TESS beginner Student and Demonstration experiments

Light, Air, Earth

Order No. 13244-02

PHYWE series of publications
TESS beginner Student and Demonstration experiments: Light, Air, Earth
Order No. 13244-02

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1st edition

Contents

Student experiments:

Demonstration experiments:

Equipment and Storage

Student Set, Light, Air, Earth 13243-88

	Description	No.	Quantity
(1)	Beaker, 250 ml	36013-01	2
(2)	Graduated cylinder, 50ml	36628-01	1
(3)	Erlenmeyer flask, nar. neck	36418-00	1
(4)	PVC tubing, i.d. 7mm	03985-00	1
(5)	Beaker, 100 ml	36011-01	1
(6)	Funnel, plastic, dia.50mm	36890-00	1
(7)	Petri dishes	64710-01	3
(8)	Rubber stopper, with 1 hole	39255-01	1
(9)	Matchbox	13243-02	1
(10)	Digital stop watch	24025-00	1
(11)	Mirror, 80x50 mm	08209-01	2
(12)	Magnifier, plastic	88002-01	1
(13)	Silk thread,200m	02412-00	1
(14)	Rubber stopper, without hole	39258-00	1
(15)	Adhesive tape, 19 mm	170455	1
(16)	Tea light, dia = 3.6 cm	13241-31	2
(17)	Circular filter,d 90 mm	32977-03	1
(18)	Paperclips, copper-plated	13231-30	1
(19)	Cress seads	13243-03	1
(20)	Scissors, straight	46970-00	1
(21)	Spoon, special steel	33398-00	1
(22)	Glass tube	322298	1
(23)	Glass rod, l=200mm	40485-03	1
(24)	Ruler, plastic, 200 mm	09937-01	1
(25)	Plastilina, 1 Stck.	167707	1
(26)	Balloons, rubber, 10 pcs	02620-03	1
(27)	White screen 12 x 12 cm	13243-04	1

Demo-Set, Light, Air, Earth 13244-88

	Description	No.	Quantity		Description	No.	Quantity
(1)	Light box, halogen	09801-01	1	(16)	Glass tube, right-angled	36701-52	1
(2)	Bottom w. stem for light box	09802-10	1	(17)	Rubber stopper, 1 hole	39258-01	1
(3)	Power supply 12V / 2A	12151-99	1	(18)	Rubber stopper 2 holes	39258-02	1
(4)	Slide mount for optical bench	09822-00	1	(19)	PVC tubing, i.d. 7mm	03985-00	1
(5)	Diaphragm with hole	09816-01	1	(20)	Porcelain dish	32518-00	2
(6)	Model earth/moon	09825-00	1	(21)	Pipette, with rubber bulb	64821-00	1
(7)	Support base variable	02001-00	1	(22)	Crucible tongs	46964-00	1
(8)	Support rod, l = 600 mm	02037-00	2	(23)	Scissors, straight,180 mm	64798-00	1
(9)	Magnifier w. handle, 6x	87004-06	1	(24)	Protective desk plate	39180-10	1
(10)	Screen, white, 150x150mm	09826-00	1	(25)	Protecting glasses	39316-00	1
(11)	Cardboards, black	06306-01	1	(26)	Litmus paper, blue, 1 box	30678-01	1
(12)	Erlenmeyer flask, 500 ml	36421-00	1	(27)	PVC-plates, pack.5 pcs.	31751-02	1
(13)	Glass beaker, 400 ml	36014-00	1	(28)	Garden trowel, steel	40484-02	1
(14)	Glass beaker, 250 ml	36013-00	1	(29)	Measuring tape, l = 2 m	09936-00	1
(15)	Funnel, glass, d=80 mm	34459-00	1				

Storage tray

How are shadows caused?

Task

Examine the shadow of a matchbox.

Material

1 Tealight
1 White card
1 Box of matches
1 Rubber stopper without hole
1 Thread
1 Adhesive tape
1 Pair of scissors
1 Ruler

Pencil
Rubber
Storage box

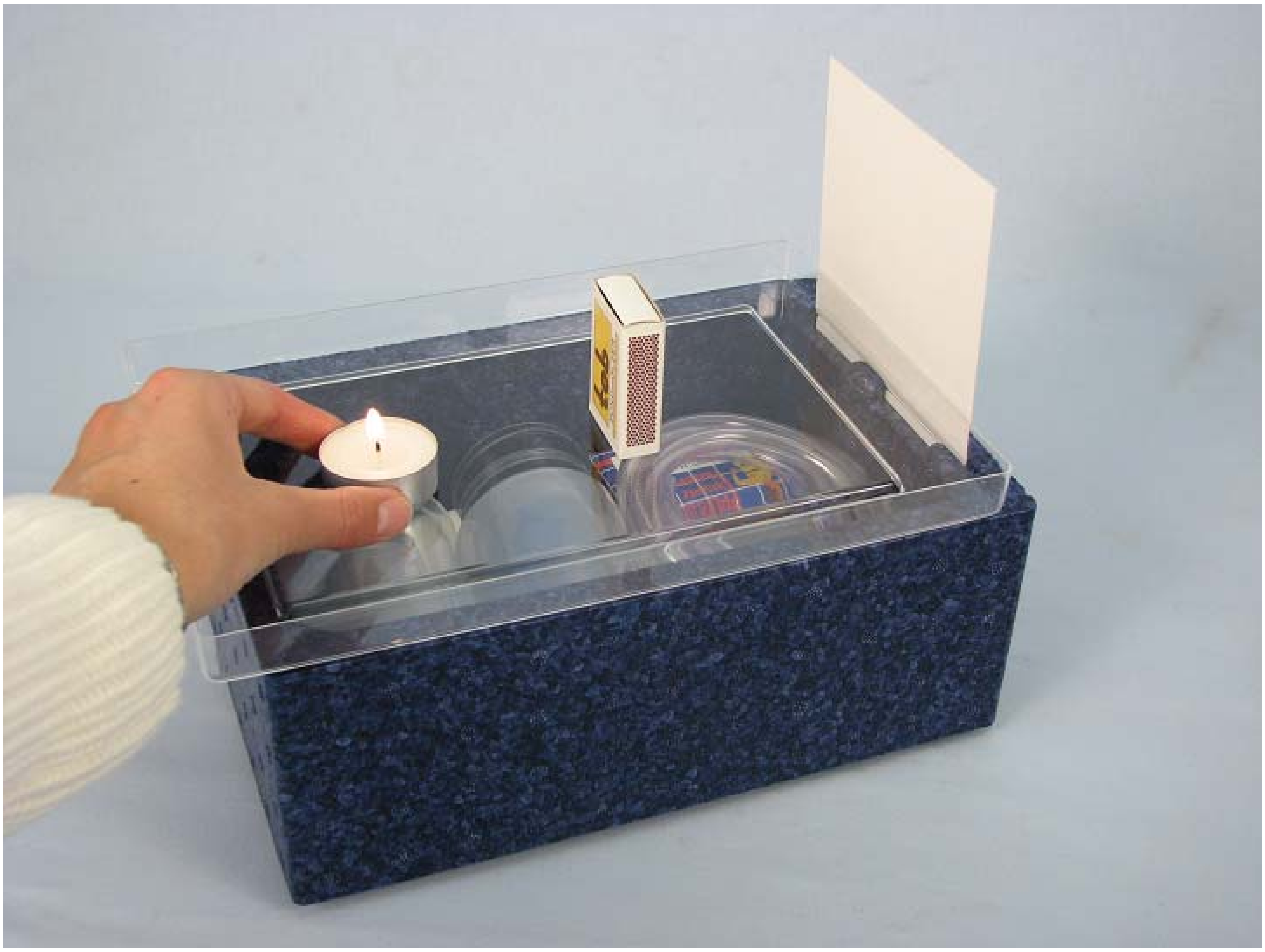

Fig. 1

Set-up and procedure

- Stand a tea warmer candle in front of the screen and light it.
- Create a shadow of the matchbox on the screen and move the matchbox back and forth between the candle and the screen.
- Move the candle to the left, to the right, further away and nearer.
- Record the changes in the shadows.
- Now stand the matchbox on end on the rubber stopper.
- Use the pencil to lightly mark the four corners of the shadow cast by the matchbox on the screen (Fig. 2).
- Blow the flame out without displacing any of the parts of the set-up.
- Use the scissors to cut off four approximately 40 cm lengths of thread.
- Stick one end of each thread exactly on a mark on the screen, each to a different corner.
- Hold onto the free ends of the threads and draw the threads out so that each thread leads to its corresponding edge of the matchbox and further. Where do the ends meet?
- When you have finished the experiment, carefully remove the sticky tape from the card and rub out the pencil marks on it.

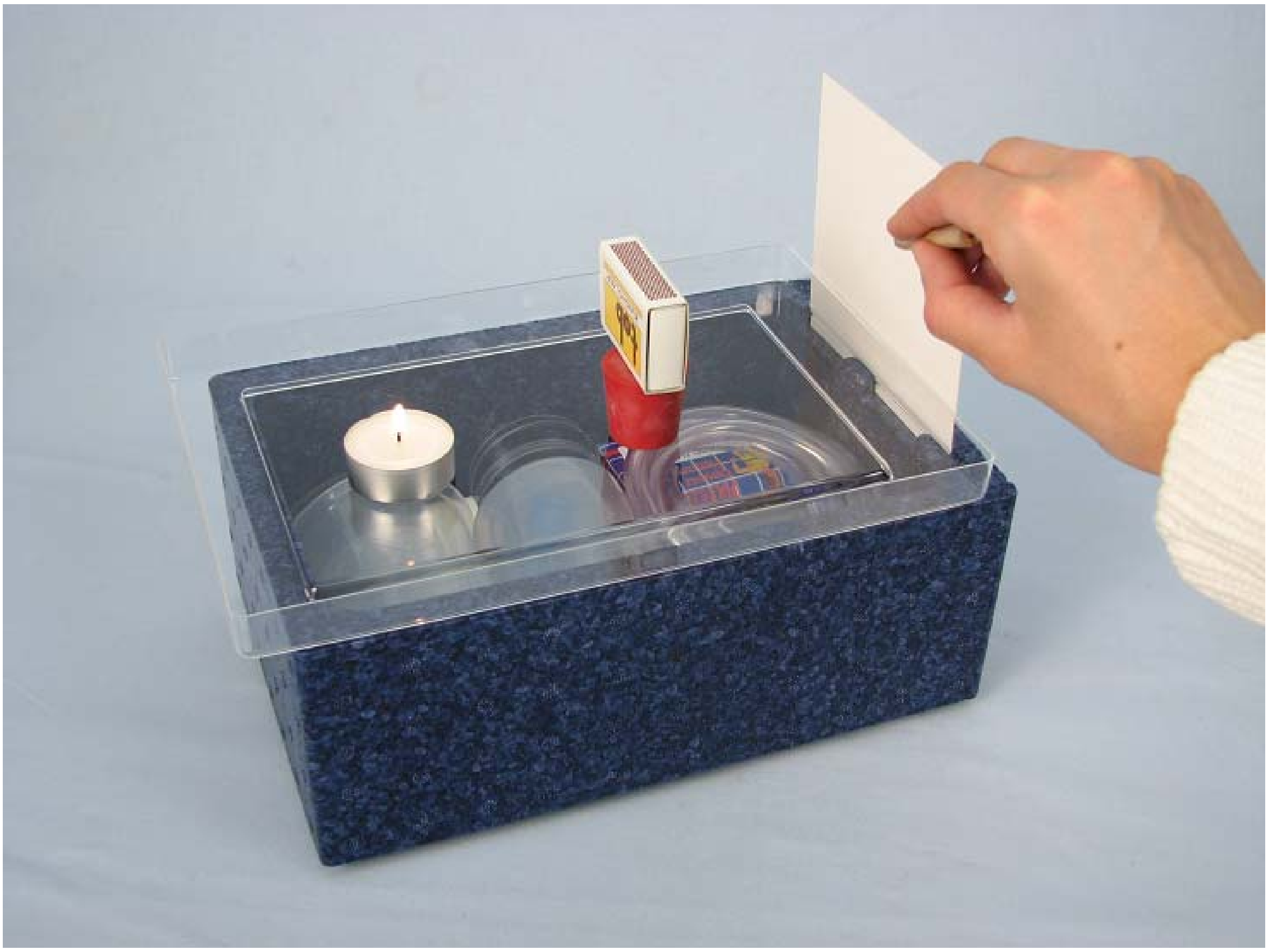

Fig. 2

Observations

1. How does the shadow change when you move the matchbox?

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2. How does the shadow change when you move the candle?

