



SINUS - Thüringen

Steigerung der Effizienz des
mathematisch-naturwissenschaftlichen
Unterrichts

Documentation for the teaching material »Light and Colors«

School:	IGS Erfurt; Staatliche Regelschule Stotternheim; Staatliche Regelschule »Pestalozzi« Weimar (grades 5–10)
Grade:	10
Subject:	Nature and Technology
Authors:	Gisela Saad, Birgit Zimmer, Iris Nußbeck, Dagmar Wirth, Regina Raßloff, Christine Eichhorn, Uta Altenburg, Annette Hirt, Jörg Triebel
Target:	Ability of explaining the properties of light, survey of color mixtures Learning the psychological meaning and effect of colors Encouraging independent work of students (acquiring information; experimentation)
Organization form/time needed:	<ul style="list-style-type: none"> • Nature and Technology grade 10, biology grade 8, subject »functions of the senses« • During normal course of the lesson/timetable • Applicable in learning at stations, time period: 2–3 lessons: Subtractive and Additive color mixture; Anatomy of the eye; Vision Experiments; Optical Illusion; Body colors • Applicable as student task are: <ol style="list-style-type: none"> 1. Colors in nature General student task (each student gets a sheet) + theme cards to pull, Groups can find together/individual work possible, Internet use or working through material at home is allowed, A lecture by students is advisable (time period: 3–4 lessons) 2. Colors and Humans Colors cards are drawn and student task (each student gets a sheet) Individual work reasonable, internet use provided, a lecture by students is advisable (time period: 3–4 lessons) The two topics can also be prepared in parallel (dividing class again).
Evaluation of the students' performances:	Providing evidence of each station, possibly control by a test, but the main focus is the experience. The students' work can be assessed with either one or two grades.
Material Requirements:	The required materials for every station or student tasks are specifically listed.
Methodical Indications:	See appendix
Students' Materials:	The required materials for every station or student tasks are specifically listed.
Literature:	See reference Landesinitiative SINUS-Thüringen



Topic: Colors of the Nature

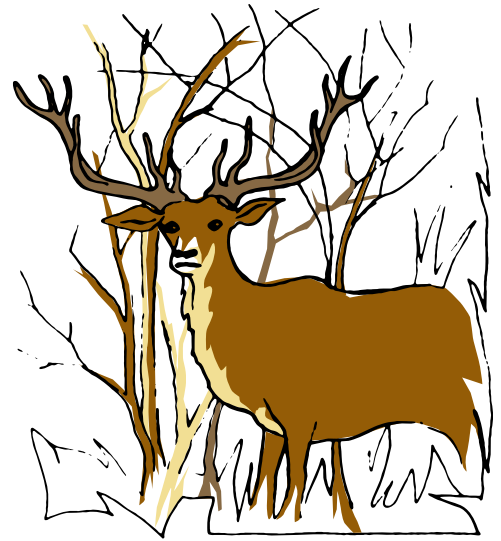
■ Student assignment for group work

■ Task:

Your group creates an info board for the topic you have drawn, and prepares a short presentation.

- Contents:**
- Meaning
 - Origin of the coloration
 - Explanation with examples

Notes: Think about a summary for your fellow students (board picture, transparency, work sheet, completion exercise, quiz etc.).



Topic: Colors of the Nature

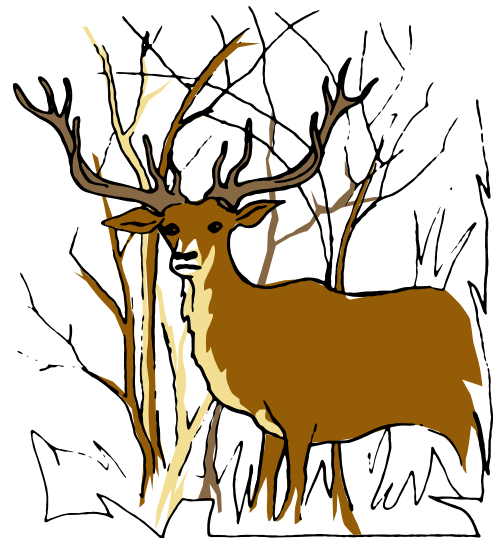
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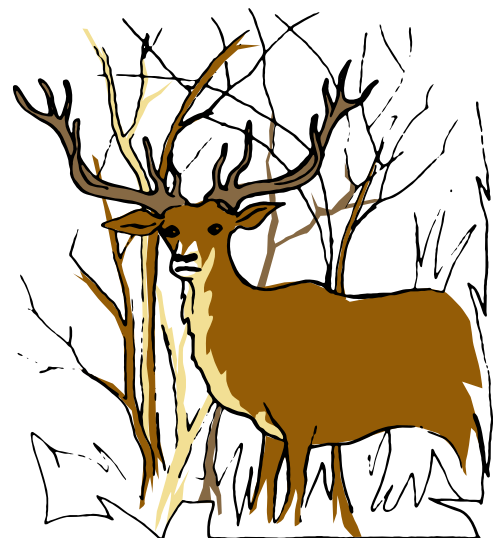
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Camouflage

