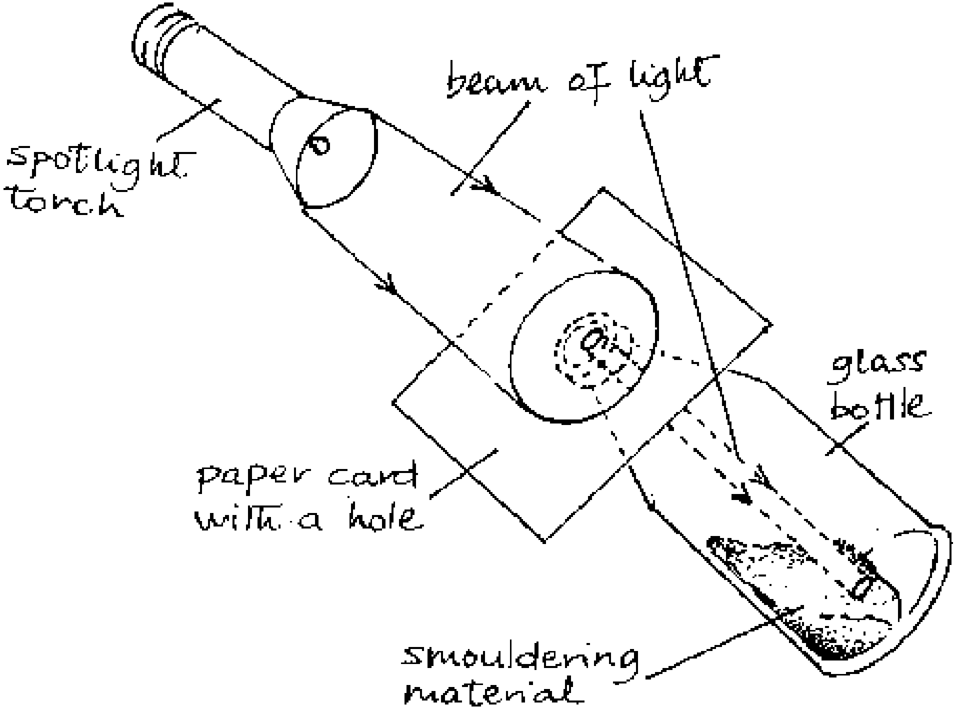
Q: How does the shadow change?

Explain this with the use of ray diagrams.

E: The shadow becomes sharper as the obstacle (pencil) approaches the screen.

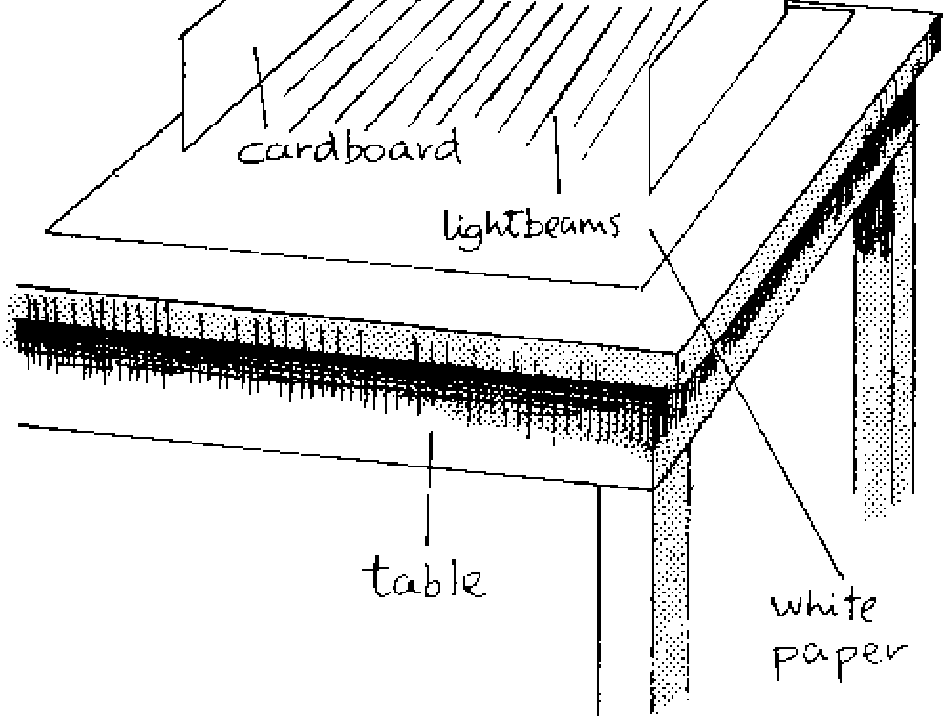
The figures show that *full shade* exists only on those points of the screen, which are *not hit at all by rays* coming from any light source. Wherever points of the screen receive rays from a *part* of the light source only (but *not* from the whole source), there is *partial shade.*

7.1.5 Shadows Using two Light Sources



P: Make a smoke box using a glass bottle and some smouldering material e.g. damp paper, cotton wool etc., as shown in the figure.

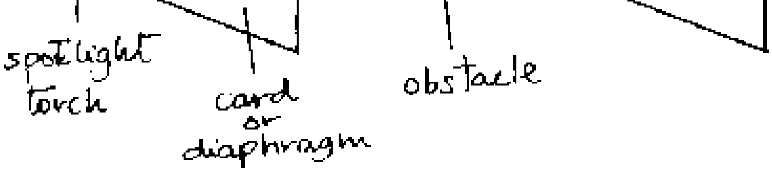
Produce parallel and divergent beams of light by using small and larger holes in the papercard covering the mouth of the bottle. In a dusty room, parallel, convergent and divergent beams of light can be visible when the floor is swept.



P: Hold a comb on a white paper placed on a table. Place pieces of cardboards by the sides of the comb (see diagram).

Q: What do you observe on this white paper? Explain.

Trace the beams of light which become visible on the white paper. Explain what is meant by the words "rays" and beam of light.



(b)

P: Place a torch light behind a cardboard with a hole in it. The assembly is called a *ray box.* Observe the shadow formed by an obstacle placed in the light from a ray box with a large hole (see fig. a).

Change the hole of the ray box to a very small size and note the shadow formed by the same obstacle on the same screen (see fig. b).

Repeat the above experiments with sunlight.

Q: In which case do you get

(i) full and partial shadow?
(ii) full shadow only?
(iii) Sharper shadows?

Explain why the shadows formed by sunlight are not typical of your results in these experiments.

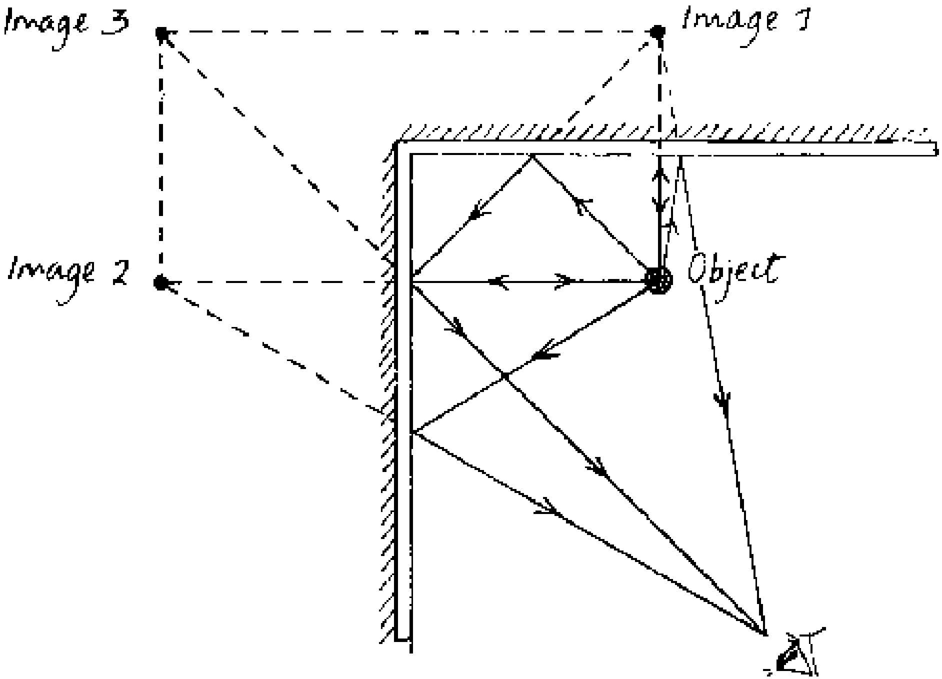
What do these experiments suggest about the way light travels?

E: All the experiments give evidence that light travels in straight lines.

Single *extended light sources* give partial and full shadows.

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.

7.2.1 The Kaleidoscope (Inclined Mirrors)



P: Arrange two plane mirrors to meet each other at right angles as shown. Confirm that three images of one object (candle) can be seen simultaneously. Refer to figure.

on the white card. Note the image distance (the distance from the mirror to the card).

Q: Draw a ray diagram for this experiment. How are the rays coming from the distant window? What does the image distance give in this case?

E: Since the window is distant, its rays meet the mirror parallel. Hence, they are reflected through F. Thus, the image distance recorded give f, the focal length of the mirror.

7.2.3 The Radius of Curvature of a Concave Spherical Mirror

Q: Measure the radius of curvature CP = r. Compare your values of f and r. What do you find out?

Draw ray diagrams to show how the mirror forms images of an object placed at different positions. How would the mirror work best as a shaving mirror?

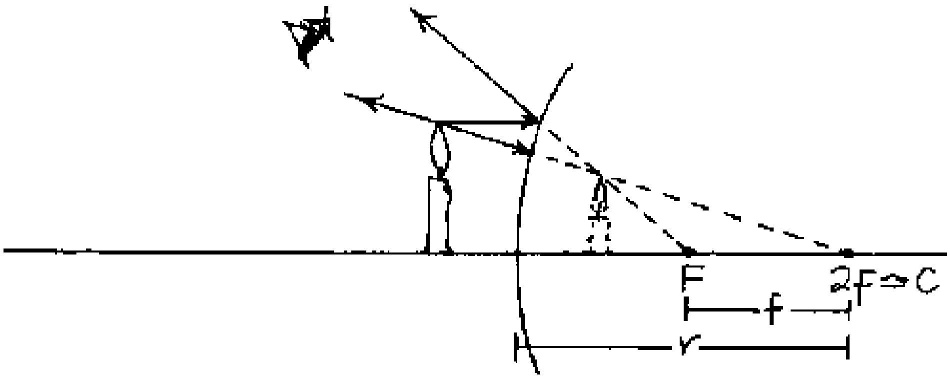
E: The ray diagram shows that C is the centre of curvature and hence r = 2f.

Ray diagrams show that (i) the *concave mirror* produces a real, inverse and magnified image, if the object is farther away than F from the mirror.

(ii) If the object is nearer to the mirror than F, the image appears to be behind the mirror and is hence virtual. However, it is erect and magnified. In the latter case the mirror works best as a shaving mirror.

A: Shaving mirror, dentist's mirror, floodlight (case (ii)); if the object (bulb) distance = f: torch, car headlight.

7.2.4 Convex Spherical Mirror



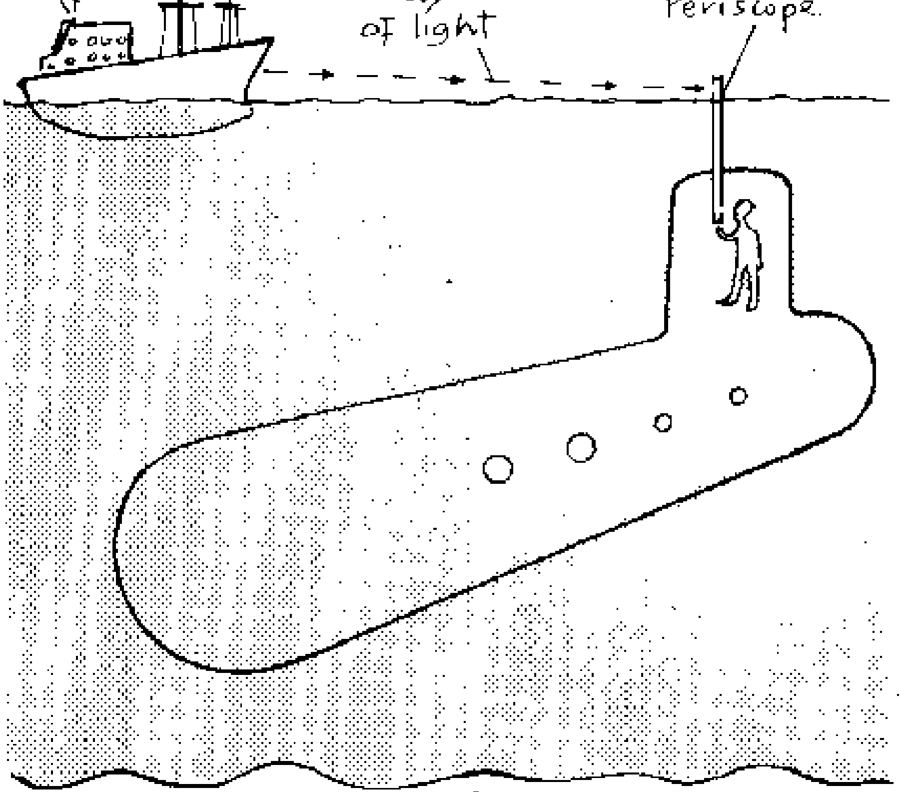
P: Place a transparent glass–pane mid–way between a lighted candle and bottle full of water. View the bottle through the glass–pane from the side of the candle.

Q: At what position do you see the image of the burning candle?

O: The candle appears to bum in the water in the bottle.

Explain this observation using a ray diagrams.

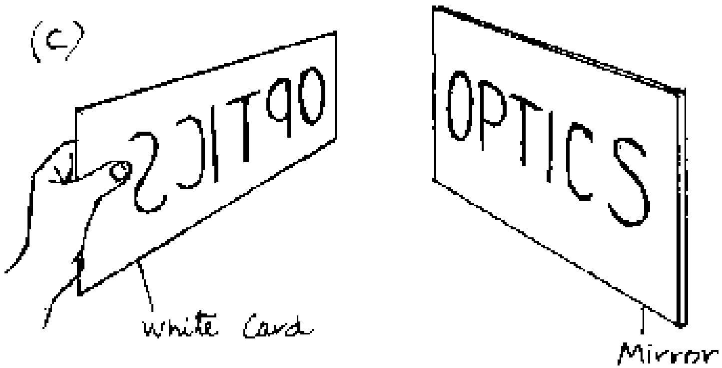
7.2.6 The Periscope



(b)

P: Arrange two mirrors in a rectangular box as shown in figure (a). This instrument is called a *periscope* and allows to observe objects behind corners.

Q: Observe objects placed behind obstacles.



P: Write the word OPTICS on an ordinary piece of paper, see figure (a). Turn the piece of paper and retrace the faint word appearing on its back, see figure (b). You will obtain the *mirror–writing* of the word OPTICS. The latter is a reversed image of the former.

Place the piece of paper in front of a plane mirror (see figure (c)).

Q: What do you see? Repeat using the word at the back side of the paper. What do you see? Compare your

P: Put a coin in the lid of a jam jar.

Hold the lid up to almost level of your eye, until you just cannot see the coin in the bottom of the lid. Gently pour water in the lid to cover. the coin completely. The coin will be visible to you again, see figures (a) and (b).

Q: Explain your observation with the use of a ray diagram.

E: The ray diagram of figure (c) shows that we can only see the coin because the light rays coming from it are deflected at the water surface away from the normal of the water surface.

P: Lower the lid and look at the water vertically from above

Q: Where does the coin appear now?

Explain the observation.

O: When viewed vertically from above the coin appears to be at the bottom of the lid. However, the bottom seems to have rised because of the refraction of those rays which reach the water surface under an angle of incidence different from 0°.

P: View the coin from different directions.

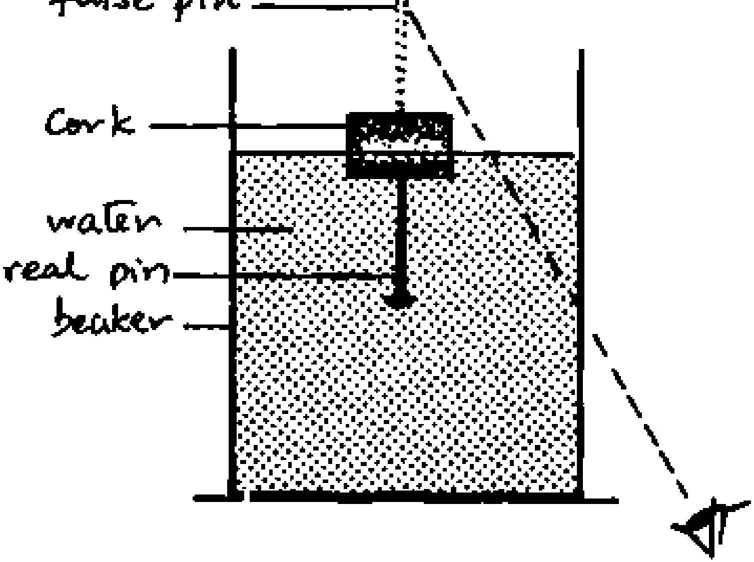
Q: How does its position seem to change?

E: When viewed at an angle from the vertical the coin appears to be raised above the bottom of the lid, therefore as the viewer changes position the coins position also seems to change because of the refraction.

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 coming from the right side into the glass of the bottom of the bottle are totally reflected and then coming to your eye, see figure (b). These rays are *not* refracted to the air outside the bottom of the bottle because their angle of incidence i is larger than the critical angle for a glass/air boundary which is 42°. These totally reflected rays are so strong that they completely cover the relatively weak rays coming from the coin. Hence, the coin cannot be seen any longer.

A: Prisms in binoculars, etc., see 7.3.6.

7.3.3 Bending a Pencil with Water



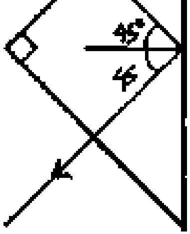
P: Stick a pin (office pin) into the underside of a small cork and allow it to float in a beaker full of water.

Hold the beaker above your head and look up through the side of the beaker at an angle from the vertical.

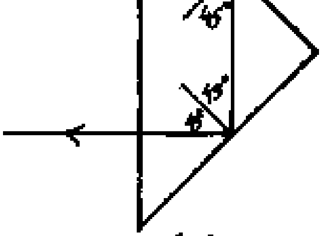
Q: What do you see?

O: You will see the real pin below the cork and a fake pin above the cork.

7.3.5 Explaining the False Pin



(a)



(b)

P: Total internal reflection occurs when light falls on a glass prism with angles of 45°, 45° and 90°. This is because a ray falling normally on any face of such a prism hits the inside face at 45°, and this is greater than the critical angle of glass/air (about 42°). In figure (a) the ray is turned through 90° and in figure (b) through 180°.

A: Totally reflecting prisms are used in periscopes (instead of mirrors) and in binoculars.

7.4 Lenses and Optical Instruments

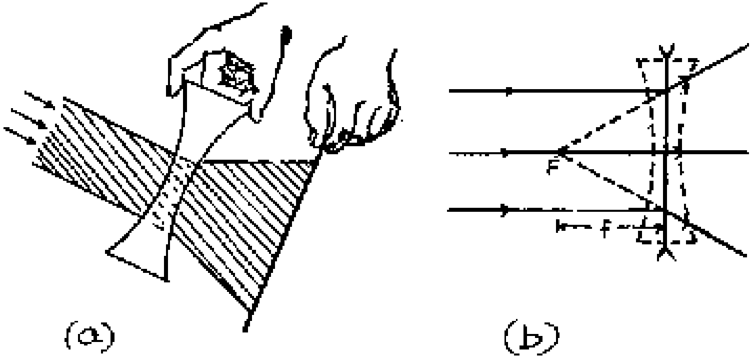
Any transparent material bounded by at least one curved surface acts as a lens. Common examples of lenses are made of glass. By their action on rays of light lenses can be put into two groups: the converging and the diverging lenses. *A converging (convex) lens* is thickest at its centre whereas this is where the *diverging (concave) lens* is thinnest. The action of a lense is due to the refraction of the rays on its curved boundaries. For the construction of *ray diagrams* for *thin* lenses the following rules are helpful:

> *For both types of lenses: rays passing through the centre of the lens travel straight on,* see figure (a).

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 of the lens or bulb on the rays is explained by refraction of the rays on its curved surfaces.

H: The bulb is *not* a *thin* lens. Hence the focus is not as sharp as with a thin lense.

7.4.2 Action of a Concave Lens on Parallel Rays



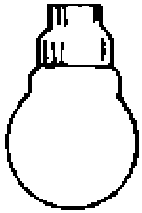
P: Try to repeat experiment 7.4.1 using a concave lens. If that is not available, the base of a soda bottle or a thin film of water on a wire loop also can serve as a concave lens.

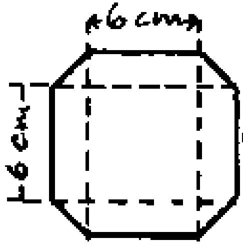
Q: What do you observe? Do you find a focal point?

O: No focal point can be found.

E: This lens *diverges* the light and hence no real focus exists.

However, the ray diagram (see fig. b) shows that a *virtual* focal point can be found on the same side of the lens on which the light source is.

(b) 



(c)

P: (i) Cut a piece of manila sheet according to the plan of a rectangular box in figure (a).

(ii) Open the bulb seal of a transparent used up electric bulb and remove the filament. Then fill it with water to make the water lens (see appendix).

(iii) Fold the manila sheet cutting (figure (a)) along the dotted lines. Fit the water lens on the slot and close the box by gluing the flaps.

(iv) Cover the open end with a piece of plain paper or (better) parchment paper as a screen using glue (see figure c).

(v) Close the slot using a sliding manila sheet cover, having dimensions of 6 cm by 30 cm with a hole to fit the bulb at its centre.

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?

E: (i) v = f because the rays coming from a distant object are parallel.

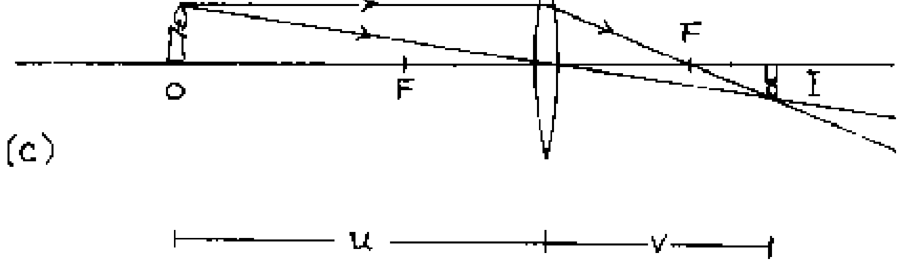
(ii), (iii) The size of the image grows larger as the object distance u decreases. First the image size is smaller than the object size. When u = 2f, then the image size is equal to the object size. All images are *real* because they appear on a *screen.*

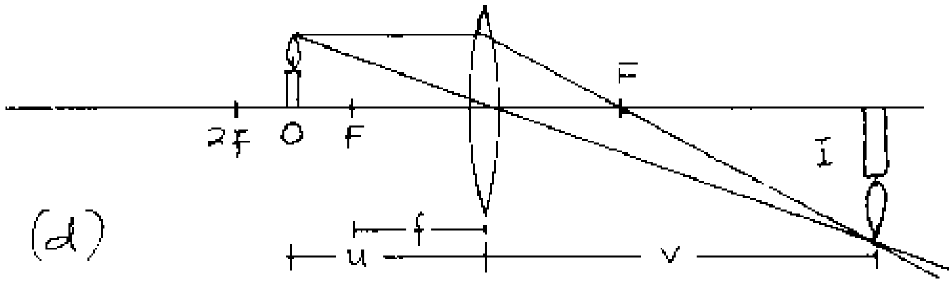
(iv) When 2f > u > f, then the image size is larger than the object size. When u < f, no *real* image can be observed.

H: The bulb is no thin lens hence the image will not be as sharp as with a thin lens which may be obtained from TAN OPTICS, P.O.B. 1929 Moshi, Tanzania.

A: (iii) Photographic cameras, (iv) projectors for movies and slides.

7.4.5 Ray Diagrams for the Box Camera





E: See figures (a) to (d) which correspond to the cases (i) to (iv) of experiment 7.4.4.

7.4.6 Magnification

(b)

P: Produce a magnifying glass by making a loop as shown in figure (a) using paper clip wire (e.g. winding it around the tip of a ball point pen). Dip this loop in. water and use it as a magnifying glass by observing letters in a book etc. Thus, this water drop lens acts as a convex lens.

Q: Explain the magnification by drawing a ray diagram. What kind of image is formed?

E: See fig. (b), the image is larger than the object. However, this image is *virtual* because it cannot be obtained on a screen. In a virtual image the light rays do not meet really in the image point. They only seem to meet there because the eye and brain of the observer are accustomed the assume that the light rays travel in straight lines only. Yet the real rays were refracted by the lens which causes the image to appear in the eye of the observer. The object distance u must be less than f: $u < f$.

H: A bulb filled with water can also be used.

A: Magnifying glass, eye lens of compound microscopes, telescopes etc.

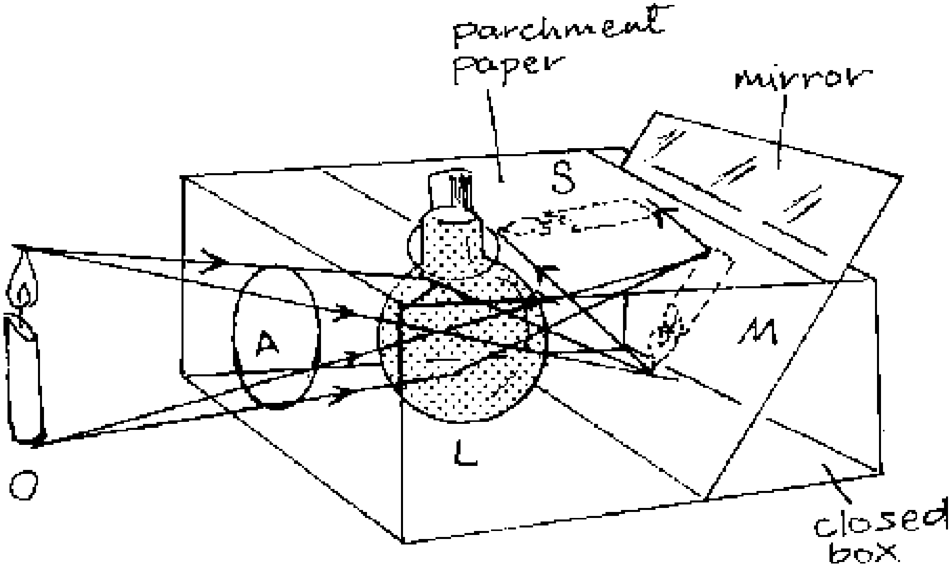
7.4.7 Simple Microscope

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 metal strip so that the water drop lens has less distance from the object than its focal length.

Q: How does the lens act here? What happens when you bring it even nearer to the object? Draw a ray diagram.

E: The lens acts here as a magnifying glass. When the object distance decreases further, the magnification will increase. The ray diagram is the same as in the last experiment.

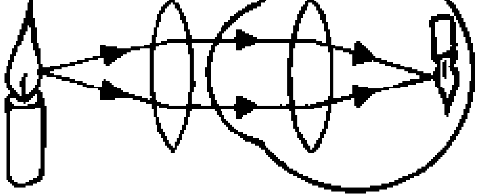
7.4.8 Mirror Reflex Camera



The eye possesses an convex lens which focusses the light on a sensitive membrane (called retina). In difference to the camera the eye lense changes its curvature and hence its focal length in order to focus the light from objects of different object distance. The focal length varies according to object distance while the image distance is kept constant and is roughly equal to the diameter of the eye, see the figure.

P: Draw a display chart of the above figure.

7.4.10 The Long–Sighted Eye



(b)

The long–sighted eye cannot focus near objects. The rays from a near object are focused *behind* the retina, see figure (a).

P: Make a *model of the long–sighted eye* by fixing the lens of the box camera (see p.90) so that it focusses a near candle *behind* the screen.

Q: How can you amend this sight defect in your model (without changing the image distance because that is *constant* in the eye)?

E: You need to place a convex lens of suitable focal length in front of the eye model in order to focus the near candle on the screen (retina), see figure (b). Thus, a long–sighted person needs spectacles having converging lenses.

7.4.11 The Short–Sighted Eye

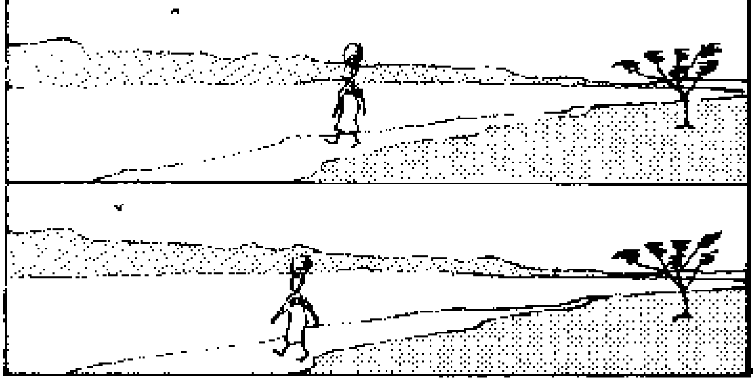
The short–sighted eye cannot focus distant objects. They are focussed *in front* of the retina, see figure (a).

P: Make *a model of the short–sighted eye* by fixing the lens of the box camera (see p.90) so that it focusses a distant candle *in front* of the screen.

Q: How can you amend this sight defect in your model (without changing the image distance because that is constant in the eye)?

E: You need to place a concave lens of suitable focal length in front of the eye model in order to focus the distant candle on the screen (retina), see figure (b). Thus, a shortsighted person needs spectacles having diverging lenses.

7.4.12 Persistence of Vision



An image lasts on the retina for about one tenth of a second after the object has disappeared as can be shown by flipping cards having motion pictures as shown in figure (a).

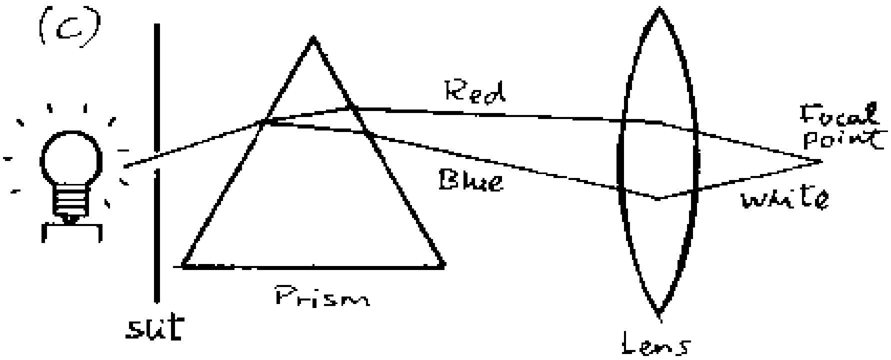
A: The effect makes possible the production of motion pictures. 24 separate pictures each slightly different from the previous one, are projected on to the screen per second and give the impression of continuity.

P: Make eight motion pictures of a walking woman as shown in figure (b). Arrange them subsequently and hold them so that each picture comes to vision after the previous one within a short time.

Q: What do you observe?

E: The woman appears to walk.

A: Movies, television, videos.



P: Arrange a glass prism, a narrow source of white light and a screen as shown in figure (a). Adjust the angle at which the ray hits the prism and the screen so that you catch the dispersion colours *(spectrum)*

Q: Which colour of light is most refracted by the prism? Which colour is least refracted by the prism?

E: The prism splits white light into its component colours. Blue light is refracted most and is observed nearest to the base of the prism. Red light is least refracted.

With the use of a second prism or a converging lens the separated light colours can be recombined to form white light, see figures (b) and (c).

7.5.2 Dispersion with a Mirror in Water

(b)

P: Place an inclined mirror in a container half full of water. Allow a light to strike at the slanted face of the mirror. Look through the submerged portion of the mirror, see figure (a).

Q: What do you observe?

O: The dispersion colours (spectrum).

P: Use the arrangement of figure (b) to obtain the spectrum on a screen.

Q: How do you explain the formation of this spectrum?

E: The refraction of the incident colours on the surface of the water and of the reflected rays again makes the water act as a "water prism".

7.5.3 Rainbow Colours from a Water Hose

P: Early in the morning or late in the afternoon of a bright sunny day spray water from a hose pipe against a dark background of trees with your back towards the sun, see the figure.

Q: What do you see? How can it be explained?

O: You will observe the colours of the rainbow in the spray from the hose.

E: The rainbow is a result of the dispersion of light rays striking water droplets.

7.5.4 Colour Mixing: Newton's Disk

There are colours of light which when mixed in varying intensities will produce all other colours, but they themselves cannot be produced by mixing other colours. When mixed in appropriate intensities, they will also produce white light. These are the *primary colours* of light. The three primary colours of white light are *blue, green and red.* Hence BLUE + GREEN + RED = WHITE, see figure (a).

Y = yellow, M = Magenta and W = White.

Secondary colours are formed by adding two primary colours, e.g. Red + Green = Yellow.

So yellow is a secondary colour of red and green.

P: Paint twelve equal sectors of a disk made from white cardboard with red, green and blue colours arranged in that order, see figure (b). Tie a string through the two holes around the centre of disk. Swing and pull the string ends with both hands, see figure (c). The disk will start spinning to and forth.

Q: What do you observe on the disk?

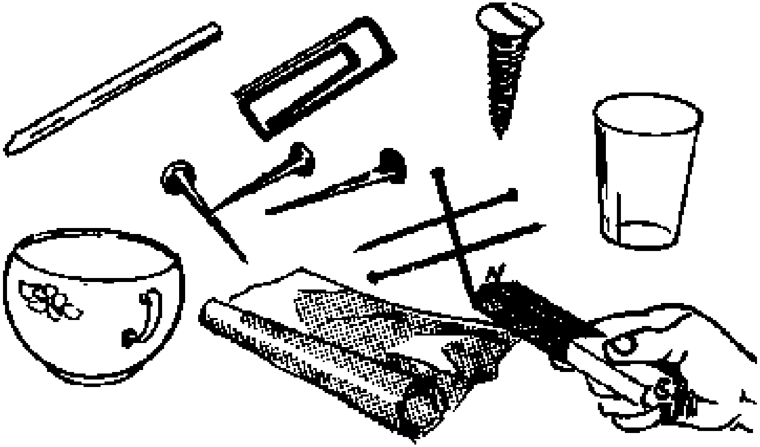
O: The spinning disk appears whitish.

E: The colours of the light reaching the eye at short time intervals mix to white light due to the *persistence of vision.*

8. Magnetism and Electricity

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 magnets at a distance without any medium being in between. *Unlike poles attract each other, like poles repel each other.*

8.1.1 Distinction of Magnetic and Non−Magnetic Materials



P: Arrange the materials shown in the diagram above on a table. Bring a magnet close to each material.

Q: What happens to each material?