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3. Where do the ends of the threads meet?

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Evaluation

1. How are shadows caused?

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(How are shadows caused?)

Preparation

The room must be darkened for this experiment.

Observation

1. When the matchbox is moved towards the screen the shadow becomes smaller and the edges more sharp. Drawing it back from the screen causes the shadow to become smaller and blurred. Moving it to the right causes the shadow also to move to the right, and moving it to the left moves the shadow to the left.
2. The shadow is larger but more blurred when the candle is pushed towards matchbox, drawing it back causes the shadow to become smaller and sharper. Moving the candle to the left moves the shadow to the left, moving it to the right brings the shadow to the left.
3. When the threads from the four corners of the shadow are held to pass straight over the four corners of the matchbox, the free ends meet where the candle was previously positioned.

Evaluation

1. A shadow is given where light falls with less light than in the surroundings.
   A shadow of the matchbox can be seen on the screen because the matchbox stops the passage of light from the candle which would have fallen on this area.
   From the point of view of the light source, the shadow is always exactly behind the object.
   The endings of the four straight threads which lead backwards to the source of light clearly demonstrate that light travels in straight lines.

Room for notes

When do you have more than one shadow?

Task

Play with shadows to generate different silhouettes.

Material

2 Tealights
1 White card
1 Ruler
1 Box of matches

Fig. 1

Set-up and procedure

- Stand both candles 20 centimetres away from the white card and light them.
- Stand the matchbox between the candles and the screen.
- Describe the shadow pattern thrown by the matchbox.
- Alternately hold a hand in front of one candle and then in front of the other. How do the shadows change?

Observations

1. What type of shadow which is given on the card screen?

   ....

   ....

2. What happens when you alternately hold your hand in front of the individual candles?

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Evaluation

1. Where do the different shadows behind the matchbox come from?

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2. When do you have more than one shadow?

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(When do you have more than one shadow?)

Preparation

The room must be darkened for this experiment.

Observation

1. A very dark shadow is given directly behind the matchbox. Brighter shadows can be seen to the left and right of this.
2. When light from only one candle falls on the screen, the brighter shadows disappear and the dark shadow which could previously be seen is still there but is no longer so dark. Holding a hand over the candle on the right causes the shadow to appear to the left of the matchbox, holding a hand over the candle on the left brings the shadow to the right.

Evaluation

1. Each of the candles creates a shadow: the candle on the right shadows to the left of the matchbox, the one on the left shadows it to the right. The shadow is darkest where these shadows overlap each other. At this position, no light from them falls on the screen. The two brighter shadows are there where one of the candles throws light. The shadow is brightest at the position which is lit up by both candles.
2. When you walk along a street which is illuminated by street lights in the dark, several shadows are thrown, although each street light only makes one shadow. As you walk further, these shadows get longer, less bright and disappear at some time while the next street light causes the next shadow to be thrown. You have several shadows simultaneously from different street lights.

Room for notes

How many shadows does a pencil have in a mirror?

Task

Examine the shadows are cast by a candle and a pencil in front of a mirror.

Material

1 Mirror
1 Tealight
1 Box of matches
Plasticine

Pencil

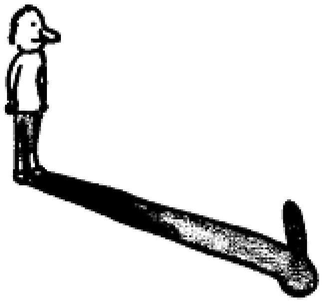

Fig. 1

Set-up and procedure

- Use plasticine to hold the mirror standing upright on the table.
- Position the candle and the pencil so that the pencil is between the mirror and the candle.
- Light the candle.
- Look carefully to see how many shadows you can see.

Observations

1. How many shadows did you find?

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   ....

   ....

2. Describe the shadows of the pencil.

   In front of the mirror: ....

   ....

   In the mirror: ....

   ....

Evaluation

1. Where do the shadows of the pencil come from?

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2. When do you have more than one shadow?

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Mirror images of shadows

(How many shadows does a pencil have in a mirror?)

Preparation

The room must be darkened for this experiment.

Observation

1. A total of six shadows were found. The shadow of the candle, the shadow of the mirrored candle and two shadows each for the pencil in front of the mirror and in the mirror.
2. In front of the mirror: The pencil casts a distinct shadow in the direction of the mirror.
   A weaker shadow can also be seen which runs away from the mirrored image. The pencil also has two shadows in the mirror, one of which runs to the mirror and the other away from it.

Evaluation

1. The dark shadow of the pencil is caused by the candle. This shadow is mirrored, so that is can be seen twice. The weaker shadow of the pencil results because the image of the candle acts as a real light source and also creates a shadow. This weaker shadow is also mirrored. A total of four shadows of the pencil can therefore be seen.
2. When you walk along a street which is illuminated by street lights in the dark, several shadows are thrown, although each street light only makes one shadow. As you walk further, these shadows get longer, less bright and disappear at some time while the next street light causes the next shadow to be thrown. You have several shadows simultaneously from different street lights.

Room for notes

What does a mirror do to an object?

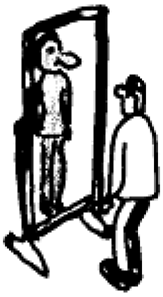
Task

Examine various mirror images.

Material

- 2 Mirrors
- 1 Ruler
- 1 Pair of scissors
- 1 Adhesive tape
- Plasticine

- Pencil
- White paper



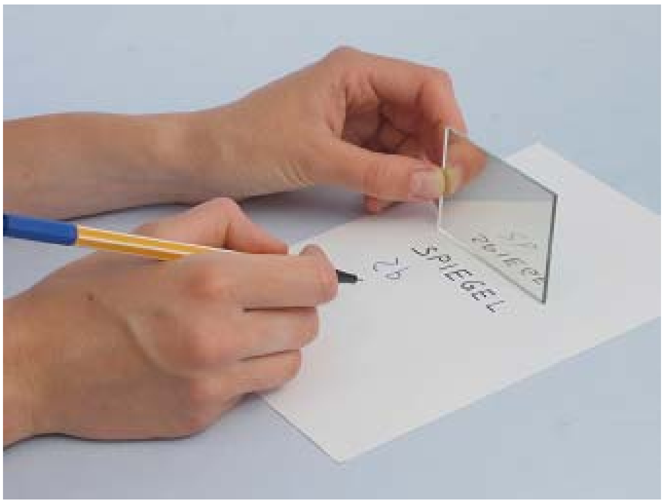


Fig. 1


Fig. 2


Fig. 3

Set-up and procedure

First game

- Write the word “MIRROR” in capital letters on a sheet of white paper and about ten centimetres down from the top edge of the paper.
- Hold a mirror behind it so that the word is shown in it.
- Write down the letters that the mirror shows exactly and look at what you have written in the mirror. What do you see?
- Draw a line towards yourself on the paper in front of the mirror and one away from you. What do you observe in the mirror?

Second game

- Use adhesive tape to stick two mirrors together at their short sides so that there is about three mm clearance between them and they can be clapped together like a book.
- Draw a roughly ten centimetres long line and place the clapped-out mirror “book” on it. Open and close the mirror “book”. What do you see?
- Look at the word “Mirror” which you previously wrote in the mirror “book”. Try to mirror the word so that it is the right way round.
- Try to make interesting patterns by putting either small objects or pictures you have drawn between the two halves of the mirror “book”.

Third game

- Separate the two mirrors.
- Use plasticine to position the mirrors upright and at a distance of about 15 cm from each other on the table, whereby the mirror surfaces must face each other.
- Place a small object between the two mirrors.
- Now look a hair’s breadth away from the side of the front mirror into the other mirror. How many times can you see the object?

Observations

1. What happens when you look at the mirror writing that you have written in the mirror?

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2. What do you observe as you draw lines away from you and towards you?

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3. What do you see as you clap the two mirrors on the line nearer to each other?

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4. How many times can you see the object which is between the two mirrors?

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Evaluation

1. What is switched in the mirror?

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2. Why does an ambulance have the inscription written as mirror image?

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3. Why do you see the object between the mirrors so many times?

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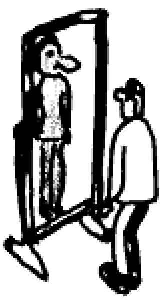

(What does a mirror do to an object?)

Material

White A4 paper

Objects for interesting mirror images

Preparation

Small colourful objects for mirror images such as jelly babies, marbles, pearls or cubes.

Observation

1. The mirror writing can now be again read correctly in the mirror.
2. When I drew a line away from me, it came nearer to me in the mirror, but a line I drew towards me moved away from me in the mirror.
3. Geometric figures are formed. First a triangle, then a square and on further closing the “book” more and more corners.
4. If you have seen the object more than twenty times you have carried the experiment out very well. The mirror images at the back become more and more indistinct.

Evaluation

1. Back and front are switched in the mirror image. This results because the part of an object which is nearer to the mirror is further away from the observer and so the image of it in the mirror shows it to be nearer. The observer therefore sees everything which is near to him further away in the mirror and whatever is further away from him or her is nearer in the mirror.
2. Cars driving in front of it should see the “Ambulance” inscription the right way round so that they quickly make way for the ambulance.
3. When two mirrors face each other, they mirror the object and the mirror image of the object and the mirror image of the mirror image of the object and the mirror image of the mirror image of the mirror image of the object and so on. A little light is lost at each mirroring, however, so that the mirror images at the back become less and less distinct.

Room for notes

How does a spoon change your mirror image?

Task

Look at mirror images given at the back of the spoon and at the front of it.

Material

1 Spoon spatula

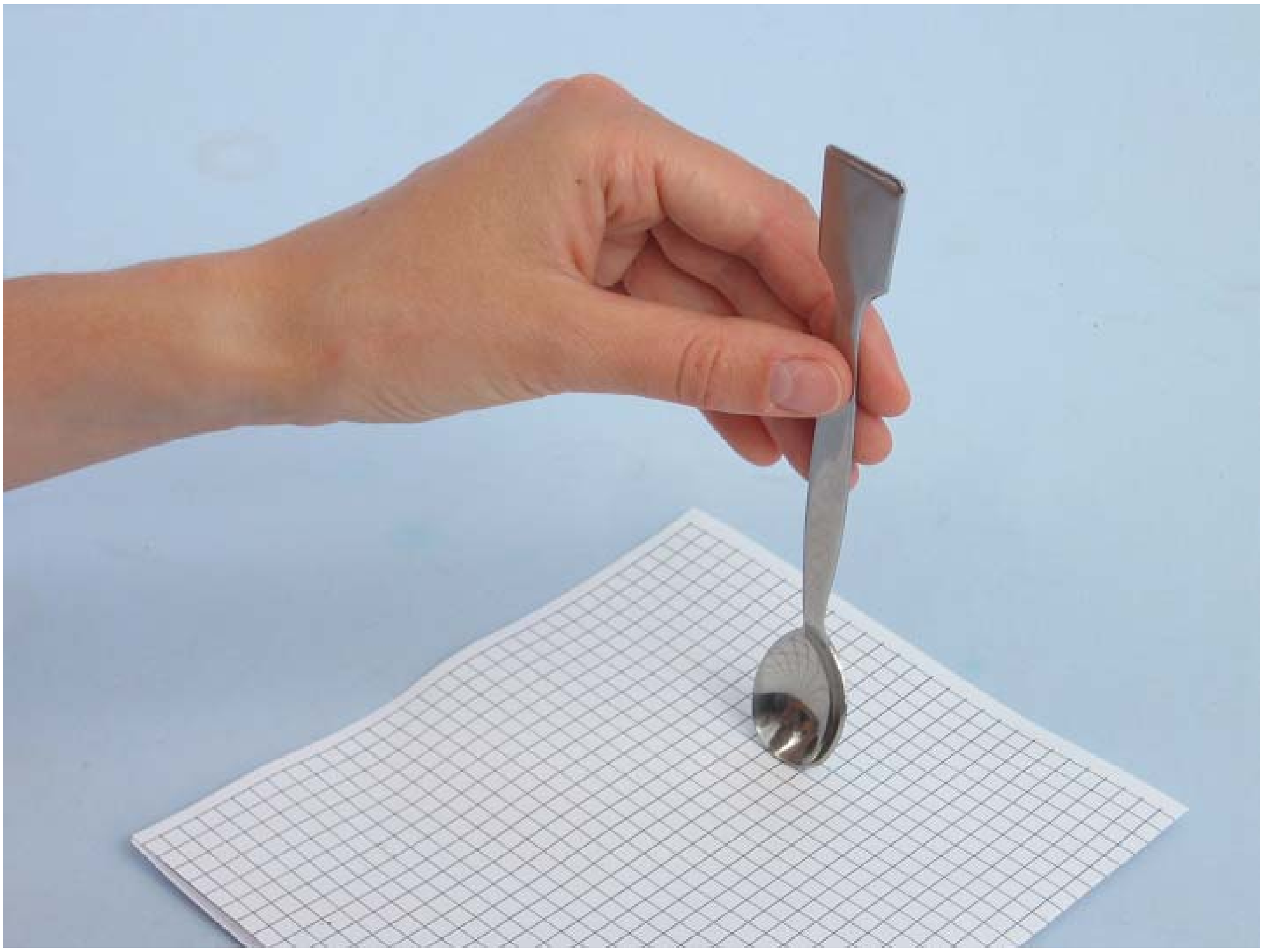

Fig. 1

Set-up and procedure

- Look at your face in the back and the front of a spoon. What do you see?
- Hold the spoon vertically on a sheet of squared paper. Turn it so that you can see the mirror image of the paper on the back of the spoon and then the one on the front of it.