Camouflage

Warning

Warning

Deception

Deception

Living together

Living together

**Pollination and spreading
fruits and seeds**

**Pollination and spreading
fruits and seeds**

Deception

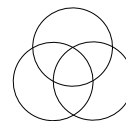
Deception





Topic: Colors and People

Student assignment



■ Task 1:

Create a collage on an A3 sheet for the color you have drawn.

- Material:**
- Large quantity of illustrations from advertising magazines, catalogs etc.
 - A3 sheet, possibly in the corresponding color
 - Paintbox, brush, colored pencils/crayons/pens
 - Glue, scissors
 - Newspaper as underlay

Note: The collage can be laminated, and used at home as a place mat.

■ Task 2:

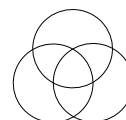
Make a short presentation about the color you have drawn.

- Contents:**
- Effect
 - Meaning
 - Occurrence and extraction of corresponding pigments
 - Pigments in human history

- Notes:**
- Find your own classification
 - Contents can be extended or limited
 - Use the Internet, e.g. www.wikipedia.de, www.seilnacht.com

Topic: Colors and People

Student assignment



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Note: The collage can be laminated, and used at home as a place mat.

■ Task 2:

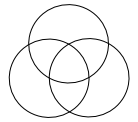
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Mixing Colors

■ Additive color mixing



Definition of additive color mixing

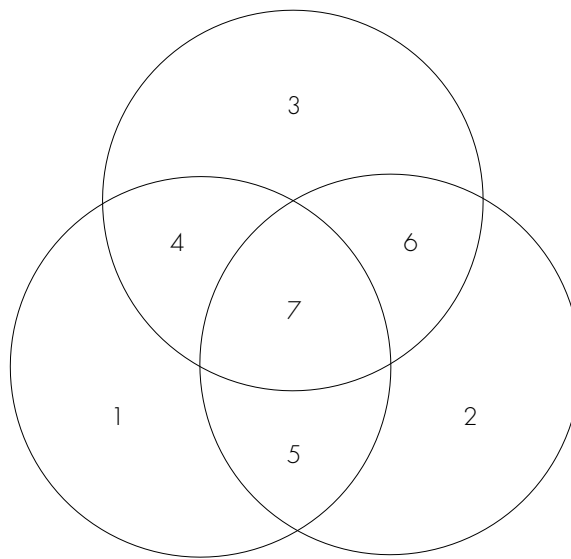
The process by which color mixtures are created by combining (adding) light of different colors is called additive color mixing.

Experiment:

Project orange (red), green and violet (blue) light on a white wall with the lamp so that the colors partially overlap.

■ Task 1:

Fill in the primary colors of the additive color mixing in the diagram, based on what you saw in the experiment.



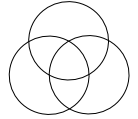
■ Task 2:

Use the literature provided or the Internet, and then answer the following questions:

- Which compound colors are made in each case when two primary colors overlap?
Fill in these in the diagram in 1.
- Which compound color is made by overlapping all 3 primary colors?
Fill this in the diagram in 1.
- State 3 examples of the use of additive color mixing.

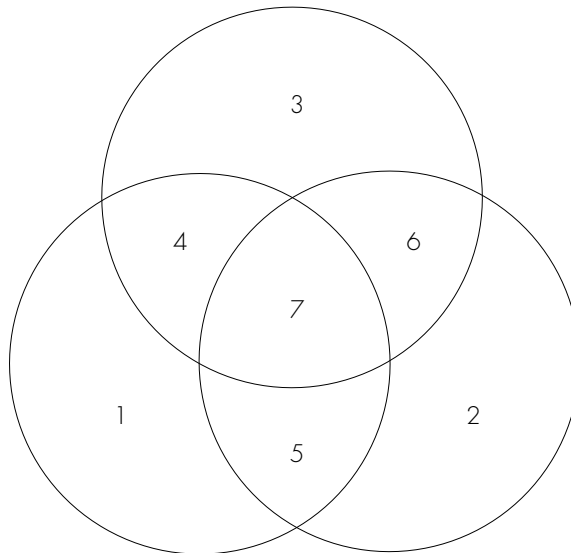
Mixing Colors

■ Subtractive color mixing



Definition of subtractive color mixing

To paint a picture with the colors in the opaque paint box, the individual colors have to be mixed with one another. When this is done, parts of the white light are faded out or absorbed by the colors. The remaining light is reflected as a compound color. Color mixtures of this type are called subtractive.