E: Those materials which are attracted by a magnet are called magnetic substances. Those which are not attracted are called non−magnetic substances.

A: One can use a magnet to distinguish magnetic materials from non−magnetic materials. For example, you can find out if dry sand collected from outside contains magnetic materials by pushing a magnet through the

Now bring the N–pole of the magnet near the N–pole of the needle.

Q: What do you observe in each case?

O: You will observe that the N–pole of the magnet attracts the S–pole of the needle; the S– pole of the magnet repels the S–pole of the needle; and the N–pole of the magnet repels the N–pole of the needle. So we say *unlike poles of magnets attract each other and like poles repel each other.*

H: In case bar magnets are not available a magnetised piece of steel can be used instead of a bar magnet, see experiment 8.1.3.

8.1.3 Magnetisation by Single and Double Touch Method

P: Move one pole of a bar magnet many times along the needle as shown in figure (a).

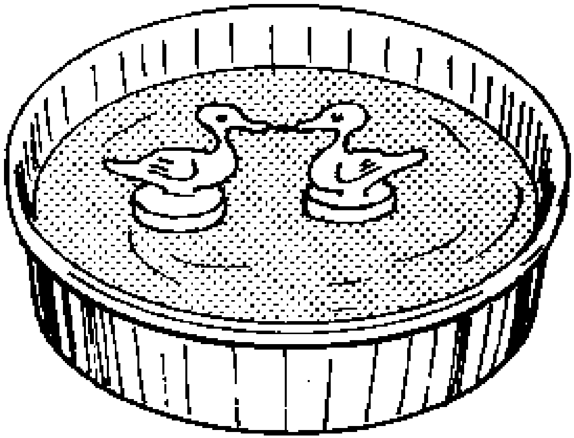
Now move the magnet along another needle as shown in figure (b). Do this several times, each time starting from the middle of the needle.

Q: Are the two needles magnetized? If so what are the poles of the needles?

O: Both needles are magnetised. The end A of the first needle is a N–pole and end B is a S– pole. The end A of the second needle is S–pole while end B is a N–pole.

H: The first needle has been magnetised by the single touch method and the second one has been magnetised by the double touch method.

8.1.4 Magnetic Ducks



P: Make a coil by winding about fifty turns of isolated wire around a bicycle spoke. Connect the coil to two or three radio cells, see the figure. After a few minutes disconnect the battery and remove the spoke from the coil. Dip the spoke into iron filings.

Q: What do you observe?

E: The iron filings are attracted by the end of the spoke. The electric current in the coil has magnetized the spoke.

H: Steel can be magnetized by this method but soft iron *cannot.*

8.1.6 Demagnetisation of a Magnet

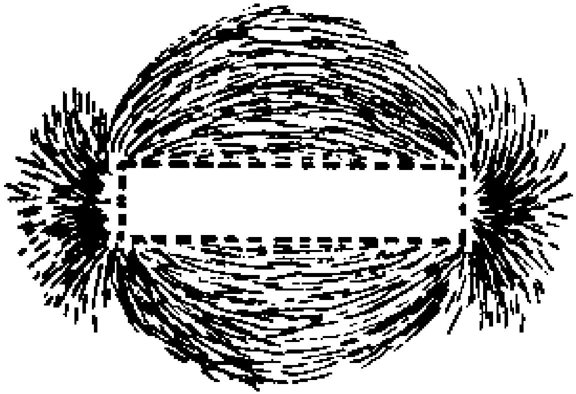
P: Magnetise a bicycle spoke and check if it attracts small nails or iron filings. Heat the spoke in a flame as in figure (a) and check again if it attracts the nails. Get another magnetised spoke and hammer it several times as shown in figure (b). Check if the spokes still retain their magnetism.

Q: What has happened to the spokes?

E: Heating and hammering of the spokes has destroyed the magnetism of the spokes.

H: Magnets should not be kept in hot places or dropped otherwise they may lose their magnetism.

8.1.7 Magnetic Field Pattern



P: Place a cardboard on top of a permanent magnet Sprinkle iron filings on the cardboard. Tap the cardboard gently several times.

Turn the suspended needle through various angles and release it.

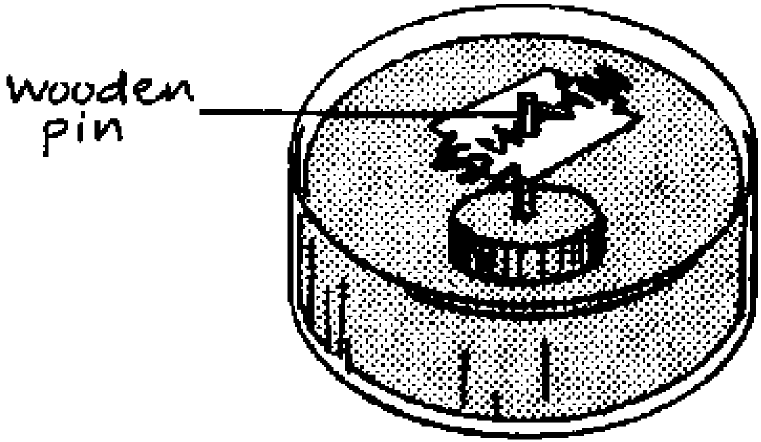
Q: What do you observe?

E: You will notice that the needle will always return to settle in the N–S direction.

The suspended magnetised needle can act as a simple divice to find the north–south direction.

A: Such a divice which shows the N–S direction is called a *compass.*

8.1.9 Making a Simple Compass Using a Razor Blade



P: Fix a wooden pin vertically in a bowl of water. Slip a magnetised razor blade along the pin and carefully place it on the surface of the water so that it can rotate using the pin as an axle. Allow the blade to come to rest and mark its N–pole and S–pole.

Q: What do you observe with the magnetised and with the unmagnetised rod respectively?

O: With the unmagnetised rod both ends are attracted by the pole of the suspended magnet With the magnetised iron rod, one of its ends will be repelled. This follows from the fact that like poles repel and unlike poles attract.

A: This is used to distinguish magnets from unmagnetised iron.

8.2 Electrostatics

When plastic materials, e.g. plastic pens, combs and rulers are rubbed with fur, woolen clothes, or hair, they acquire negative *electric charges.*

When materials made of glass are rubbed with silk or polyester clothes, they acquire positive charges.

The charges acquired are stationary (static). The study of stationary electric charges is known as *electrostatics.*

Like electric charges repel each other, unlike charges attract each other.

8.2.1 Charging by Rubbing (Friction)

Q: What do you observe?

O: The plastic pen or glass bottle picks up small pieces of paper or thread.

E: The plastic pen becomes negatively charged and the bottle becomes positively charged. Thus they both attract pieces of paper.

A: The roller in a photocopying machine is charged positively. It attracts the paper which is being photocopied. Thus the paper sticks on the roller.

H: Changing by rubbing is more effective if you use dry materials during a dry day. Most of the time, electrostatic experiments won't work on a humid day.

8.2.2 Laws of Electrostatics

is attracted by the glass bottle.

E: The existence of the same types of charges (negative) on the plastic pens causes repulsion. When the positively charged bottle (glass) is brought near the plastic pen, attraction occurs.

This experiment demonstrates the electrostatic law: *like charges repel and unlike charges attract each other.*

8.2.3 Simple Electroscope

(b) Introduce your finger between the charged strips.

Q: What happens to the strips?

O: The charged polythene strips repel each other.

(a) The strips are repelled further with the charged plastic spoon between them.

(b) The finger attracts the strips because the body is earthed. So it becomes positively charged relative to the two strips.

H: The polythene strips can be obtained from the transparent covering of a cigaratte package.

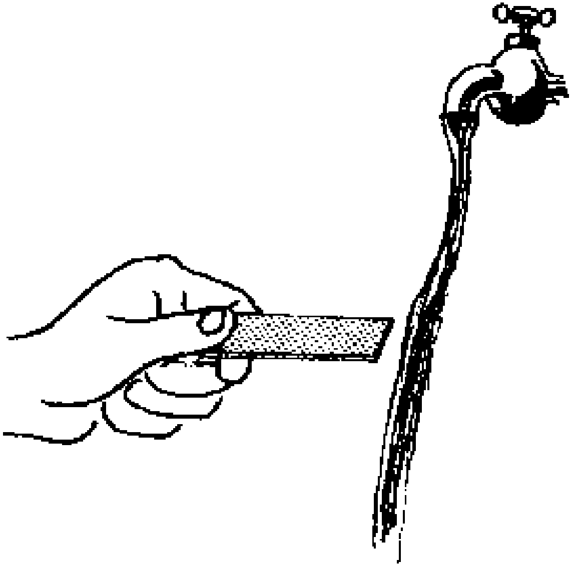
A: The electroscope.

8.2.4 Electrostatic Induction

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 the electrons in the aluminium ball away from the side of the spherical surface near the ruler. Therefore the surface near the ruler gets positive charges and so the aluminium ball is attracted by the plastic. The other side of the aluminium ball becomes negatively charged, see figure (b). The process taking place in the aluminium sphere is called *electrostatic induction.*

8.2.5 Attraction of a Thin Stream of Water by a Plastic Object



P: Charge a plastic object rubbing it on a woolen cloth. Then hold it near (but not touching) a thin stream of water from a tap.

P: Rub a balloon on a woolen or synthetic cloth or hair and then place it against the ceiling.

Q: What do you observe?

O: The charged air balloon sticks to the ceiling.

E: This happens because the negative charge on the balloon repels some of the electrons in the ceiling away from the surface. This leaves the surface positively charged and so the negative balloon is attracted by the ceiling,

H: The experiment should be carried out during dry weather. Otherwise moisture in the air will neutralize the charges and the balloon will not stick to the ceiling. Holding the balloon with bare hands may also neutralize the charge. Try using dry paper.

A: Why do gramophone records tend to gather a lot of dust?

8.3 Electric Current

When electrons flow through a conductor they may, for example, light a bulb, heat a wire and produce a magnetic field. The flow of electrons in such a conductor is called an *electric current.* Materials, which allow a current to pass, are called *conductors.* Materials which do not allow a current to pass, are called *insulators.*

Note: If your house or school has got electricity, *never use the mains for performing the following experiments. The voltage there is quite high and could easily kill you.*

8.3.1 Conductors and Insulators

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 pass, are called poor conductors *(insulators).*

H: How to construct the bulb holder and the cell holder, refer to the figure. Note that metal plates are fixed at the end of the cells as a cell holder. For the lamp holder the metal plates are fixed on the side of the bulb and under the bulb.

Metals like copper, aluminium, iron etc. are used for connecting electric circuits. Plastics, wood, porcelain, etc. are used as insulators.

8.3.2 The Electric Circuit

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 terminal.(Of course, actually *electrons* flow in the wires from the negative to the positive terminal.) The switch makes a continuous path possible and hence the current can flow. This continuous path is called an electric circuit. In an *electric circuit diagram* we always use symbols. Every component of the circuit has its own symbol.

8.3.3 Bulbs in Series and Parallel

(b)

P: Connect two bulbs as shown in circuit diagram (a) so that they are in one line (series). Close the switch and observe the brightness of the bulbs. Now connect the bulbs side by side (parallel) as shown in circuit diagram (b). Close the switch and observe the brightness of the bulbs.

Q: What difference do you observe in the brightness of the bulbs when they are connected in series and when they are parallel? Explain your observations.

O: The bulbs are brighter when they are parallel than when they are in series.

E: More current passes through each bulb when they are parallel than when they are in series. The reason is that the full voltage of the battery lies on each bulb when the bulbs are connected parallel. When they are in series only half the voltage of the battery lies on each bulb.

A: In domestic wiring bulbs are connected parallel so that they obtain the right voltage.

8.3.4 Cells In Series and Parallel

P: Connect two dry cells in series, that is the positive terminal of one to the negative terminal of the next as shown in circuit diagram (a). Connect the two cells parallel, that is the positive terminal of one to the positive terminal of the other and the negative terminal of one to the negative terminal of the other as shown in circuit diagram (b).

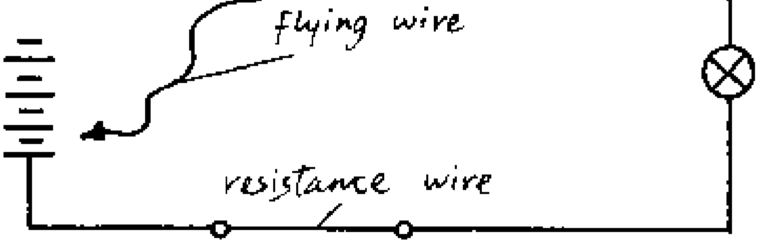
Q: What difference do you observe in the brightness of the bulb when the cells are connected in series as in circuit (a) and when they are connected parallel as in circuit (b)? Explain your observations.

O: The bulb is brighter when the cells are connected in series than when they are connected parallel.

E: More current passes through the bulb when the cells are connected in series than when they are connected parallel. The reason is that the *voltage* of the two cells add when they are in series. When they are parallel, the voltage stays the same as that of one cell.

A: In torches and car batteries cells are connected in series to get the required voltage. In cars 12 volts are needed, thus 6 cells are connected in series since one car cell has only 2 volts.

8.3.5 Ohm's Law: Increasing the Resistance



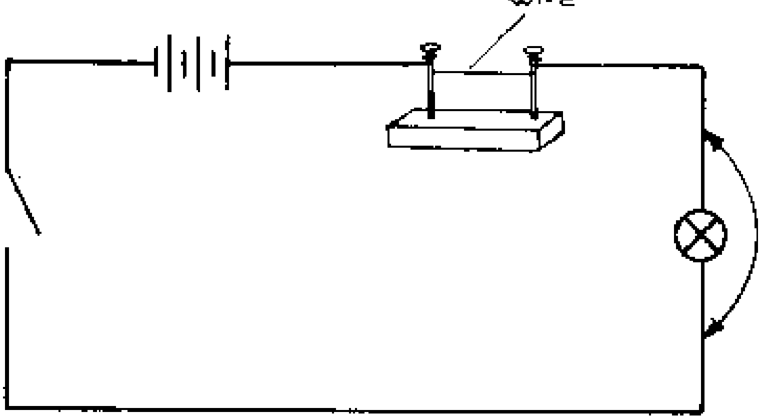
P: Connect the circuit above. Starting with the free end of the flying wire connected to one cell, successively increase the number of the cells.

Q: What difference in brightness of the bulb do you observe as the number of cells connected are increased?

O: The bulb becomes brighter when more cells are used than when one cell is used. The brightness increases with increase in the number of cells.

E: The current passing through a circuit increases with increase in the number of cells since the voltage increases accordingly.

8.3.7 Heating Effect of an Electric Current



P: Connect the circuit as shown in the diagram. Close the switch. Make a short circuit by connecting a copper wire across the bulb.

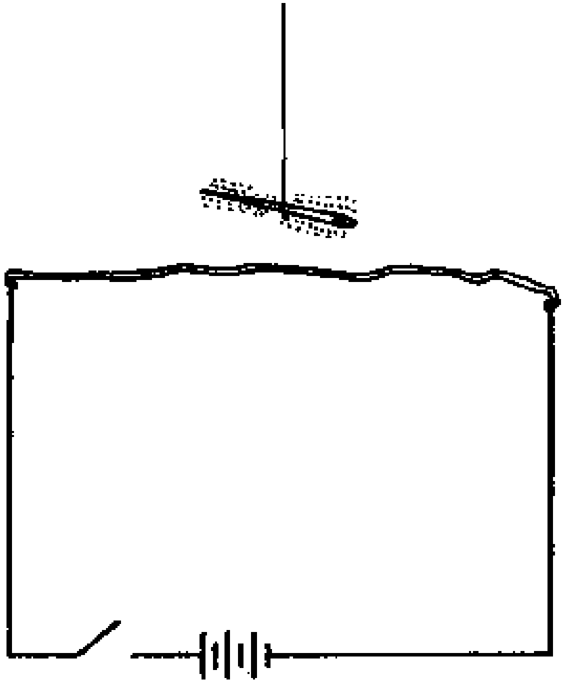
Q: What happens to the thin steel wire connected across the nails?

O: The steel wire melts (fuses) and the bulb stops lighting. This is because a large current passes through the thin steel wire. The wire acts as a fuse.

A: A fuse is used in electrical appliances and domestic wiring to cut off large currents in electric circuits which could start fires.

8.3.9 Chemical Effect of an Electric Current

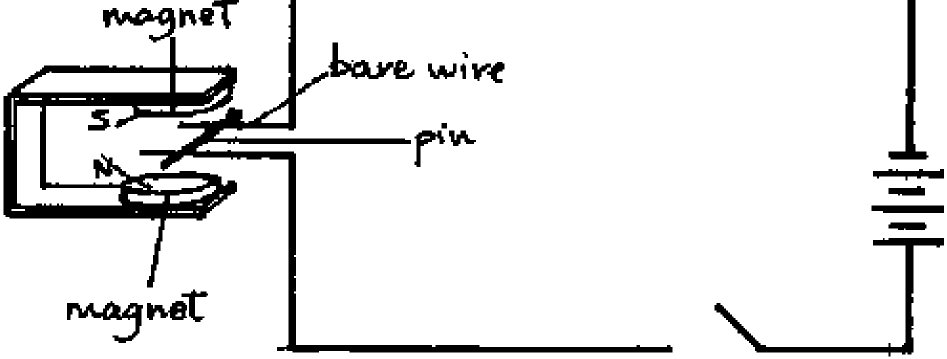
8.3.10 Magnetic Effect



P: Connect the electric circuit as shown in the figure. Suspend a magnetized needle with a piece of cotton thread just above the wire. Close the switch *only for a very short time.*

Q: What happens to the magnetised needle?

E: The magnetised needle is deflected, because the wire has produced a magnetic field.



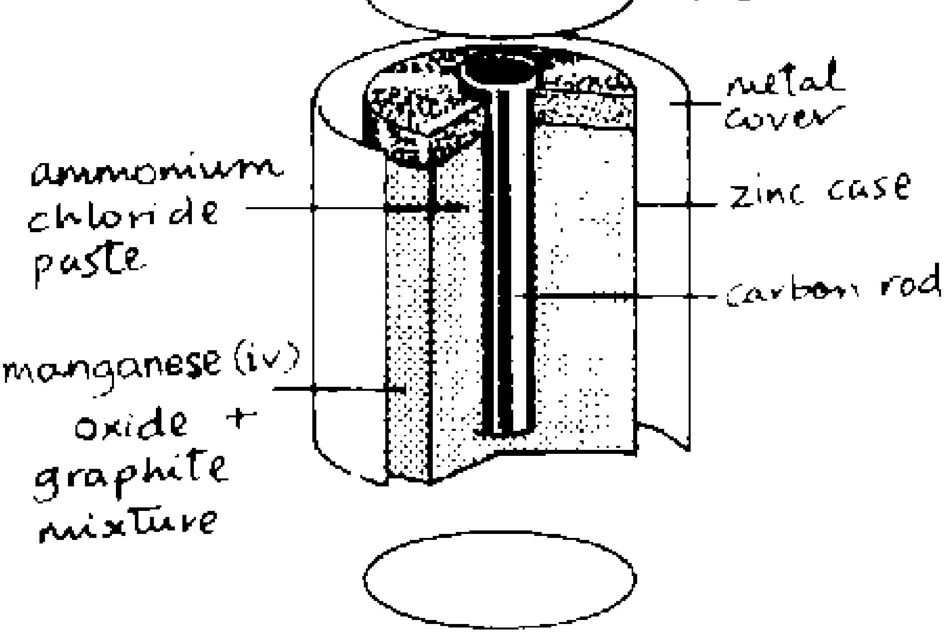
P: Connect the circuit as shown in the diagram. Place a nail across the straight bare wires between poles of the magnet and close the switch, *for a short time only,*

Q: What happens to the nail?

O: The nail rolls along the straight wires, because a force is produced on the current in the nail by the magnetic field.

A: Electric motors and loudspeakers.

8.3.13 Opening a Dry Cell

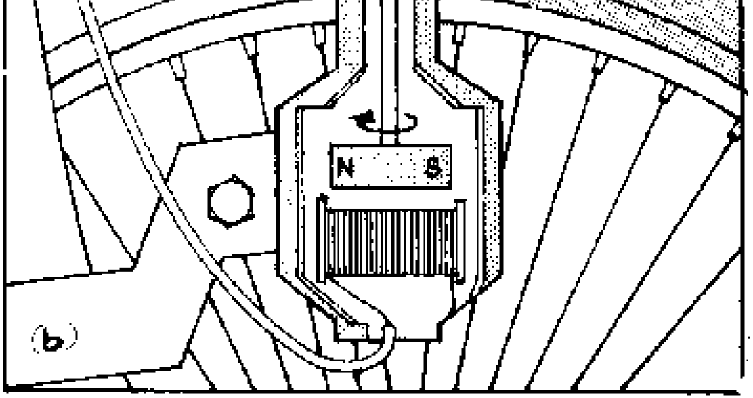


P: Open a dry cell. Examine it carefully.

Q: What do you see in the broken dry cell?

O: You will see a black rod at the centre of the cell surrounded by a black substance covered by eaten up zinc.

E: The black rod at the centre is a carbon rod (graphite). The black substance contains manganese(IV) oxide and ammonium chloride paste.



P: Connect a bulb to a bicycle dynamo by using connecting wires. Turn the wheel of the bicycle very fast and then slowly.

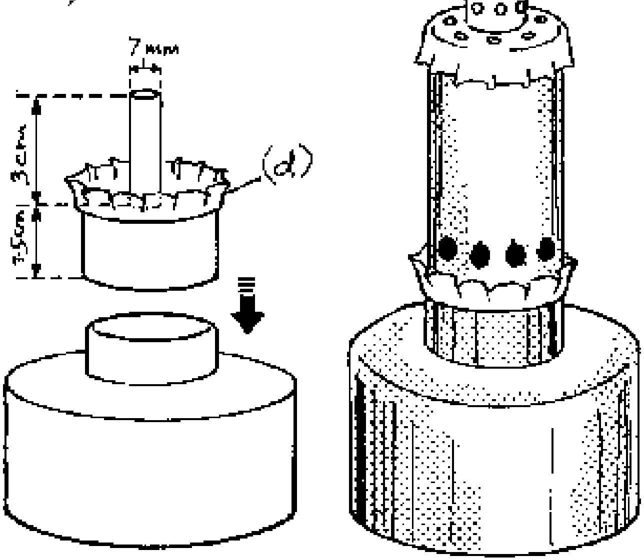
Q: What do you see when the wheel is turned very fast and when it is turned slowly?

O: When the wheel is turned very fast, the bulb gives a bright light, and when it is turned slowly, the bulb gives a dim light.

E: Inside a dynamo there is a magnet and a coil, see figure (b). When the wheel is turned, it makes the magnet rotate. The rotation of the magnet near the coil produces a current in the coil. The amount of current produced increases with the speed of rotation of the magnet.

A: Electric Generators.

perforated tube. With this burner temperatures of about 650°C can be achieved.



Test Tubes and Flasks

A cheap substitute for expensive test tubes and reaction flasks are opened worn out electric bulbs. They resist the temperature of an alcohol or kerosene burner, but *not* the temperature of a bunsen burner. Heat the bulbs carefully and do *not* use them for aggressive substances like *concentrated* acids and hydroxides.

Bulbs can be opened with pliers and a round file or even with a pointed long nail. Wrap your hand with a piece of cloth. Never hold the bulb to be opened at its glass, hold it only at its socket, see figure (a).

This is the list of materials needed for a workshop on "Teaching Physics to Beginners with Locally Available Materials."

It is assumed that the organisers will bring the materials which are needed for each kit and the tools listed below. These, therefore, are not mentioned especially under the numbered experiments below. Common materials like water, etc. are not mentioned.

The materials listed allow to produce the *Physics kit* with which the experiments described in this book can be performed. Each participant of a workshop should produce his/her own kit according to the experiments he/she selects.

Materials (needed for each kit)

Matches
Wooden rulers
Opened (transparent) bulbs (and if possible some test tubes)
Some vibatari (kerosene lamps; if possible with chimneys for a sootless flame).
Cement bag or similar paper
Nails of different diameters
Thumb pins
Office pins
Paper clips
Small and medium size tins for heating
Some transparent bottles with smooth surface
Some transparent glass jars
2–3 candles
Glue

Tools etc. (needed only once)

the lid can be used as the science tray, see Chemistry Source Book.

In addition to the materials listed above you need the following materials according to the experiments you choose:

2.1.1 Rubber band, thin wire, small plastic bags (groundnuts)
2.1.2 Bicycle, meter band
2.1.3 Thread, nut or small stone
2.1.4 Watch, meter band (better 10 m thread)
2.1.5 Thread, wooden ruler, small plastic bags, thin wire
2.1.6 Clothes–peg, wire (2 mm), thread
2.1.7 Plastic bags (groundnuts)
2.1.8 Small plastic bags (groundnuts)
2.1.9 –
2.1.10 Wooden stick, kerosene
2.1.11 –
2.1.12 5 m string
2.1.13 –
2.1.14 –
2.1.15 Sewing needle (or a piece of bicycle spoke), insulated wire, 1.5 V dry cell
3.1.1 Matchbox, smooth table or plank, some bricks, a small stone
3.1.2 The same as 3.1.1
3.2.1 A stone, a rubber band, a ball of mud
3.2.2 Card board or wooden lath, rubber band
3.2.3 –
3.2.4 –
3.2.5 Newton balance, see p. 15

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
3.7.7 Bottle, plastic bag, string, straw
3.7.8 A piece of transparent plastic tubing, string
3.7.9 Plastic or rubber tube
3.7.10 One way syringe from a hospital
3.7.11 Bicycle pump, large paper
3.7.12 Large paper
3.7.13 Large paper
3.7.14 Large paper
3.8.1 Stone, thread, Newton balance, measuring cylinder
3.8.2 Matchbox, small stone, Newton balance, overflow can (see p.25), measuring cylinder
3.8.3 Bottle, small piece of styrofoam
3.8.4 Drinking straw, a piece from a plastic bag, thread, bottle or test tube
3.8.5 Salt, egg
3.8.6 Candle
3.9.1 Wooden block, Newton balance, thread
3.9.2 Like 3.9.1
3.9.3 Rubber band, stone, branched stick
3.9.4 Stopper, used bulb, paper, burner
3.9.5 Stone, string
3.9.6 3 clothes–pegs, thread, matches
3.9.7 Funny jumper (see p.21)
3.9.8 String (to measure height), stone, watch
3.10.1 Heavy stone, tipped stone
3.10.2 Wooden block and bar, some weights (see p. 10), string
3.10.3 Wooden lath, wire (diameter 2 mm), 1 cork, card, string
3.10.4 Two pulleys (see 3.10.3), string, Newton balance
3.10.5 Two broomsticks, rope of about 5 m length
3.10.6 Table or plank, some bricks, toy car, string, Newton balance
3.11.1 Wire (2 mm), thin wire, 1 seed, 1 small fruit, 1 bulb (1 torch bulb, battery, connecting wires), 1 bottle

5.1.3 Large sheet of paper, ruler, writing facilities
5.1.4 Some oil
5.1.5 –
5.1.6 –
5.2.1 2 Wooden blocks, 30 cm wire (about 2 mm diameter), pin needle
5.2.2 –
5.2.3 2 razor blades, 1 clothes–peg
5.2.4 Thin copper wire (from used motor coil)
5.2.5 –
5.2.6 Aluminium paper from cigarette packages
5.2.7 The same as 5.1.2
5.2.8 –
5.2.9 Soda or beer bottle
5.2.10 The same as 5.2.9, plus tin for a water bath
5.3.1 Some ice
5.3.2 –
5.3.3 Some spirit or petrol
5.3.4 –
5.3.5 –
5.3.6 –
5.3.7 Piece of ice
5.3.8 Some salt, piece of ice, plastic dish (or plate)
5.3.9 –
5.3.10 –
5.4.1 A ball (from children)
5.4.2 –
5.4.3 Wire, plastic rod, wooden rod (all of similar size)
5.4.4 30 cm wire (2 mm diameter)
5.4.5 –
5.4.6 Saw dust
5.4.7 –

7.1.1 Wooden blocks as stands, cardboard, candle
7.1.2 Manila sheet, string
7.1.3 Candle, pinhole camera (see 7.1.2)
7.1.4 Pencil, candle, white paper
7.1.5 2 candles, otherwise like 7.1.4
7.1.6 Glass bottle, damp paper etc., (torch), some cards
7.1.7 Comb, white paper, piece of cardboard
7.1.8 Torch, piece of card, piece of white card or paper as screen, pencil
7.2.1 2 plane mirrors, candle
7.2.2 Spherical spoon or concave mirror, white card, candle, sheet of white paper
7.2.3 Like 7.2.2 plus candle, sheet of white paper
7.2.4 Spherical spoon or convex mirror, candle, white paper, needle
7.2.5 Transparent glass–pane, candle, bottle
7.2.6 2 mirrors, rectangular box
7.2.7 Paper, plane mirror
7.3.1 Coin, lid of a jam jar
7.3.2 Transparent bottle, coin
7.3.3 Glass or jam jar, pencil
7.3.4 Pin or needle, cork, glass or jam jar
7.3.5 –
7.3.6 –
7.4.1 Convex lens or opened bulb (see p. 110), paper
7.4.2 Concave lens or soda bottle bottom or wire loop of 8–10 mm diameter
7.4.3 Manila sheet, opened bulb (see p. 110) or convex lens, parchment paper
7.4.4 Simple box camera (see 7.4.3), window or candle
7.4.5 –
7.4.6 Thin wire or opened bulb (see p. 110)
7.4.7 Wooden box, metal strip, plane mirror, thin wire loop of 3 mm diameter
7.4.8 Box camera (see p.90), plane mirror, parchment paper
7.4.9 Large sheet of paper
7.4.10 Box camera (see p.90), convex lens

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
8.3.10 3 radio cells, switch, 1–2 mm copper wire, insulated wire, needle, thread
8.3.11 3 radio cells, switch (see 8.3.2), insulated wire, thin insulated wire (e.g. from a motor coil)
8.3.12 4 radio cells, switch, insulated wire, 2 magnets or U–magnet, wooden stand for the magnets
8.3.13 Worn out radio cell
8.3.14 Bicycle with dynamo and headlight

Questionnaire

Questionnaire About "Sourcebook for Teaching Physics to Beginners with Locally Available Materials"

(Please tick the relevant answers)

Teacher ☐ O'Level student ☐

Other occupation ....

Male ☐ Female ☐ Domicile village ☐ Town ☐

Country ....

I have used the Sourcebook	for private studies ☐
	in my occupation ☐

laboratory equipment for Physics with locally available materials.

• Students can even make their own Physics Kit and use it as a home lab to promote their talents in Physics.

• promotes creativity and shows that creative Physics lessons can take place in any scientific development.

• tries to make teachers and students aware of the resources available in heir environment which may be used for the teaching and learning of Physics and other science subjects.

ISBN 9987 552 11 0
Low priced edition

Mzumbe Book Project
P.O. Box 19 MZUMBE, MOROGORO – TANZANIA

Sponsored by:
Canadian Organization for Development through Education

A CIP catalogue record for this book is available from the British Library

Published by

CODE Europe
The Jam Factory
27 Park End Street
Oxford OX1 1HU
UK

Registered Charity No: 1021346

Illustrations: Vincent Randriantsoa
English Translation: Lynne Jagau
Design & Production Consultant: Adrian Bullock

Typeset, printed and bound in Great Britain by Alden Press, Oxford.

Acknowledgements

I would like to thank everybody who helped me devise and write this guide, and produce the layout.

First of all I must thank Ramiandrasoa Rajhonson, who has helped me throughout, and provided many ideas which have helped to enrich this book in several ways.

My heartfelt thanks go equally to all my colleagues in the German–Malagasy Tef'Boky Project, the authors of the Malagasy reading and writing books *Garabola* and *Tongavola,* quoted time and time again in this guide, in particular Narison Andriamialijaona, Randimby Rafaralahy, Lucie Aimée Raharinorombola and Jules

Claude Rabenoro, Editions Tsipika, Antananarivo

Roland Ramahatra, member of the Economic and Social Recovery Committee, Antananarivo

Aristide Velompanahy, former Minister of Education and member of the High Authority of State in Antananarivo and

Carol Warlop, Swiss Cooperation, Antananarivo.

Many, many more people have given me their support and assistance in one form or another; my warmest thanks go to all of them.

Marie Châtry–Komarek
Antananarivo, April 1993

Introduction

Producing textbooks has proved to be the best way to boost the effectiveness of education at primary level in many developing countries.[1]

Yet, the book situation has deteriorated steadily over the last fifteen years, to the point where today many pupils have no books at all. A recent study covering eight African countries[2] points to the situation in rural schools being the most serious: frequently only one or two copies of a book are available per class. The shortage of textbooks has become so severe that it is currently seen as the major obstacle to progress in primary education in sub–Saharan Africa[3].

Naturally great efforts have been made to remedy the situation. Numerous governments have tried to obtain technical or financial assistance to enable them to provide their pupils with enough textbooks of a suitable 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 appear hesitant to decide between the two main priorities that face them: providing a short–term response to the urgent demand for textbooks by investing in existing human resources, primarily authors, or responding in the medium or long term by establishing a full publishing chain along the lines of the model which has proved its worth in industrialised countries, but which would often mean creating entirely new structures in developing countries.

The nature of available literature on textbooks in developing countries also reveals the complexity of the subject. We find analyses of the status quo, which are always instructive and unanimous in their conclusion that there is an urgent and massive demand for books, particularly in sub–Saharan Africa. We also find interesting proposals as to how to remedy the situation, but these tend to intimidate the reader with their inflated expectations. The people who actually work in the field are conspicuously silent in contrast, despite the wealth of experience they must have in the production of textbooks[6]: there is little material which describes innovative experiences vis à vis textbooks, and even less on the process of designing these books.

This is a regrettable state of affairs. Firstly, teams of authors are too often forced to gain the same experience time after time, repeating the errors of those that have gone before them – reinventing the wheel as it were; analyses alone, however important they may be in order to remedy the textbook problem in developing countries, are not enough. It is imperative that they be supplemented by data collected on the spot, in practical textbook development work.

This publication is first and foremost a testimony which we hope will go some way to help fill the gap. It reflects our experience gained in the course of more than fifteen years working in GTZ[7] education projects devoted to developing textbooks for primary schools. It lifts the curtain on two textbook workshops, the German–Peruvian Bilingual Education Project[8], whose overall goal was to design didactic materials for all subjects and all classes at primary level for native Quechua and Aymara speakers (1977–1990) and the German–Malagasy Tef'Boky Project, which trained authors and devised textbooks in the national language for primary schools (1986–1994).

to analyse the various aspects of books, without aiming to follow every detail of the work of the authors[9].

The topics tackled in the following chapters are numerous and sometimes complex. They should be relevant for the production of textbooks for primary level regardless of the subject or language in question, but authors of materials designed to teach reading and writing – particularly those working in a national language – will find information which specifically addresses them.