Observations

1. What sort of a face looks at you from the back and the front of the spoon?

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2. How do the squares of the paper change when looked at from each side of the spoon?

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Evaluation

1. How must a mirror be shaped to be useful as a monitoring mirror?

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(How does a spoon change your mirror image?)

Observation

1. The back of the spoon distorts the mirror image. In addition to the face, much of the surroundings can be seen. The front of the spoon reverses the image and shows less of the surroundings.
2. The back of the spoon makes the lines look curved exactly the other way round to the front of the spoon. In addition, far more lines can be recognized at the back of the spoon.

Evaluation

1. The mirror must be thickest in the middle. The mirror image is then distorted but one has a very good panoramic view. As an example, such a mirror would enable even corners which one cannot look into with a normal mirror to be monitored so that a shoplifter would not have much chance. Such a mirror is called a convex mirror. Mirrors which are thinnest in the middle are called concave mirrors.

Room for notes

How can water make an object visible?

Task

Look at a coin and a glass rod in water.

Material

2 Beakers, 250 ml
1 Glass rod
1 Ruler
1 Pair of scissors
1 Adhesive tape

Sheet of A4 paper
Coin
Water

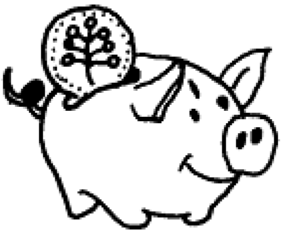

Fig. 1

Set-up and procedure

- Measure out a 9 cm wide strip at a long side of an A4 sheet of paper und cut it out.
- Use adhesive tape to fix the strip to the outside of one of the beakers.
- Place a euro coin on the bottom of this beaker and slide it so that it is against the wall of the beaker.
- Look diagonally into the beaker from above and adjust your position so that the coin is hidden, but only just hidden, by the edge of the beaker.
- A classmate is now to fill the second beaker with water and pour it slowly into the beaker with the coin which you are looking into. Record your observations.
- Take the paper strip off of the beaker.
- Stand the glass rod in the beaker which now contains water so that it is inclined.
- Look at the glass rod from all directions. What do you notice?

Fig. 2

Observations

1. What did you observe as water was poured into the beaker?

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2. What does the glass rod look like from above? What does it look like from the side?

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Evaluation

1. Explain what happened to the coin in the beaker as water was filled in?

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2. What causes the remarkable appearance of the glass rod?

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Room for notes

(How can water make an object visible?)

Observation

1. The bottom of the beaker seemed to be lifted up and this made the coin visible.
2. From the side, the rod appears to have been broken into two parts at the water surface. From the above at the front, the part in water appears to be thicker than the part in air.

Evaluation

1. Light from the coin travels through the water in a straight line, but it is “bent” at the border between water and air. This “bending” is called optical refraction, or the refraction of light, and causes the hidden coin to become visible as though it had been moved.
2. Light rays from the glass rod reach the eye. Those which pass through air propagate quicker than those which are refracted at the border between the two materials. The glass rod therefore appears to be broken at this position.

Room for notes

How can water be used as a lens?

Task

Turn a drop of water into a lens.

Material

1 Petri dish
1 Beaker
1 Paper clip
1 Glass rod
1 Ruler

Water

Fig. 1

Set-up and procedure

- Fill the beaker with water.
- Dip the glass rod in the water and take it out with a drop of water hanging on the end of it. Transfer the drop of water to the dish.
- Look at the text on this page through the drop of water. What is to be seen?
- Bend a paper clip apart and form one end of it to a ring of about six millimetres diameter. This is best achieved by bending the wire around the glass rod.
- Dip the wire ring in the water to pick up a drop of water in the ring.
- Look at the text of this page through this drop of water.

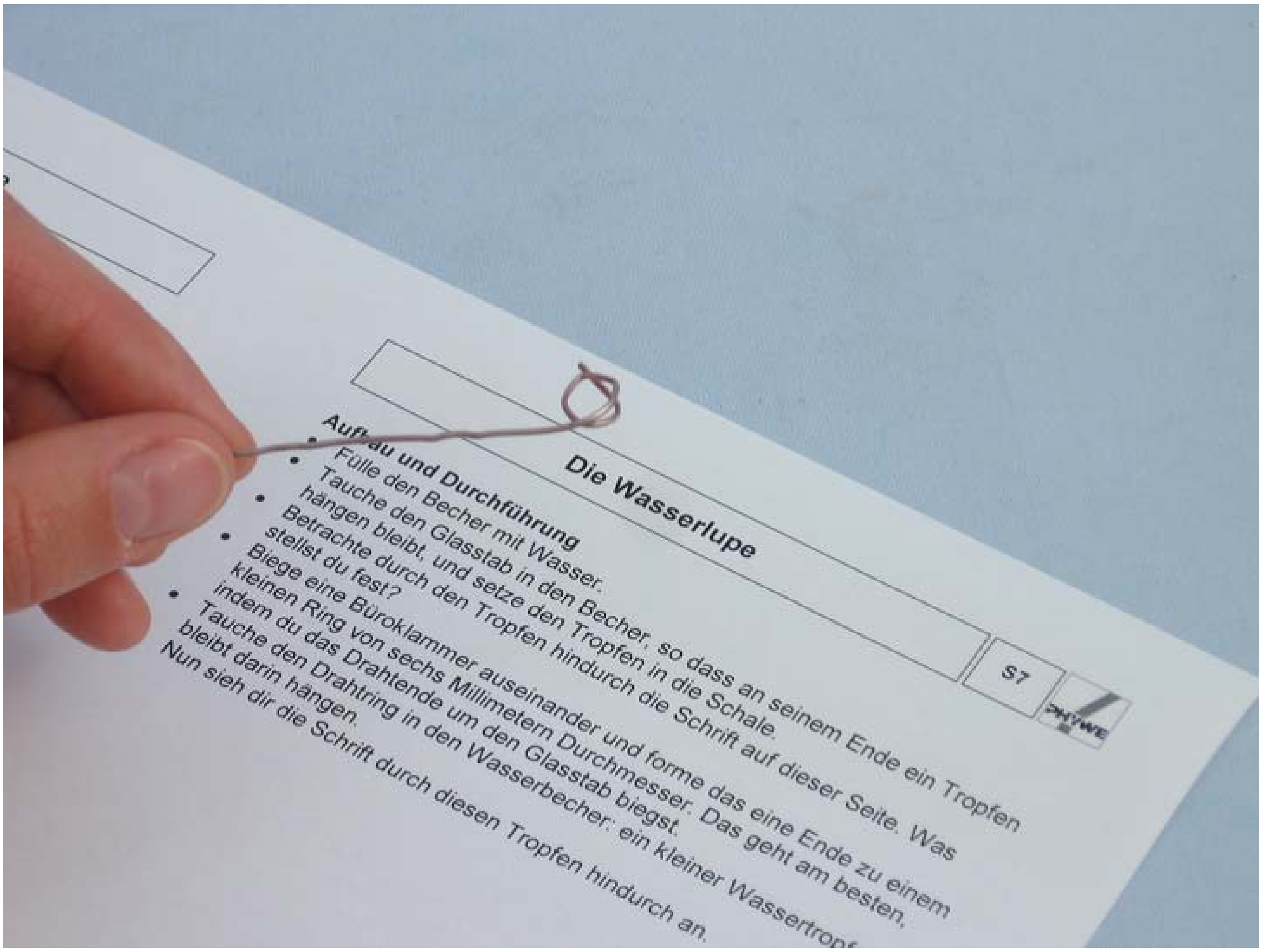

Fig. 2

Observations

1. What does the text look like when looked at through the drop of water in the dish?

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2. What did you see when you looked at the text through the drop in the wire ring?

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Evaluation

1. How does the text change when looked at through a drop of water?

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2. How important is the shape of the drop of water?

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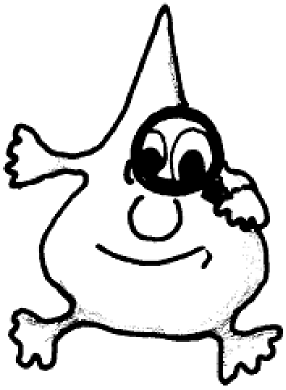
Room for notes



(How can water be used as a lens?)

Observation

1. The text appears to be magnified. When the dish is lifted up, the letters first become larger, but then blurred and distorted.
2. The text was either reduced in size or magnified. It was distorted at the rim of the drop.

Evaluation

1. The drop of water acts as a lens. Light rays which pass through it are subject to refraction. The light rays which come from the objects which are looked at through the drop of water therefore appear to be either magnified or reduced in size because of the refraction of light.
2. A lens which is thicker in the middle refracts light rays so that they are collected together behind it. This type of lens is therefore called a converging lens. The image which one sees through a converging lens is magnified.
   Lenses which are thinnest in the middle are called dispersing lenses. The image they form is reduced in size.
   The water drop on the dish has the form of a converging lens and so magnifies the text. The water drop in the wire loop is however not always of the same shape, as sometimes it is thicker at the rim and at other times thicker in the middle. The text is therefore correspondingly either magnified or reduced in size.

Room for notes

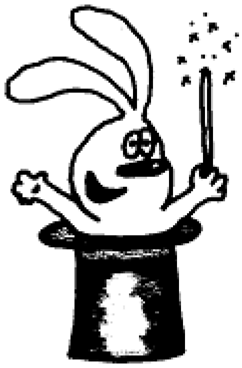
What is the secret of the magic wand?

Task

Examine what a glass rod can do to letters.