■ Task 1:

Paint in the outlined fields in the diagram with water colors in the colors stated below. Make sure that the colors of adjacent fields do not run into one another. Create the compound colors directly on the paper.

- | | |
|-----------|---------------------------|
| 1 Magenta | 4 Yellow + Magenta |
| 2 Cyan | 5 Magenta + Cyan |
| 3 Yellow | 6 Cyan + Yellow |
| | 7 Yellow + Magenta + Cyan |

■ Task 2:

Name the compound colors in fields 4, 5, 6 and 7.

■ Task 3:

Fill in the gaps and take over the text.

The primary colors of the color mixture are cyan, yellow and

Mixing them in pairs creates the three secondary colors violet, and

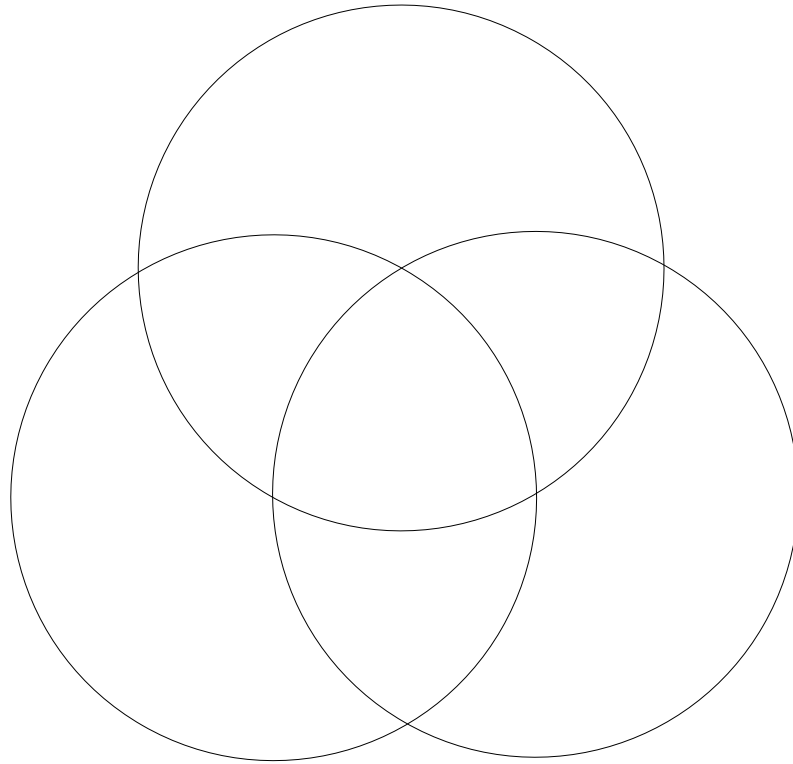
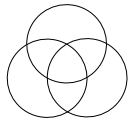
Mixing all the primary colors together creates the color

■ Task 4:

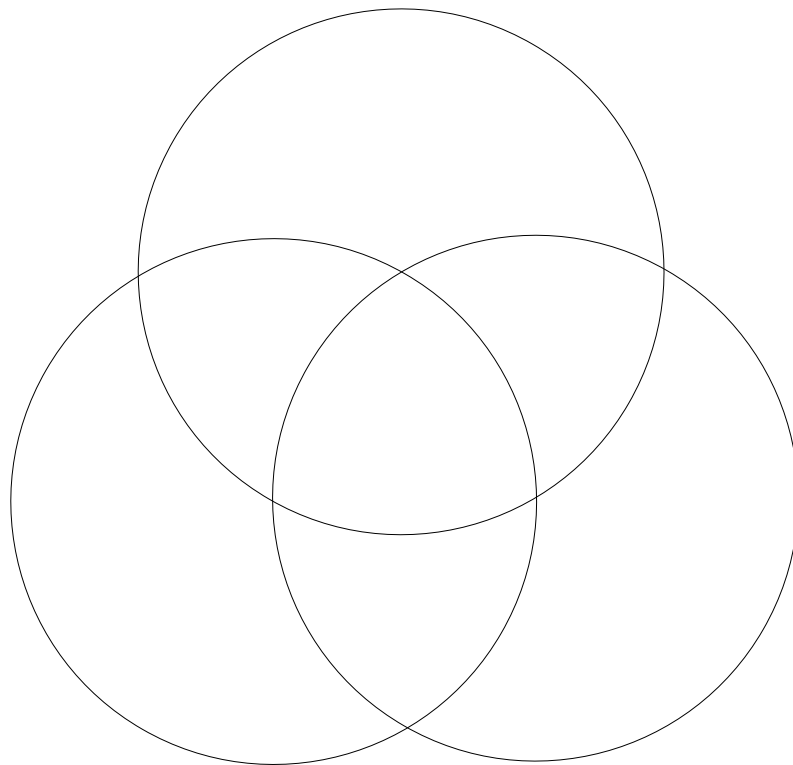
Find examples of the use of subtractive color mixing in the literature provided.