We would like to emphasise that, in spite of the number of points tackled, this work cannot be considered exhaustive, firstly because it is based on specific experience, which automatically makes it subjective and incomplete, secondly because it looks primarily at authors in developing countries and attempts to meet their particular needs[10], and finally because the development of a textbook involves numerous different disciplines which cannot be dealt with extensively within the scope of any one publication. This work cannot thus be anything other than incomplete, and certain aspects have even been voluntarily omitted: we do not go into any details which refer too specifically to any one discipline, such as textbooks for a second language or foreign language, nor do we look at things which cannot under any circumstances be the duty of the authors, or those which cannot be considered a priority in the current crisis facing numerous developing countries. The voluntary omissions include

- 4–colour printing
- Planning and managing projects for the mass production of textbooks
- Distribution strategies
- Teacher training to enable teachers to put a new textbook to the best possible use.

It will probably not always be easy to read this guide. Some authors will be somewhat discouraged by the scope and complexity of the work described, others will begin to worry about the feasibility of the undertaking, while still others will be irritated by the inevitable gaps. We would like to encourage those feeling discouraged, doubtful or dissatisfied, and point out that this guide was written, edited and published in a developing country, using precisely the inputs generally at the disposal of textbook projects in developing countries[11]. It can thus be considered a real life demonstration that the work described between these covers is indeed feasible. In terms of the outer appearance, this book cannot claim to compete with the remarkable publications on the decided to concentrate on *Garabola,* the first book to be produced in this series, which we will present in more detail below.

• Notes at the end of the chapter

• Some suggestions for further reading which can be followed up by anyone interested in going into the subject in more depth

• A systematic resume of the ground covered in the chapter.

Text Markers

Apart from the first two chapters, you should read every chapter bearing in mind the order in which work should be performed; a number of text markers will help you find your place, i.e.

• The chapter title at the top of each left–hand page serves as a rough guideline.

• A running head at the top of each right–hand page gives you your bearings more exactly.

• A telegram–style summary of the most important points can be found in bold at various points in the text.

• An index at the back of the book allows you to look up individual points, check information or rapidly find precisely the information you need.

How to Get the Most out of this Book

This guide can be said to pursue a two–fold goal: the first two chapters aim to give textbook authors the basic information they need to start work, i.e. to train them all be it in a very rudimentary fashion; the second part is

For reasons of clarity, we will outline the main features of the pilot version and the revised version below.

Garabola, pilot version

Published in 1988

Authors:

- Narison Andriamialijaona
- Randimby Rafaralahy
- Stefanoela Rakotodrainy
- Jules Ranaivoarisoa

The set

- 3,000 copies of 1 reading book, printed in two colours, 80 pages, 240 x 170 mm, saddle stitched with two staples

- 3,000 copies of 1 writing book, printed in black, 240 x 170 mm, saddle stitched with two staples

- 100 copies of the teachers' guide, photocopied, 196 pages, 297 x 210 mm, spiral binding.

The reading book contains

- Three lessons on the vowels, **o**, **i** and **a** classes scheduled for the year

• One glossary of the principal technical terms used in the guide.

Garabola, revised version

Published in 1991

Authors:

• Narison Andriamialijaona
• Marie Châtry–Komarek
• Randimby Rafaralahy
• Jules Ranaivoarisoa

The set

• 450,000 copies of 1 reading and writing book, printed in black, 96 pages, 240 x 170 mm, saddle stitched with two staples

• 17,000 copies of the teachers' guide, printed, 212 pages, 297 x 210 mm, spiral binding.

As regards the essential pupils' materials, the main difference between the pilot version and the revised version of *Garabola* is that the separate writing book was dispensed with.

The final version of the book is thus intended as a tool for both reading and writing.

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.

[6] In 1985 86 languages were recorded as being used in instruction in African primary schools. Cf. UNESCO. *Les langues communautaires africaines et leur utilisation dans l'enseignement et l'alphabétisation.* Dakar, 1985. In spite of the absence of any systematic documentation of the teaching materials produced in each of these languages it is safe to assume that a not inconsiderable number have been produced over the last twenty years.

[7] Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (German Technical Cooperation).

[8] The experience gained in this project as regards the production of reading and writing books in Quechua has been presented in a Spanish publication. Cf. Châtry–Komarek M. *Libros de lectura para niños de lengua vernácula.* Eschborn: GTZ, 1987.

[9] At this point we should mention Richaudeau F. *Conception et production des manuels scolaires.* Paris: UNESCO, 1979 which we will refer to at several points in the course of this guide.

Although his method is not the same as ours, we would recommend this publication to all teams of authors of school materials in developing countries as one of the best works of reference currently available.

[10] It would be unthinkable in a book aimed at a European or North American audience not to dedicate a significant amount of space to colour printing, but we consider this too expensive for most developing countries, and thus of only secondary interest.

[11] We refer to the first French version published in Madagascar in 1993.

1. A Textbook is Born

We term the collection of operations leading from the idea to the production and distribution of a book – in the case in hand from the textbook publication project to the pupil – the “publishing chain”.

While it is true to a degree that the steps in the publishing chain are always identical (every book is planned, designed, produced and distributed in that order), as we will see below the procedure adopted does vary, and the differences are important.

The Chain at Commercial Publishers

In industrialised countries, textbooks are generally produced by private publishing houses, which are guided by the profit motive; the various steps making up this commercial production style are systematically organised. Since it is important for you to have a thorough understanding of the work involved, we will firstly explain this work, then illustrate it and finally summarise what you have learned.

Preliminary Research

A market analysis is always conducted before work starts on a textbook. The publisher only decides to produce a book once he is certain that there is a demand for the product, i.e. once he has identified a shortage of textbooks in schools for a particular subject or when changes to a curriculum mean that new books will be required.

The Concept

Having decided to go ahead and produce a textbook, the publisher moves on to the conceptual phase. He firstly defines his pedagogical, technical and financial criteria, and then decides on the sequence in which the content matter will be presented and on the physical and design features of the book (including the format, 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.

The sheets must then be put into the final form, which involves five steps: firstly they are folded in line with the number of pages printed per sheet and the type of folding planned, then they are put together to form the inside of the book; the book is then stitched, stapled or stuck together. All that then remains is to add the cover and trim the three open sides to give a neat finish – a new textbook is born.

Storage and Marketing

The textbook is stored at a distribution centre. A promotion campaign is run to present it to those responsible for purchasing textbooks, primarily school teachers and head teachers. A distribution network then ensures that the textbook can be supplied to book shops or directly to the schools.

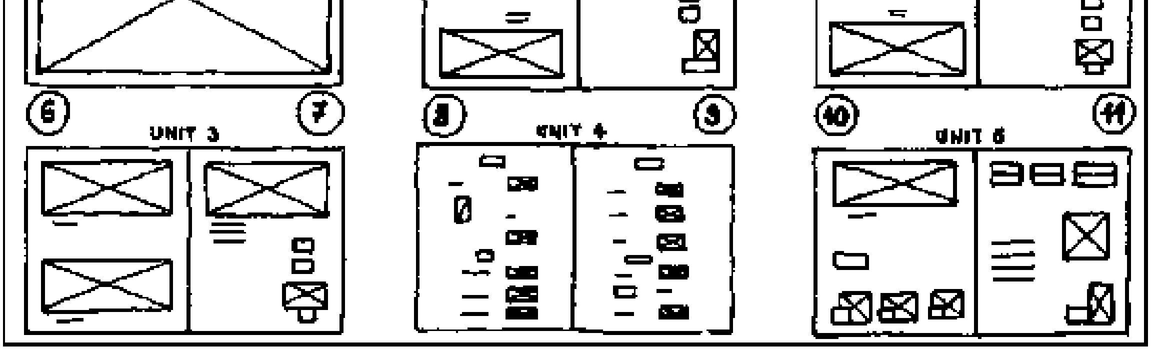
Follow–Up

> **In the field, the publishing house monitors the performance of "its" book, with a view to possible reprints**

The use of the textbook is more or less strictly monitored; the publisher thus gathers data which would be important for any reprints.

If you do not yet have much experience in this field, this initial description of the production process has probably confused you a little. You probably did not realise that so much went into producing a textbook.

The technical terms, specially those from the world of printing, are bound to be new to you, and you will have no clear idea about what certain operations really involve. But we have refrained from going into detail about the individual technical operations, and we have not even mentioned every essential step in the production of a textbook.



2. The Concept: Once the contents and the form of the textbook have been defined a design can be drawn up. Thereafter the approximate visual arrangement of the texts and illustrations can be undertaken, double page by double page; this draft is known as the layout plan. The illustration below shows the first few pages of Garabola at this stage.

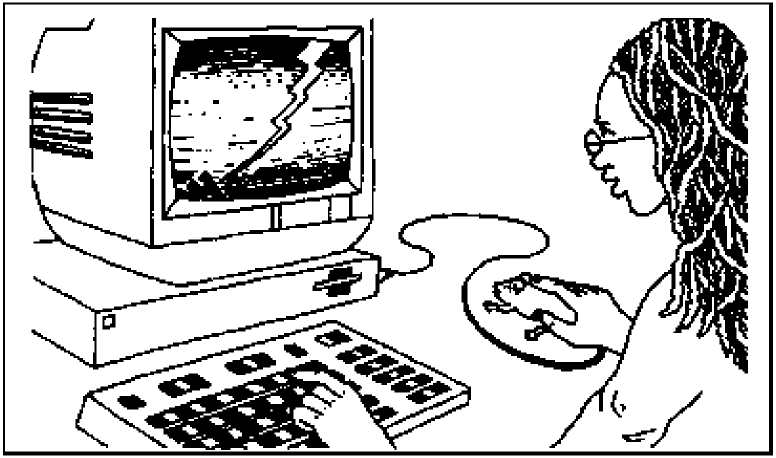
There are three reasons for this: firstly, if you are interested in discovering more about certain production techniques you will have no difficulty in satisfying your curiosity; at the end of each chapter we list a number of publications which deal with these points and illustrate them well; secondly, you should focus your attention primarily on those parts of the process which directly concern you as authors – the analysis of the subject matter, for instance – rather than getting bogged down with technical details; finally this brief presentation will be taken up again and dealt with in more detail in chronological order in later chapters, which will give you additional information and broaden the scope of this first brief introduction.

3. Producing Texts and Illustrations: The authors devise texts and exercises, while the illustrators produce the graphics, both working on the basis of the layout plan.

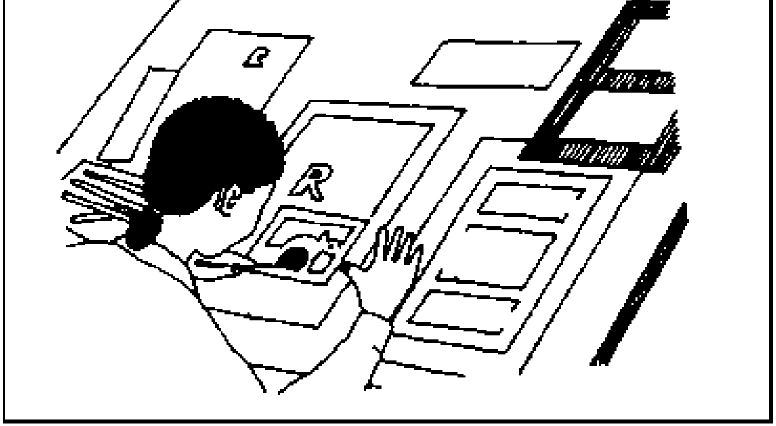
What should be grasped at this stage is the principal stages that make up the publishing chain on one hand, and the basic principles of certain tasks involved in producing a textbook on the other. To allow you to better assimilate this information, we have summarised the essential points, and illustrated some of them.

As authors you should become familiar with the various links in the publishing chain

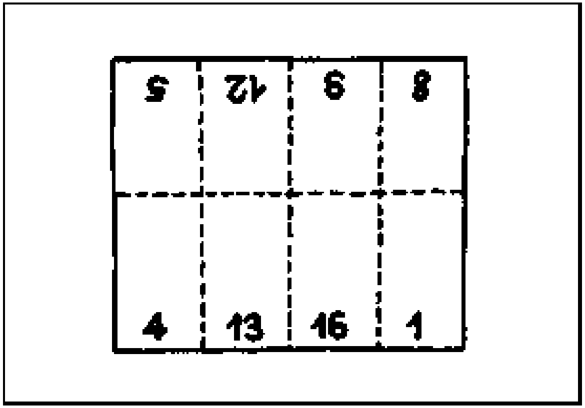
4. Preparations for Printing: You should be able to distinguish the various phases of work.



• The texts and exercises are typeset using a computer, the characters in the resultant copy are the correct



• On the basis of this, the films made for the texts and illustrations for each page are mounted.



• Finally, the imposition is checked to ensure that the pages are arranged so that they will read consecutively when the printed sheet is folded. If eight pages are to be printed together, for instance, the layout would be as shown below.

• Then the book is finished: the signatures are put together to form the inside of the book; they are sewn, stuck or stapled together, and finally the cover is added.

At first glance, the publishing chain is similar, since in both cases the preliminary research always precedes the concept, after which comes the writing, illustrating and production of the textbook. But, while industrialised countries have a long history of textbook production, as well as the resources to guarantee the quality of their work, the situation is very different in developing countries, where often even the most essential data is unavailable, as are expertise and resources. It is not unusual for there to be no official figures for the school–age population or the teacher to pupil ratio, and frequently it is not known what timetable the schools follow. This is why the production of high–quality textbooks, already an extremely complicated undertaking in industrialised countries, is all the more complex in developing countries.

1. Main Stages in the Publishing Chain and Results	
Stages	**Results**
1. Preliminary analysis	Market study
2. The concept	
Pedagogical considerations	Plan and organisation of contents
Physical considerations	Definition of format, number of pages, dummy
Graphic considerations	Decision on type of illustration and printing, layout
Financial considerations	Provisional quotation
3. Producing texts and	

existing books[1].

The publishing chain cannot be merely mechanically transferred to developing countries

The first unique feature of textbook production in developing countries: the feasibility study must look not only at the demand for textbooks, but also at the conditions under which they can be written and illustrated, manufactured and distributed

Preparations for an Education Project

Study of demand, available resources and conditions under which the books can be produced (1 year).

In industrialised countries, it is enough to identify a demand for a textbook, since the production and distribution techniques and facilities already exist. In developing countries on the other hand the production of a textbook depends on education policy, textbook policy, financial considerations, technical considerations such as the supply of paper and printing capacity, human resources, distribution and storage capacities, etc.[2] To ignore any one of these considerations may sometimes suffice to jeopardise the entire textbook project.

A period of several years may elapse before the textbook project can be launched, for, even with the support of an international or bilateral organisation, projects of this nature generally involve recruiting staff, finding premises and procuring the necessary materials.

Preliminary Research

Analysis of the context within which the textbook is to be used (6 months–1 year).

Let us once again compare the situation in industrialised and developing countries. In the former case the publisher is already fairly familiar with the target group, since he usually specialises in one subject and one

Revision of the pilot textbook, official check, printing the revised version (1–2 years).

The results of the evaluation phase allow us to revise the book before printing a large run. The length of this phase can vary; it depends first and foremost on the scope of changes felt to be necessary and the willingness of the authors to modify a product with which they still identify closely; it will also depend on the authority and provisions of the official body responsible for approving the final version, and on the various factors involved in printing a large run of textbooks (size of the run, terms of financing, country where the books are to be printed, etc.).

Nationwide Introduction

Devising and realising a distribution strategy for all schools concerned, in–service training and monitoring for teachers (2–4 years)

Let us once again compare the situation in industrialised countries with that in developing countries; in the former the new textbook is brought to the pupils without any major difficulty via book shops or schools, whereas in developing countries it is difficult to reach rural schools and rare to find an effective distribution network. Also, in industrialised countries teachers are in a position to use the new book without additional training, while in developing countries the new textbook must be systematically presented to ensure that it is put to the best possible use.

In developing countries the universal introduction phase thus demands skills, huge technical and financial resources and a great deal of time. However many schools must be served, and however many teachers must be trained, these two activities are always large–scale projects in their own right.

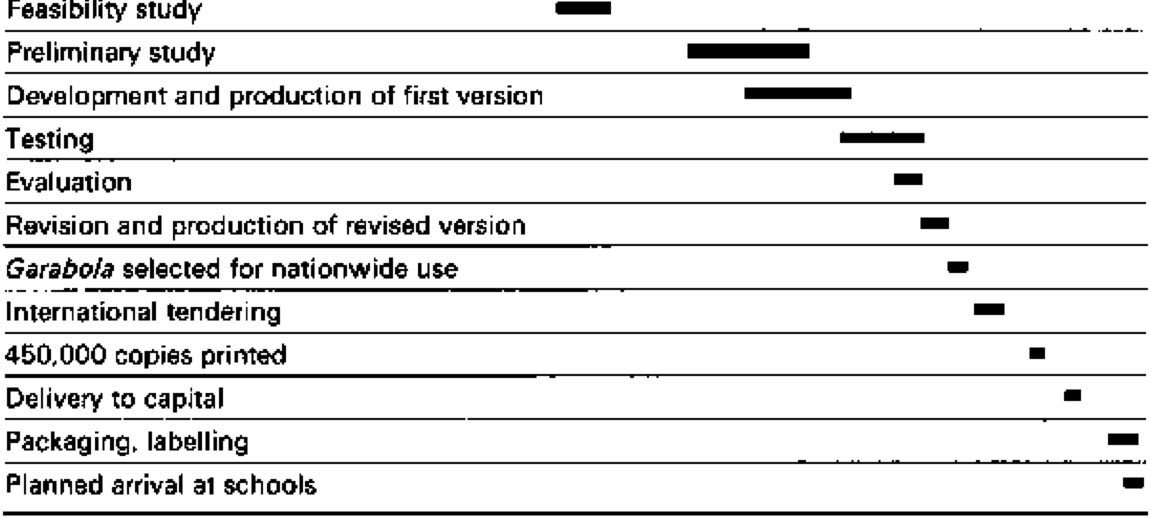
To sum up, then, the following tasks are needed in addition to the links of the commercial publishing chain to ensure that the textbooks produced in developing countries are suitably adapted to local needs:

- Preliminary feasibility study
- Field studies of the teaching and learning conditions

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 in Malagasy.

1. Feasibility Study	
	In 1984 a study committee noted a general shortage of textbooks in Malagasy for primary school pupils. The committee recommended that authors be trained to fill this gap.
2. Preliminary Research	
	In 1986 the Tef'Boky Project was launched; in October, the authors responsible for Malagasy started work. They prepared and undertook preliminary research in the field, and at the end of 1987 presented the results in a document which served both as the principal frame of reference for the materials to be developed and as a report for the education authorities.
3. Producing a Version for Testing	
	In 1988 this working group devised and develop a set of learning materials for reading and writing Malagasy. 3,000 copies of *Garabola* were printed ready for the start of the academic year 1988–89.
4. Testing and Evaluation	
	The didactic material was tested for one academic year at forty schools and the level of attainment tested at the end of the year; the results were presented officially to the ministry.
5. Producing the Revised Version	
	In 1990, the material was revised on the basis of the results of the evaluation phase and was selected for nationwide use: thanks to a World Bank loan 450,000 copies of the new textbook and 17,000 copies of the teachers' guide were printed; slates introduced to replace exercise books were also financed.

17



Textbook projects should always incorporate author training

Producing a Series of Textbooks

As you have just read, the process of providing a large number of systematically produced textbooks can be long and difficult, but it is possible with the requisite technical and financial back–up.

Nevertheless you will also have noted that, even given a favourable framework, i.e. once the technical and financial problems have been solved, the production of a first textbook takes years – no less than ten in fact[5]! How can we possibly produce two books then within a reasonable time–scale and without any drop in quality? And an entire series?

2. Those Responsible

The duties described and illustrated above should have given you a basic understanding of how textbooks are produced.

This information is undoubtedly of capital importance to you, but it is still far from being adequate to allow you to start work, far less to plan your work. Indeed until you are aware of the many actors involved in the chain and their respective tasks, you will find it difficult to define your own. You should also note in this context that it is just as important for a new author to acquire an understanding of the technical side of production as to analyse and fully understand the production system within which he finds himself.

Bearing this in mind, we now propose to look at the duties of the various units and entities which are involved in producing textbooks.

Once again, we will firstly turn our attention to the system generally adopted in industrialised countries, to allow us to better gauge the special features of those used in developing countries.

> **As authors you can only define your own task once you are familiar with those of all the other actors involved in the publishing chain**
>
> **In the commercial publishing chain we find three entities each with its own well–defined role**

Private Contractors in Industrialised Countries

In spite of certain differences it is true to say that there is only one real textbook production system in industrialised countries.

Ministry	
	Defines national education policy
	Develops or adapts curricula
	Officially approves textbooks[8]
	Evaluates levels of attainment
Publishing House	
	Decides whether or not to publish a textbook
	Defines the pedagogical considerations
	Identifies the physical and graphical form of the book
	Has a quotation drawn up
	Selects and contracts authors
	Selects and contracts illustrators/photographers
	Supervises and controls editorial work
	Organises the reviewing of texts
	Supervises and controls illustration work
	Designs the layout
	Performs / checks the typesetting
	Ensures that galley proofs are proofread

	Prints, finishes and delivers the textbook to the publisher as instructed

In either case it is the private publishing house that is really in charge of the production of textbooks: as you will see from the Table 5, it decides whether or not to produce a book and has complete control over production, monitoring and management. It monitors the textbook right up to the reception it is given by pupils and observes the use of the book to make any preparations for reprinting as early as possible.

Production Systems in Developing Countries

In developing countries we find several production systems which differ to a greater or lesser degree from the model described above. The most commonly found types are described below.

National Commercial Production

This system has many similarities with that found in industrialised countries: the ministry stipulates the content matter and may define textbook requirements; then private publishers publish and market these. There is generally no preliminary testing, neither are the textbooks presented to teachers. Thus, as in industrialised countries, it is the market which decides when several different textbooks are available for the same target group.

This system can be found in varying degrees in countries which have managed to establish private publishing capacities, such as Kenya and Nigeria.

State-Run Production

The ministry is in sole charge of textbook production, defining the subject matter to be covered by the education system, identifying textbook requirements and meeting these requirements. Often the ministry entrusts the writing and publishing work to civil servants, while the production and distribution is delegated to parastatals.

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 the respective tasks of the entities involved in textbook production, and thus to define their own role.

3. Publishing Specialists

Let us sum up what we have learned so far: we have analysed the technical steps involved in producing textbooks and the various production systems currently in use. Nevertheless, before they can identify their own role, authors must be familiar with the actors involved in the publishing chain. They must know who is responsible and who performs which work, who plans, directs and controls each stage and who performs the hands–on work.

So, let us then look at the role of publishing specialists, again making a distinction between common practice in large commercial publishing houses and in developing countries.

> **A very few developing countries use the private sector to meet their national needs. Most of them rely on state or parastatal structures, or call on foreign assistance**
>
> **The quality of textbooks in industrialised countries is first and foremost a reflection of the way publishing houses are organised**

Organisation of a Commercial Publishing House

As you have seen it is the publisher who directs the writing and production of textbooks in industrialised countries. To meet his many–fold responsibilities, he needs managers who are responsible for various aspects of the process and technicians to perform the work required. Let us look in more detail at these two groups and their respective duties.

	Defines physical features of the textbook
	Estimates the production costs
	Plans and monitors production
	Obtains quotations from production companies
	Monitors typesetting and photoengraving work
	Monitors printing and finishing work
Commercial Manager	
	Performs market analysis
	Calculates approximate price of finished book
	Runs promotion campaigns
	Organises storage, distribution, marketing

Book Technicians

When a publisher first decides to publish a book it is not only these four people who swing into action; to perform the necessary work, they mobilise a veritable army of specialists, both within and outside the publishing house.

One does not always find the same technicians in every publishing house of course, but in general it is fair to say that the four managers whose tasks we have just described delegate some of their work to specialists; the form this collaboration takes is illustrated in Table 7.

7. Main Duties of Technicians within a Publishing House

Working with the Commercial Manager		
	Promotion Manager	Designs and realises the promotion and marketing campaign for the textbook
	Sales Manager	Ensures that the textbook is available to readers
	Distribution Manager	Ships textbooks to points of sale

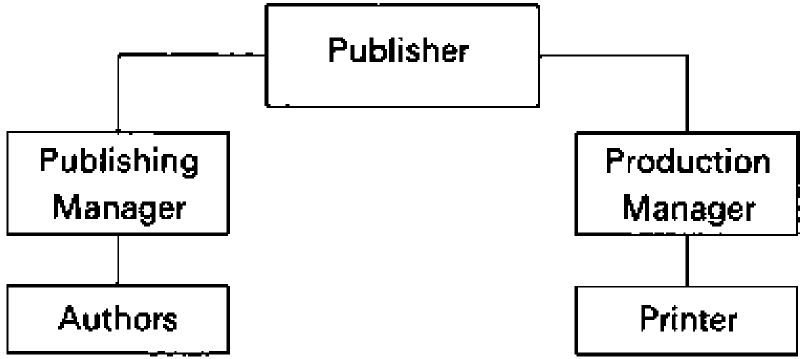
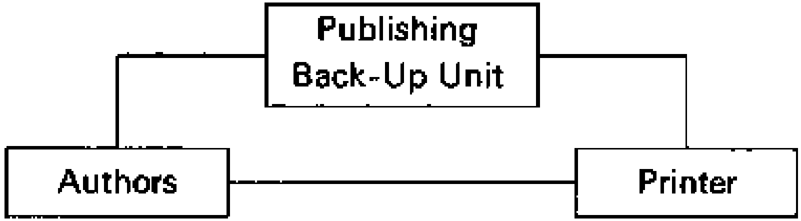
Publishing Specialists in Developing Countries

Let us now look at the situation in developing countries. The first difference is in the number of actors involved; generally textbook production teams are very much smaller in developing countries. Yet, if we leave aside the few countries with well developed private–sector publishing capacities, the main difference between the two systems is the absence of the publisher or the failure to appreciate the importance of his role, and the inevitable redistribution of the duties that would otherwise be assumed by the publisher among the other actors involved, in particular the authors and the printer: the former often do a great deal more than devising the concept and writing textbooks and the latter, whose role should be limited to the actual printing, is frequently forced to take on some of the publisher's duties too.

In some countries, it is fair to say that there is no national publishing capacity, in either the state or the private sector. In others private publishers address only that part of the population that constitutes a potentially interesting market, even if this is a tiny minority of the population: this was true in Peru, for instance, where, at the start of the 1980s private publishing houses were geared only to Spanish–language publications, and were not interested in local languages. In still other countries the role of the publisher is not understood or is not known: often the ministry is not properly informed about the role of the publisher, while authors do not readily accept him, seeing him as one more irritating control between them and the printer, which only swings into action once the manuscript is finished.

The lack of understanding of the publishing chain, the wariness of the authors vis à vis the publishing unit, the lack of technical know–how of insufficiently trained publishing managers and the difficulties of coordinating the work of different departments can thus lead to an astonishing redistribution of responsibility: as we will see,

8. Main Duties of Principal Actors in the Publishing Chain

In industrialised countries textbook authors are at hands–on level. Their duties are limited and well defined; they have no contact with the printer.	
Where there is a publishing unit its duties are sometimes ill defined or little understood; in this set up the publisher, authors and printer may be in contact with one another without any clear definition of their respective duties.	
In some developing countries which have no publishing capacity, the authors must assume some publishing responsibility and as such have direct contact to the printer, with whom they share responsibility for publishing.	

In developing countries the traditional roles of the publisher, the authors and the printer are re–allocated

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 grasp of the stages involved in producing a textbook – and this is the *sine qua non* for you to commence and indeed one day finish your work.

The tasks of textbook authors in developing countries are not always identical in every country. In some cases you will be working within a structure which allows you to concentrate on writing a manuscript on the basis of a pre–defined concept; in others you will have to perform certain publishing work in addition to this, perhaps even all the publishing work. In other words your tasks will always be defined in terms of the publishing support at hand: the less efficient the publishing unit, the more you will have to do, to the point that in some cases you could justifiably be termed “publisher–authors”[10].

Let us take stock at this point. Try to call to mind the various stages involved in the production of a textbook, and the entities and specialists needed to perform the relevant work. Then identify the support that you can expect in your work. In this way you can define what the officials implicitly expect of you most of the time, gauge the scope and complexity of the work, accept it and, in the ideal situation, optimise it.

Supervision and Training

But how, you will ask, can we as authors or future authors of textbooks measure up to responsibilities of this magnitude? How can we become the “publisher–authors” that the country needs, when we are at best “apprentice authors”? If, as is generally the case, you are former teachers, pedagogical advisers or even school inspectors you will only be able to meet your commitments if you have technical supervision, or if you have had pertinent training.

We feel that several years of on–the–job experience, plus technical supervision, perhaps in conjunction with internships together make for the best training.

This was, in any case, our experience during the first few years of the Tef'Boky Project. To mitigate the shortages of textbooks the authors in the project learned their craft on the job, producing textbooks with the assistance of specialists; they were then able to systematise their knowledge with the help of short training

Notes

[1] See Seguin R. *L'élaboration des manuels scolaires,* p. 15–19. Paris: UNESCO, 1989 for information on the translation and adaptation of textbooks. It should be noted that textbooks for the primary level can rarely be translated, especially reading books in the national language; the rest of this guide should explain why.

[2] Cf. Read A. *A guide to textbook project design and preparation.* Washington D.C.: World Bank, 1986 for information on the preparation of textbook projects.

[3] “Tetik'asa famolavolana boky malagasy ho an'ny sekoly” (Tef'Boky) can be roughly translated as the “Malagasy Textbook Workshop”.

[4] The Unité d'Etude et de Recherche Pédagogique (UERP) (Pedagogical Research and Study Unit) within the Ministry of Education.

[5] “A minimum of six years is required to write a manuscript, print, publish and distribute the finished book, and it is reasonable to plan an overall period of some ten years, given the time required for preliminary studies, planning, recruitment and, in many cases, training”. In: Seguin R., op. cit. p. 6.

[6] The date of printing a large run of *Tongavola* is not indicated; it was delayed for several years again for reasons which are neither technical – the final version has been ready to print since 1991 – nor financial – the funds required have been pledged – in nature. This situation is unfortunately by no means exceptional. Even when technical and financial preconditions are met, there is no guarantee that the work will be published, far less than this will happen within the planned time–scale.

[7] We should specify that the Ministry of Education is not always responsible for the tasks described hereafter; in very decentralised systems, these may be delegated to a body at regional level, or to research institutes. To simplify the issue though, we will not take these cases into account here.

[8] The situation varies from one country to another. In Germany, for instance, publishers complain that they have to submit their textbooks to the relevant ministry for approval at regular intervals, in some cases every

GROUPE DE LA CITE INTERNATIONAL *Le livre. Sa conception, sa réalisation. Documentation.* Paris, undated

HUOT, H. *Dans la jungle des manuels scolaires.* Paris: Seuil, 1989

LAPOINTE, C. *Le livre du livre.* Paris: Gallimard, 1987

Textbook Production in Developing Countries

ALTBACH, P.G. et al *Textbooks in the Third World. Policy, content and context.* New York: Garland, 1988

BUCHAN, A., DENNING, C. AND READ, T. *Etudes sur le secteur du livre en Afrique.* Washington D.C.: World Bank, 1991

CHATRY–KOMAREK, M. *Libros de lectura para niños de lengua vernácula. A partir de una experiencia en el Altiplano peruano.* Eschborn: GTZ Schriftenreihe No. 193, 1987

FARRELL, J.P. AND HEYNEMAN, S.P. (Ed.) *Textbooks in the Developing World.* Washington D.C.: World Bank, 1989

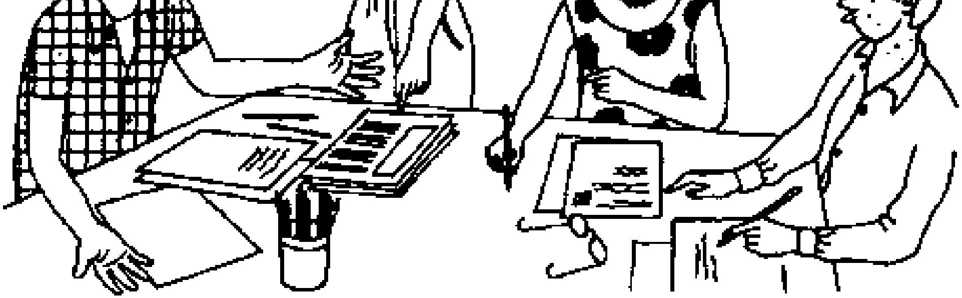
GUDSCHINSKY, S. *Manual de alfabetización para pueblos prealfabetas.* Mexico: SEP/ Setentas, 1984

RICHAUDEAU, F. *Conception et production des manuels scolaires. Guide pratique.* Paris: UNESCO, 1979

SEGUIN, R. *L'élaboration des manuels scolaires. Guide méthodologique.* Paris: UNESCO, 1989

To Sum Up

In industrialised countries textbooks constitute an important market. Private–sector publishers write, produce and market them. The laws of the market force them to act professionally; the textbooks are produced by highly–qualified specialists who stick exactly to the various steps in the publishing chain. As a result the



The Authors

Once the feasibility study has been performed, work can start on producing the textbook; the first stage involves examining the context within which the book is to be used.

This field work marks the start of the work which, in most instances, will fall to you. You thus enter the scene and can expect to be there for a long time before the curtain falls. Given the length and importance of the work awaiting you, we feel that it is crucial to look at how you can best prepare yourself intellectually and in terms of materials, before going on to describe this work.

Please note that we will not be describing in detail the infrastructure you will need to do your work properly. Some of you will find a four–wheel–drive vehicle vital to undertake your preliminary research work, and later for the testing and evaluation of your material; it will be important for all of you to have a room where you can meet and access to a computer.

But, while recognising the importance of this infrastructure, we will not dwell on it, partly because the working conditions vary enormously from one team to another and your scope to influence your own working conditions is limited, and partly because the infrastructure alone is never responsible for the quality or

• Skills in adapting didactic material to suit the profile of future users;

• The ability to write texts addressing both children and adults on a pre−defined topic within the space allocated;

• The ability to devise good exercises; exercises where the subject matter corresponds to both the attainment targets and to the demands of the layout;

• A basic understanding of the publishing chain; in particular as regards the essentials and possibilities open to various agents involved in the course of textbook production.

Indispensable Attitudes and Behaviour

Where there are recognised publishing facilities the above know−how will generally suffice to ensure that a textbook is produced: it will allow authors to prepare a manuscript of good enough quality to be published by the relevant unit, then printed and finished.

For authors without the back−up of a good publishing team, on the other hand, this know−how alone may well not be enough to allow them to meet all their commitments; if they are to take on the numerous and complex duties they will then be expected to perform, they will also have to acquire certain attitudes and behaviour, the most important of which are described below.

Know−how and attitudes are more important for an author than a highly developed infrastructure

Step One – Learn to work in a group

Ability to Work in a Group

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 knowledge you would be failing in your duties, and you would run the risk of either paralysing production or producing didactic materials that are poorly adapted to the actual environment in which they are to be used.

You should thus be prepared to look beyond your subject and become familiar with new fields, to look at a subject from several different aspects and compare these before taking an appropriate decision. You do not have to learn everything and know everything, but you should be attentive and well informed enough to react in time, and you should know who to turn to when you need assistance.