Material

1 Glass rod



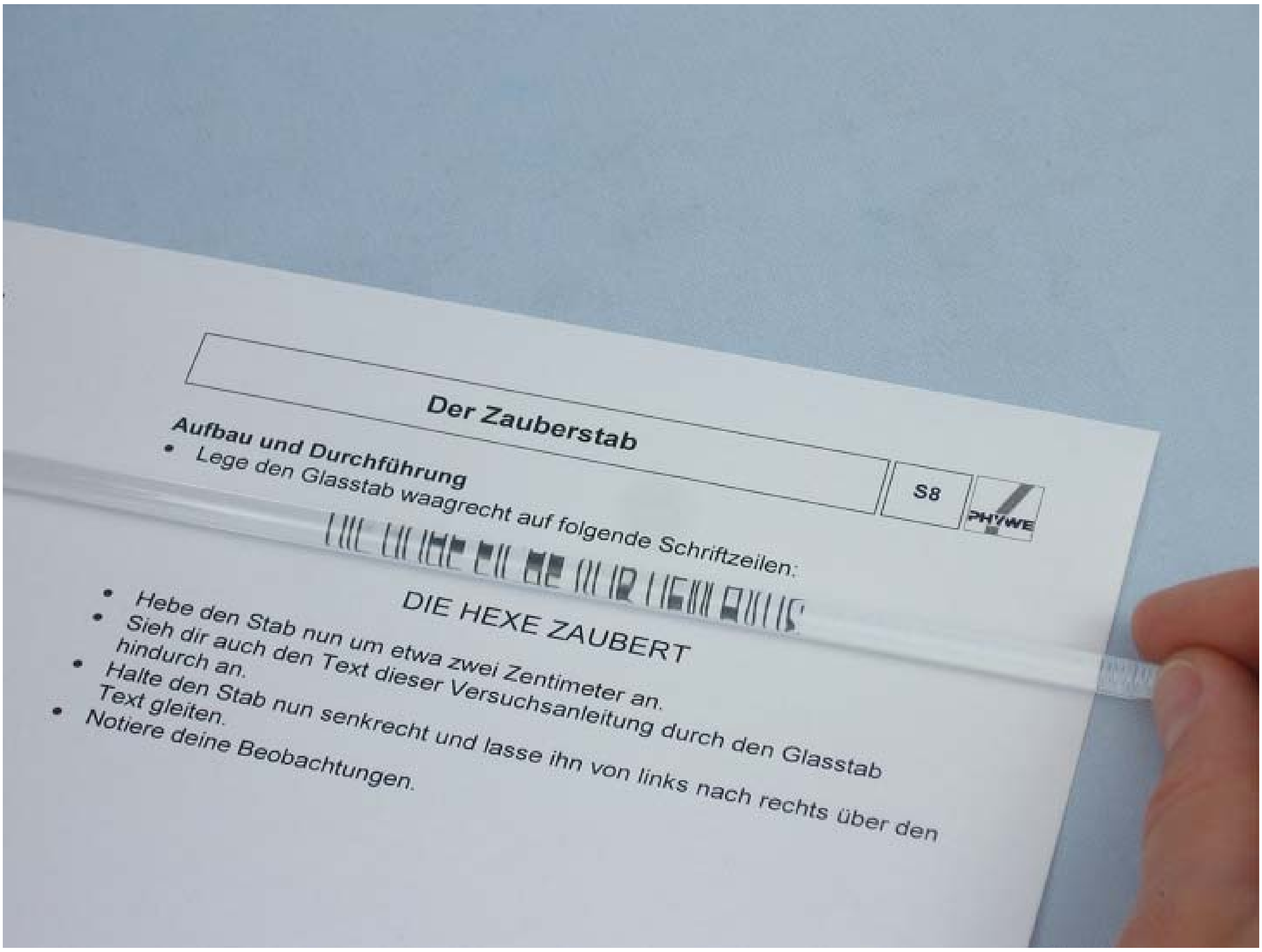


Fig. 1

Set-up and procedure

- Position the glass rod horizontally on the following lettering:

A LAMP AND A BOX UP AN OAK TREE

A PRAM OR A BIKE

- Lift the glass rod about two centimetres up.
- Look at the text of these instructions through the glass rod.
- Now hold the glass rod so that it is vertical and slide it across the text from left to right.
- Record your observations.

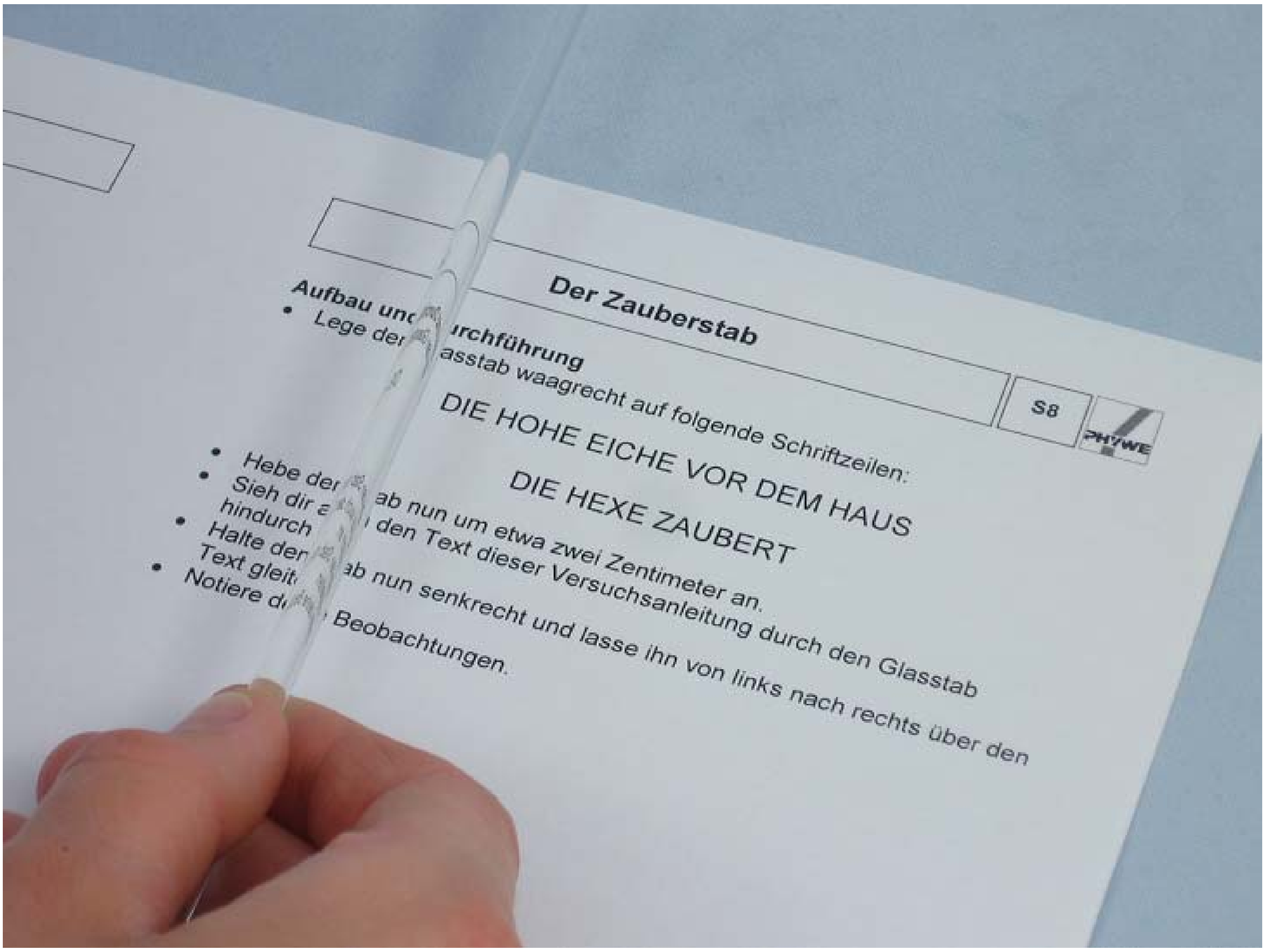


Fig. 2

Observations

1. How did the text look when you placed the glass rod directly on it?

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2. What happened when you lifted the glass rod?

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3. Describe what you observed as you slid the glass rod over the text from left to right.

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Evaluation

1. Explain why a spell is cast on some words but not on others?

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2. Write down a magic sentence which you have thought up yourself.

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3. How does a glass rod transform letters?

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(What is the secret of the magic wand?)

Observation

1. The letters were drawn out lengthwise but upright.
2. As soon as the glass rod was lifted up, some of the words turned upside down but others remained as they were.
3. The words appeared to roll past from the back to the front. Some letters were mirrored.

Evaluation

1. The glass rod turns all letters upside down, but one only notices this with unsymmetrical characters. When a horizontal symmetry level is present, upside-down symmetrical letters still look the same as before.
   Unsymmetrical letters: A, F, G, J, L, M, N, P, Q, R, S, T, U, V, W, Y, Z
   Symmetrical letters: B, C, D, E, H, I, K, O, X
2. You can make sentences which can be turned upside using unsymmetrical letters and those which still look the same with symmetrical letters.
   Examples for symmetrical words are: BIO, BIKE, BOOK, BOX, CODE, COOK, DEO, DICE, DIE, HIDE, HOOK, HIKE etc.
3. The glass rod acts as a lens in that it refracts rays of light so that they lead to a reversed appearance, which is similar to what was observed with the lens in demonstrations D2 and D3.

Room for notes

How much space does air need?

Task

Try to inflate a balloon which is inserted in a flask.

Material

1 Erlenmeyer flask
1 Balloon

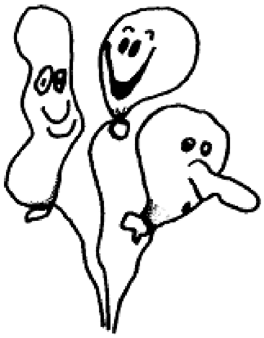

Fig. 1

Set-up and procedure

- Fit the balloon in an Erlenmeyer flask so that the open end is poking out.
- Take hold of the rim of the balloon and fit it over the neck of the flask.
- Now try to blow air into the balloon in the flask. What do you find out?

Observations

1. What happens when you attempt to inflate the balloon in the flask?

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Evaluation

1. Do you have an explanation for the difficulty in blowing it up?

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A balloon in a flask

(How much space does air need?)

Observation

1. Regardless of how hard I blew, I couldn't inflate the balloon.

Evaluation

1. The air which is already in the flask completely fills the space there. To inflate the balloon in the flask, therefore, one would have to compress the air in the flask. This is hardly possible by breathing air in, however, so the balloon could not be inflated.

Room for notes

Can you turn a water-filled beaker over without water emptying out?

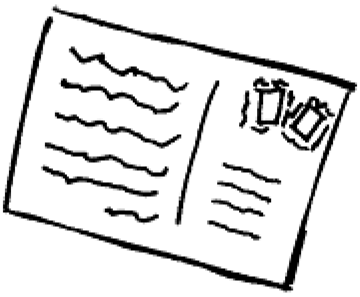
Task

Use a postcard to completely close a beaker containing water.