Mixing Colors

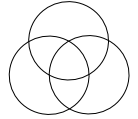
■ Additive color mixing



■ Subtractive color mixing



Color Mixing Answer Sheet



■ Additive color mixing

■ Task 1:

1 = Green; 2 = Red; 3 = Blue

■ Task 2:

a) 4 = Blue-green (Cyan); 5 = Yellow; 6 = Magenta

b) 7 = White

c) Lighting, color monitors, color vision

■ Subtractive color mixing

■ Task 1:

See sheet

■ Task 2:

4 = Red (Orange); 5 = Blue (Violet); 6 = Green; 7 = Black

■ Task 3:

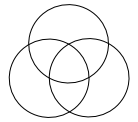
The three primary colors of subtractive color mixture are cyan, yellow and magenta.

Mixing them in pairs creates the three secondary colors violet, red (orange) and green.

Mixing all the primary colors together creates the color black.

■ Task 4:

Laser jet printer; paint with colors



List of Materials

■ Additive color mixing

- Lamp for mixing colors with color transparencies (orange or red, green, violet or blue)
- White wall
- One work sheet for the two color mixtures for each student

■ Subtractive color mixing

- One work sheet for the two color mixtures for each student
- Water colors, brush, beaker of water



Colors of Objects and Complementary Colors



Why are objects colored?

The colors of materials and objects are always a result of the interactions between light and the particles of which the materials are made. Light absorption is fundamental to the colors of objects. White light falls on an object, part of the light is absorbed, another part reflected.

Experiment 1:

Look at the given object, first without glasses, and then through the glasses of different colors.

■ Task 1:

Write a summary containing the following information:

- Color of the object without glasses
- Color of the glasses used to look at the object
- Color seen through each pair of glasses



Experiment 2:

Look at the small squares on the colored paper one after the other for about 40 seconds, fix your eyes on the square but relax. Then look at the white area on the sheet.

■ Task 2:

a) Copy the following table into your file, and fill it in.

Color of the small squares	Color seen on white paper
Red	
Yellow	
Blue	

b) Look at figure 12/1 on page 12 in the »Colors« book, and read the text alongside on page 12 and the top section on page 13. Answer the following questions in writing:

- (1) Where are the colors in the color wheel which are alongside each other in your table?
- (2) What are the colors called?
- (3) Why do we see objects in color?



Answers: Colors of Objects and Complementary Colors

■ Why are objects colored?

Why are objects colored?

The colors of materials and objects are always a result of the interactions between light and the particles of which the materials are made. Light absorption is fundamental to the colors of objects. White light falls on an object, part of the light is absorbed, another part reflected.

■ Task 1:

Color of the object without glasses	Color of the glasses used to look at the object	Color seen with each pair of glasses
Red	Yellow	Orange
	Green	Brown
	Blue	Magenta
	Red	Red
Yellow	Yellow	Bright Yellow
	Green	Pale Yellow
	Blue	Yellow
	Red	Orange
Green	Yellow	Light Green
	Green	Grass Green
	Blue	Greenish-blue
	Red	Dark brown

■ Task 2:

a)

Color of the small squares	Color seen on white paper
Red	Green
Yellow	Blue
Blue	Red

- b)
- (1) Opposite each other on the color wheel
 - (2) Complementary colors
 - (3) White light falls on objects, is partially absorbed, partially reflected; the mixture of the reflected portions of the white light creates the color seen