Step Two – Look beyond the narrow confines of your subject and examine the environment within which the book is to be used

Openness to Innovation

The ability and willingness to innovate will be every bit as important for you as the skills laid out above.

If you intend to produce textbooks that are in line with the demands and the resources of the country you will often have to go your own way: you will not find many valuable discussion partners in large publishing houses which have different options and face their own problems; equally it will be difficult to find contacts in developing countries, where it is rare to find individuals who have sought out new paths and devised original solutions to specific problems. Indeed, authors of textbooks in developing countries tend to base their work more or less openly on foreign models[3].

You must thus be open to new ideas: you should devise specially tailored answers to specific problems rather than looking for tried and tested recipes. You will have to fight against preconceived ideas, make your own hypotheses, and verify, check and analyse these. In fact you will have to become a researcher more than anything else. Otherwise what you produce will not be adapted to the needs of your country; it will be but a pale copy of existing materials.

2. Tools of the Trade

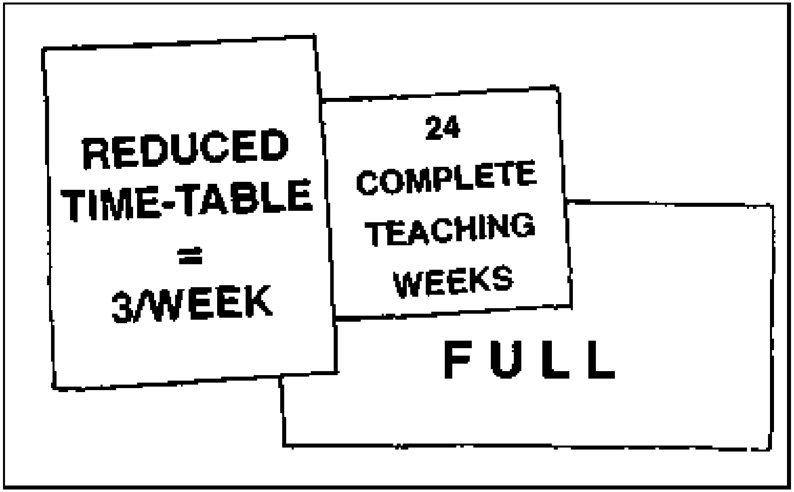
The skills and knowledge described above are not always in themselves enough to allow authors to perform their work satisfactorily.

They will rapidly realise that it is not easy to work in a group, and that it becomes more and more cumbersome to consult the accumulated mountain of notes, references, decisions, texts and exercises when they need to. Paper and pencils are not enough: they need a high–performance tool, which will allow them to optimise the inputs and participation of each team member and to manage the data properly; an instrument which both enhances group dynamics and boosts the quality of the group's work.

Having practised it ourselves for several years, we recommend that you get used to a system of visualising your contributions. This is a working method which is inexpensive and easy to understand – if not always to use in practice. In our experience, displaying your work visually from the research phase to the preparation of the printer's copy is a much better guarantee of quality than any super de luxe electronic equipment.

Here are the tools you will need and the various steps involved in the procedure explained in a few words and several illustrations.

2. Identifying the topic: The topic you wish to work on should be defined verbally by the complete group. This way you avoid having to explain to those who have just arrived what has been decided on.



3. Initial brainstorming: Now you can start the written work. Allow about ten minutes for each participant to write cards without attempting to structure his or her contributions: contributions should be printed legibly, taking one card per idea and expressing it in a telegram style using no more than a dozen words.

Notes

[1] To convince yourself of the relative importance of the infrastructure for your work, look at books produced some thirty years ago; the quality of some is quite remarkable, and they were produced without much in the way of mechanical aids, and certainly without computers.

What authors at that time managed to do with paper, pencils, scissors, a ruler and some glue, you can manage today. Do not let yourself be discouraged by a lack of materials or tools. They are important, but not essential.

[2] This does not only apply to authors in developing countries, but also to some in industrialised countries; H. Huot notes that in France, the textbooks for lower secondary schools and primary schools, "are written by authors, most of whom have no specific qualifications in the subject for which they claim to speak, who are often not even aware of the most accessible specialised works, and who are incapable of gauging the risk or possible consequences of certain presentations or explanations." In: *Dans la jungle des manuels scolaires,* op cit. p. 60–61.

[3] Cf. Le Thank Khoi: L'enseignement en Afrique et le modèle européen. In: Coquery–Vildrovitch C. and Forest A. (Ed). *Décolonisation et nouvelle dépendance.* Lille: Presses Universitaires de Lille.

[4] The vanity and desire of some authors to produce a splendid–looking book explain some wrong decisions, such as opting for extremely expensive 4–colour printing where there is no real reason for this, or the production of a pupils' book which is sometimes thought to offer greater prestige than a teachers' guide, although the latter would have served the pedagogical purpose and would have been considerably less expensive to produce.

Although these mistakes, which are easy to understand, are not fatal in a rich country, which can afford certain luxuries, they are dangerous in poorer countries, which cannot afford to make a mistake in this field, so every effort must be made to avoid them.

Recommended Reading

Preliminary Research

Your first task if you have just been made responsible for producing textbooks is to conduct preliminary research. You will not be able to throw yourself into the conceptual phase without first identifying the actual needs and possibilities of the future users.

Preliminary research work must always be rigorous and meticulous, for the results will be of capital importance for the textbook in the making. If we compare our textbook to a building, the first phase is equivalent to the foundations; the data that you collect not only on the process of teaching and learning at classroom level and on the relevant subject matter, but also on the school environment as a whole ought to give you a solid base on which to build your book. The research work will almost invariably be complex and wide−ranging, and will generally require at least one year. It is thus quite impossible to describe this work

Decision to produce textbook	
	Education authorities
	Curriculum unit
	Publishing unit
Writing and illustrating	
	Authors
	Illustrators
	Publishing unit
Production	
	Printer
Distribution	
	Distribution unit
Modalities of textbook utilisation	
	Parents
	Education authorities
Presentation to users	
	Training unit
	Authors

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 field study, select a representative area in order to analyse conditions in the country's schools, develop the materials on this basis, and be able to test it at these schools at a later date. Here is a brief summary of the work involved and an outline of how it was performed.	
Listing factors to be examined (2 months)	
	The newly formed working group had to learn how to work as a group, become familiar with an alien form of visualisation and tackle a relatively new field of research all at once.
	By way of introduction, the apprentice authors identified the factors and criteria they felt were important to determine the quality of a textbook in general; this was a sort of introduction to the field of textbook production.
	Then they listed the factors that it was imperative to analyse in the Malagasy context to ensure that the new materials were in line with the needs and possibilities of the future users.
Devising research instruments (2 months)	
	Among the factors to be analysed the team checked information already available and planned the analysis thereof.
	The team then devised and developed research instruments for missing data which would have to be gathered in the field, primarily in rural schools and villages: these mostly took the form of questionnaires and interview guides for adults (animateurs, teachers and parents), tests and guidelines for recording pupils' responses.
	These instruments were pre–tested at several schools in a peri–urban zone before being used in the field.
Identifying a test zone (1 month)	

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 materials.

It is important that you adopt a methodical approach, to guarantee that the information you compile is as complete as possible. There are two reasons for this: firstly, this is the best way to ensure that you do not have to come back to this phase later, interrupting the conceptual phase which is long and complex enough without these irritations, and secondly any omissions and oversights you make at this stage may spawn serious errors in the concept, development and production of the textbook.

The factors to be analysed will not, logically, be the same in every case. To avoid major omissions, we suggest a two−stage approach. Firstly, identify the factors which are always important, i.e. factors related to the teaching and learning conditions. Secondly look at the supplementary factors, which are pertinent for the case in hand.

Conditions in the Schools

Start by identifying the factors to be analysed

Whatever the class and the subject for which the textbook is intended, the authors must examine in detail the conditions under which the teaching and learning process takes place.

This analysis must go beyond the narrow confines of the school itself, and look at the educational environment as a whole. We would recommend that you first collect data on the political and educational framework in the country, before looking at the way education is organised, i.e. the day−to−day life of teachers and pupils. Finally you should round off this information by analysing the various target groups affected by the new materials, which will include not only the educational authorities, (primarily inspectors and educational advisers) but also the teachers, pupils and parents.

Having seen ourselves how one automatically tends to devise voluminous instruments that are not sufficiently

		Ratio of teachers–pupils	Group and individual learning activities
		No of pupils per class	Ditto
		No. of classes per teacher	Didactic pointers in the teachers' guide
	Teachers' working conditions		
		Administrative responsibilities	Adaptation of material to availability of teacher
		Didactic back–up materials	Preparing teachers to accept innovative ideas
	Pupils' working conditions		
		Location of school	Suitable format for pupil to carry to and from school
		Ratio tables–chairs to pupils	Format of material, composition of set
		No. of textbooks available	Pertinence of textbook production project
		Other teaching materials	Attitudes of parents to school
		Individual equipment	Identification of suitable writing tools
Target Groups			
	Educational advisers		
		Professional training	Level of innovation of material to be defined
		Official duties	in terms of educational advisers' ability and
		Supplementary duties	capacity to train teachers
		Means of performing work (e.g. transport)	

Textbook Projects

Ideally in an educational project, the authors will be able to rely on a complete and reliable feasibility study; where this is the case they will be able to devise material appropriate for the needs and resources of the country on the basis of an examination of pre–defined factors. But authors may be called upon to produce a textbook on the basis of a less than perfect feasibility study, or where no real study has been conducted. In these cases they must also examine the project environment to avoid the pitfall of producing inappropriate material. Often this will not involve performing or repeating an entire feasibility study, but merely checking certain factors.

Table 12 lists some of the factors and aspects which we think are relevant in most cases, along with some essential questions which should be answered. Once again do not let this list discourage you; identify the factors that are important in your own specific case and, if you feel that a really exhaustive procedure is called for, consult the literature on the preparation of textbook projects that you will find listed at the end of this chapter.

Take a methodical approach: you can use the results of research based on this table as the foundation of your textbook

Schools and National Languages

As we mentioned above[2], in 1985, 86 local languages were used as languages of instruction in sub–Saharan Africa. There are thus many textbook authors on the African continent working with a national language.

If this applies to you, it is vital that your preliminary analysis of the situation includes a linguistic component. You will have to find ways of solving the problems of using languages which are for the most part still little standardised in the classroom.

Again, the situation will vary from one case to another. Some languages, like Malagasy whose alphabet has existed in its present form for more than 150 years, have had an adequate system of transcription for many

		you be officially charged with this work?
	Capacities of the publishing unit	
		Can the publishing unit perform all the tasks expected of it? What is the quality of its services?
	Responsibilities of the group of authors	
		Which of the many activities presented in the first chapter are to be entrusted to the authors? Are any other bodies involved in producing textbooks for primary level?
	Legal aspects	
		How are royalties and copyright

	Definition of conditions of use	
		Do you plan to produce one textbook for two or three pupils, or one per pupil? Will the books be bought or borrowed? Do you intend to set up a revolving fund?
	Capacity and quality of preparations for printing	
		Does the printer have the capacity for typesetting? Photoengraving?
	Capacity and quality of printing	
		Is the printer's equipment suitable for textbook printing? Is it suitable for printing large runs while maintaining high

	National statistics	
		Does the unit in charge of distribution have reliable information on the school roll by school and region?
	Precise information on transport routes	
		Are the precise itineraries known for the points to be served?
	Organisational capacities	
		Does the unit have the ability to devise a distribution strategy? And to put it into practice?
	Technical and financial resources	
		Does it have the means of transport to ensure

		back–up resources and what budget does the teacher training unit have at its disposal?

For this work you will need qualified staff and a great deal of time; it can take up to five years to devise an alphabet[4]. That is why this work must never be part of a textbook project; it is an indispensable prerequisite for launching projects in this field.

Preliminary linguistic work

Although it is out of the question for you as authors to transcribe a language, every time you use a local language you should examine the linguistic and socio–linguistic factors that are likely to have an impact on the teaching and learning process. On the following pages you will find a list of factors which you should pay attention to during this preliminary research phase, whatever the degree of standardisation of the local language you intend to use in your textbook[5].

Once again, you should adapt our suggestions to the case in hand; try to identify the factors of vital importance which must be examined without delay and those which are neither really urgent nor so important. You should realise that at this stage of your work, it is less a question of making immediate decisions regarding writing or vocabulary than of gathering data which will allow you to make the relevant decisions at a later date, in particular during the writing phase when you will periodically come up against linguistic difficulties.

> **No research work is an island: every issue will have immediately applicable consequences for your textbook**
>
> **In the absence of a feasibility study, you must also examine the environment in which the textbook will be used**

		Does the alphabet selected for use in textbooks correspond to a scientific analysis of the language?
	Functionality of the alphabet	
		Is the method of writing selected suitable for school–level learning or is it more in line with the needs of researchers?
	Respecting variants	
		Have dialect variants been identified? Can the alphabet respond satisfactorily to their special features? What line do you intend to take in textbooks destined for nationwide use?
	Conformity to other alphabets	
		Does the alphabet used for the national language in question differ from those used for any other national languages without good reason? Does it differ from the world language used in the country?
	Spelling	
		Are there conventions for hyphenation? For contractions? For spelling loan words taken from a world language?
	Punctuation	
		Has any work been done on standardising punctuation? Do the punctuation rules differ from those used by the world language used in the country for no good reason?
Institutional Factors		
	Training teachers	

The preceding phase will have enabled you to identify those factors which will have to be examined before you start writing your material.

You are thus now in a position to plan research activities; you should start by setting the deadlines, even if it is difficult to gauge the time that will be needed for certain activities, such as selecting a representative sample, and you may be forced to adjust your schedule at a later date.

To avoid getting bogged down in poorly prepared work or work that is not in line with your needs and your possibilities, you should concentrate on compiling as exact a schedule as possible, taking the following factors into account.

If you work in a local language, analyse the linguistic environment of the textbook

Base planning on practical options rather than wishful thinking

Institutional Priorities

The first textbook will require the greatest amount of research work, but it is also the book that will be most impatiently awaited. It is thus not unheard of for the institutions concerned, the Ministry of Education, and sometimes the donor to exert pressure on the authors to accelerate the preliminary research phase and complete the long awaited textbook rapidly.

It is not uncommon for an insufficiently standardised language to become the language of instruction, and for the scope of linguistic work to be underestimated by the education authorities – who nevertheless intend to meet their political commitments at any price.

You should of course plan your activities taking into account these pressures, but we have seen time and time again that ill–considered haste never pays off: the speed at which the work was performed is quickly forgotten, and all that remains are the shortcomings of the finished book. You should then consider carefully must then contact the latter and ensure that they will be available when required.

Technical and Financial Resources

The research work always demands a minimum of technical and financial resources. You should thus evaluate the costs of the operation and not start planning until you are sure that you have the resources you need. In most cases you will need office supplies, a four–wheel–drive vehicle, enough funds to cover the costs of the mission and the fees for short–term experts.

Scope of Data to be Collected

When the schedule is drawn up for your activities, you will see the scope. One often tends to underestimate the time needed to process the data collected in the field, particularly when recordings have to be transcribed.

If you have to work in a national language which is still not commonly written, and you intend to record information, plan the recordings with a view to the follow–up work, i.e.

Transcription

Under these circumstances you had better calculate one hour to transcribe five minutes of recorded speech. If you delegate this work to individuals whose only qualification is verbal mastery of the language you must also think about approaching an experienced linguist to revise the transcriptions.

Analysis

The recordings, thus transcribed, will then be analysed in various ways. If you aim to produce a reading book you will have to pinpoint the words most frequently used by children, classify these words by length, origin (from a dialect variant, loan words, etc.), among other things. If you are unable to do this by computer, you will have to perform the work manually which will take some time.

Data Processing

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 this chapter.

But you should not forget that research in the field should never be an end in itself, it is merely a means to an end – which is the production of textbooks that are in line with the needs and resources of the country. You should thus attempt to surround yourselves with the skills which will prevent you as far as possible falling into the traps of woolliness or arbitrariness during your research, but do not lose sight of the fact that you are above all authors of textbooks. Your primary target group is the pupils who are waiting for their books, while university researchers must be relegated to second place if they appear at all on your list. Let us retain our pragmatic approach and again make the distinction between what is desirable – a piece of work which is scientifically unassailable and will require a lot of time and experienced staff – and what is possible under the given circumstances. It is up to you to make the best of the situation, even if your resources are minimal (e.g. novice researchers, or the fact that you are not given all the professional back–up you would like).

Within the scope of this guide, we will introduce you to a relatively simple way to identify research tools which you can use in most cases.

Prepare functional and well–targeted tools
Consult specialised books to find out about tools

Data to be Verified in the Office and in the Field

You should start by differentiating between the data available in the office and those you will have to verify in the field, before going on to define the activities needed to analyse each of these.

14. Initial Break–Down of Tasks to be Performed
Data to be verified in the office – Activities
Education Policy

be factors which are easily observable, verifiable or quantifiable.

Thirdly, and lastly, you should select the instruments which will allow you to verify the indicators you have just identified.

Let us take an example to better illustrate the links between hypotheses, indicators and instruments. Let us assume that you are required to verify that the pupils achieve the attainment target for handwriting at the end of the first grade, i.e. that they are able to copy a sentence on the basis of a model in cursive style, forming the letters legibly and understanding the meaning of what they write. You could then devise the following table.

Developing Instruments

You have identified the research instruments you need – now you can develop these.

Adapt the instruments for the case in hand

15. Identification of Instruments	
Hypothesis: Pupils achieve the official attainment targets for handwriting at the end of their first year of schooling.	
Indicators	**Instruments**
Time allocated for handwriting in the official time–table	
	Analysis of official curriculum
Importance attached to handwriting by teacher	
	Examination of pupils' exercise books

investigating, and will need tailor–made instruments, especially if you expect them to work relatively independently.

The instruments must, of course, also be tailored to the needs of those interviewed. It is up to you to identify instruments which will neither shock nor intimidate adults and children who are not familiar with investigations.

Finally you must take into account the conditions surrounding your research work, and take a pragmatic approach. If you have to be on the move for weeks on end, for instance, use only instruments that you can transport – no vast packages of tests and questionnaires. Sometimes you will not be able to use recordings because the logistics preclude this. To illustrate this, we have reproduced below a few pages taken from the investigation conducted in 1986–1987 by the Tef'Boky Project. Examine them carefully and identify the precautions taken at that time to ensure a minimum of uniformity of investigation conditions and to guarantee precise results – and see how you can adapt these to suit your own circumstances[8].

Do not underestimate the importance of physical and logistical considerations

Nothing is too self–evident to ensure that the instruments are properly used

Preliminary Testing

You now have research instruments, but no guarantee that they are precise enough or suitably tailored to your investigators and to the people investigated to give you the data you need.

For this reason you should organise a preliminary test run with the instruments, especially those aiming to evaluate school attainment levels. We recommend a test run in at least two schools offering teaching and learning conditions that can be considered representative for the country as a whole, which will usually mean moving away from urban areas.

To ensure that your instruments really work as intended, you may have to modify them, and then organise a second test run. This may prove impossible however. In our experience every expedition demands time,

	Collecting data at CIRESB	○
2.	Instrument Group 2	
	Collecting data from animateurs in the area	○
3.	Identification sheet	
	The village / the school	○
4.	Instrument Group 3	
	Target Group: Grade–one teachers	○
5.	Instrument Group 4	
	Target Group: All teachers	○
6.	Instrument Group 5	
	Target Group: Parents	○
7.	Instrument Group 6	
	Classroom observations (grade one)	○
8.	Instrument Group 7	
	Cultural features – inventory	○

INSTRUMENT GROUP 5
Target Group: Parents
Method: Interview based on questionnaire

QUESTIONNAIRE NO. 1
Objective:

Verify the hypothesis: Parents have low incomes.

Instructions:

1. Take one family per economic stratum (and one form per family)

rich ◯ average ☒ poor ◯

2. Select families on the basis of information given by teachers, community workers and VIP

1. Family situation

	Number	Members of Family	Dependent Children	
Sex			At School	Not at School
Male				
Female				

Comments: ....
....

2. Income–generating activities

Observation

What phases did he then go through?

Expression

Exploitation

Application

3.1.5. Method

The teacher called on pupils' experience

The teacher guided pupils

The teacher developed the subject alone

A dialogue emerged between teacher and pupils

between pupils

3.1.6. Behaviour and attitude of pupils

Most pupils

Ask the teacher how he goes about solving the major difficulties encountered by pupils learning to read.

....
....
....
....

IN THIS CONTEXT NOTE THE FEATURES THAT STRUCK YOU MOST IN THE COURSE OF THE READING LESSON, WHICH YOU CONSIDER INTERESTING BUT DID NOT FIT INTO ANY OF THE OTHER QUESTIONS

5. Give investigators written detailed instructions

File No. 2	Instruments for Field Research Work

INSTRUMENT No. 12
Target Group: First–grade pupils
Type of Instrument: Test

Objective:

Verification of the hypothesis:

Children in rural areas have specific concerns and interests (2213)

Guide:

RECORDING RECORD SHEET

Label your cassettes!

List them in this record sheet and fill in the relevant information!!!

Place	Cassette No.	Date	Child Recorded			Subject
			Male	Female	Age	

2. Pertinence of tests	
	Each test should correspond to one specific, clearly formulated objective which will, in its turn allow you to determine whether or not the general target has been achieved.
3. Reflecting the pupil's world	
	The tests should only involve elements with which the pupils are familiar, or which are at least known to them.
	You should thus naturally avoid tests concerning the arrangement of seats in an aircraft, or the keyboard of a computer, but also other objects which may still not be common in certain places, such as showers or calculators.
4. Interpreting illustrations	
	Illustrations must be unequivocally understood by pupils. They must correspond to the cultural and psychological perception of the children. Pay special attention to the use of techniques such as movement or perspective which could be wrongly interpreted.
5. Duration	
	The duration of the tests should take into account the pupils' concentration span.
	For instance, 20 – 30 minutes should be allowed for all reading or writing tests in grade one of primary schools, interspersed with short breaks.
6. Preparing the investigators	
	All investigators should conduct the tests in as similar a way as possible.
	There are two ways of preparing investigators; call a meeting of all investigators before leaving to perform the field work, at which the procedure to be followed is repeated once again; and print the instructions on how to conduct each test at the top of each set of tests.

6. The Sample

Now your instruments are ready, and you can identify a sample of schools in which to use them.

Why do you need a sample? Firstly, of course because it would not be feasible to gather information from every school in the country, and secondly to ensure that the information you obtain is representative for the country as a whole. Certain sample selection techniques will enable you to identify a zone where you can gather reliable data which will reflect the situation throughout the land. Finally, a sample will enable you to count on the long–term support of those concerned; you will need a representative group not only for the preliminary tests, but also to test the materials you produce one after the other. You can only create a good feed–back system if the sample selected does not change significantly over a period of several years.

We suggest that you select your sample in two stages, as follows.

Defining Selection Criteria

> **Select your sample with care; you will have to work there over a period of several years**

When you come to select zones and schools as part of your sample, you should firstly define your selection criteria. You must proceed with great care since this sample is going to be your laboratory not only for the research work at this stage, but also for testing the pilot textbooks at a later date.

Again, try to make the best possible use of our hints; look for feasibility, representativeness, sustainability, and the support of those concerned, each of which we will look at in more detail below, and decide which are the most important criteria for you.

> **A good author is also a good organiser: what is the point in preparing good instruments if you don't know how to manage the application?**

• the professional and economic profile: the professional occupations and income of those observed within the sample must reflect those of the majority of parents throughout the country.

• experience of scientific work: if the test zone is a preferred area for research and testing, the inhabitants may have adopted certain mechanisms which do not reflect the situation of the population as a whole; if it was the test zone for a failed education project, it would be preferable to select another zone.

Sustainability

To ensure that the sample remains representative over a period of several years you should try to guarantee:

• a sufficiently large initial sample: in the course of time, some villages or some schools will, for various reasons have to be dropped; in some cases the villagers will demand that they are dropped to avoid official visits, in others the sudden and prolonged absence of a teacher or the closure of a school will force you to take this step. To allow for these defections, it is imperative that the initial sample be relatively large.

Agreement and support

Finally, to allow you to conduct your work, you must have the active support of teachers and parents, without which no cooperation is possible, or at least no good cooperation.

Determining your Sample

On the basis of your selection criteria, you should identify a few zones which could be taken as a sample.

Regular Comparing of Notes

Regular meetings should be held to discuss progress. A weekly report before returning to the field, for instance, allows the team members to swap the most important information and, if necessary, modify the way some instruments are applied, add more instruments or drop some.

8. Results

You must now process and interpret the results of the data your team have collected in the field. This is a relatively long phase – it took some 4 months in the Tef'Boky Project – and must be conducted rigorously and meticulously if all the work to date is not to be nullified.

Some teams will call on the services of specialists to help them interpret the statistics, or guide them in their linguistic work, for instance. Be this as it may, you should think of the data you have collected as being at once extremely precious and far from complete.

Major Indications

The results that you will obtain will undoubtedly give you relevant information on the school situation. This makes them vitally important and you will find them useful not only for one textbook but for an entire textbook production project.

But you must not fall into the trap of thinking of them as complete and irrefutable. The situation will rarely allow you to do so. For example, let us assume that you have evaluated school attainment levels; your battery of tests may be appropriate and your results differentiated (girls/boys; school–age children/ significantly older pupils; pupils repeating the year/pupils enrolled for the first time; pupils who have lived in the area for some time / pupils who have recently moved to the area; pupils whose mother tongue is the language of the tests/ pupils who are learning the language, etc.) but the population tested will not necessarily remain the same lead the authors to propose a revision of the official attainment targets, a decision which the education authorities would be reluctant to make.

The report on field work here becomes a piece of evidence which the authors can use to explain, justify and even defend some of their proposals; it is a vital document which cannot be replaced by verbal explanations or the raw and uncollated results of research.

It is thus often a good idea to end this phase by publishing a document which should be accepted by the education authorities: having been prepared and implemented with care, the research work must be presented in this document with the necessary professionalism.

Document your research

Notes

[1] According to Landsheere, “A curriculum is a collection of planned activities for instruction, comprising the definition of teaching targets, the content matter, the methods (including evaluation), materials (including textbooks) and the arrangements for suitable training of teaching staff. In *Dictionnaire de l'évaluation et de la recherche en éducation,* p. 65. Paris: PUF.

[2] Cf. Introduction.

[3] Cf. Sow, A.I. *Langues et politique de langues en Afrique Noire,* p. 46. Paris: Nubia/UNESCO, 1977.

[4] “Some five years are needed to fully describe all the sounds in a language that has never been written.” *Langues et politique de langues en Afrique Noire,* op. cit. p. 39.

[5] In this context the work performed by the German–Peruvian Bilingual Education Project from 1979–1989 provides interesting practical information; cf. Châtry–Komarek M. *Linguistische Faktoren bei der Erstellung von Schulfilbeln in Vernakularsprachen,* Osnabrück: Osnabrücker Beiträge zur Sprachtheorie 31, 1985 and Intentos de codificatión del quechua en libros escolares. In: Lopez, L.E. and Moya, R. (Ed.) *Pueblos indios,*

CALVET, L.J. *La guerre des langues et les politiques linguistiques.* Paris: Payot, 1987

COULMAS, F. *Linguistic minorities and literacy: language policy issues in developing countries.* Berlin: Mouton Publishers, 1984

COULMAS, F. *Sprache und Staat. Studien zur Sprachplanung.* Berlin: W. de Gruyter, 1985

RUBIN, J. Textbook writers and language planning. In: *Language planning.* Rubin J. et al (Ed.) The Hague: Mouton Publishers, 1977

SOW, A.I. *Langues et politique de langues en Afrique Noire.* UNESCO/Nubia, 1977

UNESCO *L'emploi des langues vernaculaires dans l'enseignement.* Paris, 1953

Research Instruments

BOUDON, R. *Les méthodes en sociologie.* Paris: PUF, Coll. “Que sais–je?”, 1969

GRAWITZ, M. *Méthode des sciences sociales.* Paris: Dalloz, 1984

QUIVY, R. AND CAMPENHOUDT, L.V. *Manuel de recherche en sciences sociales.* Paris: Bordas, 1988

Preparations for Investigative Work in the Field

CHAMBERS, R. *Développement rural. La pauvreté cachée.* Paris: Karthala, 1990

To Sum Up

When the education authorities of a developing country decide to produce a textbook for primary level, they turn to a group of individuals, generally inspectors and educational advisers, and often expect them to

The Contents

The conceptual phase is often welcomed as a deliverance by groups of textbook authors: after all these months of research, they believe that they can develop the materials relatively rapidly. More often than not they are disappointed, for months of hard word are needed to produce a textbook or a teachers' guide, as you will see in this chapter.

For didactic reasons, we will break down the conceptual phase into two parts and deal with each part in two separate chapters. The first will look at the contents, while the second focuses on the form, as though the two were not related. In fact the final form and contents of a book emerge from the very interaction between these two fields. Also for didactic reasons we have decided to present the work involved in a more or less logical sequence. Textbook teams generally take a “spiral” approach which allows them to lay down the rough structure of the material progressively. This approach involves taking one step back at regular intervals to

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.

This figure is often more a recommendation than an absolute prescription, however. It may not take into account even official interruptions such as exams or once−a−term upgrading meetings for teachers.

To identify the effective length of the academic year you will also have to look at the statistics of the Ministry of Education regarding pupil attendance, and to analyse the data you gathered yourself in the field. There may be a wide discrepancy between the official number of teaching weeks and the number actually observed in the schools. You must then decide on the figure on which you wish to base your textbook.

At this stage you should be aware of the fact that any decision to base your work on the “shortened” school year may have serious repercussions: a reduction in the number of teaching weeks may entail a radical modification of the attainment targets for the entire primary cycle[1].

You should also consider the “legality” of your decisions. Even if you are involved in a pilot project, which by its very nature needs a certain scope for action, you should check to what extent you are required to move within the confines of the official remit and to what extent the education authorities will allow you to work outside an official framework, even if it is considered outmoded or erroneous.

If you feel that you should introduce innovations, try to analyse the situation so that you can decide when to inform the education authorities of the changes introduced in your material: sometimes it may be prudent to keep them informed of your intentions, while under other circumstances new ideas may have a better chance of being accepted if you remain silent until the pilot material is presented. This is a vitally important consideration which applies not only to defining the time−frame, but to the entire conceptual phase of your work.

Time−Table

Having decided on the number of teaching weeks you wish to take into account in your new textbook, you should examine how schools manage this time at present.

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 “mother tongue” the latter would not only stipulate the time to be allowed for reading, writing and speaking and listening, but would also break down the time reserved for writing into the time earmarked for handwriting, vocabulary, grammar, spelling, conjugation and creative writing. We recommend that you analyse the type of break–down found in your official curriculum.

Sometimes the break–down may surprise you, since it does not correspond to the methodological approach you had intended to take. Let us take an example. If you are to produce reading and writing materials for grade one, would you leave “handwriting” in the field of “art” as prescribed in some countries, or would you integrate it into your textbook, thus saving valuable time? You must of course specify the methodological approach you intend to take, but at this stage it is vital to know which subject “handwriting” is deemed to be part of before you can tackle the issue of the total time allocated for your subject.

These considerations may appear pointless to you if it is only a question of adding half an hour per week to the total time allocation for the subject; they may indeed be of secondary importance when the academic year comprises 35 weeks with a 27–hour school week, but they are anything but superfluous when the pupils spend no more than 15 hours a week at school and the school year is no longer than 24 weeks. Thus, again, take great care making your decision.

We should add that the approach you take must again be tailored to the circumstances. Sometimes you will have to consult with your colleagues who are responsible for producing textbooks for other subjects and/or with the curriculum development unit. Sometimes you will be unable to engage them in a real dialogue and your efforts to harmonise the procedure adopted for various subjects will be doomed to failure such that, to avoid paralysis, you may choose to confront the others with a fait accompli[3].

Number and Length of Lessons

Now you know the time–table to be respected and the overall time to be taken into account for your material. Would it then be appropriate at this stage to determine the exact number and length of lessons per week reserved for your subject, and to draw up a sort of time–table?

and a full time–table of 5 hours a day. It follows that the length of time dedicated to each subject depends on the working conditions: in grade two of primary schools 10 hours and 50 minutes a week are reserved in the full time–table for learning the mother tongue whereas only 5 are available for pupils following the short time–table.

When materials were devised for this grade the authors of the Tef'Boky Project decided to design a “common core” of texts to read, and speaking, listening and writing exercises for all pupils, with supplementary activities for those following the full time–table.

To this end they analysed the time officially allocated to speaking and listening, reading and writing in the two time–tables and drew up two plans so as to allow for at least one lesson of more of less identical length per day for each of these sub–topics, to be followed by all pupils. The temporal framework for the new materials to be produced was as follows:

Sub-Topic	**Full Time–Table**	**Short Time–Table**
Speaking and listening	5 x 20 min. 5 x 10 min.	5 x 15 min.

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 you to refer back to them at a glance.

Use the pinboard for all conceptual work

2. Methodological Approach

The aim of this phase is to identify the methodological approach which you intend to adopt.

Why, some of you will ask, should we once again delay looking at the content matter, and look first at the methodology. Before you can rationally decide on the contents, you must lay down the approach, for this can have major repercussions on the volume of knowledge to be acquired.

To illustrate this let us take the example of first–grade mathematics: you must decide whether to accord priority to calculating rather than counting, i.e. if your aim is to teach pupils to find solutions to problems rather than merely to count. This decision will have a direct impact on the subject matter, which you will define in the course of the following phase: in the latter case the child will have to learn to count to 100, while in the former he will probably only be able to count to 20, or 50 at the limit.

We will not go any deeper into subject–specific considerations here, but we will comment briefly on the points that you should analyse when selecting a methodological approach no matter which subject you are tackling.

Practice in the Schools

Your preliminary field research should have provided you with information about practice in the schools.

You should look at the preferences of teachers of the subject, any weaknesses in the methods generally employed and the principal difficulties encountered on the one hand; on the other you should analyse the level

3. Defining Content Matter

Having defined the temporal framework and the methodological approach you can now go on to the next phase, which will aim to stipulate the volume of knowledge to be acquired for the subject and grade in question given the practical options and limitations of existing schools on the one hand, and the expectations of those involved on the other.

There are several different aspects which you will need to look at to help you identify the subject matter progressively.

Current Curricula

You should start by analysing the subject matter laid down in the current official curricula.

> **Don't modify the contents of the official curriculum without first checking how much leeway you have**

In industrialised countries authors merely adopt the contents of these curricula without checking whether or not they are relevant. Indeed one of the first criteria applied when evaluating their products is the extent to which it corresponds to these official directions.

In developing countries, however, the situation is not always so clear. It is not unusual to find that the contents of official curricula do not tally with the actual learning conditions for a variety of reasons, such as the country's colonial past. The official learning time, for instance, may be at odds with the actual time available in practice. Where this is the case it is preferable to propose that the official curriculum be modified. Some specialists even recommend that textbook projects should be more or less systematically preceded by a full–scale overhaul of the national curriculum where needed, which can be expected to take some two years[6].

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 step, rather like traditional written examinations[9].