Material

1 Beaker

Postcard
Water



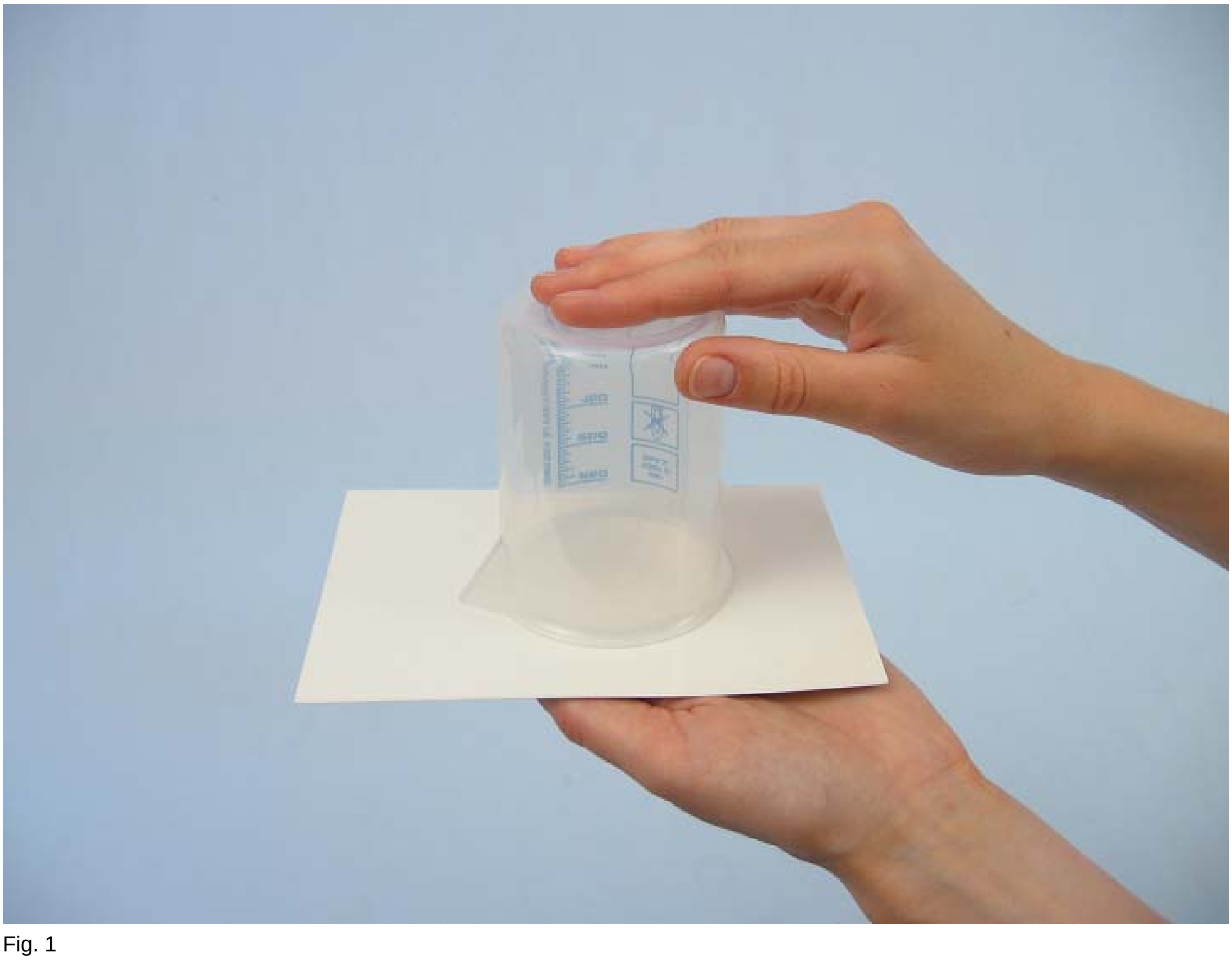


Fig. 1

Set-up and procedure

- It is best to carry out this experiment over a washbasin.
- Fill the beaker to the rim with water.
- Lay a postcard on the top of the beaker with the smooth side down.
- Press the postcard firmly against the rim of the beaker while turning the beaker completely over.
- Now take your hand from the postcard. What happens?
- Repeat this procedure with a half-full beaker.

Observations

1. What happens when you turn the full beaker over?

   ....

   ....

2. What happens when the beaker is not full?

   ....

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Evaluation

1. How does the postcard trick function?

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2. Why is the experiment only successful with a full beaker?

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The postcard trick

(Can you turn a water-filled beaker over without water emptying out?)

Observation

1. The postcard appears to stick to the mouth of the beaker and no water flows out.
2. When the half-full beaker is turned over and one lets go of the postcard, water immediately empties out.

Evaluation

1. Two forces act on the postcard, the weight of the water from above and the atmospheric pressure from below. In this experiment, however, the atmospheric pressure is greater than the water pressure. The postcard is therefore pressed against the mouth of the beaker and closes it.
2. Air above the water in the beaker exerts the same pressure as the outside air. The postcard is so now subjected to air pressure both from above and from below. Together with the pressure of the water, therefore, the pressure from above is greater than the pressure from below and the card drops off.

Room for notes

How does air behave on being heated and cooled?

Task

Examine how air behaves when it is heated and cooled.

Material

1 Erlenmeyer flask
2 Beakers, 250 ml
1 Beaker, 100ml
1 Rubber stopper with hole
1 Glass tube
1 Piece of tubing
1 Pair of scissors

Water
Ice cubes

Fig. 1

Set-up and procedure

- Cut an approximately 30 cm long piece off from the tubing (the same length as an A4 sheet of paper).
- Ease the glass tube in the hole in the wider side of the stopper until the leading end reaches the end of the hole. This is easier to do when you first have your teacher put a drop of glycerol on the tube.
- Ease the tubing over the end of the glass tube which protrudes out of the upper end.
- Put the stopper on the Erlenmeyer flask.
- Fill the small beaker with water.
- Let your teacher pour 100 ml of hot water in one of the large beakers and a few ice cubes in the other one. Fill the beaker containing ice cubes up to the 100 ml gradation with water.
- Dip the Erlenmeyer flask as deeply as possible in the hot water and simultaneously dip the open end of the tubing halfway down in the icy water. What do you observe?
- Keep holding the tubing dipped in the icy water when you now take the Erlenmeyer flask out of the hot water and put it in the icy water. What do you observe?

Observations

1. What happened in the small beaker while you held the Erlenmeyer flask dipped in hot water?

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   ....

2. What occurred in the tubing while you held the Erlenmeyer flask dipped in icy water?

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Evaluation

1. What happens to air when it is heated?

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2. How can you explain what happened when the air was cooled?

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(How does air behave on being heated and cooled?)

Preparation

Each group of students needs a few ice cubes and approx. 100 ml of hot water at a temperature of about 60°C. This temperature is sufficient for the heating of the air in the Erlenmeyer flask while not being hot enough to be a potential cause of burns to students.

Observation

1. Bubbles formed and ascended in the water
2. Water rose up in the tubing.

Evaluation

1. Air expands when it is heated. It therefore needed here more space than was available in the Erlenmeyer flask. Excess air therefore flowed out through the tubing.
2. The volume of air shrinks when it cools. There was therefore more space left here in the Erlenmeyer flask so that air was drawn in through the tubing. Water then filled the space which was left.

Room for notes

What happens to air during breathing?

Task

Examine how long a candle burns in fresh and exhaled air.

Material

1 Stopwatch
1 Beaker, 250 ml
1 Piece of tubing
1 Tealight
1 Box of matches

Fig. 1

Set-up and procedure

- Light a candle, cover it with the beaker and use a stopwatch to determine how long it burns.
- Lift the beaker up, wave it around a little in the air and then position it on the table with the mouth of it down and so that the lip of it protrudes just a little over the table edge.
- Lead an end of the piece of tubing up through this small opening and into the beaker.
- After blowing ten breaths into the beaker, immediately push the beaker back on the table a little so that the opening is closed.
- Light the candle, quickly cover it with the beaker and again measure the time until the candle goes out.

Observations

1. A candle in fresh and exhaled air

Measurement conditions	Burning time of the candle
In fresh air	
In exhaled air	

Evaluation

1. Why does the flame of the candle under the beaker go out?

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2. Name possible reasons why the candle burnt for different periods of time in fresh and exhaled air.

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(What happens to air during breathing?)

Observation

1. A candle in fresh and exhaled air

Measurement conditions	Burning time of the candle
In fresh air	11 seconds
In exhaled air	4 seconds

Evaluation

1. A candle needs fresh air to be able to burn. The flame is extinguished as soon as the air is spent, because fresh air cannot flow in under the beaker.
2. During breathing one consumes exactly a part of the air which the candle needs to be able to burn. Exhaled air contains less of this part of air so that the candle is more quickly extinguished. The part of air which both we and candles needs is naturally oxygen.

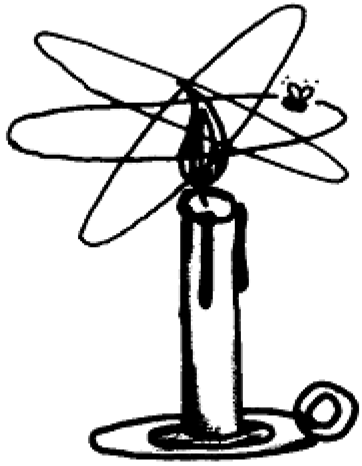
Room for notes

What does a candle need to be able to burn?

Task

Examine what happens to a lit candle under a beaker.

Material



1 Beaker, 100 ml
1 Beaker, 250 ml
1 Tealight
1 Ruler
Plasticine

Storage box cover
Box of matches
Water

Fig. 1

Set-up and procedure

- Form a roll of plasticine of about eight centimetres in length and five millimetres in width. Bring the two ends of the roll together to form a ring and press this ring tight on the cover of the storage box.
- Stand the candle on the plasticine ring so that is in the middle of the cover and gently press it down.
- Now use the large beaker to fill the cover to just under the rim with water.
- Light the candle.
- Put the small beaker over the candle and hold it so that it is in the water but does not quite reach to the bottom.
- Keep a good watch on what now happens.

Observations

1. What happened after you covered the candle with the beaker?

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Evaluation

1. Can you explain what happened under the beaker?

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(What does a candle need to be able to burn?)

Material

Matches or lighter

Water

Preparation

Make sure that the students understand that they are not to fill the cover of the storage box up to the rim, as water would then probably overflow when the beaker is inserted in it.

The plasticine ring is used so that the wick of the candle does not get wet when the water level rises in the beaker and so enables the experiment to be carried out several times. It could be that the candle does not burn as well after it has been lit and extinguished a few times. This is because the burning time is too short to allow much wax to melt. A larger flame is again obtained when the candle is allowed to burn for somewhat longer.

This experiment requires some skill. The beaker must be held very steady as otherwise the rising of the water level cannot be observed. In addition, care must be taken not to tilt the beaker so that air can flow in.

Observation

1. The candle went out and the level of the water in the beaker rose up a little.

Evaluation

1. The candle needs a certain part of the air, oxygen, to be able to burn. The candle no longer burns when this has been consumed. Water comes into the beaker to make up for the part of the air which has been consumed.

   This experiment does not lead to the quantitative concentration of oxygen in air, which is 21 %, as carbon dioxide is created during combustion. This dissolves in water to some extent, however, so that only a part of it takes up space in the beaker. The rise of water is additionally not continuous with the gradual consumption of oxygen. This becomes particularly clear when the candle stops burning. As long as the candle burns, the air in the beaker is heated and so exerts a greater pressure. When the candle is extinguished, the temperature decreases and water can rise up more in the beaker.

Room for notes

How does cress like it best?

Task

Examine under which conditions cress grows best.

Material

3 Petri dishes
1 Spoon spatula
1 Beaker, 250 ml
Cress seeds

Cling film
Potting compost
Water

Fig. 1

Set-up and procedure

- Cress growth is to be examined under various conditions: With light, air, soil, water and warmth (dish 1), in the dark (dish 2), without air (dish 3), without earth (dish 4), without water (dish 5) and in the refrigerator (dish 6).
- Both the lids and the dishes of the three Petri dishes are to be used, so that you have six growth-test dishes.
- Dish 1. Fill a layer of potting compost in and wet it with water. Scatter a few cress seeds on the compost and place the dish somewhere bright. In the days that follow, make sure that the soil is always quite moist but never wet.
- Dish 2. Treat this exactly as dish 1, but place it in the dark, for example, in a cupboard and only open the cupboard over the next few days to keep it moist.
- Dish 3. Treat this exactly as dish 1 except that you are to cover it with cling film before you place it beside dish 1.
- Dish 4. Do not add and potting compost here. Simply scatter some seeds in and water them to be quite moist. Place this dish beside the other two and keep the seeds moist over the next few days.
- Dish 5. Fill potting compost into this one and scatter seeds in, but do not add water. Place this dish beside the other three but do not add water to it over the next few days.
- Dish 6. Treat this exactly as dish 1, but place it in the refrigerator. Keep it moist over the next few days.
- In the days that follow, keep an exact record of the development of the seeds in the six dishes.
- When the cress grows well, it should be about 5-6 cm high and you can harvest it.
- You can use it to season salads or quark, or simply scatter it over a slice of bread and butter. Enjoy your meal!

Observations

1. What did you observe in the six dishes over the days which followed?

Dish	Day 1	Day 2	Day 3	Day 4
1				
2				
3				
4				
5				
6				

Evaluation

1. What does cress need to grow well?

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(How does cress like it best?)

Material

Potting compost

Cling film

Preparation

This experiment should be started on a Monday if possible, so that four days remain in which the growth can be monitored.

Observation

1.