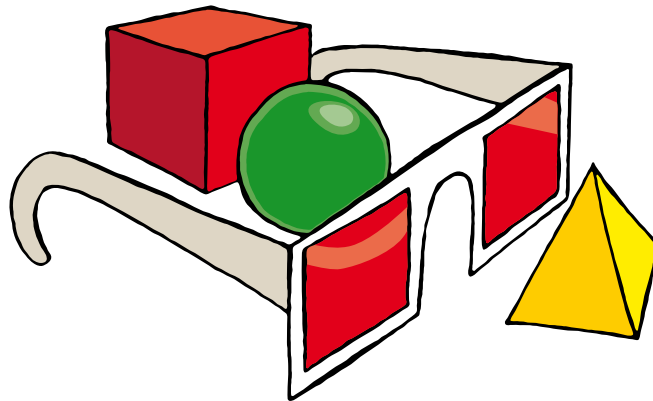
Colors of Objects and Complementary Colors

■ Task 1:

- Glasses with color filters
- One green, one red and one yellow object (plastic objects, mathematics)

■ Task 2:

- Fold three A4 sheets in landscape format in the middle
- Stick a red, yellow and blue square of paper on the left-hand side of the sheet
- The right-hand side of the sheet remains white
- »Colors« book of people and knowledge



Learning with the Eyes

Part I



■ Structure of the eye

Material:

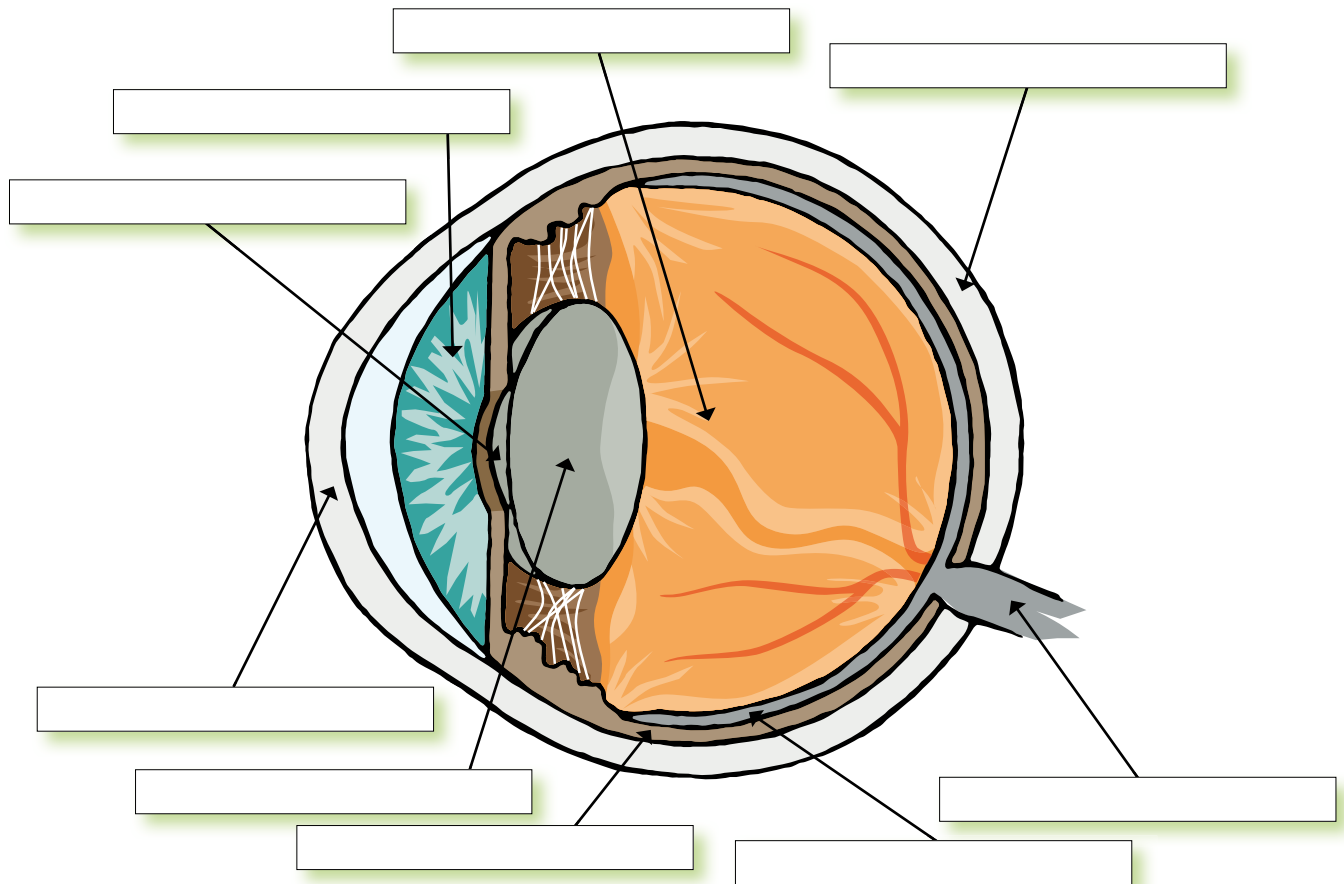
Model or diagram of an eye

■ Task 1:

Find out about the structure of the eye in suitable literature (biology books, lexicon).