In many developing countries, the rate of absence of pupils is high, primarily as a result of sickness, agricultural work and bad weather; inevitably pupils who have been absent drop behind and represent a real case of conscience for a teacher hemmed in by a tight schedule: either he proceeds according to the time–table so that the school is worthy of its name, or he deviates from it to focus on pupils who have missed a lot. And how can a teacher confronted by this dilemma be evaluated?

Before you lay down the learning contents, you should then re–examine the temporal frame that you have drawn up; remember that the less time available, the more the teacher is likely to be straight–jacketed by the materials you are going to produce, and act accordingly.

Attitudes of Groups Concerned

When determining the content matter for your textbook you should also take into account the attitudes of the education authorities, teachers and parents. It is not always easy to identify these; in our experience parents and even education authorities are often only able to express their wishes once they have the book in their hands. Nevertheless, if you intend to cut the volume of subject matter covered you can expect the following sorts of reactions:

Education Authorities

- A systematic refusal to accept any significant change to the volume of subject matter

- Spontaneous rejection of "bargain basement education" as compared to neighbouring countries and especially as compared to the curricula of the former colonial master

- Fear of incurring the wrath of parents.

4. Fine Tuning

The relevance of a textbook production project should have been verified twice already, once by the feasibility study and once during your field research work.

If you wish to be absolutely certain that it is worthwhile continuing your work, check again at this stage that it is relevant. Some of you will consider this unrealistic in view of the advanced state of the work, but they should bear in mind that it is not necessarily the people who make the textbook who have performed the preliminary research, and they may still not have all the information they need. They should, however, have enough information to allow them to decide whether or not the decision taken by others to produce a textbook is genuinely justified.

If you are in this position, refer to the results of the preliminary investigation and re−examine the following options.

Adoption of an Existing Textbook

Check once more whether there is not already a textbook in your country or another country which has the features you have stipulated, i.e. which covers the relevant volume of material and adopts the methodological approach you have selected.

The production of new didactic material is always so expensive for a country, that you cannot justify starting work until you are absolutely certain that it is indispensable.

Adaptation or Translation

You should also check whether there are not already books which could be adapted or translated. If the negotiation of reproduction or translation rights is not a major problem, this can be a satisfactory compromise,

6. Set of Materials

You have now defined the content matter that is relevant for you and formulated it as targets. It is time for you to move on to identify the nature of the materials and the number of these materials you are going to produce.

Decide on the composition of the set after careful consideration

You may find this superfluous, since you think you know the answer and will thus be tempted to start work immediately. Beware – the most obvious solution is not always the best one and the choice of the type of materials is always complex and has many consequences. If, for instance, you are attempting to produce reading and writing material for the first grade of the primary cycle, you should not necessarily produce a reading and writing book and a teachers' guide. It may be more appropriate to produce a writing exercise book or complementary pedagogical tools such as letter cards, word cards or pictures.

18. Vague and Incomplete Attainment Targets
In 1987, the authors of the Tef'Boky Project, who were responsible for devising didactic materials for learning to write in grade one of primary school analysed the existing curriculum, which made a distinction between handwriting and written expression. The target for handwriting in the first year was defined as "Knowledge of lower case letters", which was then further explained as: "Knowledge of cursive lower case characters: • Vowels, consonants, figures • Letters and figures of different sizes". During the analysis these directions proved to be so vague that it was not necessary to contravene them, but too imprecise to be translated into didactic materials without the authors making additional decisions. The main questions facing the authors were as follows.
The term "knowledge"

Financial Aspects

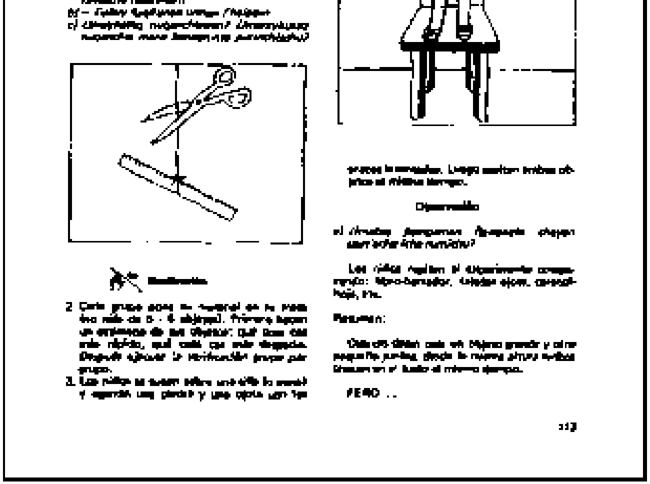
Refer again to the results of your preliminary research, paying particular attention to the following points:

- the number of textbooks which each pupil in the class must purchase and the price of these books;
- the amount that parents are able and willing to pay for their children's school materials;
- the way individual school materials are bought or lent at present, or which are likely to be accepted;
- the way the teachers' materials are acquired;
- the way any large–scale reprints of the new materials will be funded.

You may reconsider your initial decisions in the light of these facts. You may, for instance decide to do without any expendable material, and to dispense with tools except the textbook and the teachers' guide.

We should point out that a textbook is, of course, still the best way to learn to read, but it is not imperative in other subjects. If you are producing materials for mathematics, for instance or, better still, science, you should explore the possibility of producing only a detailed teachers' guide, at least for the first two years of the primary cycle.

A teachers' guide is not, anyway necessarily a dull tome as many first–time authors seem to think; to convince you that it can be interesting look at the two examples below of teachers' guides for mathematics and science. They are designed for primary level, and were produced within the scope of the German–Peruvian Bilingual Education Project and the German–Malagasy Tef'Boky Project respectively.



Kawsayninchis Fifth–Grade Science Lima–Puno, 1987

Even if you are preparing a limited number of pilot copies in the first instance, you should bear in mind the logistics of any subsequent large–scale distribution.

You should thus avoid materials that are difficult to pack, heavy or fragile. If you intend to produce expendable materials you must ascertain that they can be distributed to the schools in good time every year.

Ideally, the field work will have given you some indication as to the sort of material that is needed; in practice, however, this data may not be sufficient. You cannot foresee all the repercussions of the new material from the outset; mistakes can be made in spite of all the precautions taken by authors and they are always serious at this level. This is what happened in the Tef'Boky Project with a writing exercise book, written for beginners, which proved counter–productive. The failure of this exercise book seems to us to provide such a good example of what can go wrong that we have looked at the history of the book in detail in Table 19.

7. Arranging the Subject Matter

Now that you have defined the content material to be covered in the subject and the grade in question, and have decided on the set of materials to be produced, you must determine how you wish to arrange the subject matter within the materials you plan to produce.

19. Conceptual Error
The research work performed in the field by the future textbook authors of the Tef'Boky group revealed that the level achieved in writing in the first grade of primary school was particularly low. The group then proceeded as follows to systematically identify the reasons for this low level, with a view to designing materials which would be best suited to remedy this serious problem.
1. In the Official Curricula

	4.2. They see writing as only a senseless and boring copying exercise.
5. Role of Parents	
	5.1. The parents have never been told how important writing is, and thus do not worry about providing enough indispensable expendables such as, exercise books and pencils.
The best way of tackling so many problems appeared to be individual material for each pupil, with the following features:	
	A personal exercise book (cf. section 2.2.)
	Involving fine motor coordination exercises (cf. section 4.1.)
	Allowing pupils to learn to write systematically (cf. section 3.1.)
	With writing models (cf. sections 2.3, 2.4., 3.1)
	With various types of exercises, to reinforce reading lessons (cf. section 1.2)
	With reminders and practical advice for the teacher (cf. sections 3.2, 3.3., 3.4)
	Designed like a game (cf. section 4.2)
	No more expensive than common exercise books (cf. section 5.1.)
Since the analysis indicated that parents were used to buying at least one writing exercise book and one pencil per year, the authors did not expect any negative reactions on their part. And indeed the exercise book was well received by everyone.	
Yet, when the level of attainment was evaluated at the end of the year, the exercise book appeared to have had a counter–productive influence on handwriting: to the surprise of everyone concerned, the level achieved by pupils in the sample was lower than that achieved in the control group, who had learned to	

length of lessons dedicated to the sub–topic in question.

Stages of Learning

Refer back to the attainment targets and identify the various stages that are indispensable if the targets are to be achieved. Thus, if first–grade pupils with no pre–school experience are learning to write, for instance, the major stages involved could be as follows:

- visual distinction and pre–writing exercises
- systematically learning to form the letters of the alphabet
- copying words and sentences
- composing and copying words
- composing and copying sentences.

Contents and Learning Time

Now you must ascertain that the learning targets can be achieved by all pupils. Those following a reduced time–table in particular must be able to systematically go through all the stages identified above as being indispensable.

Divide up the contents and proceed step by step

Supplementary Subject Matter

Finally you should define the content matter of supplementary activities for pupils following the full time–table.

If we assume that you are tackling the sub–topic "speaking and listening", for instance, and the target for the week is aural recognition of the sound [o], all pupils must be able to recognise this sound. It is not difficult to imagine a few, simple exercises, such as asking all pupils to clap their hands when the teacher uses this sound in a list of words. For pupils who have more time, you could add supplementary exercises, like 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.

To illustrate this, the time unit adopted for *Garabola* was a week and the work unit a letter, as you can see from the illustration opposite.

Define the relation between time unit and learning unit

Order of Presentation of Contents

You now have the bare bones of your textbook. This overview is essential, but not in itself enough. Now you must organise the content matter to be learned, as defined by your group. Let us take the example of a reading book, again. If you have decided on the relation of time unit to work unit, you can decide in which order you wish to introduce the letters.

Depending on the material in question, you could select one of three approaches.

A First Reading and Writing Book

The first step is to determine how you intend to present the elements to be learned within the scope of reading lessons, in view of the fact that this will, in part, also determine the sequence for the writing lessons which will run parallel to reading.

The organisation of a first reading book always poses very specific problems. And again, there is no universal formula applicable in every situation and to every language.

Nevertheless we think that it is interesting to consider the approach taken by the Tef'Boky Project faced with the task of organising the schedule for learning the 21 letters of the Malagasy alphabet and the 13 complex graphemes in the language; this experience is illustrated in Table 20.

Apriy	1	F. p. 1. Paska	★	★
	2	F4	★	★
	3	•	18	d (vak.= tak. 58-59 ; sor.= lak. 60-61)
	4	•	19	j (vak.= tak. 62-63 ; sor.= lak. 64-65)
May	1	•	20	b (vak.= tak. 66-67 ; sor.= lak. 68-69)
	2	•	21	k (vak.= lak. 70-71 ; sor.= tak. 72-73)
	3	•	22	p (vak.= tak. 74-75 ; sor.= lak. 76-77)
	4	•	23	z (vak.= tak. 78-79 ; sor.= tak. 80-81)
Jona	1	•	24	f (vak.= lak. 82-83 ; sor.= lak. 84-85)
	2	Fanadinana	★	★
	3	Fanadinana	★	★
	4	Fanadinana	★	★

23

Fitting together several sub–topics

Often the subject is subdivided; then you not only have to organise the sequence of learning one sub–topic, you must also ensure that the various sub–topics interlock as well as possible.

In first–grade maths, for instance, where priority is accorded to arithmetic, although geometrical concepts and measurement are also introduced, the subtopics cannot necessarily interlock on a repetitive basis, as is the case with reading and writing, described above. Indeed you must check in each instance which level of arithmetic is needed to progress in the other sub–topics.

The permanent interaction between the various sub–topics will, in this case, determine the structure of the textbook little by little, like a jigsaw. The best way to work systematically is to return to the pinboard.

> **Base your arrangement of the subject matter to be learned on the interaction of the many sub–topics covered by your textbook**

	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 presented separately, as were tr and ts, etc.
Visual distinction	
	Letters with vaguely similar forms, were separated from one another by at least one other letter whose form offers enough of a contrast, taking both printed and joined–up forms into account as far as possible. Thus n and m were separated by t, d and b by j and e and l by r.
Finding a common element	
	Complex graphemes were sometimes tackled together where the authors felt that this would make it easier to learn them and would emphasis any common element; thus mb and mp followed on from one another as did nd and ng, etc.

Writing Exercises

The organisation of the contents of materials for writing becomes extremely complex as soon as the pupils start to study the language, i.e. often as from the third grade. The authors must then define and harmonise at least five sub–topics: handwriting, vocabulary, spelling, grammar and creative writing.

It is important to create a coherent approach within each of these sub–topics, and then ensure that the pupil's progress in each of them is harmonised: it is impossible, for instance to introduce the concept of sentences in grammar if the pupil has not yet learned to write upper case letters. The contents of the exercises will interlock more and more closely as time goes on thanks to the permanent interaction, until an intra and interdisciplinary coherence emerges. If you are in this situation, you can begin to familiarise yourself with the complexity of the subject by consulting the contents page of recently published books. If the book is well written, it should contain an overview of all subject matter presented in the book and the page make–up should make the links clear.

At the end of this phase you can draw up a list of the subject matter you wish to cover, and the order in which the material is to be presented. Be aware though that you may have to modify this provisional arrangement:

• General information on the language

• Presentation of the subject “Malagasy” and the sub–components reading, writing and speaking and listening

• Detailed information:

Sufficiently precise information for every lesson throughout the year in each of the three sub–topics, for the two time–tables – a sort of script;

Brief explanations on how to present an exercise involving a new mechanism;

Examples for some speaking and listening lessons

• Systematic visual presentation:

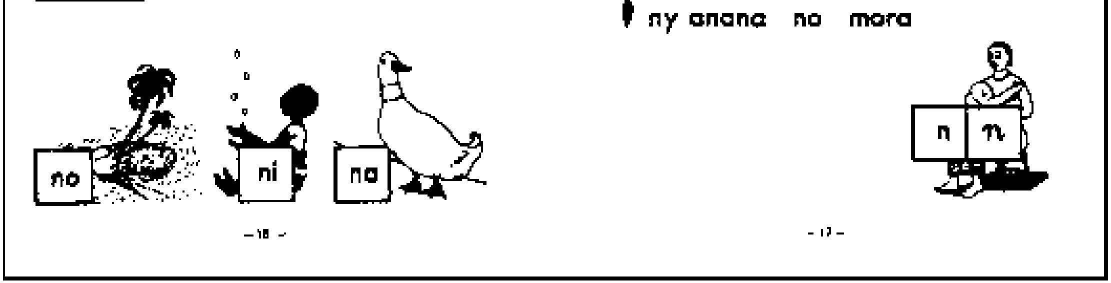
Reading and writing lessons in boxes
The form of the letter in joined–up writing

• Teacher's texts:

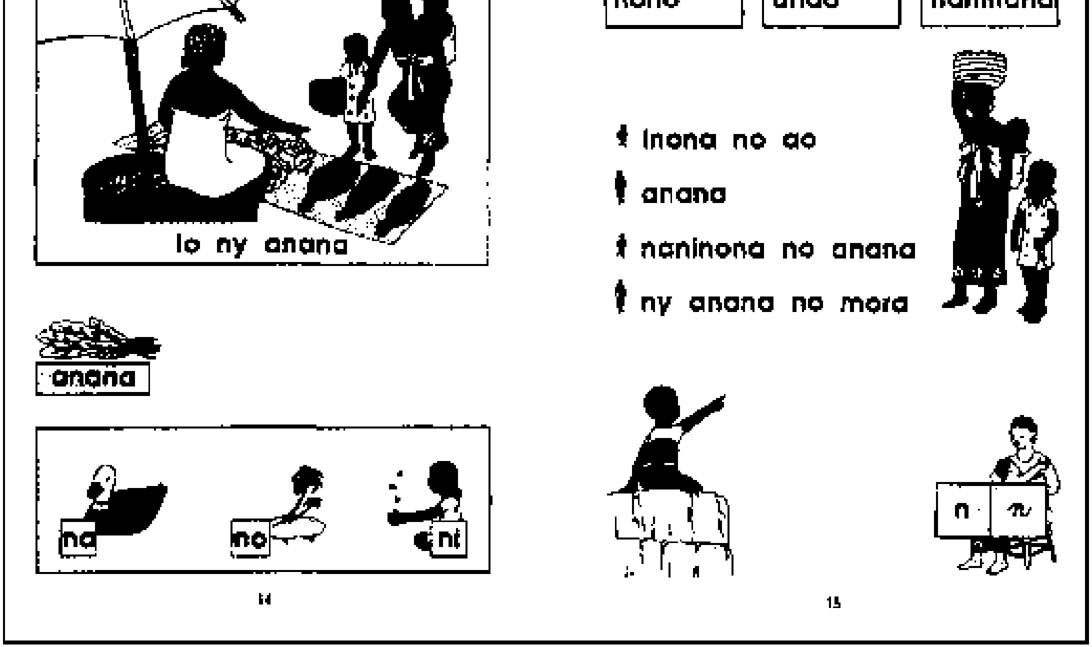
Texts for reading, to read to the class, to answer an aspect of the speaking and listening target (“The pupil can listen to and understand messages read to him...”)

Short weekly poems

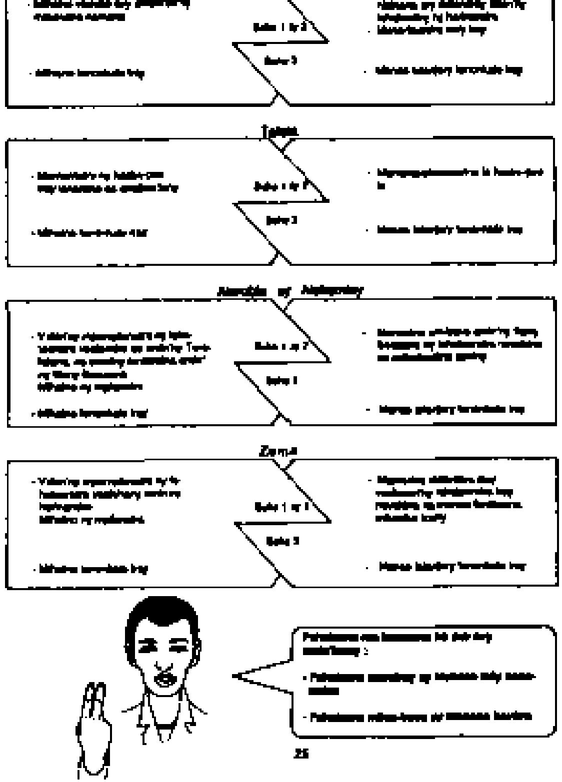
1.1. Having read the guide the teachers change nothing in their practical work[10] 1.2. No sanctions on the part of the administration	1. Teachers do not pay enough attention to the guide	1. Teachers are not motivated	1.1. Teachers do not pay enough attention to their classes
2.1. Lack of training and/or willingness	2. They are not able to put the ideas in the guide into practice	2. Teaching remains superficial	2.1. The target is not achieved
3.1. Para–professional activities take priority	3. They only take time to read the guide during lessons	3. Teachers do not manage their classes	3.1. Pupils get bored
4.1. Teachers unaware of their own limitations	4. They believe that they know enough	4. Teachers, self–satisfied, give dogmatic lessons	4.1. Pupils are passive 4.2. Level of attainment is mediocre.
5.1. Shortage of well–written pedagogical documents	5. They do not have the benefit of a literate environment	5. Teachers see their work as a routine	
6.1. Inability to synthesise information and pinpoint the essentials 6.2. The guide lacks the recommendations needed for easy adaptation	6. They do not adapt the instructions properly to the actual classroom situation	6. They have no critical spirit. There is a lack of initiative and creativity	



1. Pilot version of the textbook. A typical reading lesson



1. Typical reading lesson



1. Use of graphics – the interlocking of reading

10. In Conclusion

Where do we go from here?

At the end of this phase you should have two lists of contents, one for the pupil's textbook and one for the teachers' guide.

It would obviously be preferable for you to write these two books in concert. The advice and instructions should at least be devised at the same time as the texts and exercises in the textbook, if not written in a final form.

However desirable this may be, though, it is not always possible. You will appreciate that each publication demands the closest attention of the authors over a period of several months, which generally precludes authors switching from one publication to another. You should not worry, then if you concentrate more and more of your energy on the textbook and end up gradually putting off work on the teachers' guide until later. Make do with noting the important points that you might otherwise forget and continue your work on the textbook – decide how to present the contents that you have now identified. The next chapter is devoted to the presentation work.

Notes

[1] The repercussions of decisions relating to the temporal framework are numerous, e.g. the Tef'Boky Project, noting that the time actually available in schools was significantly lower than the official allocation decided to spread the basic “Mother tongue” course over two years rather than one, thus drastically changing the attainment targets for this subject throughout the primary cycle.

[2] In Madagascar some isolated schools do not even manage to provide the reduced three–hour session and others are open for barely 20 weeks a year. When they devised their didactic materials, the textbook authors

[9] In the curricula which the authors of the Tef'Boky Project proposed to the education authorities in Madagascar, it was stipulated that 70% of all pupils must achieve the attainment targets.

[10] This is the only problem that cannot be solved by the manual; the solution lies elsewhere – the promise of a career structure, reintroduction of inspectors' visits, etc.

Recommended Reading

Curricula

BABIN, N. AND Pierre, M. *Programmes, Instructions, Conseils pour l'école élémentaire.* Paris: Hachette Ecoles, 1986

BUDE, U. *Culture and environment in primary education. The demands of the curriculum and the practice in schools in sub–saharian Africa,* Bonn: German Foundation for International Development (DSE), 1991

HAMEYER, U. et al (Ed.) *Handbuch der Curriculumforschung,* Weinheim, Basle: Beltz, 1983

MAGER, R.F. *Comment définir des objectifs pédagogiques.* Paris: Bordas, 1977

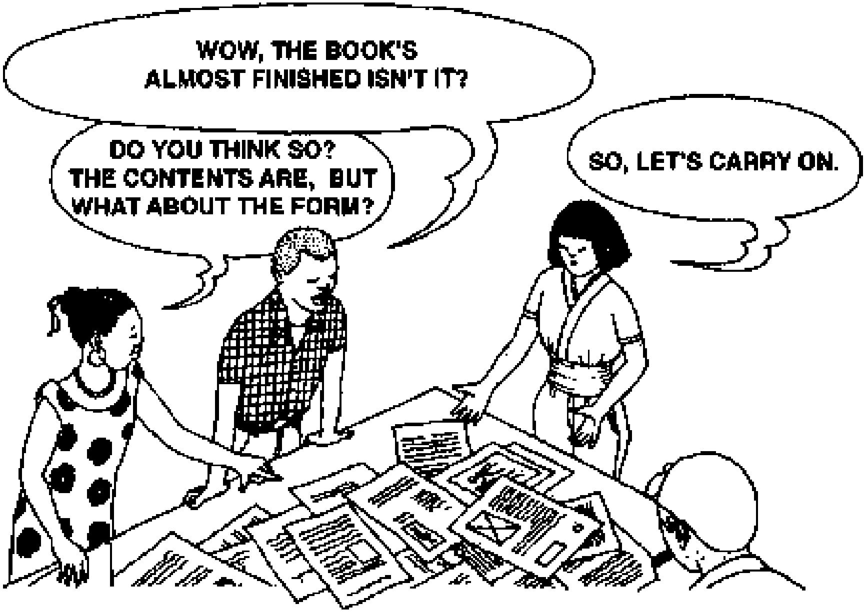
SEGUIN, R. *Curriculum development and implementation of teaching programmes. Methodological guide.* Paris: UNESCO

Innovation

AREGGER, K. *Innovation in sozialen Systemen. 1. Einführung in die Innovationstheorie der Organisation.* Berne, Stuttgart: Paul Haupt, 1976

AREGGER, K. *Innovation in sozialen Systemen. 2. Ein integriertes Innovationsmodell am Beispiel der Schule.* Berne, Stuttgart: Paul Haupt, 1976

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.



The Form

The last chapter enabled you to identify the contents of the didactic material to be produced; in this chapter we will look at how to ensure that text and illustrations are of the quality required while staying within your budgetary constraints.

size (297 x 210 mm) and most are somewhere between these two extremes (e.g. 240 x 170 mm).

The format of a textbook should never be a coincidence. The main elements that you should take into account to ensure that the dimensions are appropriate for the purpose intended, i.e. that they meet the needs of users and producers alike, are described below.

Pedagogical and Didactic Considerations

First and foremost you should identify the dimensions which guarantee optimum readability, in terms of both the structure and the text. Take the following points into consideration.

Macro–legibility – the structure[3]

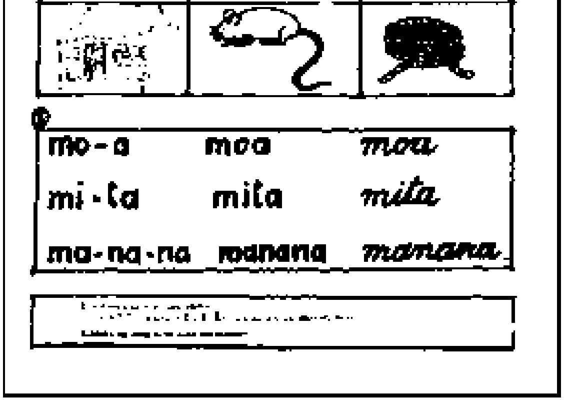
The dimensions you choose must make the general structure of the textbook easily comprehensible. Other factors, including typographical aspects and layout considerations naturally play a contributory part, but it is the size of the pages more than any other single factor which will determine the macro–legibility of your book.

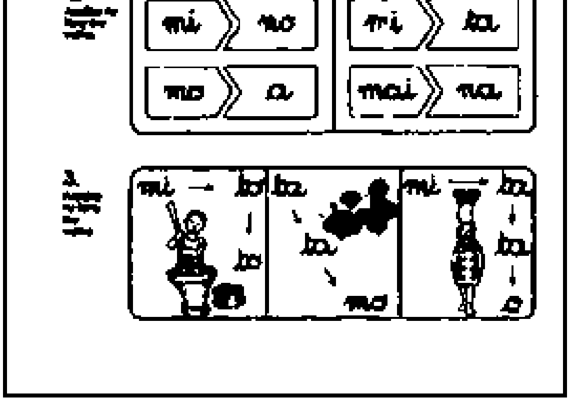
The format you choose must firstly reflect the structure of the lessons. If you are producing a first reading book, where it is important to respect certain stages of learning, the page should be big enough for the links to be quite clear. If you have chosen an analytical learning form, the reader should be able to recognise at first glance the progression from the sentence to the word, the syllable, and perhaps the letter.

Equally, the format must reflect the various functions of the text. Let us take an example to illustrate this: let us assume that you plan to print exercises along with brief instructions in your book. The page dimensions must then be such that each block (exercises and instructions) is easily recognisable at first glance.

The two illustrations below reveal how important this aspect is.

First priority: the format must be large enough to ensure that the structure is easily recognisable



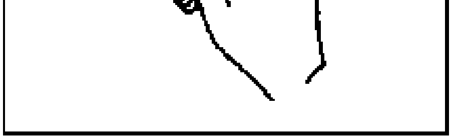


The left hand page shows a draft, the right hand page the final version of Garabola exercises. Look at the two, and see how important it is to arrange the exercises and instructions in a way that makes them easy to understand. Think about the consequences of the two versions: if the instructions are printed at the bottom of the page, the textbook must be long enough to separate them clearly from the exercises; if they are printed on one side of the page, on the other hand, the textbook must be wide enough for the exercises to be printed completely.

Secondly, you should bear in mind the learning conditions observed during field work: if the classrooms are poorly lit, if most pupils have not enjoyed preschool education, and if they have little contact with printed materials, you may have to raise the levels of readability determined for industrialised countries[6], and use a larger format for the first grades at primary level.

Practical Considerations

This is the second important factor which will influence your decision on the appropriate format, and may force you to modify your original decisions. If you have, until this point, given priority to pedagogical and didactic considerations, you probably intend to use a relatively large format; but under the circumstances in which



School Furniture

The dimensions must also be appropriate for the school furniture available.

Return to the field study and determine how the schools are equipped in terms of tables and chairs; and more precisely look at the width of tables, the average seating space per class and the general state of repair of pupils' furniture. In some classes an unnecessarily large textbook can be a nuisance for pupils and will be rapidly destroyed.

Utilisation

Finally, when deciding on the dimensions of a textbook you should bear in mind how it is going to be used, by one pupil or several.

If it is to be used by more than one pupil, the book will only be borrowed by pupils and will be kept in the school building. It can then be relatively large, especially if the system involves two or three pupils sharing a book. On the other hand, if parents are expected to buy the book, it will have to be carried back and forward to school in a small canvas or raffia bag; if this is the case you should come down on the side of a small, compact book, which will be easy to carry and won't be destroyed so quickly. Specialists reckon that textbooks for primary level in rural areas should have a maximum format of 220 x 140 mm to ensure a maximum service life[7].

You should pay all the more attention to these considerations since the other factors which will help determine the service life of your textbook (paper used, material used for cover, binding) may not be of top quality.

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 format of the available paper.

What you, as authors, must be aware of is that it is rare for a book to be printed one page at a time; for reasons of economy a maximum number of pages is set for each sheet printed. The forme thus obtained is slotted into the printing press, and the printed sheets are folded and then cut on three sides. You then have a “signature”. The body of the book is made up of several signatures put together.

To print the maximum number of pages at a time on one press you should define the final format of the finished work with great care, on the basis of the paper format. If, for instance the paper available for printing is A1 format (594 x 841 mm), and you decide that your textbook should measure 250 x 190 mm, you can print 16 pages at once, as illustrated below, 8 right hand and 8 left hand pages; the blank edges will make it easy to trim the pages once they have been folded[10].

Format of Printing Presses

The format of your textbook must also correspond to the format of your printer's printing presses. To take the same example as before, if the dimensions of the printing press are 920 x 640 mm you should not select a finished format of 300 x 240 mm for your book; because of a few centimetres too many you would only be able to print eight pages at once rather than 16, the wastage would be high and the cost of the paper would almost double.

The paper wastage may appear to you to be negligible for a pilot run of a few hundred books, but if the prototype is approved for general nation–wide distribution with a run of say 50,000, the additional costs of your lack of foresight will be enormous.

Publishing Considerations

Finally, you should not forget that the dimensions you select for your textbook need not necessarily apply only to this one volume.

If you have been asked to produce a series, you should bear in mind that one feature of the set will be the identical format of all textbooks. Reconsider your decision in this light, and see if it is appropriate for the series as a whole.

2. Number of Pages

The number of pages, which is closely linked to the format, and partly determined by it, should also be stipulated at this stage.

For most books, the number of pages can only be identified once the manuscript has been written: a system of counting, called “casting off”, allows us to count the number of characters used and thus to calculate the space needed by the text once it is set. The complex structure of textbooks, however, precludes this approach. Indeed quite the reverse is true: before the authors start to write, the number of pages must be determined, and the text they write will be shaped by the exact number of pages and the relatively precise space allowed for text on each page.

We propose that you examine the following aspects and achieve as great a harmony as possible when deciding on the number of pages.

Pedagogical and Didactic Considerations

The number of pages must first correspond to the material to be covered, and the methodological approach that you have decided on in line with chapter 4. The following are the main aspects to be taken into account in

The number of pages in a textbook is decided before the book is written

The number of pages allocated for each lesson must allow for an effective layout of the contents

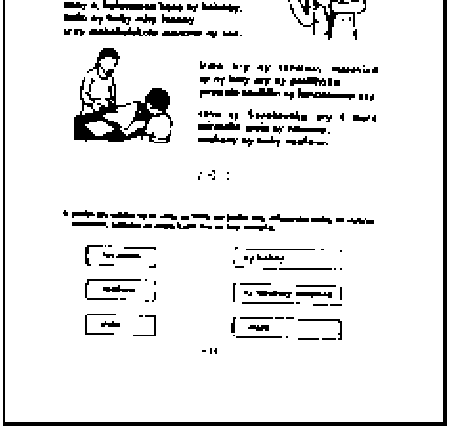
Macro–legibility of the Book

The number of pages must make for good macro–legibility. If you opt for an even number of pages per unit, the arrangement of the contents should be fairly transparent; the first page of every unit will either be a right–hand page, or a left–hand page.

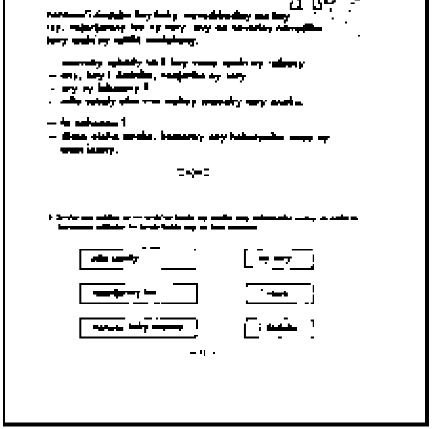
If you chose an uneven number of pages for your units, you will not get any such clear structure; the first page in a unit will sometimes be a right–hand page and sometimes a left–hand page. If you intend to have units of 3 or 5 pages in length we would urge you to reconsider the wisdom of this before progressing.

To illustrate this point we have printed the arrangement of one unit of the pilot version of *Tongavola,* a reading and writing book for grade–two pupils in Malagasy. The authors saw no other option open to them but to opt for 6–page units; the first five units address all pupils, the last is made up of supplementary exercises for pupils following a full time–table.

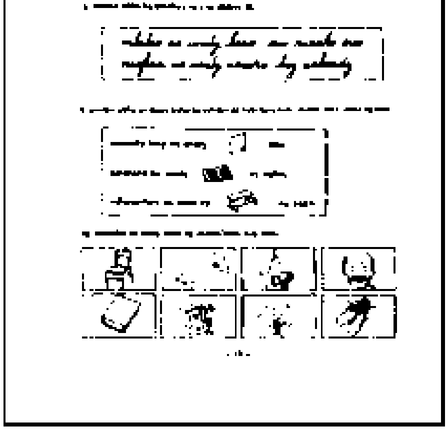
Given the heterogeneity of the contents of certain pages, it was vital for the units to have an even number of pages, to give the reader a marker in the form of the first page, which is always on the same side. The figure below shows the first unit of *Tongavola* to illustrate this.



4. Second reading text, procedural in nature, followed by a grammar exercise



5. Third reading text, narrative in nature, followed by a composition exercise



6. Additional text comprehension, spelling, grammar and vocabulary exercises

To ensure that readers can find their way around the book easily, you should opt for an even number of pages for each lesson

Financial Considerations

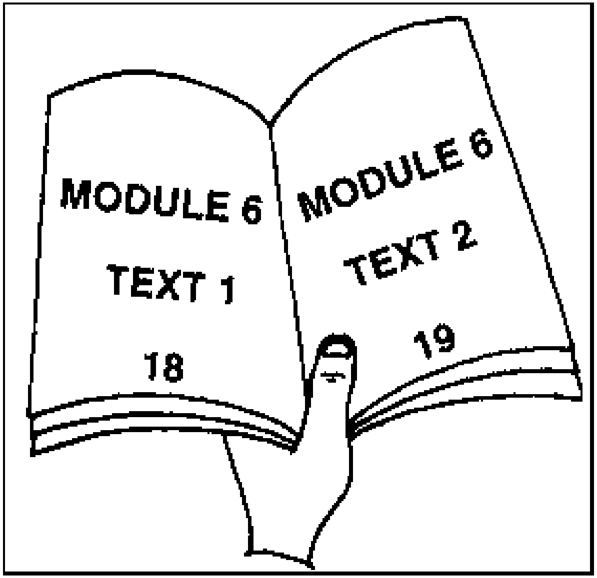
Beginners are often tempted to incorporate as much of their own knowledge as possible in their first book. Not only do they often overestimate the volume of work which teachers and pupils in developing countries can realistically get through, but they forget to gauge the financial implications of printing non–essential pages.