Dish	Day 1	Day 2	Day 3	Day 4
1	Germination begins: Seeds open, shoots 0.5 mm	Shoots 4-5 mm, green, erect	Shoots 2-3 cm, green, turned to light, erect	Shoots 4-5 cm, green, strong leaves turned to light
2	Germination begins: Seeds open, shoots 0.5 mm	Shoots approx. 1 cm, yellow, erect	Shoots 3-5 cm, yellow, erect and straight	Shoots 8-9 cm, yellow, erect and straight, leaves small
3	Germination begins: Seeds open, shoots 0.5 mm	Shoots 2-4 mm, green, erect	Shoots ca. 1 cm, gre-en, bent, mould	Shoots ca. 1 cm, gre-en, bent, more mould
4	Germination begins: Seeds open, shoots 0.5 mm	Shoots 2-4 mm, pale, lying	Shoots 4-5 mm, gree-nish, lying	Shoots approx. 1 cm, greenish and violet, erected a little
5	No germination	No germination	No germination	No germination
6	No germination	No germination	No germination	Germination beginning

Evaluation

1. Cress needs light, air, warmth, water and soil if it is to grow well.
   It remains pale without light, growth is delayed and the soil becomes mouldy without air, growth is slowed in the cold, it does not even germinate without water and the plants have no hold without soil.
   Nutrient salts which are necessary as plant nutrients are also dissolved in water and soil.

What does soil consist of?

Task

Examine the components of samples of various soils.

Material

1 Measuring cylinder, 50 ml
1 Petri dish
1 Spoon spatula
1 Magnifier

Samples of various types of soil
Water

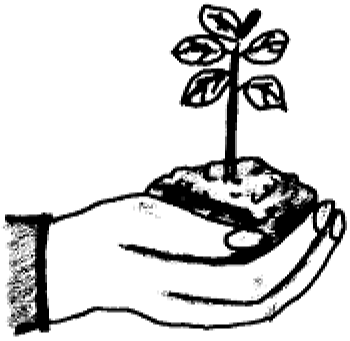

Fig. 1

Set-up and procedure

- Put a sample of one of the soils in the beaker.
- Take a close look at it. Use the magnifier for this.
- Use the spoon to break up the sample as finely as possible.
- Fill soil sample loose-packed into the measuring cylinder up to the 15 ml mark and, following this, pour water in up to the 50 ml mark.
- Close the measuring cylinder with the ball of your thumb and shake it vigorously so that all soil particles are suspended in the water.
- Put the measuring cylinder on the table and allow it to stand undisturbed.
- Observe what happens over the following minutes.
- Use the same procedure to examine each of the other soil samples.

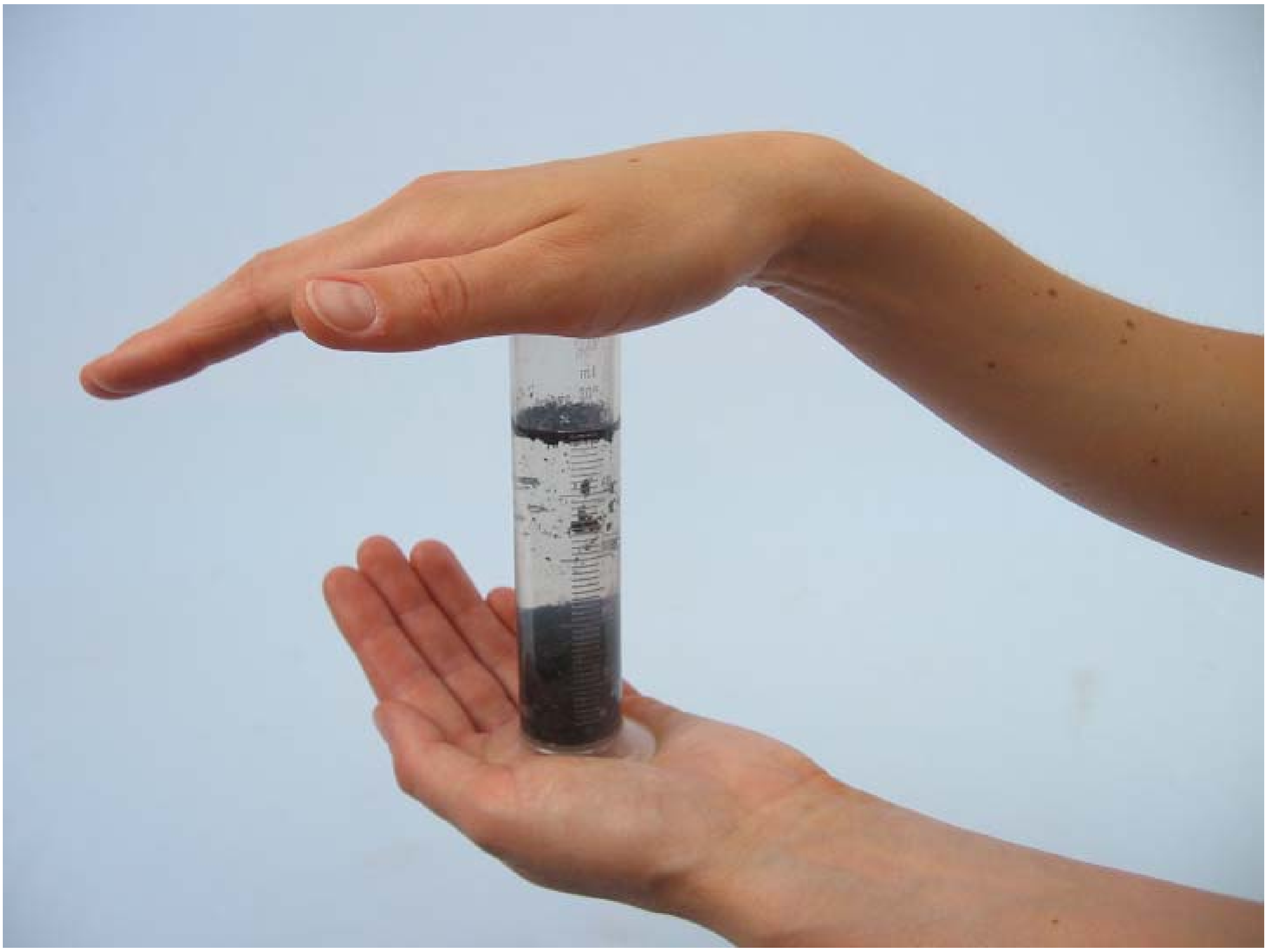

Fig. 2

Observations

1. Which components of the soil samples did you recognize?

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2. What did you observe after shaking the measuring cylinder?

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3. Record the mark to which the soil particles settled in the following Table.

	Height of the settled soil particles
Sample 1	
Sample 2	
Sample 3	

Evaluation

1. Experts separate soils into various types in the following succession of their particle size: Gravel, sand, silt and clay soils. Loam is a mixture of sand and clay and has very good properties for plant growth. As sand always first settles, you can differentiate between your samples according to the sand content. The lighter components, such as silt and clay, settle much later.
   Enter the samples here in the succession of their sand content.

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2. If you allow the measuring cylinder with an incompletely settled soil sample to stand for a long time, for example up to the next lesson on this subject, then the lighter particles will also have settled. Describe what you then see in the measuring cylinder.

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(What does soil consist of?)

Material

1 Spade

Plastic bags

Preparation

The spade is to be used to take samples of various soils, for example from a vegetable plot and from a grassy area. The samples should be as different as possible and not too moist. Dig the spade in vertically to collect about 3 cm samples, whereby the sampling depth should be 15-30 cm in farmland and 10 cm in a grassy area. Stones, parts of plant and foreign bodies such as glass, metal or plastic material should be removed prior to the experiment.

Observation

1. The samples contain crumbs and grains of different sizes but no plant residues.

   A differentiation is made between sand of different particle sizes, 2 – 0.2 mm is called coarse sand, 0.2 - 0.02 mm fine sand. Silt and clay are less than 0.02 mm in diameter. Nutrients are particularly well stored by clay minerals. Soils with a high content of clay are so very fertile, whereas soils with a high sand content are comparatively low in nutrients.
2. The soil particles settled at different rates in the measuring cylinder.
3.

	Height of the settled soil particles
Farmland	approx. 13 ml
Garden	approx. 10 ml
Grassy area	approx. 8 ml

Evaluation

2. The soil particles have settled in layers. The lowest layer is course-grained sand, on this fine-grained sand (silt) and clay. A dark humus layer which consists of rotted plant material is often to be seen as top layer.

Room for notes

How can an earthworm breathe in soil?

Task

Test soil to see if it contains air.

Material

2 Beakers, 250 ml
1 Spoon spatula

Samples of various soils
Water

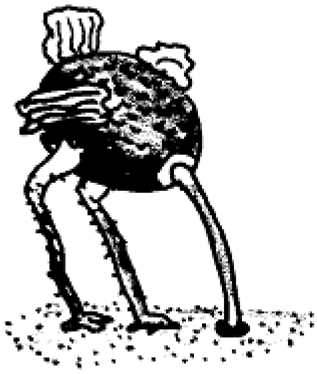

Fig. 1

Set-up and procedure

- Transfer enough of one of the soil samples to a beaker to make it up to the 150 ml mark and press lightly on the sample.
- Fill water into a second beaker and pour water from it into the beaker containing the sample to bring the level up to the 250 ml mark. Observe exactly what happens.
- Repeat the above procedure with each of the other soil samples. Compare their behaviour.

Observations

1. What did you see in the beaker containing soil after you poured water into it?

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Evaluation

1. Where do the bubbles in the beaker come from?

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2. Which soil sample contains the most air?

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(How can an earthworm breathe in soil?)

Material

1 Spade

Plastic bags

Preparation

Soil samples from experiment S 15 can be used here. They should be as dry as possible, however, as they then contain more air. The samples can also contain some small stones, as there is a particularly large amount of air in the hollow spaces of porous stones which would then escapes as a stream of bubbles. The reason why the sample is to be gently pressed is that, when water is poured in, the sample would be whirled up in the water above it if it was too loose. When it is pressed too hard, though, water stagnates above it.

The water should be previously boiled as water always contains air. On boiling, the heat causes this air to escape, so that one can be sure that the air bubbles came from the soil.

Observation

1. Small air bubbles were formed at the soil surface. Whole streams of bubbles came from some of the stones. The stones sometimes moved or even crackled.

Evaluation

1. There is air in soil in the fine hollow spaces between the soil particles. Earthworms and other small subterranean animals can so breathe under the soil surface. When water is poured in the beaker, it displaces air from the hollow spaces and this rises up in the form of bubbles. Porous stones contain a particularly large amount of air. When water penetrates into a stone and displaces the air which is there, the swelling stone can be heard to crackle and creak.
2. Crumbly humus soil contains most air.

   Heavy agricultural machines can destroy the crumb structure of soil. They compress the soil so much that it offers little room for roots and small subterranean animals.
   As water can no longer penetrate in the soil very well, it is builds up on the surface and carries the upper layer away (erosion). The soil dries out more quickly.

Room for notes

How much water can soil take up?

Task

Compare how much water passes through samples of different soils.