■ Task 2:

Label the model of a cross-section through the eye.



■ Task 3:

Find the parts of the eye on the model or in the diagram. Name and show the parts of the eye to your partner.

Source: OcuNet GmbH & Co. KG, Qualität im Auge

Answers: Learning with the Eyes

Part I



■ Structure of the eye

Material:

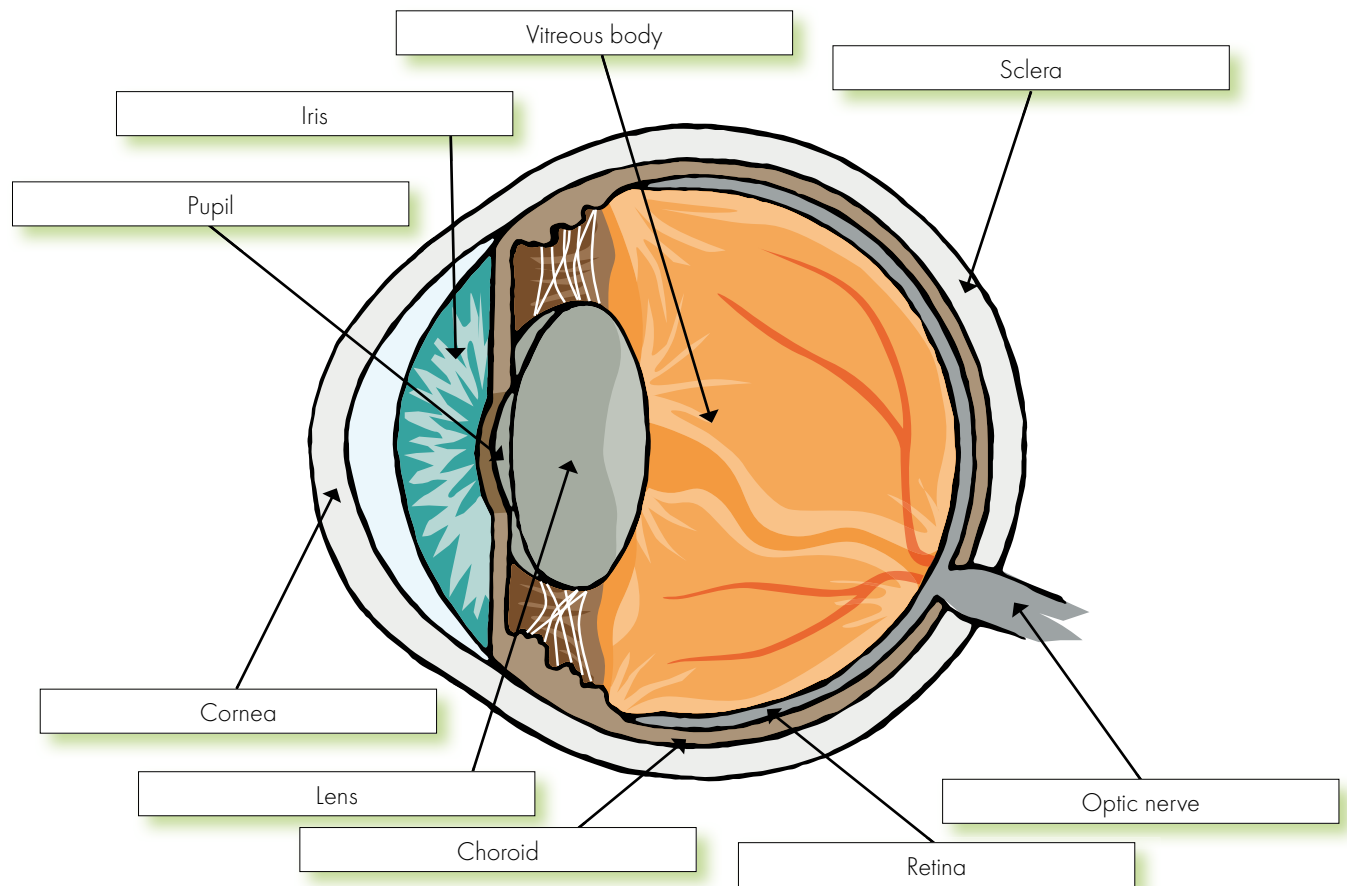
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Vision/Experiments

Part II



Perform the experiments according to the instructions. Describe or sketch your observations. Explain the observations. Use the literature provided or the internet to help you do this.