Paper is always expensive. Calculate for yourself the cost of an extra eight–page signature in a run of 100,000 or more.

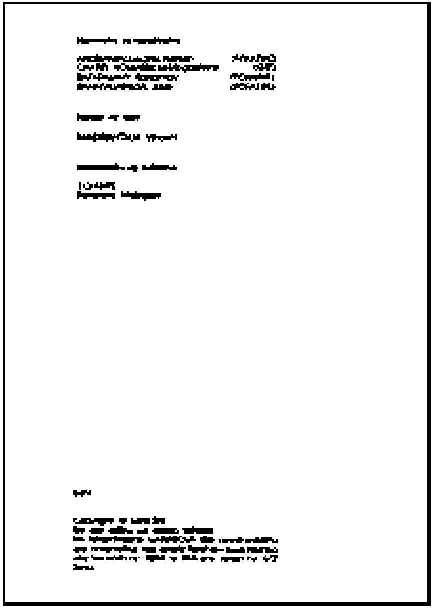
Publishing Constraints

This is the final point that you must take into account when deciding on the number of pages your book will have.

The books for each class should be at least as thick if not slightly thicker than the preceding volume. You should thus ensure that the grade one book does not take on the dimensions of a small encyclopaedia, which is bound to cause problems later in the series.

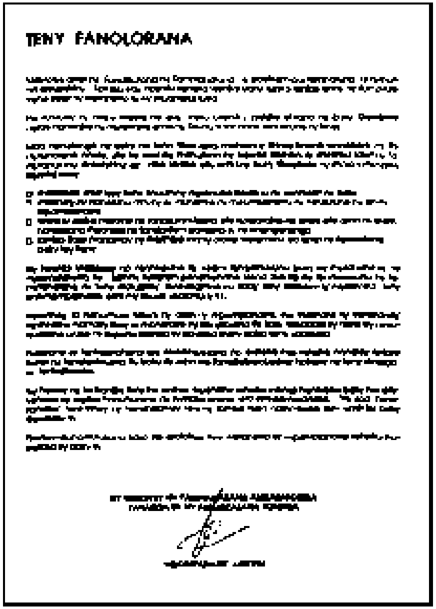


Run one last check at the end of this phase: if a page has remained blank due to an oversight it is easy to correct this oversight either at the start of the book (add a preface, spread the table of contents over two pages rather than one, for instance), or in the body of the text (in a reading book you could add an extra title attracted by the illustration, informed as to the contents of the book and told whether or not the book is officially approved.



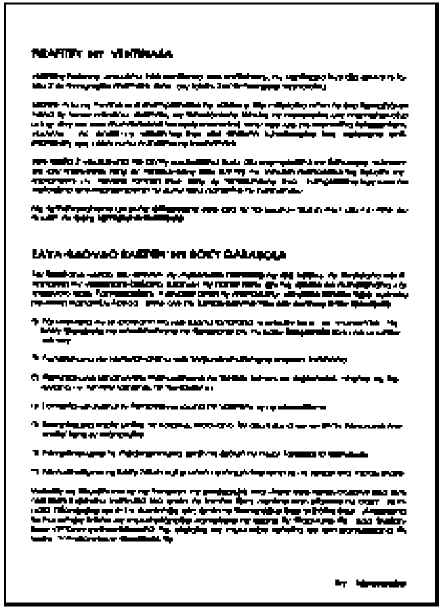
Copyright Page Contents: Authors' names; Illustrator's name; Publishing unit; Copyright Reasons: Legal reasons: Who holds the copyright; Recognition of the moral

purchaser must be told whether or not the book is part of a series; Legal and practical reasons; The printer must be specified.


TENY FANOLORANA

Preface
Contents: General preface signed by the Minister of Education
Reasons: Institutional reasons:

Reasons: Institutional reasons; Practical reasons: Even if the cover is lost the full–title page gives the essential information



Introduction to the Book Contents: Text by the authors laying out the learning targets of the book and the different stages in its completion, including the evaluation phase framework, which will probably have to be modified, adapted and specified in greater detail later.

We are touching on a field which, in large publishers, would be the task of a professional layout person. When the authors themselves are in charge, they do not always appreciate the importance of this phase, or do not have the training they need. This is why, although we describe how to proceed, we also advise you to seek the advice of a professional and to train yourself systematically to evaluate the graphic aspects of books. Once again do not be discouraged: find out about the subject by examining the layout of other books and by reading specialised books, including those listed at the end of this chapter.

Function of Visual Markers

What is the point of identifying an underlying visual structure? – to make your book a good learning and teaching tool. If it is to be a valuable tool, it is not enough to have appropriate, well–organised contents; the presentation must facilitate the understanding of the content matter, and more precisely, you will need visual markers which will clear up doubts, prevent misunderstandings, visualise the progression and spotlight key information.

To this end you must put together the various elements which make up a page (texts, illustrations and blank space) in a form appropriate to the content matter. You will create the underlying structure, which will be repeated more or less identically in each unit. In this way you will give the book a uniformity and transparency which is vitally important for pupils and teachers who have little contact with the printed word.

Organising a Learning Unit

The basic structure will be determined at unit level, i.e. at the level of the chapter or lesson. You should thus design your unit step by step, using sketches and ideas, comparing these and modifying them one after another.

If we come back to the example of a reading and writing book, you could reflect on the following basic questions:

ideas, feeling your way forward, and changing your plan time and time again

Double Pages

Once you have decided how to arrange your unit, you should examine the resultant structure of the double pages; remember that the reader will always be confronted with a double page when he opens the book, and that your basic structure must build on this.

You may find certain shortcomings and feel that you should modify the arrangement of the unit. Let us assume, for instance that for a four–page unit comprising reading and writing you had decided to alternate one page reading and one page writing. You then discover that every double page throughout the book will follow an identical pattern, giving your book an apparent lack of structure.

One double page of reading followed by a double page of writing like *Garabola,* reproduced at the top of this page will give you greater transparency and dynamism.

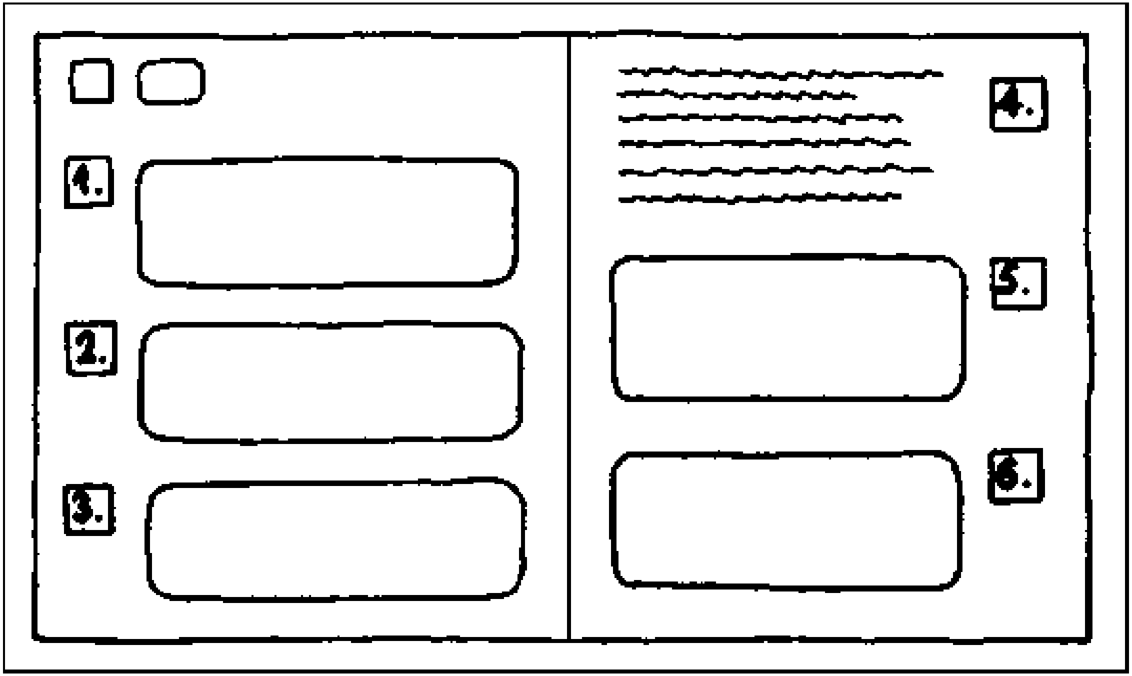
The Page

If you are satisfied with the organisation of the double page, it is time to look more closely at the organisation of the individual pages. You must look at the size of all the elements which go to make up a page and make any necessary changes.

By the end of this phase you should have a rough model of the contents of your book, page by page

There are no universal prescriptions for a good page layout, but the following pointers are important. Avoid cramming the page too full and leaving it too empty; if you intend to put together an illustrated text and an exercise on one page, sketch the layout for each, and do not hesitate to revise your decision if you find that you don't have space to present the exercise properly at the bottom of the page. If you have a page of

Right–hand side; A table of new words; A text to reinforce what has been learned; A visual reminder of the new grapheme



The two pages dedicated to writing consist of

Left–hand side: Words to read and copy in joined–up writing; Two–syllable words to write and copy; Ditto.

Right–hand side: A space for a text to reinforce the writing of syllables based on vignette;

Photos			
Realistic drawings			
Abstract drawings			

Purpose of the Illustration

Decide now what you want to achieve with the illustration; this will give you an initial idea as to which type would be best suited to your needs.

If, for instance, your primary aim is to impart information to the reader, you will find photographs (in history books for example) or abstract drawings (maps, diagrams, etc.) most suitable.

In a reading book, on the other hand, the illustration allows young readers to recognise visual elements from their own environment and thus to identify with the book at an emotional level. It facilitates the move towards the written word and helps young readers memorise certain written elements. The reader must thus be able to decipher the illustration with as little doubt and uncertainty as possible.

Realistic drawings, which allow the reader to select the relevant elements and discount any unnecessary information will often be more suitable than photos here.

Financial Considerations

The type or types of illustrations you have selected can be printed in three different ways: either in 4–colour, which will give you colours that are very close to natural shades, or in two colours, generally black and a light colour, or in one colour, which is usually black.

Sometimes the purpose of the illustration will force you to use colour; usually though your choice will be guided more by financial considerations, taking into account the following points in particular.

Image Processing

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 or plates) fitted, the presses regulated, set, and of course the colours printed separately. For limited runs, the costs can be exorbitant[14].

Two–colour printing, on the other hand, lightens a purely monochrome print, by using black (and the various shades thereof in grey tones) and orange (and the shades from a very bright orange to the palest hue). The result is sometimes perceived by an uninitiated reader as being a “colour print”. Although the procedure is considerably more complex than monochrome printing it offers better value for money than 4–colour, especially in developing countries, where the screens are prepared by hand, making them fairly cheap.

Imposition

You may not plan to use colours on every page. If only some illustrations are to be reproduced in colour, you must identify which illustrations and which pages are involved.

You should then ask the printer about his imposition, i.e. the way pages are arranged on the sheets of paper for printing. Try to put the illustrations to be printed in colour on one sheet of this sort, since this can make for major savings[15].

Paper and Printing

If you are considering 4–colour printing, do not make a final decision until you are certain that the paper and the printing are of good quality.

> **There is no point in 4–colour printing on poor quality paper or under mediocre printing conditions**

The paper must not look like blotting paper and must be sufficiently opaque for the printing not to shine through onto the other side; “bulky news” (the paper used to print newspapers), for instance, which is 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 ensure that it is within the limits of your budget.

To this end you will have to draw up your technical specifications, which will determine the costs of development and of manufacture.

Development Costs

In large publishing houses the publisher determines the costs of writing the manuscript and of the artwork. In other words this is the latest time to decide about the entitlements of the authors and the illustrator or photographer.

In general a distinction is made between the moral rights of authors and the royalties; the first entitles them to associate their name with the book that is considered to be their work, and the second could be considered remuneration for their work.

If you have worked on behalf of a private publisher, you will generally have to renounce the rights to your manuscript for a lump sum payment or a certain percentage of the sales price, in exchange for which the publisher will undertake to print your name in the finished work, among other things. If, on the other hand, you are a civil servant and produce textbooks within the scope of your normal duties, the ministry may not recognise your literary or artistic property, considering that this would make too great a distinction between your work and the work of your colleagues, which is just as important but much lower profile (e.g. in the field of teacher training). In this situation, certain international organisations specialised in this field, e.g. UNESCO, may be able to suggest a solution that is satisfactory to both sides.

It is a complex subject and the situation is changing all the time. Given the special profile of “publisher–authors” in some developing countries, certain international organisations are starting to re–examine the rights accorded to authors working within state structures, with a view to upgrading their work. Contact the body which has charged you with producing the book and settle this issue without any further delay.

Printing

Under this heading the printer will look at three items: the inputs, such as ink, the costs of labour and materials needed to undertake the preparations for printing, (preparing films, process work or plates), and the labour costs of printing the book (the inside pages and the cover).

The printer must know what size the run is to be, i.e. how many copies are to be printed, before he can calculate his costs.

Finishing

This heading includes all the costs of folding the signatures, putting them together to make the body of the book, and binding the finished book.

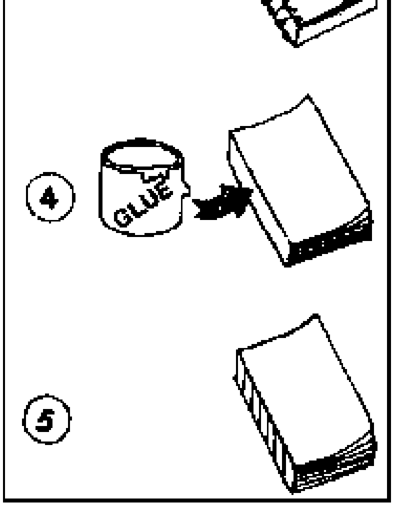
Educational materials need a firm binding

You should pay particular attention to the binding of your book – it would be madness to jeopardise all the work you have already put into the development by choosing the wrong binding.

The world of binding is complex, but we can sum up what you need to know as follows (see illustrations on the following page):

- Saddle stitching with staples is cheap, but there is a danger that the pages may fall out if the staples are too short. It is not suitable for thick books, since, when you come to trim the book, you will have to trim the pages in the middle more than the outside pages; this is unaesthetic and can be dangerous if the margins are narrow, since you run the risk of trimming away some of the text. (Fig. 1)

- Signatures can be block stitched (i.e. stapled flat) and then stuck together to the covers. This is a firm binding, which is relatively cheap, but it has the disadvantage that it is difficult to



Paper

This heading covers not only the price of the paper, but also the cardboard used for covers and any treatment required (e.g. reinforcing the cover with plastic).

Again, find out about the main features of the paper from your printer (whiteness, thickness, tearing strength, impermeability, smoothness, price). Ask him what quality of paper and cardboard he can procure.

The quotation you are given should be considered provisional; it is a guideline for you to help you ensure that your decisions are well–founded, and to allow you to make any necessary modifications.

The instructions you give the printer must, however, be as clear and complete as possible – as should his quotation. If you do not pay enough attention to this point you may have a nasty surprise later, and you may not be able to pay the additional unforeseen costs.

These individuals will review your manuscript and help improve it. They will include proof readers to eliminate typing and printing errors, educational advisers who will ensure that the book is appropriate for the teaching and learning conditions in rural areas, subject specialists who will focus on the contents, etc.

We recommend that you look for these individuals at as early a stage as possible and that you obtain their agreement in principle to work with you. We will look at the cooperation with them in more detail in the next chapter.

Publishing Unit

If the publishing unit rather than the printer is to typeset your texts, you will have to ask it to do the following:

- firstly, once the first unit of the textbook has been written, the publishing unit will set it to give you an idea of the length of the texts and the provisional layout;

- once the entire manuscript is completed, it will set all texts, including those that do not address the pupils (introduction, table of contents, etc.);

- finally, once the proofs have been reread and corrected, it will make the changes you want and do the layout on the basis of your detailed instructions.

In view of the fact that this unit is bound to have other commitments, lay down the approximate date on which you intend to submit your manuscript now so that the publishing unit makes time for you.

The Printer

Agree on the various things to be submitted to the printer, and the dates he can expect to receive them.

Work Schedule

By the end of the conceptual phase you should have drawn up a detailed work schedule, which will allow the textbook to be ready for the start of the academic year planned.

To give you an idea of the time needed, the table overleaf shows the planned schedule for the development and production of the pilot version of *Garabola.*

Keep a careful record of all decisions made during the conceptual phase

Notes

[1] Re–read the first point in the first chapter of this book to refresh your memory if necessary.

[2] The basic form of textbooks is always a rectangle, which creates a certain dynamism, rather than a square, which would neutralise tensions; for interesting ideas on this topic see Duplan, P. and Jauneau, R. *Maquette et mise en page,* p. 93–99. Paris: Usine Nouvelle, 1986.

[3] We have adopted the distinction made by F. Richaudeau between the "legibility corresponding to the integral reading of the lines of a text, or micro–legibility, (and) a second type of legibility, which corresponds to the image of the page as a whole, or macro–legibility." In: *Manuel de typographic et de mise en page,* p. 9. Paris: Reitz, 1989.

[4] The limits of readability, as stipulated by M.A. Tinker for primary school children in the USA are as follows:

Grades	Bodies of letters
1	14–18
2	14–16
3–4	12–14

Cf. Typography for children's books. In: Bases *for effective reading,* p. 155. Minneapolis: University of Minnesota, 1965.

This means that the largest lower case letters without ascenders or descenders should be some 3 mm high (body 18), while the smallest characters should be some 2 mm (body 12).

The most common paper dimensions in the "A" series (in mm) are as follows:

A0: 841 x 1188

A1: 594 x 841

A2: 420 x 594

A3: 297 x 420

A4: 210 x 297

A5: 148 x 210

[10] There are, of course different ways of folding, cross folds, former folds, etc. It may be a good idea to use a combination, but the printer will have to plan for the necessary folding and inserting, and calculate the costs. Contact him and check that you have not made a mistake in either your choice or your calculation as to the number of pages.

[11] There are ways and means of not using a 16–page signature for non–text information; the printer is bound to suggest a half–signature (8 pages) for instance. If you are apprentice authors, we suggest that you do not go into this in any more detail, but that you consult the printer, and devote your own time and energy to tasks where you have no back–up.

[12] Beware of yourselves – authors who demand that their book be printed in 4–colour are always convinced that they are right and can easily fall into the trap of accusing anyone who disagrees of thinking small, and wanting to throw a spanner in the works. Our most recent experience in this regard was a group of authors who wanted four–colour printing in a first–grade maths book because of pictures of butterflies in some exercises.

[13] You must bear in mind that every additional step in the production, even apparently simple steps, can entail unforeseen complications. When fuel is sometimes rationed, for instance, the printed may be tempted to clean his machinery less scrupulously, since petrol is often used to clean printing machinery.

Manufacturing Costs

DURCHON, P. *Photogravure et impression offset.* Paris: Usine Nouvelle, 1987

SMITH, D. *Les problèmes économiques de l'édition des livres dans les pays en développement.* Paris: UNESCO, 1977

Author's Rights

ALTBACH, P.G. Copyright in the Developing World. In: FARRELL, J.P. AND HEYNEMAN, S.P. (Ed.) *Textbooks in the Developing World.* Washington D.C.: World Bank, 1989

COLOMBET, C. *Grands principes du droit d'auteur et des droits voisins dans le monde. Approche de droit comparé.* Paris: Litec, UNESCO, 1990

UNESCO *L'ABC du droit d'auteur.* Paris, 1982

To Sum Up

Once the authors have defined the subject matter to be covered by the textbook they are still not ready to start writing: they still do not know how long the texts should be or how to fit them together with the artwork. To allow them to write well–founded texts and avoid the blunders that a poorly planned assembly of texts and illustration would entail, they should draw up a model of the book.

Before you design each page, it is important to define the main physical aspects of the book as a whole, in particular the format and the number of pages. It is equally important to think about the graphic aspects, i.e. to work out a provisional layout and decide on the nature of the illustrations. Much of this work demands specialised know–how, which is why publishers contract specialists who report to the production manager and the artistic manager.

Writing the Text

During the previous phase you decided on the contents of your textbook and on the artwork, which enabled you to define the sequence of the learning matter to be covered, and to lay down a basic visual structure for the book. The phase you are about to start will be a continuation of this work, culminating on one hand in finished texts and exercises, and on the other in the sketches or “roughs” for accompanying illustrations.

The literary and graphic work during this phase must go hand in hand. In large publishing houses the authors are responsible for the literary side only, while the artwork is entrusted to a layout man and/or a graphic artist. In developing countries, however, authors are almost invariably responsible for both sides. In this chapter we will first look at the preconditions for creating what Richaudeau terms the “text–image couple”[1], before going on to look at the subsequent stages step by step.

Some of you will be sufficiently familiar with text–writing for it not to present any major difficulties. The visual presentation and illustration of texts and exercises on the other hand will be new ground for many of you, and difficult for all of you. You will have to understand the importance of bearing the visual aspect in mind as you write your texts. You will need to learn to do so by constantly weighing up the demands of the text and the presentation.

Even if you are no longer a novice where writing is concerned, we would urge you most strongly to read this chapter thoroughly, to ensure that you glean not only scattered pieces of information, but the entire systematic approach. Put yourself in the place of authors who have defined a detailed conceptual framework, and must now write, present and illustrate the contents of their textbook within a relatively short space of time; read the chapter from start to finish, point by point.

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.

Why, you may ask, can't we get down to writing the texts at last after all the research and the conceptual work? Because you must firstly define the framework, without which your subsequent work will be subject to inopportune interruptions. You should thus accept a certain amount of “lost time” at the start of this phase in order to guarantee optimum writing conditions. Look in particular at the following points.

Start by deciding how much time you will need for the writing phase

Rate of Working

Take stock of the work ahead of you, before you do anything else. Recall the number of texts to be written: for a reading and writing book with 24 units, for instance you will have to write 24 texts if you plan to have a single text per unit, or 48 or 72 if you plan two or three texts respectively per unit.

Then recall the principal features of the contents and the presentation of these texts: to take the above example, once again, look at the sort of texts (adventure stories, fairy tales, historical texts, scientific texts, etc.), the approximate space available for each text on the page, and the average size of characters to be used. You should then turn your attention to the number of exercises to be devised: if you plan to devise two pages of exercises for each of 24 units or lessons with three exercises per page, you will need no less than 144 for the textbook as a whole. Finally, you should count the number of general information pages and look at the length of texts on these pages.

Now and only now can you set the markers which will allow you to lay down your time schedule. You should either lay down a daily or weekly quota for the writing work, or set deadlines for the individual parts of the book.

23. Developing the Garabola Reading and Writing Book

	Once the manuscript was completed, various people from outside the group of authors reviewed the texts checking the linguistic aspects (pertinence of newly created technical terms, correctness, clarity, uniformity of style), subject−related aspects (coherence and exactness of contents), and pedagogical and didactic aspects (suitability for the given teaching and learning conditions). Others reviewed the illustrations from the pedagogical angle (clarity, exactness and pertinence of the scenes or objects represented), and from the cultural and political angle (respect of local customs, representation of scenes that are applicable for the country as a whole and not just certain regions).
Writing General Information Pages	
	The authors wrote texts for the cover and general information pages at the front of the book, taking into account pedagogical aspects (the technical presentation of the textbook), legal requirements (credits and copyright), institutional factors (preface and mention of the ministry), and editorial conventions (on the covers and all pages in question).
Preparing a Copy of the Manuscript	
	Having examined the internal suggestions and those of the external reviewers, the authors modified the initial manuscript and had a typewritten version prepared.
Preparations for Official Approval	
	To obtain authorisation to print, the authors prepared a file for the education authorities, containing a list of information and a hand−crafted mock−up of the textbook, on the basis of the typewritten manuscript and photocopies of the sketches. They were granted authorisation to print, the final layout was performed and the graphic work finished: the two files were then submitted to the printer to allow him to start work on the textbook.

Whatever you decide, try to avoid two common errors a) under−estimating the volume of work which is not directly related to writing, such as organising external checks; just when you think you have finished writing, you will often need several weeks more to complete the manuscript; b) with reading and writing books, under−estimating the level of complexity of the exercises, and not planning the development properly.

texts for a reading book. Read these and adapt them to your own particular situation.

Individual Writing and Correction

Here, the texts are written by individuals, revised at individual level and then, perhaps commented on by the group.

Individual writing can jeopardise the uniformity of the texts

24. Work for which authors are responsible		
To allow you to gauge the scope of the work for which authors are often responsible during this phase, we list below the tasks from the previous table which fell to the authors of *Garabola.* We have made a distinction between the work they had to perform themselves and the tasks they only had to organise or supervise.		
No.	Task	Organisation and Supervision
1	Overall plan of texts and artwork	
2	Devising and writing reading texts	
3	Internal revision of reading texts	
4		Preparation of illustrations for reading texts
5	Correcting sketches	
6	Devising and developing writing exercises	
7	Internal revision of exercises	

or at least on a general direction, a basic text which can then be reworked to a greater or lesser degree.

25. Identification of Key Words in the Group	
In reading books graphemes are generally systematically introduced with the help of certain words known as "key words". Team work is needed to identify these words. It is the best way to harmonise criteria as demanding as those listed below.[3]	
Productivity and interest for pupils	
	The key words must trigger a strong emotive response in the pupil. If the basic vocabulary of the pupil has been studied, you should refer to the results of this study and select the most frequently occurring words.
Pedagogical and didactic considerations	
	Key words must reinforce the new element which the pupil is to learn in the course of the lesson. If it is a consonant, it should be at the start of the word, or at least at the start of the syllable.
Simplicity of syllable structure	
	Wherever possible, you should select key words made up of V (vowel) syllables or CV (consonant–vowel) syllables; try to avoid CVC syllables, which would be an obstacle later when you come to splitting words into their component syllables.
Control of new **elements**	
	The new element which is the object of the lesson should, if possible, be the only unknown element in the key word; you should thus avoid choosing key words with more than one consonant or vowel elements which has not already been presented systematically.
Grammatical category	

run harmoniously over a longer period.

Working Language

If you are writing textbooks in a national language, it is conceivable that some members of your team may not speak this language. You will then have to agree on a common working language; this situation, common in projects which have received external technical or financial assistance is certainly not ideal, but it is sometimes unavoidable.

If, on the other hand, all the members of your group speak the national language in question, and this is accepted as the working language, other problems may arise to which you should be receptive. If the language in question does not have a long written tradition, it will often lack the technical terms you need, or these terms will not be precisely defined, lacking the background information which surrounds these terms in languages with a long written tradition. A certain laxity can result, which will prevent the national language from being an effective tool, consistent, diversified and precise.

Thus, if you are dealing with a teaching syllabus, will the language provide you with one word for “goal” and another for “finality”? Would you know how to say “sequence of numbers”, “set of numbers”, or “double–entry table”, all terms which will be vital for first–grade maths? How can you express “key word”, “word card” “word table” or “minimal pairs” so important for the development of reading materials?

Agree on the language of communication
Identify key words together

If your work is too often interrupted by terminological considerations, you should analyse this handicap, and take appropriate steps, to allow you to complete your work. You can systematically record neologisms and put them on the board to farce yourselves to use them; or draw up a definition of terms which you keep stumbling over. You can include these definitions in a glossary at the back of the teachers' guide.

Write directly in the national language to follow the logic of the 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.

This approach too is less than perfect; in particular, if we take up the same example, the pedagogue is not always able to judge precisely whether or not his instructions concerning reading have been fully understood and correctly translated.

Yet, it is often more effective than translation. Firstly, it allows those in charge of writing texts in the national language to re–formulate technical information in their own language; they can move away from the initial wording and organise the information appropriately, following a chain of argument which will be better understood by readers, and especially by teachers[4] – the local writers are in a much better position to judge this than the external specialist.

This formula also allows all those concerned to see themselves as fully fledged authors and thus to identify with the product which really is the result of a joint effort.

3. Texts Addressing Pupils

You have now organised writing and defined your framework. Your next objective is to produce a manuscript for all the reading texts, that has been revised by the group of authors.

To achieve this as methodically as possible, we suggest you take a step–by–step approach, as described below.

Criteria

Whatever the discipline and the grade, you must always base your pupils' texts on precise criteria. Do not simply agree that these texts should be dictated primarily by pedagogical and didactic considerations; take it

First of all check how the curriculum defines the role of the school within society, and see if detailed topics are listed as is often the case. If this applies to you, check whether you are bound to remain within the official framework and tackle a certain number of topics.

Type of “reading book”

At this stage you must decide what sort of reading book you want to produce. It may address solely native speakers learning their own language, in which case the aim will be to improve their reading skills, which will give you a lot of leeway to choose topics. However, when pupils have only a reading book and a maths book, you should consider whether a simple compilation of reading material is really the best option. You may chose to add texts which will introduce children to common scientific, historical and geographical knowledge for instance. This is a fundamental decision, which is bound to have repercussions on the choice of topics and on the curriculum.

Social Options

The topics broached in a primary–level textbook will help form the adults that the pupils very soon become, especially those individuals who will read few other books in the course of their lives. It is up to you to organise an in–depth discussion to define the factors which you believe should be given priority, where the curriculum is vague.

Openness to Innovation

Finally, bear in mind that it is difficult for authors of primary–level textbooks to find resource material: try not to fall back on your own experience and on the past. Read and re–read as much as you can, from legends to adventure stories, from extension manuals to foreign books, from cartoons to the best books written for children world–wide, to put you in a position to innovate as regards the content matter. Textbooks for the upper classes of primary level will always demand a lot of preparatory work here.

Development of a Model Unit

	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 languages with a primarily oral tradition, which are not easy to dissect in this way.
Readability of texts	
	The texts must be clearly structured, with an introduction, however short, and an unambiguous conclusion; within the text the sentences should follow on one from another. If necessary the text will be divided into paragraphs, which will also follow on logically. Punctuation marks, which underline the structure of the text should be introduced gradually and with discretion.
Functional texts for teachers	
	Texts should be structured to make them easy to read in class. Thus, if a text is to be read at two sessions, it should be written accordingly, i.e. in two main sections, not counting the introduction and the conclusion.
Degree of visualisation	
	The words, sentences and texts must be selected to provide an appropriate degree of visual back–up so as to form a whole which meets both pedagogical and aesthetic demands.
Familiarity to pupils	
	The topics dealt with should be at least known to the pupil. In a first reading book, they will be dictated by the choice of key words and should preferably be taken from the pupils' immediate environment. Subsequent reading books should expand their scope gradually to take in the region, the nation and then other countries.
Variety of topics	
	The topics selected must be varied enough to hold the attention of pupils. This is a difficult criteria to meet in an entire series: authors frequently repeat themselves, with the

	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.

Initially stick to the first unit, which will be a sort of test ground for you, and adopt a three–step procedure: refer to the basic structure and work out approximately where the texts and illustrations will be; write the texts in question and decide on the contents of the illustrations; prepare the text with the size of characters required for the level in question, which will allow you to see the average length of texts in the book, and prepare a sketch for the illustrations.

We would advise you to tailor your procedure to the subject and the grade concerned. Thus, if you are responsible for producing a series of books for pupils learning their native language at primary level, you should distinguish between the two types of book described in more detail below.

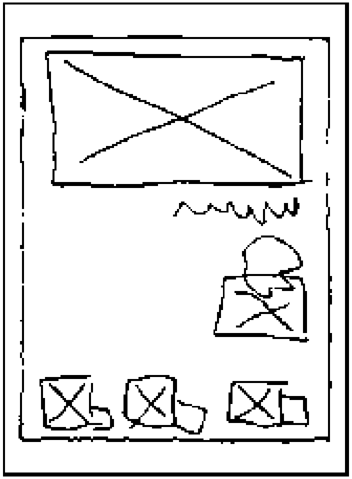
First Reading Book

Given the primordial importance of the picture, which will take up a large part of the page and form a bridge between real–life and the new technology of reading, it is often preferable to work manually. You should thus draw up test pages in the correct format, and then write very short texts yourself, and make a rudimentary sketch of the illustration to accompany the text.

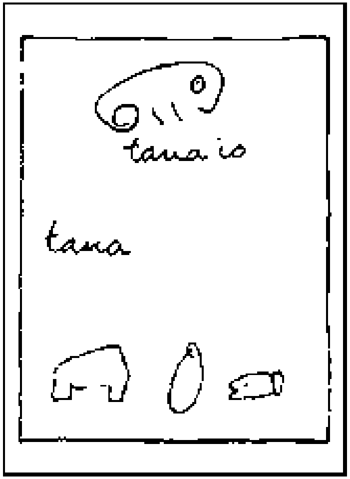
In view of the fact that this parallel approach to text and image often leaves a lot to be desired we have reproduced opposite the steps involved in the birth of one page of *Garabola.*

Books for Other Grades

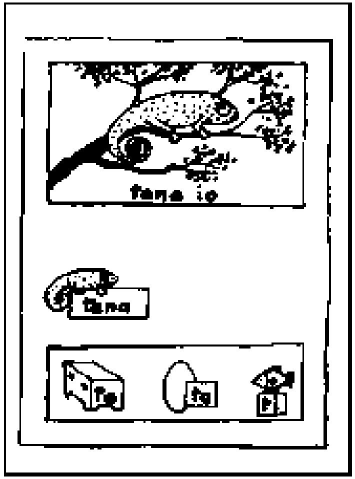
When the texts are more dense, it is more difficult to assess the length. If you are working on a book for a higher grade, submit the first unit to the publishing unit, which should typeset it in line with your instructions. You can then re–work the text to ensure that it is of the right length, and make a sketch of the drawings planned.



1. Conceptual phase – the contents and the form
Contents are defined and a mock–up of the page completed.



2. A text–image unit is created and the text written
Texts and sketches of illustrations completed.



3. Layout and illustration
Text typeset, layout finalised and illustrations done in ink.

Remember, you cannot postpone this work; it must be completed before the other external revisers start their work. We would suggest that you examine the following aspects in particular.

Legal Aspects

Many of you will be well informed about the rights of reproduction and know that it is strictly prohibited to reproduce texts or illustrations without authorisation[10].

Although authors do not generally infringe copyright, they may have absorbed existing texts to such a degree that they reproduce them, as they are, changing only details. Even if they are not aware of this, they will be

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 number of syllables. List the words used only once and try to limit these. Look at the intervals at which words are repeated, etc. If you are producing a textbook for upper grades look again at the linguistic readability which you considered in advance, and see if you have respected your own criteria.

If, on the other hand, you are producing a book in a language with no written tradition, you should run specialised linguistic checks, for which it may be difficult to find back–up literature.

Given the importance and the complexity of the subject, we will take the liberty of dwelling on it a little in the table on the following page.