Material

1 Measuring cylinder, 50 ml
1 Beaker, 100 ml
1 Beaker, 250 ml
1 Spoon spatula
1 Funnel
1 Pack of filter paper

Samples of various soils
Water

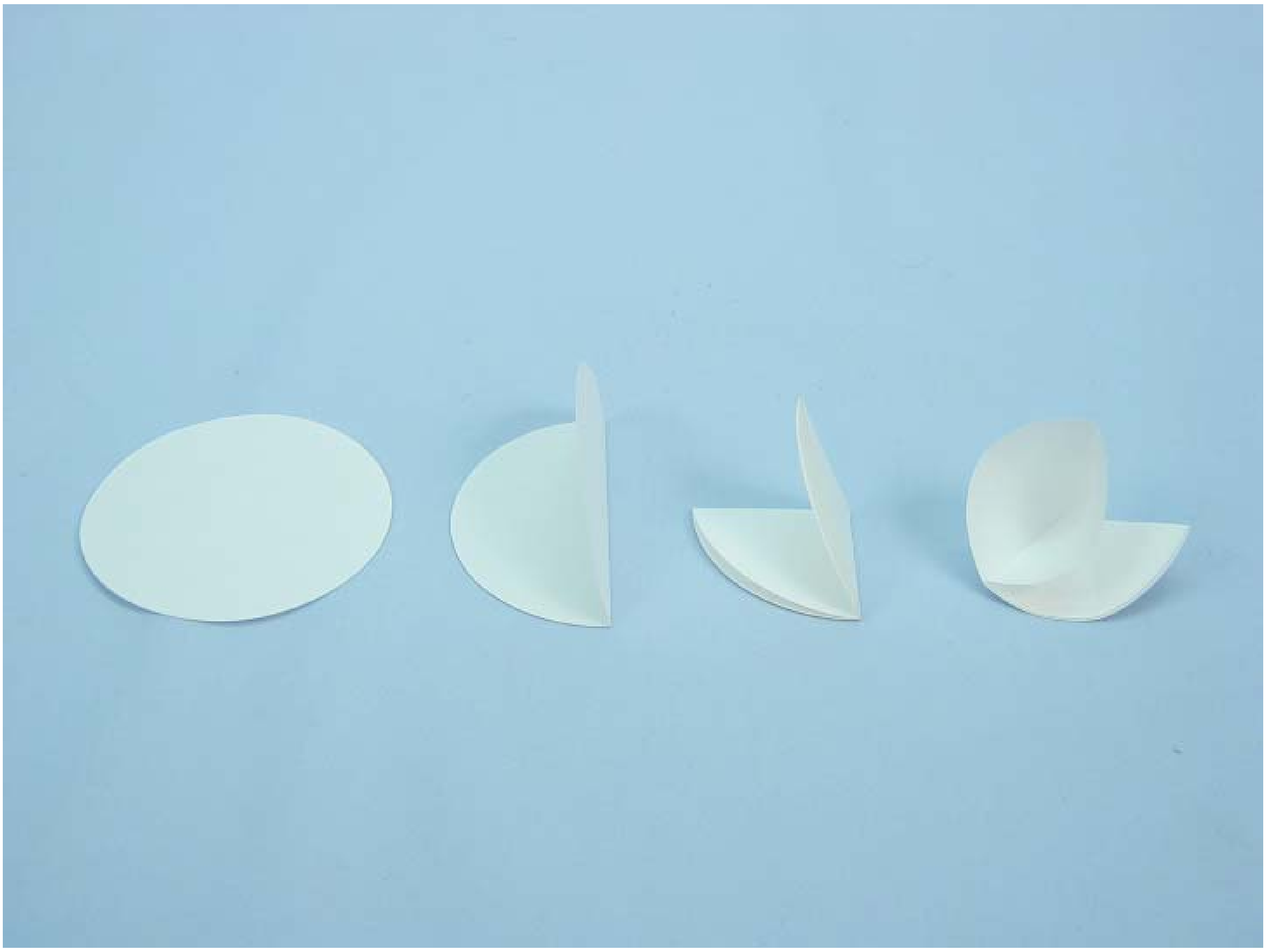

Fig. 1

Set-up and procedure

- Let your teacher put some of a soil sample in the 250 ml beaker.
- Fit the funnel on the measuring cylinder.
- Fold a piece of filter paper as shown in Figure 1 and position it in the funnel.
- Put soil in the funnel by the spoonful and press the soil to make it a little firmer.
- Fill water into the 100 ml beaker to the 30 ml mark and pour it slowly in the funnel (Fig. 2).
- Record the volume of water which flows out into the measuring cylinder.
- Repeat the above procedure for each of the other soil samples.

Fig. 2

Observations

1. Write in how many millilitres of water flowed into the measuring cylinder for each of the samples in the following Table.

	Water in the measuring cylinder in ml
Sample 1	
Sample 2	
Sample 3	

Evaluation

1. Enter the sample numbers here in the succession of the smallest amount of water in the measuring cylinder to the largest amount:

   ....

   ....

   ....

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2. If you have used the same samples as were examined in experiment S 15, you can write in here how water permeability is dependent on the sand content of the samples.
   The more sand, the ...

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   ....

3. If you had two plants to plant, one of which preferred a dry soil and the other a moist one, which type of soil would you choose for the one and for the other?

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(How much water can soil take up?)

Material

1 Spade

Plastic bags

Preparation

It is of advantage to use samples of the same soils as were used in previous experiments S 15 and S 16, as the results are then even more interesting. One can not only show how soil components affect the air content and water capacity, but can also clarify why not all plants grow well in the same soil.

Observation

1. Sandy soil allows more water to run through into the measuring cylinder, clay soil less water.

	Water in the measuring cylinder in ml
Sample 1	25 ml
Sample 2	20 ml
Sample 3	18 ml

Evaluation

2. The more sand, the ...
   ... more water which flows through the sample into the measuring cylinder, the less water which is retained by the soil.
3. The plant which grows better in a dry soil needs a soil with a higher sand content. The plant which prefers a moist soil needs a soil containing more clay.

   When roots are too moist, as can be the case with clay soils, then they rot. When water runs through too quickly, as can be the case with clay soils, the roots dry and shrink. Most plants prefer a soil which has a balanced sand-clay ratio. Soils rich in humus containing a lot of rotted organic material hold the ideal amount of water for plant growth. The crumb structure also plays an important role with regard to the water capacity of a soil. Each crumb is a mini water reservoir which fills up when it rains and successively releases the water it contains.

Room for notes

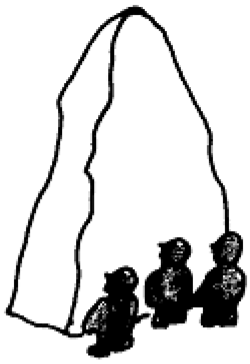
How are mountains created?

Task

Examine a model of how forces from the interior of the earth influence the surface of the earth.

Material

- Plasticine
- 2 Sheets of cardboard



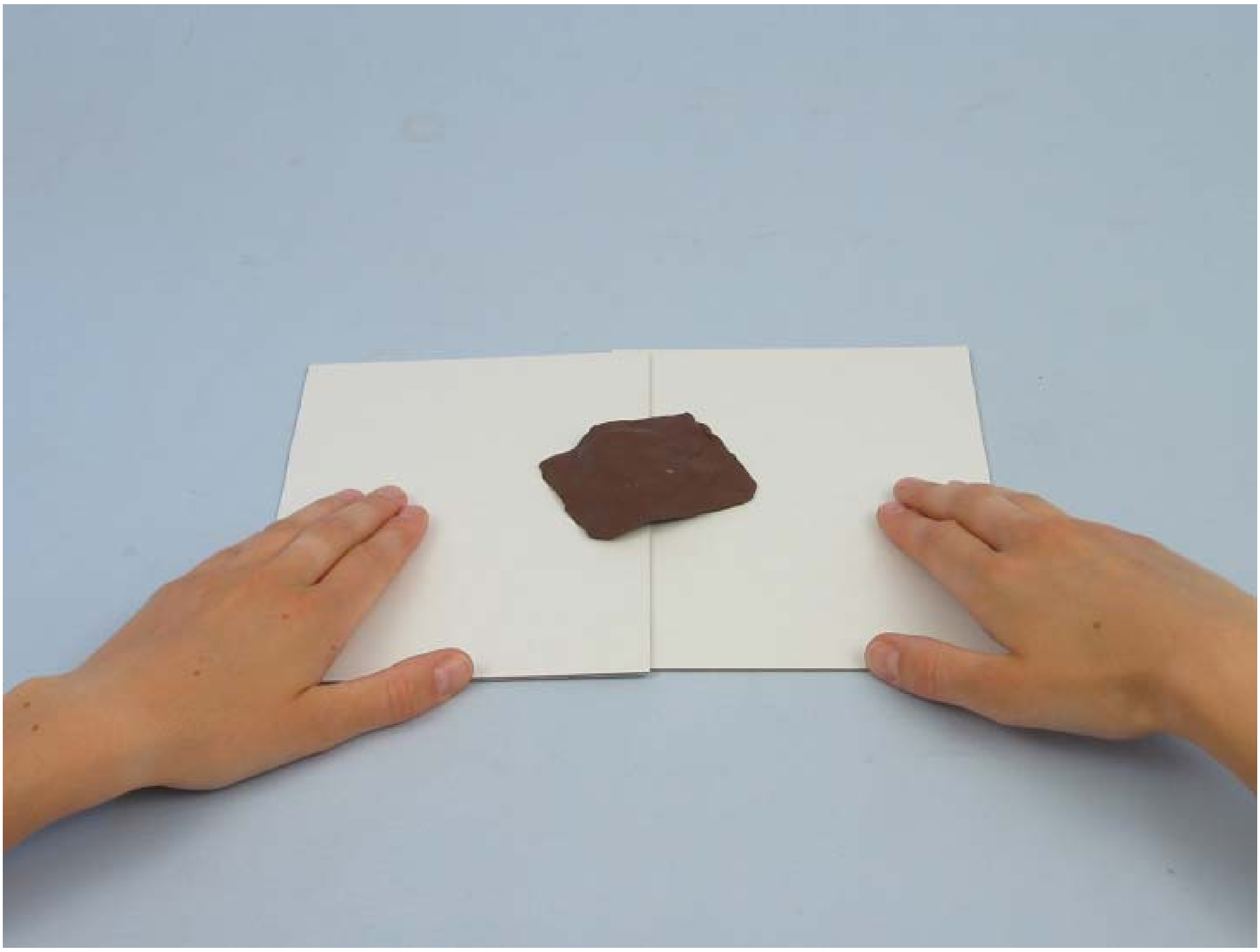


Fig. 1

Set-up and procedure

- Use the plasticine to make a flat rectangle with a width of about two millimetres. This is to represent the surface of the earth.
- The pieces of cardboard represent continental plates which float on the mantle of the earth, just as ice floes float on sea water. Place the two pieces on the table so that they overlap a little.
- Position the plasticine surface of the earth on the continental plates so that part if it is on the upper plate and part on the lower plate. Press the two ends of the plasticines earth's surface so that they are firmly held on the continental plates below.
- Push the continental plates to each other, away from each other and then the ends to each other. What happens to the earth's surface?

Observations

1. What did you observe as you moved the continental plates?

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Evaluation

1. With this model in mind, can you explain how mountains and valleys are created?

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....

(How are mountains created?)

Material

Cardboard

Preparation

Each group of students needs two sheets of cardboard of about A5 size.

Observation

1. The piece of plasticine distorts in very different ways according to the direction in which it is pushed. Bulges and hollows are created. When the cardboard sheets are drawn further and further apart, it is finally tears and a break edge is formed. When the torn parts are moved towards each other, one can be pushed over the other.

Evaluation

1. The continental plates move on the liquid mantle of the earth. When they thereby rub against each other or collide, massive forces are released which can fold, bend and raise the surface of the earth. Earthquakes sometimes result from such movements.
   Such folding could possibly cause mountain ranges to be created.

Room for notes

Rays of light from the sun are only incident on the side of the earth which is turned towards it. It is day on this side. There is darkness on the side which is turned away from the sun, it is night here. As the earth carries out one full turn on its axis every 24 hours, night and day succeed each other.

The moon revolves around the earth once every 27.3 days, whereby it always has the same side turned towards the earth. The particular lunar phases depend on how much of the moon is seen to be lit by the sun from the earth.

An eclipse of the sun can be observed when the moon is exactly between the sun and the earth and the sun is thereby fully or partly covered by the moon. A lunar eclipse occurs when the moon is in the shadow of the earth.

Material

1	Light box, halogen	09801-01
1	Bottom w. stem for light box	09802-10
1	Power supply 12V / 2A	12151-99
1	Slide mount for optical bench	09822-00
1	Diaphragm with hole	09816-01
1	Model earth/moon	09825-00
1	Support base variable	02001-00
2	Support rod, l = 600 mm	02037-00

Fig. 1

Set up and procedure

- Set up an optical bench with the support rods and the variable support base: Separate the stand base into two halves by pressing the two middle yellow-marked locking connectors. Connect the two halves by inserting the support rods and tightening these in position by lifting the four clamping devices.
- Now position the bottom with stem under the light box and tighten it to the left part of the base by means of the clamping screw. The lamp must hereby point along the optical bench, the lens away from it. Fit the opaque diaphragm at the back of the box.
- Screw the earth-moon model on the slide mount and position it at about the middle of the optical bench.
- Connect the light box to the power supply and then the power supply to the mains.

Night and day

- Turn the moon to the back as it is not needed in this experiment.
- Turn the earth slowly around its axis. The students can now try to work out where it is day and where night, in which direction the globe is correctly turned (clockwise or anticlockwise), and what the time it is in their own home town and in various countries in the world.

Phases of the moon

- Turn the earth-moon model in the mount so that it is inclined towards the lamp. In this experiment, the moon is to be so turned that no shadow of it is cast on the earth.
- Turn the moon around the earth. When is it full moon, when half-moon and when new moon?