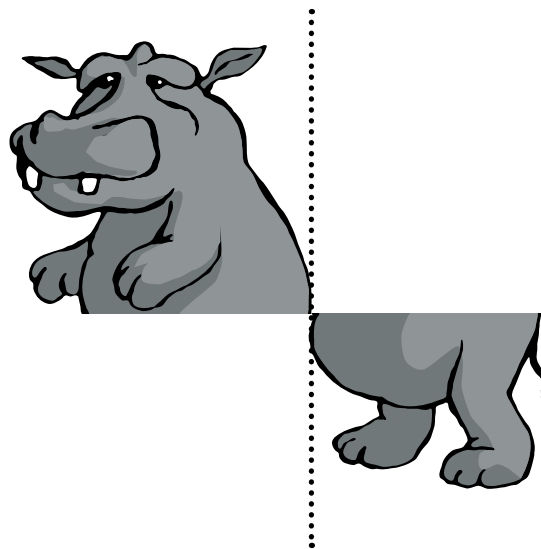
■ Experiment 1: Looking through

Hold a paper tube (rolled up A4 sheet) to your eye like a telescope.
Hold the left hand about 10 cm in front of the your closed left eye.
Look through the »telescope«, open the left eye.



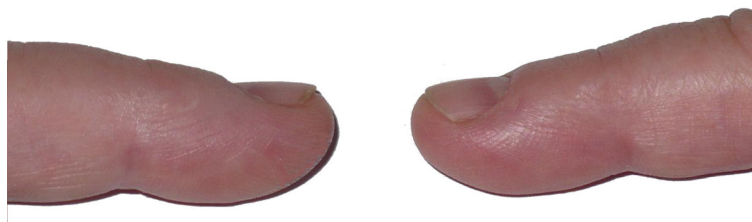
■ Experiment 2: Hippopotamus

Place the rectangular card vertically on the dotted line
and move your head closer towards it. Look with both eyes.



■ Experiment 3: Finger

Hold your forefingers pointing towards each other about 1 cm apart at a distance of about 30 cm from your eyes.
Now look at a more distant object.



Vision/Experiments

Part II

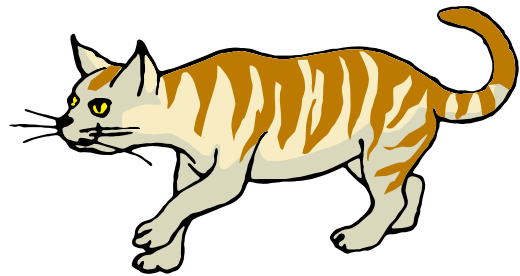


■ Experiment 4: Pencils

Close the left eye. Hold a pencil pointing upwards in your left hand with your left arm outstretched. Now try to touch the point of the pencil with the forefinger of your right hand. Repeat the attempt several times.

■ Experiment 5: Cat and mouse

Hold the work sheet at arms' length in front of you. Close your right eye and look at the cat with the left eye (bottom right of the picture). Keep looking at the cat and slowly bring the work sheet towards you. Be aware of the mouse (bottom left of the picture) but don't move your eye. Repeat if necessary.



■ Experiment 6: Look me in the eyes

A test person closes one eye for about 30 seconds. He/she then looks at a bright window or into the light. The partner observes the student in the test person's eye.

■ Experiment 7: All clear?

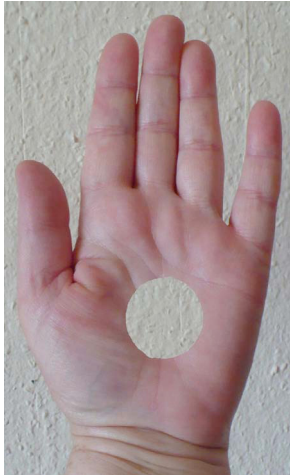
Hold a pencil horizontally about 30 cm in front of your face. Focus on the pencil. How do the objects further away appear? Now look into the distance. How does the pencil appear?