4. Exercises

The first version of the reading texts has now been completed. If your time schedule permits, you can put these on hold and concentrate on the rest of the book. If you are working under time pressure, as will often be the case, however, you should first finalise the artwork, adopting the procedure laid out earlier, so as to ensure that the illustration work can run parallel to your work on the exercises.

Writing exercises, unlike copying or traditional "fill–in–the–gap" exercises demand special skills. Since there is little specialised training available in this field, authors with the skills required to design good exercises are equally extremely rare ... and those who appreciate the degree of difficulty of this work are even rarer.

We see the results of this shortcoming everywhere: in some European textbooks the objective of the exercises is anything but clear, the mechanism used is sometimes overly complicated, the games aspect is often poorly represented and even errors are not unheard of[11]; textbooks produced in developing countries often dedicate a limited space to exercises, and reflect a certain disarray on the part of the authors.

	In view of the fact that textbooks venture out into the world beyond the school yard, they can be deemed to play a primordial role in the normalisation and standardisation of national languages. The authors must thus help create a coherent, homogeneous and dynamic linguistic environment. Some of you will be able to consult a language planning institute or the linguistics faculty of a university[12] while others will have to solve the problems they encounter alone. In either case you should pay particular attention to the following aspects.
Spelling	
	Without a solid spelling system there can be no proper readability: the human eye which can easily memorise the contours of words stumbles over words written in diverse fashions with no rhyme or reason, and the reader is unsettled, particularly if he is only a beginner. It is thus important to read and re–read your manuscript, and to have it read by others to ensure uniformity. You will always come up against awkward cases, which cannot be solved with the help of your reference tools (at best a dictionary and a grammar book) alone. Ensure that the two following aspects at least are standardised:
	Separation Check the criteria for separating elements, particularly in nouns and composite verbs, and ensure that you have used hyphens and apostrophes consistently throughout. If you intend using justified type, in columns, decide at this stage what criteria are to be applied to hyphenation and ensure that these are strictly applied.
	Borrowed words National languages always borrow words from the European language with which they come into contact. In general, there is no homogeneous rule for writing these words: uncertainty rules as to whether to take the original spelling or whether to adapt it more or less to fit the phonology and spelling system of the national language. Although it is not your profession to establish spelling standards, it is up to you to make the language first and foremost a valuable learning medium, by observing strict and consistent rules regarding the form of borrowed words, verifying that these

	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 apply the code of the former colonial language which they themselves learned at school; they only realise this at a later date when the punctuation rules that they know and that are appropriate for the European language in question causes dissonance in the national language. Before punctuation rules can be formulated in–depth linguistic studies are needed, which cannot be the task of textbook authors. Once again, we can only urge you to be vigilant: firstly do not create rules which are unnecessarily at odds with those of the second language which the children will have to learn later; secondly bear in mind the fact that it is easier to create rules of usage than to modify them later, and thirdly beware of any uses which create vague feelings of unease; solve the problems as best you can and then apply the punctuation you have created uniformly since textbooks are a powerful force in standardising a language.
Spoken and Written Languages	
	National languages tend to be primarily spoken languages. You should complete your linguistic checks by analysing the level of language of your manuscript. See in particular whether the circular logic which is characteristic of oral discourse has been satisfactorily replaced by the linear logic common to written language. Once again, there is no simple solution, and no standard advice except to keep your ears and eyes open to the reactions of the individuals outside your group who re–read your manuscript.

Attainment Sub–Targets

The first criteria of an exercise is that it correspond to a precise attainment target. Even if you identified learning steps during the conceptual stage, you will now see that these are too vague to be directly translated into exercises.

To allow you to work properly, you will thus need to break down the general attainment target into a number of sub–targets. To this end you will bring together the basic structure, which stipulates how many exercises are planned per unit, and the sub–targets, which you should list by priority, thus ensuring that the most important 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 them, make them more detailed, so that they fit the bill for your specific situation and the language you are working in.

In either case though, do not simply accept the first mechanism that comes to you. Try to improve on this and keep all your drafts. They may be useful later, especially when you do the layout.

Devising Model Exercises

The activities outlined above should allow you to go on to devise the exercises for your first unit, which will give you a frame of reference for the rest of the book.

As you saw when you came to write the texts, you should adopt a three–step approach here. Firstly check how much space has been allowed for each exercise in the basic structure. Secondly look at your draft exercises and select those which best correspond to the principal criteria we looked at earlier. Thirdly either prepare sample pages in the same format as the book, or give the exercises to the publishing unit and let it do this where the exercises are longer. Sketch in the illustrations. Either way, this first unit will allow you to judge the average length of the exercises.

> **Step by step with the help of sketches, drafts and numerous new starts the exercises will begin to take shape**
>
> **An exercise must meet a number of primarily pedagogical and didactic criteria**
>
> **The exercises must also meet certain aesthetic criteria**

28. Criteria for Developing Writing Exercises

Mechanism that pupils can follow	
	The exercises must be in line with the level of maturity and knowledge of the pupils; thus exercises that are too easy or too complex must be rejected, as must those that would require too many explanations on the part of the teacher. Appropriate exercise types should be identified and repeated several times, perhaps with slight variations to avoid pupils wasting too much time and energy understanding the mechanism.
Games aspect	
	The exercises must meet the demands of the subject matter in question, and be tailored to the target group; if the latter is made up of young children, they will learn more rapidly and easily if the exercises have the appearance of a game.
Harmony of exercise–image entity	
	The presentation of the exercises and any illustrations must form a harmonious whole with the content matter; the form must not only meet aesthetic requirements, but should also help pupils to understand the contents and/or the mechanism of the exercise.
Harmony of the double page	
	Not only must the exercises follow a logical sequence, they must be placed in a harmonious fashion on each double page. For young pupils, for instance, care should be taken that the exercises which comprise only text alternate with text illustrations to make the pages “airy” enough.
Professional aspect	
	The presentation of exercises will implicitly convince readers of the professionalism of the team of authors. Sometimes we forget that certain graphic aspects of the book, including the presentation of exercises can be decisive for decision–makers who cannot necessarily judge other aspects of the book. Thus exercises that are too “home–made” in appearance should be abandoned and replaced

Example of presentation of content matter
World map to illustrate the use of capitals (Rosovola, p. 78)

As you will have realised, once again the form and the content matter go hand in hand. Take care to select a form which is both functional and aesthetic; the form must allow you to present the mechanism of the exercise visually or to illustrate the content. Here is an example of two exercises where the form is a good illustration of the content matter.

Designing the Other Exercises

You should be able to design the other exercises without too many difficulties now, although this is not always the case. During this phase, authors often encounter obstacles in terms of the mechanism, the contents or the presentation, which force them to make modifications. Let us assume, for instance, that the planned exercise! Thin out exercises where the sheer length is off–putting.

Ensure that there is a balance between the form and the content matter: modify exercises that take up too much space for a limited subject matter, for instance.

Secondly, look at the harmony of the individual page and the double page. In books for the first few grades, you should pay particular attention to alternating exercises with examples or special presentations (words in a box, or a circle, for instance). You should always ensure a balance between the exercises on facing pages.

> **Undertake to excel in all aspects of the exercises, correct them, polish them, re–write them entirely if necessary until you are completely satisfied**
>
> **No three–word exercises and no "essays" of instructions that are twice as long as the exercises**

Publishing Considerations

At this level, you can record in detail the illustrations, writing and layout for the exercises.

Look first at the number, contents and dimensions of text illustrations or other illustrations to be produced by an illustrator. You should also plan the volume of text to be written in cursive style: if you do not have a computer programme which can reproduce italics, some of which are in any case unsatisfactory, and all of which are costly, you will have to have these parts written by hand. In some countries this is the work of professionals.

Finally, you should check the complexity of the presentation of exercises and ensure that the publishing unit can reproduce the layout you have planned.

assessment of your work, and identify any fundamental errors which other proof readers will probably not notice.

Education Authorities

Identify the education authorities whose support might be important when the book is introduced in schools and involve them in the production of the book by asking them to make their comments which can still be taken into account if they are pertinent.

Animateurs in Rural Areas

Make a special effort to gain the support of animateurs in the test zone; given their excellent knowledge of the area and their training, they are often best placed to assess whether or not the material is appropriate for the normal teaching and learning conditions. If possible try to reserve several days to re–read the manuscript in their company.

You should also bear in mind that the same animateurs will be responsible for supervising teachers in the test schools during the test phase, and that as such they should be involved in the process of producing a book which they will have to explain and perhaps defend.

Teachers

If you have produced a pilot book, you will plan to run a test in a sample of schools and then evaluate the results of this test phase. It is thus in your own interest to involve the teachers concerned in the production of the materials, by asking them for their opinion of the manuscript. Often it is not so much their comments per se which will be important, but the chance they are given to identify with the materials they will later be expected to use. This identification is crucial for the adoption of the material.

Parents

This phase, which in large publishing companies is the responsibility of the publisher, can mean a great deal of extra work for textbook authors in developing countries; sometimes you may have to undertake several trips into the field, organise trips to the main district towns, plan and chair meetings to pool results, etc.[15]. But, given what is at stake, we recommend that you plan and execute this work with the rigour which you have adopted throughout.

Think of organising proof readers as a mini–project in its own right

6. Writing the General Information Pages

After this phase of contact with the outside world you will have to return to your garret to finalise the manuscript.

You still have to write the general information parts, which generally make up the first few pages of the book and those found on the front and back cover. Pay attention to the following aspects.

First Pages

The first few pages contain the information which we looked at in more detail in the chapter on the concept of the physical and graphic aspects of the textbook.

Don't relax once the pupils' texts are finished – you still have to write the general parts of the book

Write these parts carefully, because they will be a visiting card of sorts for the entire book. These are the parts that will be examined first by all adults interested in your book.

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 irreversible and any modifications that can still be made will be long, difficult and costly.

Check the procedures for printing your textbook at the end of this phase, and act accordingly before having the typesetting, layout and illustration work done.

Notes

[1] In: *Conception et production des manuels scolaires,* op. cit, p. 88 (in inverted commas in original text.)

[2] We look at the illustrations in more detail in the next chapter; whenever the time schedule allows, it is preferable for the illustrator to start work when the precise format and place of the illustrations has been determined. It is up to you to decide whether or not you have time to proceed in this exemplary fashion.

[3] These criteria, which were initially drawn up to help identify key words in Quechua, can certainly be used as a reference for other languages. Cf. Châtry–Komarek, M. *Libros de lectura para niños de lengua vernácula.* Eschborn: GTZ, 1987.

[4] “You argue, and we attempt to convince”, as one of the Tef'Boky authors summed up the difficulties of translating a French text with a linear structure into Malagasy for primary school teachers. Antananarivo, June 1990.

[5] These criteria were systematically applied to the reading books produced for the first two years of primary schools in Madagascar, *Garabola* and *Tongavola.*

[6] Many studies have been conducted on the controlled use of words in reading books for primary level: we would refer you, for instance, to McCullough, C. and Chacko. C. In: “Developing Materials for Instruction, In: Staiger, R.C. (Ed.) *The teaching of reading.* UNESCO/Ginn, Paris: Lexington, 1973.

[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 read is a case in point; it was extremely time–consuming and took an enormous amount of energy.

[16] For instance print the colophon, indicating the month and year and the authorised supplier.

Suggested Reading

Readability

DE LANDSHEERE, G. *Le test de closure.* Paris: Nathan, 1973

FLESH, R. How *to test readability.* New York: Harper and Row, 1942

HENRY, G. *Comment mesurer la lisibilité.* Paris: Nathan, 1975

RICHAUDEAU, F. *Le langage efficace.* Paris: Retz, 1973

Creating Technical Terms

CALVET, L.J. *La guerre des langues et les politiques linguistiques.* Paris: Payot, 1987

CHATRY–KOMAREK, M. Intentos de codificación del quechua en libros escolares. In:

LOPEZ, L.E. AND MOYA, R. (Ed.) *Pueblos indios, estados y educación.* Lima, 1989

CLAS, A. *Guide de recherche en lexicographie et terminologie.* Paris: ACCT, 1985

RUBIN, J. et al *Language planning processes.* The Hague: Mouton, 1977

UNESCO *L'emploi des langues vernaculaires dans l'enseignement.* Paris, 1953

Preparatory Chain

Until now you have focused on both the development of the contents and the development of the graphic design, which has allowed you to produce the texts and the sketches for accompanying illustrations. At this stage you must put them both into their final form.

In large publishing companies this work would be split among several people: illustrators and photographers would complete the illustrations on the basis of the sketches, or sometimes just on the basis of the author's instructions; then, ideally a graphic artist would decide which typeface should be used for the texts which will be typeset by computer; finally a layout man would produce the layout. All these tasks would be organised and supervised by the Art Director.

Illustration work

The illustration work, which commenced during the writing phase, continued parallel to the layout work. Little by little ink drawing replaced the sketches. The exercises which needed careful placing of text illustrations and text were illustrated once the layout was complete, and the letters, words and sentences to be written in cursive style were added last. Generally the illustration work was never finished until the job envelope is handed over to the printer.

Stipulating the final layout

The format of the book and the basic visual structure had been clear for several months; it was time to decide on the final layout; firstly the stencil was defined, i.e. the precise frame within which the text and illustration blocks were to be arranged; secondly the typographic characteristics of the text were determined. The manuscript was coded to ensure that all instructions were clear to the photocompositor.

Typesetting the text and correcting proofs

The texts and exercises in the manuscript still had to be typeset by computer. Given the shortness of the text and the complexity of the layout, no running text was produced; it was broken down immediately into its final form. The proofs thus obtained were examined by each of the authors. This was a time–consuming task: firstly the authors were not professional proof readers and had to learn to track down errors; and since the Malagasy language is still undergoing standardisation, they had to check that standard linguistic criteria had been applied throughout (regarding newly created words, spelling and punctuation in particular).

Preparation of a pasteup guide

The authors prepared a pasteup guide to be used as a model for the assembler. This is a more detailed version of the layout plan, in which every page is prepared on the basis of a photocopy of the texts and the illustrations.
This model was extremely useful and made up to some extent for the absence of professional proof

	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 were no omissions[1] or changes[2], before giving the printer the go–ahead for each page. Let us specify that after this the authors were only involved in very sporadic monitoring; even this, however, allowed them to pinpoint and remedy some errors which they never dreamt could happen.[3]

As you will see, the work is long and relatively complex, and, in most cases, it is your team which will be in charge.

To help you understand the sequence better, Table 30 lists the tasks for which Garabola authors were responsible, broken down into those which they performed themselves and those which they only had to organise and supervise. Take a good look at this table and see what you can expect.

30. The Authors' Responsibility		
No.	**Performed by Authors**	**Organised and Monitored by Authors**
1		Finishing illustration work
2	Final check of illustration work	
3	Putting together the stencil	
4	Identifying typeface	
5	Preparing the manuscript for typesetting	
6		Typesetting text on a computer
7	Proofreading	
8	Preparing a provisional layout plan for the printer's assembler	

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 technicalities of 4–colour printing, focusing on representational drawings in one colour, with shading or without, and in two colours.

All teams of authors must work with the illustrator, but their specific tasks will not always be the same. In large publishing houses the authors will give the illustrator instructions as to the illustrations that are to accompany the text, and, for technical drawings they may compile a dossier of basic information. In developing countries on the other hand the authors are often in charge of all graphic work.

If you find yourself in this position, here are the steps you will generally have to take.

Drawing up a Contract

As we pointed out at the end of chapter 5 you should have sounded out the illustrator during the conceptual phase. You will have selected the artist whose skills and attitudes are best suited to the job in hand. When he reappears on the scene, which will not generally be before the texts have been completed, your first task will be to draw up a contract. Generally artists work as free–lancers, and prefer to be paid by the unit, depending on the type and dimensions of the illustrations to be produced.

Most of you will not have to deal with the legal and financial aspects of a contract of this sort, since it is unusual for the authors of a book to be responsible for the financial side[4]. But you will almost certainly be consulted to ensure that the contract reflects the services actually required; you should proceed as follows.

General Presentation of the Textbook

Start by giving a thumbnail sketch of the textbook; inform the illustrator of which grade and subject it addresses, the format and the number of pages, the subject matter covered, the fundamental visual structure, etc.

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 point quite clear at the start to avoid working with artists who have not been properly informed about the working conditions and are too full of themselves or unable to knuckle down to the quality and time requirements found in the world of textbook production.

Finally, if you plan to print your textbook in two colours, you must decide who is going to be responsible for preparing the half–tones – you or the illustrator.

Many of you will be responsible for the entire preparatory chain

Methods and Steps

Now you have established the general framework of collaboration you can move on to the details of your work with the illustrator.

Firstly, you should decide where he is to work. If conditions permit, put him in the same rooms where you meet; this is the best way to ensure smooth and rapid progress. Secondly, decide what tools he will require, which of these your organisation already has and which you will have to provide him with. Finally, determine the various steps to be undertaken from the first sketches to the final version of the illustrations: nothing is more demoralising for everybody concerned than having to redo or have someone else redo a drawing which has already been completed in ink because the original specifications were not clear.

To ensure that deadlines are respected, you too should make changes only to the drafts and agree at the outset on the number of finished drawing which can be revised without incurring any extra costs.

Deadlines

Set a deadline for the submission of all original drawings and draw up a contract which covers all the points we have touched on.

	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.
Precision vs. Generalisation	
	The illustrations must have a high level of precision and authenticity, allowing the reader to recognise beyond any shadow of a doubt everyday life on Madagascar (habitat, customs, countryside, dress, etc.). At the same time, however, they must abstract every element that is too closely linked to any one region, the objective being not that every pupil feels himself to be addressed directly, but that no pupils feel excluded by the life depicted. For Madagascar, for instance, no elements should be depicted which refer exclusively to either the coast or the high plateaux.
Traditional vs. Modern Elements	
	The illustrations must do justice to traditional instruments and work that are still in use, while adequately documenting the progressive introduction of new technologies; plastic and the radio have a legitimate place alongside dugout canoes and oxen–drawn carts.
Diversity of Visual Techniques	
	The visual techniques used must allow readers who have had little contact with printed materials to decode the illustrations without difficulty, but techniques should also be used which signal a certain leaning towards modernism and will familiarise pupils with graphic styles commonly used in industrialised countries. Thus, the perspective chosen should, for instance, be easy to decode, while making use of cartoon techniques to a certain extent (arbitrary cutting off of parts of the element shown, unusual perspectives, caricatures, etc.).
Humour and Criticism	
	Efforts should not necessarily be made to renounce humour and criticism, but you should avoid using elements which, although they may be widespread and generally accepted elsewhere are liable not to be understood or to be considered shocking in the context in question – e.g. the

To ensure that the illustrator is on the right lines, you must insist that he show you his first drafts. Examine them and let him know whether he can finalise these or whether he must take an entirely different approach. React quickly to avoid the illustrator continuing under false apprehensions.

Revision of the Final Drafts

The illustrator will often produce a series of drafts, which will become gradually more and more precise. The last of these drafts, which should be the more or less final version, must be examined in great detail: peruse them in the company of the illustrator to ensure that they are in line with pedagogical and didactic requirements and with the criteria you listed in advance. Specify any changes that will have to be made.

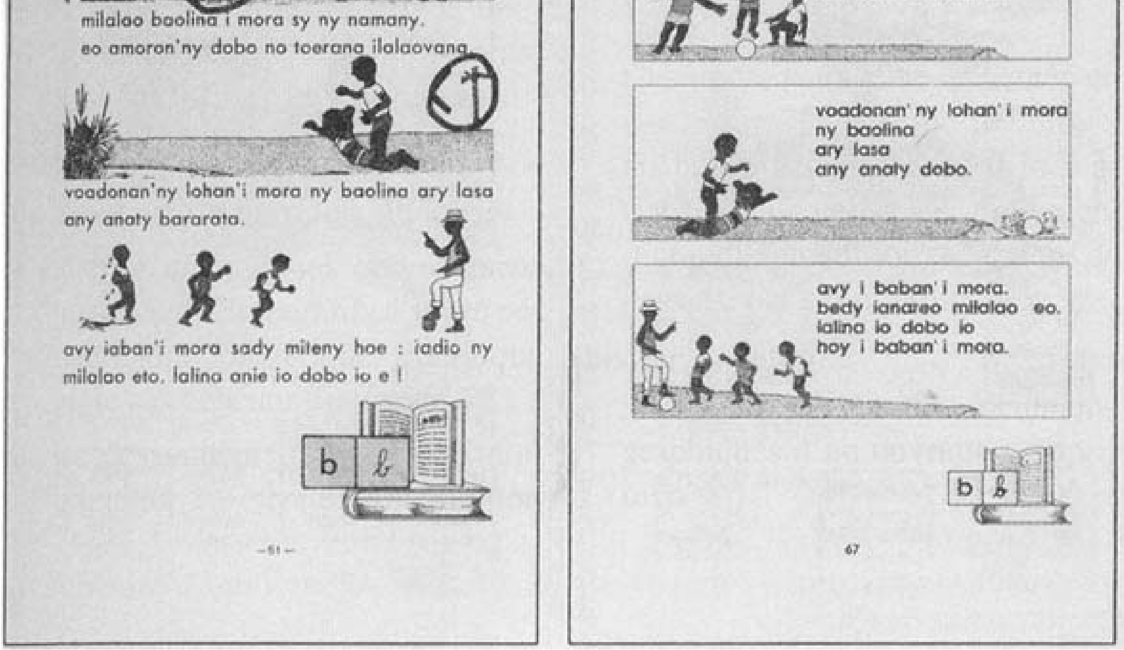
To give you a better understanding of your role as a supervisor of sorts during this phase look at the examples below; compare the pilot version with the corresponding pages of the revised version of *Garabola* and deduce the reasons for the modifications made in the interlude, indicated in the following figures by a circle.

You will have to make some corrections to the graphic artist's work

Examine each drawing carefully and be precise and consistent in your comments

Correct illustrations on the basis of precise pedagogical and didactic criteria

The illustration should help create a “text–image unit”



2. Remove any elements that are purely decorative.

4. Add any elements that are essential to allow the reader to identify the scene.

atao tato tana

mora

tana tana

inona inona

io tana

tao anaty inona io tana io

tato anaty anana

-18-

mora a

inona inona

tana tana

atao inona tana

tano io tana io

19

6. Use images to reflect the dynamism of the text.

8. Get rid of superfluous elements which distract the reader or get in the way of visual decoding.

Final Versions of the Drawings

To ensure that the arrangement of text and illustration is as perfect as possible, it is better not to start with the final versions of the drawings until the text has been typeset and the text layout finalised.

When the authors are responsible for supervising the illustrator they must not only examine the drafts and suggest any changes. They must also decide which tools the illustrator will need (Rotring pens, fountain pen, tweezers, etc.) and which materials are best suited to the printing procedures to be adopted (tracing paper, The size of the margins can be set professionally; layout artists today still set the margins on the basis of calculations or diagrams, and many still refer to what has been done in the past[6]. You need not be so scientific in your approach, but you should respect three basic principles.

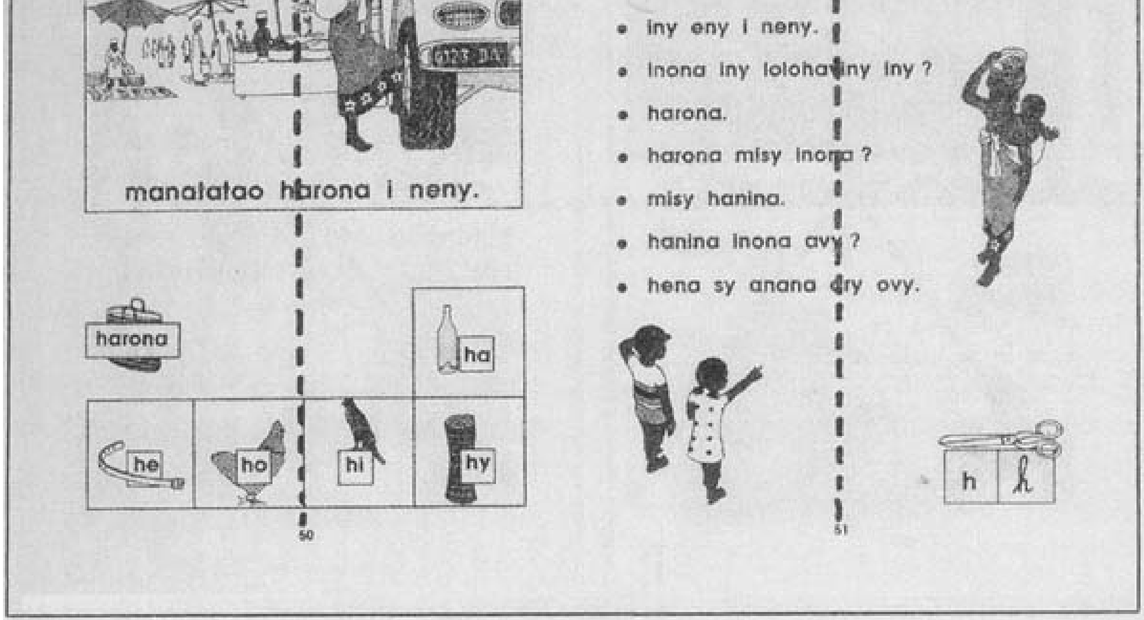
A good layout person seeks excellence in every layout detail
Leave wide enough margins

Firstly, the outside margins on each page must be wide enough for you to hold the book in your hand without concealing the text. Secondly, convention dictates that the margins increase slightly from the interior of the page/towards the top called the “head” and from the outside of the page/towards the bottom, or “foot”: the most important thing to observe with margins is, however, that they present the text to its best advantage. A one−centimetre margin, for instance, is quite inadequate and will give your book a cramped look. Finally, once you have decided on the margins they must be respected throughout the book, from the first page to the last. In general nothing should be printed in the margins except the page numbers, or “folio” as they are known and any headers or footers, such as the ones at the top and bottom of the pages of this book. These elements are arranged outside the frame set by the margins, known as a grid. If it is absolutely essential for some elements to go beyond the frame thus set, for instance if you decide to incorporate bled−off illustrations which cover the page in its entirety, you should ensure that they are positioned in such a way as to make the continuity of the grid easily recognisable for the reader.

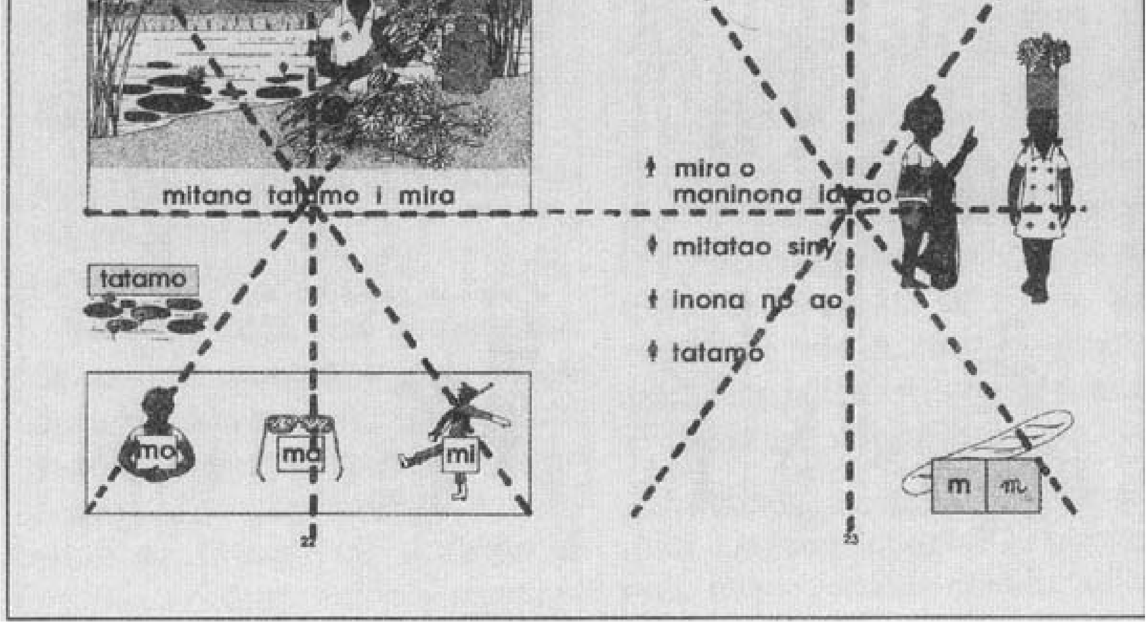
Arrangement of the Various Elements

Having decided on the margin width you should turn your attention to the arrangement of the various elements on the page.

You have already decided on a basic structure which allowed you to produce texts of the required length, but now you must decide on the finer points, laying down the final arrangement of texts and illustrations. The aim is to find the positioning that best reflects your pedagogical objective, i.e. to find the layout that best captures the reader's attention and facilitates the learning process.



1. Decide on a basic structure for double pages; here we decided for two columns.



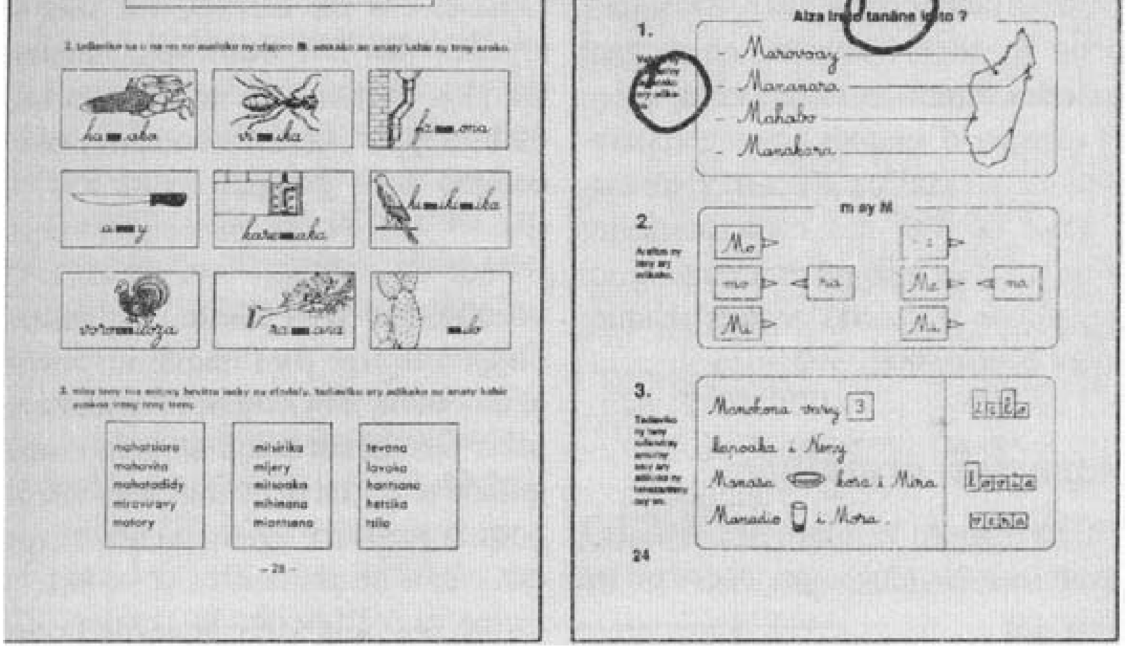
2. Position the various elements on your double page with the help of horizontal, vertical and diagonal lines of reference.

4. Make a clear optical distinction between the various elements on a page.

mora
tana tana
inona inona
io tana
tao anaty inona io tana io
tato anaty anana

mora a
inona inona
tana tana
atao inona tana
tano io tana io

6. Respect the grid.



8. Use different sizes of typeface to indicate the relative importance of the texts.

There is no sure–fire recipe for a successful layout, you must gather experience and know–how and always examine the quality of the final product.

Given the fact that this book is not dedicated solely to layout, we have chosen to illustrate a few of the basic principles, again with the help of real–life examples. On the following pages you will find examples of some of the pages of the pilot version of *Garabola* for which the contents were arranged intuitively on the page by the authors, side by side with the final version where the layout was corrected by a professional[7].

To avoid repeating information that you will find in any specialised literature, we have decided not to dwell on any details that are not immediately relevant for textbook authors. For reasons of clarity we will equally take only a cursory look at those typographical features which will feel are important for a first reading book. Read the following pages in the knowledge that they are far from being complete, and try to adapt the recommendations to suit your own specific circumstances.

We would suggest that you adopt the following procedure to decide on the typographical features for a first reading book.

Aspects to Take into Account

First of all make a list of all the aspects to be taken into account, the most important of which will be:

1. The characters

- class
- type family
- fount
- category
- size of type body
- weight of type

2. The texts

- character spacing
- word spacing
- line spacing
- paragraphs
- line length and justification

garabola

Type Family

Several families of characters are affiliated to each of the classes.

If you are producing a first reading book for which you have decided on a class without serif, you can now look at the form of the lower case characters of the different families that go to make up this class. For optimum readability, each letter should be immediately identifiable, without any chance of confusion, even when the letter stands alone. You should thus examine every individual character, one after another.

Check that the descender of the **j**, for example, finishes with a curve and does not only consist of a downward stroke. Likewise, the curve of the **r** must be clear enough, etc.

You should also pay particular attention to the form of two letters, the **a** and the **g**; to make it easier for the pupils to learn to read and write at the same time you should select a form which is as close as possible to the shape they will learn to write.

In the next books in the series you will have more leeway to chose the family of characters, once the pupil has been systematically introduced to the new forms of the **a** and **g**.

Look at the two examples below, before you decide on the form of **a** and **g** you wish to use.

garabola
garabola

Fount

GARABOLA

Size of Type Body

If you look closely at this book you will note that not all the characters used are the same size. We say that the type body is of different sizes, and we define this size in points; to give you an idea of sizes, the main body of this text is printed in Palatino, 10 point.

At the start of a first reading book you could use 24 point and then go on to use 18 point. Before deciding, try out the different sizes; and for the moment look at the following models.

Avant–Garde, 24 point

Garabola

Avant–Garde 18 point

Garabola

Weight

The weight, or thickness, of the characters used can vary; to convince you of this look once again at this book. You will find normal and bold characters: in photocompositors' catalogues you will find other options including the following:

Word Spacing

For maximum typographical readability, the space between words should equally not be too wide or too narrow.

But, for texts written in large characters, such as those found at the start of a first reading book, it may be advisable to use double word spacing. This will allow beginner readers to identify each word more easily as a unit. If you leave a double space between words, however, take care that the sentences do not appear disjointed.

Here is an example of single and double word spacing

Garabola, school textbook
Garabola, school textbook

Line Spacing

This is the space between two lines within the same paragraph.

You should be able to decide on a line spacing which will give your text optimum readability. If the line spacing is too large, each line will seem artificially isolated on the page, which will slow down the reader. On the other hand if the lines are too close together readability will also be poorer because the descenders of the letters on one line will become confused with the ascenders of the letters on the line below.

Computers insert automatic spacing; if you wish to modify this, try out different spacing.

The example below shows automatic, narrower and wider line spacing.

For a first book, unjustified or ragged–right settings are generally preferred, i.e. the left hand edge of the text is aligned, but not the right hand edge. The gaps in the text at the right hand edge often correspond to natural breaks in the text, in line with the meaning units.