Solar and lunar eclipses

- Now turn the earth-moon model so in the mount that the earth is inclined to the side and the moon can cast its shadow on the earth.
- Again turn the moon around the earth. The students should find out here when an eclipse of the moon occurs and when an eclipse of the sun.

Observations

Night and day

It is always so that only a half of the earth is shone upon by the sun, the other half is shadowed. The turning of the earth causes the shadow to wander over every country in the world.

Phases of the moon

Looking at the moon from the earth, the moon is lit differently by the sun as it orbits the earth, sometimes fully, sometimes partly and sometimes not at all.

Solar and lunar eclipses

In the sun – moon – earth line-up, the moon casts a shadow on the earth.
In the sun – earth – moon line-up, the moon is in the shadow of the earth.

Evaluation

Night and day

It is day on the half of the earth which is facing the sun and night on the other half. Day and night follow each other because of the rotation of the earth about its own axis. It is midday along the whole degree of longitude which directly faces the sun, and midnight along the other side. There is a twelve hour time difference between the opposite sides of the earth.
The sun rises in the east and sets in the west, so that the earth clearly rotates anticlockwise.

Phases of the moon

When the moon is exactly between the sun and the earth, the shaded side of it is turned towards the earth and so, when looking from the earth, is not illuminated. It is new moon. When the moon travels further on its orbit, a part of the moon which is turned towards the sun can be seen from the earth. After a quarter of the orbit, it can be seen as half-moon. When the moon is exactly on the other side to the sun, the whole side of the moon turned towards the sun can be seen from the earth. It is full moon.

Sun and moon eclipses

An eclipse of the sun is to be understood as a total or partial disappearance of the sun behind the moon which can be observed from a certain point on earth. For this, the moon must be between the sun and the earth and all three must lie along a line from the point of view of the observer. A solar eclipse can only occur at new moon, because the moon must be between sun and earth.
A lunar eclipse is a total or partial disappearance of the moon in the shadow of the earth.
For this, the earth must be between the sun and the moon and all three must also lie along a straight line. A lunar eclipse can only be observed at full moon, as the earth is then between the sun and the moon.

Room for notes

A lens collects rays of light which come from a lit object and brings them to a point which is called the focal point. Such a lens is therefore also called a converging lens. The rays radiate apart again behind the focal point. The greater the curvature of the converging lens, the smaller is the focal length, which is the distance between the lens and the focal point. When the lens is brought nearer to the object, the object is seen as being larger. When it is nearer to the lens than the focal point, it acts as a magnifying glass. When it is behind the focal point, the image is back to front and inverted.

Material

1	Magnifier w. handle, 6x	87004-06
1	Screen, white, 150x150mm	09826-00
1	Slide mount for optical bench	09822-00
1	Cardboards, black	06306-01

Fig. 1

Set up and procedure

The lens as burning glass:

- This experiment can only be carried on a sunny day.
- Hold the lens in front of the window and let the rays of the sun pass through it and onto the black card held behind it.
- For this, hold the lens so that the point where the sunlight is concentrated is as small as possible and is kept at one position. The experiment does not function as well when white paper is used instead of black card, as white paper reflects a large part of the incident rays.

The lens as creator of pictures:

- Fit the screen on the slide mount.
- Hold the lens in front of the window and position the screen so behind the lens that a picture of the surroundings is obtained. Now change the distance between the lens and the screen.
- The following experiment should be successively carried out by each student.
- Hold the lens directly in front of an object and draw it further and further away. This can be best carried out standing up and looking through the lens at a text which is lying on a table.

Observations

The lens as burning glass:

When there is a blue sky and no clouds which shade the sun, a small plume of smoke is visible within a few seconds and a hole has soon been burnt in the card.

The lens as creator of pictures:

The window and the outside surroundings appears on the screen smaller, back to front and inverted. A sharp window picture is only given at a certain distance of the lens from the screen.

When the lens is held very close to an object it magnifies the object. Moving it further away causes the object to suddenly turn over.

Evaluation

The lens as burning glass:

The lens collects the parallel rays of sunlight together at one point, the focal point. It can become so hot at this point that the ignition point of paper is exceeded. Such a lens is also called a converging lens.

The lens as creator of pictures:

The rays of light coming from a point of the window and impinging on the lens are refracted by the lens and collected on the screen, where a point of a picture appears. Numerous points are created from the numerous window points and these make up a picture of the window, whereby the rays from the different window points cross over so that the top and bottom, and also left and right of it, are reversed.

The picture given is only sharp at the position at which each object point is bundled to a picture point. This is the focal point of the lens.

When the lens is held nearer to an object than the focal length, the object is seen as being magnified. This effect of the lens is caused by the increase in the angle of view. A lens of 50 mm focal length enables an object to be looked at from a distance of 50 mm instead of from a distance of 250 mm, which is the distance of clear unaided vision. The lens so has a 5-times magnification (magnification = 250 mm / 50 mm). When the lens is moved past the focal length, the image is inverted.

Air is a gaseous substance which fills a certain space. In this experiment it will be shown that air must be displaced from a vessel when water is to be filled in.

Material

1	Erlenmeyer flask, 500 ml	36421-00
1	Glass beaker, 400 ml	36014-00
1	Glass beaker, 250 ml	36013-00
1	Funnel, glass, d=80 mm	34459-00
1	Glass tube, right-angled	36701-52
1	Rubber stopper, 1 hole	39258-01
1	Rubber stopper 2 holes	39258-02
1	PVC tubing, i.d. 7mm	03985-00
	Water	

Additional material

Glycerol, 100 ml	30084-10

Fig. 1

Fig. 2

Set up and procedure

- Set up the experiment as shown in Fig.1.
- To make it easier to ease the glass funnel outlet tube through the hole in the one-hole stopper, apply a little glycerol to the funnel tube and the hole. Make sure that the stopper is tightly seated in the neck of the Erlenmeyer flask.
- Pour water in the funnel from a 250 ml beaker. The students are to watch what now happens.
- For the second part of the experiment (Fig.2), replace the one-hole stopper with the two-hole stopper.
- Apply a little glycerol to each of the stopper holes and to the right-angled glass tube so that it is easier to ease the funnel tube and the right-angled tube through the holes. The stopper must again be tightly seated in the neck of the Erlenmeyer flask.
- Fill the 400 ml beaker with water, ease the tubing onto the glass tube and place the open tube end in the beaker.
- Again try to fill water into the flask through the funnel. What can now be observed?

Observations

In the first part of the experiment, the attempt to fill the Erlenmeyer flask with water is unsuccessful. Apart from a few drops, the water remains in the funnel.

The second part of the experiment with the two-hole stopper is successful, however, and air can be seen to be bubbling up in the water-filled beaker.

Evaluation

The air in the flask is a gaseous substance which takes up a certain volume. Where air is, there cannot also be water. To be able to fill the Erlenmeyer flask with water, the air in it must first be displaced.

In the first part of the experiment, air cannot flow out because the only opening is closed by the water pressing on it from above. Only a few drops manage to get into the flask against the air which is compressed in it, the rest of the water remains in the funnel. In the second part of the experiment, however, a second opening allows the air to flow out, as can be seen by the bubbling in the water-filled beaker.

Air pollution

Combustion of coal, petrol and gas results in many million tons of waste gases being passed into the air every year. Oxides of sulphur, nitrogen and carbon are particularly harmful to health, the environment and the climate. Particulates and other combustion products also have harmful effects, however. Waste gas cleaning processes, such as are used in desulphurization plants, as well as particle filters and catalysers can greatly limit the emission of pollutants.

This experiment is to demonstrate not only how much particulate matter which is emitted by the combustion of petrol would pass into the environment without the use of appropriate filters, but also that unofficial refuse incineration causes harmful substances such as acids to be uninhibitedly released to the environment.

Material

1	Porcelain dish	32518-00
1	Pipette, with rubber bulb	64821-00
1	Crucible tongs	46964-00
1	Scissors, straight,180 mm	64798-00
1	Protective desk plate	39180-10
1	Protecting glasses	39316-00
1	Litmus paper, blue, 1 box	30678-01
1	PVC-plates, pack.5 pcs.	31751-02

Additional material

Benzine, 100-140 °C, 500ml	30037-50
Matches or lighter	
ESBIT dry fuel	
Water	
Lemons	

Fig. 1

Set up and procedure

Air pollution by exhaust gases from cars

- Place an evaporating dish on the protective desk plate and use the pipette to drop a few drops of petroleum ether into it.
- As soon as you have added the drops, set light to the petroleum ether. If you wait too long with the ignition of it, a gaseous mixture of petroleum ether and gas could form which could explode when the open flame approaches it.
- As soon as the petroleum ether in the porcelain dish is burning, use the crucible tongs to hold the second evaporating dish upside down in the flame.

Air pollution from unofficial incineration of refuse

- In a preliminary experiment, dip litmus paper in water and in lemon juice.
- Cut an approximately 5 cm long and 1 cm wide strip from a PVC plate. PVC is a plastic material which is contained in numerous objects of daily use. As an alternative to it, therefore, other such objects, such as a piece of a floor slab or of cable insulation, can be used.
- Break a piece of ESBIT in half and place the two halves in an evaporating dish so that one half is inclined above the other.
- Place the dish on the protective desk plate and light the dry fuel. Then lay the piece of PVC in the flame.
- Moisten a strip of blue litmus paper and use the crucible tongs to hold it in the combustion gases of the PVC.

Observations

Air pollution by exhaust gases from cars.

The inside of the dish is blackened.

Air pollution from unofficial incineration of refuse

Litmus paper did not change colour in water, but turned red in lemon juice.

The moistened litmus paper also turned red in the PVC combustion gases.

Evaluation

In the combustion of petrol, not only carbon monoxide, carbon dioxide, nitrous oxides and sulphur dioxide gases are liberated, but also particulate matter. These particles are harmful for the respiratory organs and are carcinogenic. Catalysers and particle filters can reduce the emission of this pollutant.

It has been shown here that the combustion of PVC liberates acids, as litmus changes colour from blue to red when it contacts acids. These acids can cause considerable damage to the environment. Because of this liberation of harmful substances, the combustion of refuse is only permitted in specially constructed waste incineration plants which prevent the passage of harmful substances to the environment.

Soil is not uniformly structured in its depth. It consists of various characteristic layers which differ in their contents and are called soil horizons. These horizons have been created during the course of the development of the soil and reflect the development history of it. The top layer is of a scattered type, the layers below it increasingly rock-like.

Material

1	Garden trowel, steel	40484-02
1	Measuring tape, l = 2 m	09936-00

Fig. 1

Set up and procedure

This experiment must be carried out outdoors in the field.

A soil horizon can best be recognized at an excavation which reveals an at least a one metre deep vertical section of the soil, whether this is self-made or already available, at a building pit, for example. It is difficult to dig a hole of this size even with a spade as the soil gets increasingly harder the further down one digs. The trowel is useful for working on a vertical section which you have found so that the layering can be better seen however.

Observations

The following layers can be typically recognized.

An organic covering lying on the firm ground which consists of more or less decomposed remains of vegetation and humus (completely decomposed plant and animal residues, dark in colour).

The topsoil below the humus covering is full of life, root-rich and, because of the humus, distinctly darker than the horizons below it.

A reddish brown layer of weathered rock is often found.

More or less unchanged original rock.

Evaluation

The soil horizons can be differently distinct and also combined. Soils which have the same soil profile are at the same stage of development. The type of soil at a location is dependent on the original rock, relief, climate, the living things in and on the soil and the duration of development.

Rock is the starting material for the creation of soil. Great fluctuations in temperature cause cracks in the rock. Water can penetrate into these and causes the rock to burst when it freezes. Carbonic acid dissolved in the water causes chemical changes to occur in the stone. Weathering liberates mineral substances from the rock which serve as nutrients for plants. When plants die, they are decomposed by animals, fungi and bacteria, which leave excretions and thoroughly mix the soil.

Black earth, for example, has a thick upper humus layer. It is the result of a continental climate with long, cold winters and dry, hot summers (the climate conditions which were prevalent in North Germany 10,000 years ago), which hindered the decomposition of organic matter. Black earth is one of the most fertile soils. It is to be found at the “Magdeburger Boerde”, aroun Hildesheim and Erfurt.