The right–hand edge of the text can also be justified as you can observe in the outside columns on each page of this book, or the text can be centred, with neither edge justified.

Use recently published textbooks to help you make your typographical decisions

Level and hierarchy of text

The typography must make the text easy to read, by giving the reader a series of clear visual signs. When you decide on the layout of a book two things are important: firstly to distinguish between the text that addresses the pupils and the accompanying notes and instructions which are not necessarily meant for them, and secondly to show the hierarchy of the text, i.e. to identify the various headings and sub–headings.

You can guide the reader not only by separating the text blocks from the instructions, but also by using different typographical features, i.e. the judicious use of different sizes, founts and weights can indicate to the reader which parts of the text are headings, sub–headings, notes, etc. without your having to number them.

Let us add that this fact is extremely important to ensure linguistic and typographical readability in the teachers' guide. When you decide on the layout, you should thus re–read your manuscript and mark the various levels of text.

In our experience even if the plan is detailed and the points seem to follow on logically one from another, there are almost always imperfections. For instance we find a major heading, which we will call a level 1 heading, followed by a level 2 heading, and then we find that the text suddenly jumps to a level 4 heading, completely by–passing level 3.

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 pictograms to a minimum.

5. Job Envelope

You have planned and defined the illustration and layout work. Generally you will then have delegated this work to the illustrator on the one hand and a keyboard operator on the other.

But, as this work is returned to you, you must check the quality before submitting it to the printer, and it is up to you to do this.

What you now have to compile is a copy of your book which is at least definitive if not complete; the printer must not have to add, remove or modify anything. And once he has received your job envelope and your written instructions regarding the printing, he should not have to consult you with any further questions. Once you have given him the final version of all the documents and the written instructions he should be able to print without delay – or to be more precise he should be able to put together the pages to make signatures, have you check that the imposition is correct by submitting the blueprints to you, prepare the printing plates, install these in the printing press, load up the paper and print and trim the book.

The quality of the printing will depend almost entirely on the quality of the preparatory work. To make sure that it is as good as possible, you should adopt a methodical procedure, as follows.

> **This is the last part of your work as “publisher–authors” – take care not to nullify all your work to date**

First Proofs

Precision

Read the proofs again and again and track down all the errors.

You must bear in mind that as from a certain stage the authors themselves become blind to the mistakes in their work; they can read and re–read their manuscript without picking up the errors. Thus, you should read and re–read the first proofs several times, but do not consider this work definitive. At a later stage you will have to read the second set of proofs, which you will receive once the layout has been done and the typographical choices translated into practice.

Pertinence

If you are working in a language which still has few standards, you will be bound to have some doubts as to how to split a word for instance, the use of the apostrophe in a compound word, the use of capitals or how to write certain abbreviations. Do not correct these points before you have agreed on clear standards with your colleagues or checked if such rules already exist.

We must stress that when several groups of authors are working on didactic material in the same national language it is crucial – and extremely difficult – to ensure that the language used by all the groups is standardised. Care and discipline are vital to achieve this.

Functionality

Do not make corrections just for the fun of it. As we said the last author corrections have been made. Remember that the text you submitted to the keyboard operator had already been read by numerous people, and unless you find a really serious error that none of them has found, do not make any more changes. If you really feel, in spite of everything, that you have to make more changes, consult your colleagues first.

Re–read proofs with great care

Final Proofs

Graphics Dossier

Everything which has not been processed by the keyboard operator must be submitted separately to the printer. When your book is a reading and writing book for primary level, this dossier will generally include the original drawings and hand–written examples of writing. You should ensure that the dossier is complete and that it contains the following instructions.

Dimensions of the Illustrations

Some drawings can be executed without difficulty in the size required, but for very small illustrations, such as text–illustrations for exercises, it would be better to have the illustrator produce larger drawings. In this case you must instruct the printer of the extent to which they must be scaled down, or "reduced".

Shadings

If you decided to print your book in two colours, or to use one colour only but to add shades of grey in illustrations you must check that you have included a photocopy of the originals indicating exactly which colour or shade has to be printed where.

Assembly Instructions

If the page contains several elements it is not enough merely to submit the text and the illustrations to the printer; you must also give him precise instructions as to the layout of each page.

The best way to do this is to prepare as complete a layout guide as possible for every page, using photocopies of the originals. The layout artist will base his work to the millimetre on this hand–made model: he generally has the instruments and the skills required.

Final Checks

Before you submit the job envelope to the printer ensure again that it is complete.

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 by page, as it is pinned up on the board and make sure that everything is complete.

Here too we have modified the way we work over the years. For years and years we submitted a text dossier and an image dossier to the printer separately. Today we do things differently. For every page of the book, we prepare one large envelope on which we write the page number. The envelope contains all the pertinent elements for that page.

Thus for the revised version of *Garabola* each envelope contained

- The original copy of the texts
- The original copy of the illustrations
- A photocopy of the illustrations bearing the instructions for shading and, in some cases, for reducing the illustration
- The original copy of the hand–written examples in cursive style
- A montage using a photocopy of the texts and illustrations.

Once you hand this job envelope over to the printer, your work as authors is almost over. Afterwards, if you have prepared your dossier well, the printer will not have to contact you again before he submits the blueprints; these are the last proofs, printed on blue paper to allow you to check the assembly of the elements on the page, the imposition and perhaps also the shading. The blueprints will be submitted to you one signature at a time; you should check them, and if there are no errors you should give the printer the go–ahead, signing each one. The book is then out of your hands and you won't see it again until it is published.

to the printer, i.e. all the costs of preparing the manuscript, the graphics dossier and the layout work.

Overheads

These are costs which do not relate directly to any one task, such as general administrative services, rent or vehicle maintenance, so important for field work.

Costs of distribution and/or sale

These costs cover the packing and transport of the books to the schools; in some cases they will also include the costs of advertising and promoting the book.

Throughout this book we have emphasised the huge responsibility borne by authors, the honesty they must bring to their work, the rigour and precision required. The costing exercise will convince you of the truth of this if nothing else has: authors of textbooks may not under any circumstances act negligently.

Notes

[1] The blueprint does not always allow you to check the different shades of grey very exactly, but you can spot omissions in the shading, which may be printed white if not corrected.

[2] The blueprint allows authors to check changes made by the printer and remedy any errors. One example we encountered was the exercise on telling the time in an English book, where the printer had had the clock redrawn; it had certainly gained in aesthetic quality, but the time on the clock face no longer corresponded to the English sentence next to it, which the pupils were to learn.

[3] The monitoring showed them that even the highly improbably is possible and allowed them to correct some errors: thus we noted that the red Pantone ink which we had ordered overseas to print the cover had been wrongly delivered and that the cover was about to be printed in pale pink.

BAUDIN, F. La préparation de la copie. In: DREYFUS, J. AND RICHAUDEAU, F. *La chose imprimée.* Paris: Retz, 1977

GUERY, L. *Manuel de secrétariat de rédaction.* Paris: C.F.P.J., 1990

PRESSE ET FORMATION *Abrégé du code typographique à l'usage de la presse.* Paris: C.F.P.J., 1991

Layout

DUPLAN, P. AND JAUNEAU, R. *Maquette et mise en page.* Paris: Usine Nouvelle, 1986

GUERY, L. *Précis de mise en page.* Paris: C.F.P.J., 1988

RICHAUDEAU, F. *Manuel de typographie et de mise en page.* Paris: Retz, 1989

Typography

AICHER, O. *Typographie.* Lüdenscheid: Druckhaus Maack, 1989

DREYFUS, J. AND RICHAUDEAU, F. *La chose imprimée.* Paris: Retz, 1985

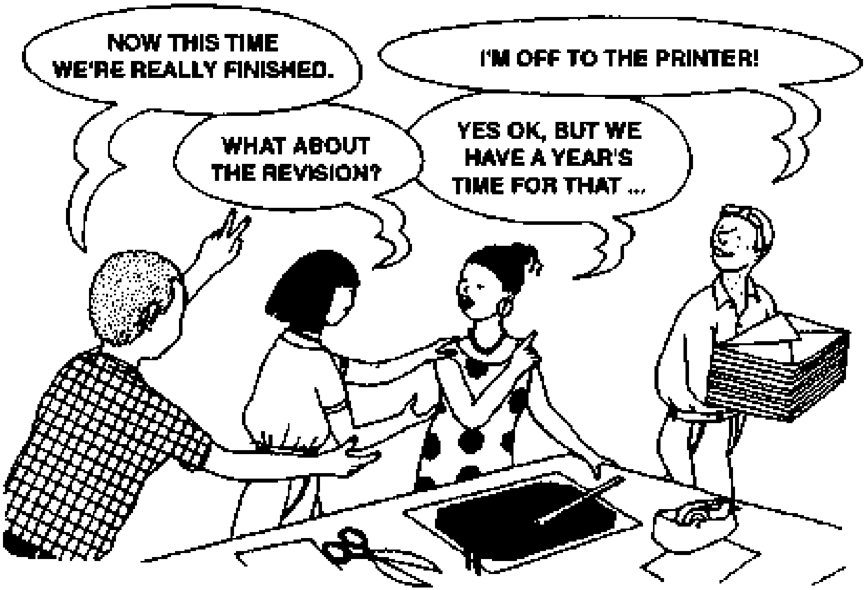
SALBERG–STEINHARDT, B. *Die Schrift: Geschichte, Gestaltung, Anwendung.* Cologne: DuMont Buchverlag, 1983

TSCHICHOLD, J. *Meisterbuch der Schrift.* Ravensburg: Otto Maier, 1965

ZAPF, H. *Variations typographiques.* Paris: Hermann, 1965

Illustration

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 production costs, but also the overheads and the costs of distributing the finished product to the schools. This is vital feed–back but it is all too seldom passed on to the authors in developing countries.



By Way of Conclusion

You have now devoted several years to preparing a school textbook and you have just handed in the final version to the printer.

Annexe: Evaluation

Pupils have worked with the pilot version of your book over a period of one or several years. But your odyssey is not quite over yet; if you look back at the first chapter you will see that in developing countries the evaluation of pilot materials is an integral part of the chain. And, now that you have the chance to look at your book with a certain distance, you will be the last to stand in the way of a revised version: not only will you stumble over minor errors which you will find inexplicable after all the double, triple and quadruple checks, but certain doubts will also begin to sprout in your mind regarding the contents and the graphic features. An evaluation, followed by a revision of the pilot materials is thus called for in most cases.

How should you go about this? In some countries the ministry will assume responsibility for the evaluation. It will examine the books presented by private publishers and decide whether or not to accord the book official authorisation. It is not the actual performance of the book in schools that is evaluated here; the book is simply assessed according to a grid comparable to the grids you will find in the recommended reading at the end of this chapter. It is generally a sort of censorial work.

In our opinion grids of this sort are useful for authors performing internal checks as they write didactic materials, but they are quite unsuited to revising school publications. It is, in any case not sufficient to analyse new didactic material from your desk; it is imperative to look at how it actually works in schools.

For most of you, the evaluation work will constitute a new research project. You will have to carefully plan and execute numerous, complex activities and the work will sometimes involve managing significant human, technical and financial resources.

You should realise that this phase has much in common with the preliminary research phase, which is why we will only give you some general pointers, to help you understand how to make the preparations for the systematic revision of pilot materials; we will not repeat the information presented in chapter 3, but will simply refer you back to it whenever appropriate.

- designing, organising, realising and evaluating the presentation of pilot materials to the 40 teachers concerned

- initiating the design work on *Tongavola,* reading and writing materials for the second year of primary school.

The authors could not do everything themselves, so they devised an evaluation strategy which only demanded their participation on a sporadic basis: they concentrated on devising evaluation instruments, taking part in classroom observations and interpreting the final results. The major logistic work, including gathering data and processing it systematically, was entrusted to a small team specially set up for this.

Daily Self–Evaluation Grid

October 1988

The first evaluation instrument was a daily self–evaluation grid. This was the first priority of the authors so that it could be completed and distributed to 9 teachers in time for the start of the academic year. The nine were recommended by animateurs for their professional ethics; they undertook to fill in the grid every day.

First Test Series

December 1988

The second instrument was a series of tests to be run at the end of the first term in all 40 test schools. This activity had a dual objective: to evaluate the very first results obtained with the new materials and to examine the level of receptiveness in the schools, which would enable the team to take remedial steps at an early stage if necessary.

Classroom Observations

July–August–September 1989

The team of evaluators was charged with processing the test results and the other information gathered. The authors then examined the data and interpreted it.

Development of an Evaluation Report

September–December 1989

In view of the fact that the material broke with certain practices, notably significantly lowering the attainment targets laid down in the official curricula[2], it was important to inform the education authorities of the results.

A reference document was thus produced by an educationalist, since the authors were too busy to take on this task as well, and the document widely circulated.

2. Aspects of the Evaluation

Now that we have looked briefly at the possible evaluation activities for a pilot textbook, let us come back to the first stage, i.e. identifying precisely the aspects to be evaluated. Here is a short summary of the features that should usually be examined with care.

Effectiveness in Terms of Attainment Targets

You must prove that the materials actually do their job by analysing the results obtained using the new material as compared to the attainment targets.

The results of tests of this sort must, it is true, always be interpreted with care, but the results are of capital importance for you. If they are positive, general aspects of your material, in terms of the volume of subject matter presented, the learning method adopted and the composition of the materials can be considered

Although it is relatively unimportant if a pilot book looses pages or rips easily after one year of use, the revised version must be robust, particularly if a large run is to be printed and used nation–wide.

It is important to examine the material after it has been in use for a certain period, so that you can take the necessary technical and financial steps in time to ensure that the revised version of your materials enjoys a long service life.

3. Evaluation Indicators and Instruments

Once you have decided which aspects you wish to evaluate, you must identify the instruments which will help you obtain the results required.

To this end you should take the same approach as you did during the preliminary research phase: firstly formulate indicators, i.e. easily observable, quantifiable or verifiable elements, and then determine which instruments will enable you to verify each of the indicators.

We suggest below a few indicators and instruments which can be used to examine the four aspects quoted above. Analyse them and adapt them as appropriate to your own circumstances.

4. Planning the Activities

Ideally you would be able to use all the instruments you have listed, but this will not always be possible.

When you come to draw up a systematic plan for the evaluation phase you will be able to identify which ones you will actually be able to use. You should draw up your work schedule, taking the following elements into account.

	Parents' attitude	
		Talk with parents
		List of school attendance rates of their children
	Teachers' attitude	
		Talk with teacher
		Verification of the frequency with which the material is being used, by checking its physical state
		Daily lesson plan
	Pupils' attitude	
		Talk with pupils
Physical aspects of the book		
	Strength when handled frequently	
		Examination of books
	Ease of handling	
		Examination of books
		Classroom observations
		Talks with teacher

Institutional Priorities

Work Involved in a Comparative Analysis

The work involved in conducting a comparative study of school results is sporadic, it is true, but the tasks are many and varied, and are generally spread over an entire year. Here is a list of the principal tasks:

Identification of Test Schools

- Define a common profile for schools to be selected from the group of test schools and from outside this group (e.g. geographical location, teacher:pupil ratio, etc.)

- Undertake a first theoretical selection of schools having used the material to be evaluated

- Conduct a field visit to verify the data for the first set of schools

- Undertake a first theoretical selection of the control schools, followed by a field visit to check the selection

- Take the necessary administrative steps to allow you to operate outside the test zone.

Development of Tests

- Identify attainment targets to be evaluated

- Draw up a list of criteria referring to the contents, presentation, course of tests, marking scale and interpretation of results

- Develop the tests

- Illustration, layout and preparation of an adequate number of tests

Systematic Processing and Interpretation of Results

- Issue instructions to those in charge of processing the data, regarding marking systems as agreed on earlier

- Examine and mark each test

- Draw up statistics

- Interpret the results

- Draw up a document presenting the procedures adopted and the results of the evaluation

- Distribute it to all interested parties.

5. In Conclusion

By way of conclusion we would just refer you to chapter 3 to refresh your memory about the follow–own work, in particular devising instruments, work in the field and data processing, and to some of the evaluation instruments which were used to evaluate *Garabola* and which may be useful to you, if not as a model, then at least for reference purposes[5].

Notes

[1] This always happens when the financing for a large run is available before the evaluation work is finished. The situation is not exceptional, but is always unpleasant for authors; time considerations often take precedence over the issue of quality.

Bibliography

ABERNOT, Y. *Les méthodes d'évaluation scolaire. Techniques actuelles et innovations.* Paris: Bordas, 1988

AICHER, O. *Typographic* Lüdenscheid: Druckhaus Maack, 1989

ALTBACH, P.G. Problemas esenciales del libro escolar en el tercer mundo. In: *Perspectivas,* Vol. XIII, No. 47. Paris: UNESCO, 1983

ALTBACH, P.G. Copyright in the Developing World. In: FARRELL, J.P. AND HEYNEMAN, S.P. (Ed.) *Textbooks in the Developing World.* Washington D.C.: World Bank, 1989

ALTBACH, P.G. et al *Textbooks in the Third World. Policy, content and context.* New–York: Garland, 1988

ARCIVAL, D. et al *Guide pratique des techniques de l'imprimerie.* Paris: AFNOR, 1983

AREGGER, K. *Innovation in sozialen Systemen 1. Einführung in die Innovationstheorie der Organisation.* Berne, Stuttgart: Paul Haupt, 1976

AREGGER, K. *Innovation in sozialen Systemen 2. Ein integriertes Innovationsmodell am Beispiel der Schule.* Berne, Stuttgart: Paul Haupt, 1976

AVALOS, B. *L'enseignement aux enfants démunis. Une étude ethnographique en Amérique Latine.* Ottawa: Centre de recherches pour le développement international, 1986

BERGER, G. AND BRUNSWIC, E*. L'éducateur et l'approche systématique.* Paris: UNESCO, 1984

BERTHELOT, J. *Petit guide à l'usage des auteurs débutants et de quelques autres.* Paris: Hachette, 1991

CLAS, A. *Guide de recherche en lexicographie et terminologie.* Paris: Agence de Coopération culturelle technique, 1985

COLOMBET, C. *Grands principes du droit d'auteur et des droits voisins dans le monde. Approche de droit comparé.* Paris: Litec, UNESCO, 1990

CONFEMEN. *Promotion et intégration des langues nationales dans les systèmes éducatifs. Bilan et inventaire.* Paris: Editions Champion, 1986

COULMAS, F. *Linguistic minorities and literacy: language policy issues in developing countries.* Berlin: Mouton Publishers, 1984

COULMAS, F. *Sprache und Staat. Studien zur Sprachplanung.* Berlin: W. de Gruyter, 1985

CROZIER, M. AND FRIEDBERG, E. *L'acteur et le système.* Paris: Seuil, 1977

CUMMINGS, W.K. *L'enseignement primaire à coût modique. Mise en oeuvre d'une innovation dans six pays.* Ottawa: Centre de recherches pour le développement international, 1986

DE LANDSHEERE, G. *La recherche en éducation dans le monde.* Paris: PUF, 1986

DREYFUS, J. AND RICHAUDEAU, F. *La chose imprimée.* Paris: Retz, 1985

DUPLAN, P. AND JAUNEAU, R. *Maquette et mise en page.* Paris: Usine Nouvelle, 1986

DURCHON, P. *Photogravure et impression offset.* Paris: Usine Nouvelle, 1987

ESCARPIT. *L'Ecrit et la communication.* Paris: PUF, 1973

GUERY, L. *Précis de mise en page.* Paris: Centre de formation et de perfectionnement des journalistes, 1988

HAMEYER, U. *Vier Gesichtspunkte zur Förderung von Innovationsprozessen im Bildungssektor.* Kiel: IPN–Kurzbericht 14, 1978

HAMEYER, U. et al (Ed.) *Handbuch der Curriculumforschung,* Weinheim, Basle: Beltz, 1983

HAVELOCK, R.G. AND HUBERMAN, A.M. *Solving educational problems. The theory and reality of innovation in developing countries.* Paris: UNESCO, 1977

HEYNEMAN, S. P. et al *Textbooks and achievement. What we know.* Washington D.C.: World Bank, 1978

HUMMEL, C. *School textbooks and life–long education: an analysis of schoolbooks from three countries.* Hamburg: UNESCO Institute for Education, 1991

HUOT, H. *Dans la jungle des manuels scolaires.* Paris: Seuil, 1989

HEALTH LEARNING MATERIALS PROJECT *Guidelines on how to produce a manual.* Kathmandu: WHO–UNDP, 1988

KOMAREK, K. (Ed.) *La série Garabola. Dossiers I et II.* Eschborn, Antananarivo: GTZ, 1993

LAPOINTE, C. *Le livre du livre.* Paris: Gallimard, 1987

LEINO, J. *Theoretical background and development of instructional materials.* Helsinki: Department of Education, University of Helsinki, 1989

LE THANH KHOI L'enseignement en Afrique et le modèle européen. In: COQUERY–VIDROVITCH, C. AND FOREST, A. (Ed.) *Décolonisation et nouvelle dépendance. Modèles et contremodèles idéologiques et culturels dans le Tiers Monde.* Lille: Presses Universitaires

Bank, 1986

RICHAUDEAU, F. *Conception et production des manuels scolaires. Guide pratique.* Paris: UNESCO, 1979

RICHAUDEAU, F. *Recherches actuelles sur la lisibilité.* Paris: RETZ, 1984

RICHAUDEAU, F. *Manuel de typographie et de mise en page.* Paris: RETZ, 1989

RUBIN, J. Textbook writers and language planning. In: *Language planning.* Rubin J. et al (Ed.) The Hague: Mouton Publishers, 1977

ROGERS, E.M. AND SHOEMAKER, F.F. *Communication of Innovations. A cross–cultural approach.* Toronto: Collier–MacMillan, 1971

SALBERG–STEINHARDT, B. *Die Schrift: Geschichte, Gestaltung, Anwendung.* Cologne: DuMont, 1983

SEGUIN, R. *L'élaboration des manuels scolaires. Guide méthodologique.* Paris: UNESCO, 1989

SEGUIN, R. *Curriculum development and implementation of teaching programmes. Methodological guide.* Paris: UNESCO, undated

SMITH, D. *Les problèmes économiques de l'édition des livres dans les pays en voie de développement.* Paris: UNESCO, 1977

SOW, A.I. *Langues et politique de langues en Afrique Noire.* UNESCO/Nubia, 1977

STAIGER, R.C. *The teaching of reading.* Lexington: UNESCO/Ginn, 1973

UNDP *Education and training in the 1990s. Developing countries' needs and strategies.* New York: Education Development Center, 1989

UNESCO *Rapport mondial sur l'éducation 1991.* Paris, 1991

UNICEF *Communicating pictures in Nepal.* Kathmandu: National Development Service, 1976

UNSEL, S. *L'auteur et son éditeur.* Paris: Gallimard, 1983

VARGAS VEGA, R. *Materiales educativos y post–alfabetización.* Mexico: UNESCO, 1982

VESSILIER–RESSI, M. *Le métier d'auteur.* Paris: Bordas, 1982

WORLD BANK *Education in Sub–Saharan Africa. Policies for Adjustment, Revitalization, and Expansion.* Washington D.C., 1988

WORLD BANK World Development Report 1991. Washington D.C.

ZALTMAN, G. et al *Innovations and organizations.* New York: Wiley, 1973

Glossary

Attainment

The total of results obtained at a certain level in a given subject. In general, the education authorities attach great importance to attainment in the initial evaluation of the impact of a new textbook. These figures should, however, merely be taken as a rough indication as to the effectiveness of the book, and must be examined in more detail.

The evaluation of attainment is not in itself enough of a basis on which to revise a pilot textbook.

Author of School Textbooks

typographical readability of the text.

Copy

Typed text with instructions for typesetting and layout.

The authors should bear in mind the fact that the copy contains the complete, definitive text of the book, and should refrain from making their own corrections at a later stage, which always entail delays and additional costs.

Creating Words

Lexical additions to a language which can take the form of neologisms, or loan words from other languages.

In textbooks written in national languages which have not yet been adequately standardised, technical and scientific terms will have to be created; in the absence of an institute of applied linguistics, the authors will have to check themselves whether or not the technical terms they need already exist, and where none exist will need to create new words, and ensure that they can be disseminated so that they will be generally accepted and used.

Development

Link in the publishing chain.

During this phase the textual and graphic elements that will make up a page are produced and combined.

The term development is sometimes preferred to simply “writing” since it underlines the fact that during this phase not only are texts written, but a text–image unit is created.

Devising the Contents

Person put in charge by the publisher of finding all the documents to accompany the texts of a book, and of checking them for pertinence and technical quality.

Double Page

Visual unit made up of the left–hand page, which will bear an even number, and the right–hand page which will bear an odd number.

The double page is the basic layout unit.

The layout artist assembles the pages two by two, arranging text and illustrations on the basis of a framework known as the grid, which covers the two pages at once.

Evaluation of a Textbook

All activities which aim to provide information about the way the textbook is used in classrooms.

When the evaluation phase is designed to provide information for the revision of the book in question it must not only determine the extent to which the attainment targets can be achieved with the help of the material in question, but must also give precise information as to what aspects of the contents, the physical form and the graphics must be revised.

Evaluation Grid

A research instrument which makes it possible to examine the contents and form of a textbook.

Evaluation grids are useful and should be used systematically by authors running a final internal check on their own manuscript.

Film

The reproduction of a document on a transparent film which will then be used to make plates.

Finishing

The step which transforms the printed sheets into a finished book.

Finishing work, which comprises mainly folding, gathering the signatures and binding, must be closely supervised by the publisher, or the authors, in order to ensure that all the work to date has not been in vain.

Folio

The page numbers in a book. The even numbers will be on the left hand page, while the odd numbers will be on the right hand page.

Graphics Dossier/File

All the graphics documents for a book to be printed.

For a textbook this will include not only drawings and photographs, but also hand–written models of writing in cursive style.

Grid

Document which lays down the margins and the basic structure of a book and which helps to typeset a manuscript precisely and to produce various models, and make–ups.

The stencil is an indispensable tool for books with a complicated layout, as textbooks generally are.

Hierarchy of Text

Innovation involves all those who are indirectly affected by the book: the curriculum unit, teacher training unit, field supervisors, i.e. animateurs, educational advisers and inspectors, as well as parents.

Innovation is naturally geared to the teachers, whose resistance to change is often exaggerated, since their work in the field often makes them excellent change agents.

Finally innovation concerns the authors who often become the locomotive of change. Their status as civil servants, their professional training, their integration in the system and their aspirations are often barriers to a frame of mind that welcomes innovations, without which, however, no transformation worthy of the name is possible.

Instructions for Teachers

Precise, practical instructions for teachers printed in the textbook itself or in the teachers' guide, to help them with every–day lessons.

Textbook authors who aim to provide teachers with an effective tool in this way, find themselves confronted by the problem of how to ensure immediate effectiveness without surrounding the teacher with repetitive and stupefying instructions, which will in the long run cramp his or her teaching style and prevent him or her from developing and being inventive.

The shorter the learning time available the more carefully planned lessons must be and the more acute this dilemma.

Job Envelope

All the text and graphics documents to be submitted to the printer so that he can print the entire book.

Some of these documents are submitted in their final form, while others are accompanied by precise instructions as to how they are to be processed (enlargements or reductions of illustrations for instance).

the book is printed. It is up to the authors to ensure that it performs its primary task – to help learners.

Layout Grid

A grid for arranging the elements on a page in line with vertical, horizontal and diagonal axes.

Newspapers and journals often need complex grids; in spite of the relative simplicity of the layout of a textbook the elements should not be arranged by chance, but in line with a few major axes.

Layout Plan

Guide for the layout of the book being produced, double page by double page. The layout plan is prepared at the end of the conceptual phase and should show the contents of each page and the approximate layout of illustrations and text.

Letter Card

Piece of card on which one letter is printed. Letter cards are commonly used by teachers to develop analysis and synthesis skills when pupils begin to learn to read. They are useful and inexpensive.

Letter cards are only suitable for use by individual pupils when good storage facilities are available in the classroom.

Line Length

Length of lines of a typeset text, often expressed in millimetres.

A text is said to be justified when all lines are the same length; in a reading book for beginners the text is always justified at the left side only leaving the text unjustified right, which means that the lines are of different lengths. This avoids having to split words which would get in the way of the efforts of beginners to decode the text.

Texts which accompany the contents of a book.

These are texts which appear on the cover and the first and last pages of a book and give the reader general information.

In a textbook the authors must generally write these pages too. They must be written with particular care since they will be the visiting card of sorts of the book.

Official Approval

The official authorisation of the education authorities to use a textbook or other materials freely in schools.

When official approval is mandatory, as is the case in the Federal Republic of Germany, the titles thus selected are presented in a catalogue on the basis of which the education authorities, ad hoc committees and teachers can make their choice.

In pilot projects to produce textbooks in national languages, the education authorities often insist on checking to ensure that the particular socio–linguistic and socio–cultural features of the target group have been respected, to verify that the attainment targets are pertinent (i.e. that they do not deviate significantly from the official targets), and to ensure that an appropriate methodological approach has been adopted.

One–Teacher Schools

Schools where one teacher teaches all classes at primary level and also assumes the responsibilities of head teacher.

When the majority of the target group can be found in one–teacher schools the didactic materials produced must be geared as soon as possible to as independent a learning style as possible, which will allow the teacher to pay some attention to the other classes.

Pilot Textbook

Provisional version of a textbook which is tested in a number of schools so that it can be analysed, and revised as necessary. In a developing country this phase should always last at least one academic year.

Preliminary Research

Important link in the publishing chain to produce textbooks in many developing countries.

Preliminary research is indispensable when the available data on the teaching and learning conditions are incomplete or unreliable.

Authors should carry out the lion's share of this work if not all of it, to ensure that they are in possession of all the facts, and to allow them to start work on the textbook on the basis of a common level of information. But, although they always bear the overall responsibility they will have to call on the services of specialists: a sociologist, a statistician, sometimes an anthropologist, an expert in teaching second languages if the project in question involves bilingual education and a linguist where textbooks are to be produced in a national language.

Preliminary Testing

Preliminary testing of the evaluation instruments in a smaller number of schools which are nevertheless representative of the conditions in schools in the country as a whole, before using them on a wider scale.

The attainment tests should always undergo preliminary testing and then be revised. When the technical and financial framework permits, the authors should conduct a second preliminary test if major revisions proved necessary.

Printer

The individual responsible for printing and finishing a book.

Publisher

Person who plans and directs the publication of a literary piece of work, and manages the promotion and marketing. In developing countries it is common for the publisher not to assume all the tasks within the editorial chain that would be the responsibility of a publisher in industrialised countries. This work is then distributed among the various other actors, and is often assumed by the authors alone.

Publisher–Author

Neologism which refers to the many individuals in developing countries who are incorrectly termed “authors”.

In addition to the writing work, publisher–authors take on a greater or lesser part of the work that would traditionally be performed by the publisher.

Publishing Chain

All operations involved in translating an idea into a book, and publicising this book.

In textbook production it refers specifically to all the operations taking place from the start of the publishing project until the pupils have the finished books in their hands.

Publishing Specialist

Manager or specialist involved in the publishing chain.

Large publishing houses have many publishing specialists with well defined roles. In developing countries the responsibilities of the various individuals involved are often modified, and it is common for authors to have to assume some of the responsibilities generally borne by the publisher.

Revised Textbook

Textbook which has been revised after having been tested at a number of schools.

Only a properly revised textbook should be considered for a large run.

School Enrolment

The number of pupils attending school within one class, school or country.

Serif

Small horizontal, vertical or oblique line across constituent parts of the type.

In this guide, the main body of the text is printed in *Palatino,* which displays serifs, while the tables are printed in *Univers* which does not.

Set of Didactic Materials

All didactic materials devised and developed for one subject and grade.

The decision as to the composition of the set must always be well thought through and should depend not only on pedagogical and didactic considerations, but also take into account practical, logistic and financial considerations.

Sheet of Printing Paper

A large sheet of paper on which several pages are printed at once.

The format and the number of pages of textbook must correspond to the dimensions of the sheet to be used.

where innovation generally originates from research institutes and is circulated in specialised technical journals.

Technical Specifications

List of the most important physical and graphic aspects of the materials to be produced.

The technical specifications are generally drawn up by the Art Director, the Commercial Manager and the Production Manager. They are vitally important since they allow those in charge to check the feasibility of the production project: the printer prepares his quotation for the costs of printing and finishing on the basis of the technical specifications.

Testing Textbooks

Link in the publishing chain.

In developing countries the lack of reliable, complete data on conditions in schools and the heterogeneity of teaching and learning conditions make it vital to test the new textbook over a period of at least one academic year in a representative sample of schools.

Textbook Illustrator

Graphic artist who uses his skills to illustrate textbooks, complying with pedagogical, didactic, aesthetic and perhaps financial considerations. A textbook illustrator must work closely with the authors who are generally in overall charge of the illustration work.

Textbook Projects

Education project set up to supply text–books for a developing country.

Where several different time–tables exist side by side for pupils of the same grade, the authors' work is made more complex by the fact that they must develop one set of materials for all pupils, which will enable the different target groups to achieve the same attainment targets within the same time.

Two–Colour Printing

Generally black and a light colour, which may be printed in a solid block or screened to produce shading effects. The shades of colour thus obtained relieve the harshness of monochrome print, at a significantly lower cost than 4–colour (four–colour) printing.

Unformatted Typesetting

The typeset text is justified at the left–hand side, but comprises no hyphenation or layout.

This text constitutes the first set of proofs which must be re–read and corrected, before a second set of proofs is obtained, which will take the hierarchy of the text into account. In practice authors often by–pass these two sets of proofs, especially when they have access to a computer.

Weight

Thickness of the lines of a character.

A text may be printed in extra light, light, semi–light, medium, semi–bold, extra bold and ultra bold. Judicious use of these different weights can help underline the hierarchy of the text and enhance the typographical readability.

Width (of Characters)

The visible width of type character. The width of characters can be modified, to make them more condensed or more expanded, which has repercussions on the typographical readability of the text.

Marie Châtry–Komarek has worked for more than fifteen years in Africa and Latin America on the production of school textbooks in national languages. In this book, she describes the work carried out by a German–Malagasy project, supported by the German Agency for Cooperation (GTZ), the objective of which was to provide teachers and students with textbooks in Malagasy, adapted to their specific needs. She has previously written about the systematic development of texts in *quechua* and *aimara* in a book in Spanish: *Libros de lectura – para niños de lengua vernácula.* At present she is preparing a book on the training of author–publishers of textbooks in developing countries.

The German Foundation for International Development (DSE) is an institution for the initial and advanced training of specialists and executive personnel from developing countries. In addition, it prepares German experts for their assignments in a developing country, and maintains the Federal Republic of Germany's largest centre for documentation and information on development policy.

The DSE works in the areas “Education, Science and Documentation”, “Economic and Social Development”, “Public Administration”, “Industrial Occupations Promotion”, “Food and Agriculture” and “Health”. Its objectives are an international exchange of experience and the qualification of specialists and executives from developing countries.

Dialogue and advanced training programmes (conferences, meetings, seminars, training courses, etc.,) support projects which serve economic and social development. The DSE thereby contributes to an effective, sustainable, and wide–ranging development process.