Answers: Vision/Experiments

Part II



■ Experiment 1: Looking through



■ Experiment 2: Hippopotamus



■ Experiment 3: Finger

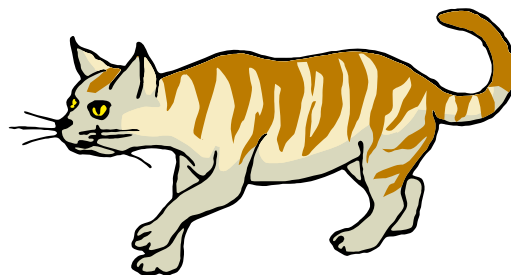


■ Experiment 4: Pencils

At first the pencil is missed, successive attempts get better.

■ Experiment 5: Cat and mouse

The mouse disappears.



■ Experiment 6: Look me in the eyes

The large student immediately gets smaller, enlarges a little, then becomes smaller again.

■ Experiment 7: All clear?

Focused on the pencil: The object behind is blurred

More distant objects: come into focus, the pencil is blurred

List of Materials: Vision/experiments:

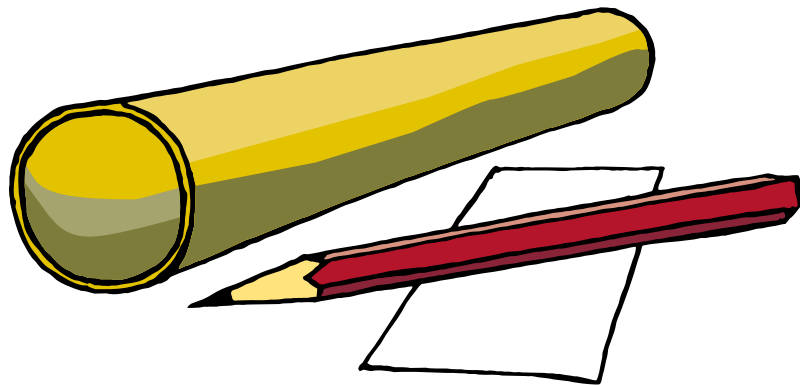


■ Vision/experiments:

- Work sheet »Learning with the eyes«
- Model or diagram of an eye
- Biology books, lexicon
- Paper tubes
- Thin, rectangular card (4 x 6 cm; laminated visiting card)
- Pointed pencil

■ Notes for the teacher:

- One copy of the work sheet »Learning with the eyes« for each student



Optical Illusions

■ I can see what you don't see.

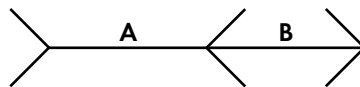


Definition of optical illusions

The brain has to construct an image out of a flood of signals from the retina in a fraction of a second. It also relies on its experience to do this. Performers and researchers can sometimes trick our brains with unusual patterns of lines, unusual contrasts between light and dark, ingenious color patterns, and other means. As a result we perceive the patterned objects incorrectly.

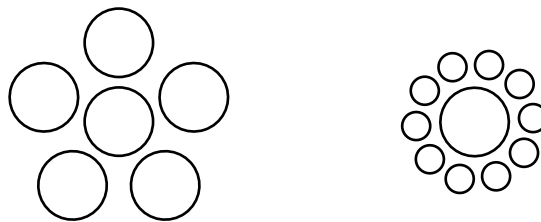
■ Task 1:

Are the lines of equal length? Now measure. How do you explain the result?



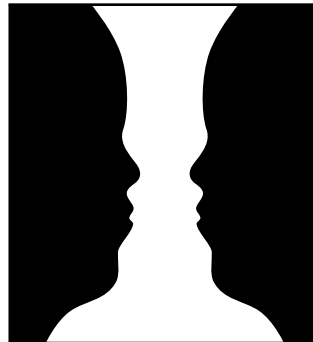
■ Task 2:

Compare the sizes of the two central circles with one another. What do you notice? Try to find an explanation for it.



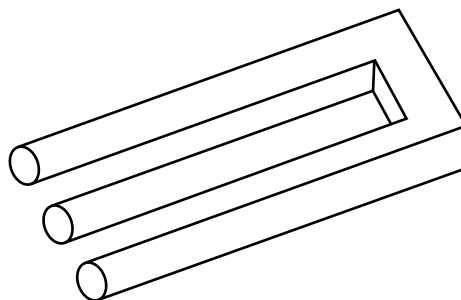
■ Task 3:

Look at the images. What do you see?



■ Task 4:

Draw the following image.





Answers: Optical Illusions

■ I can see what you don't see.

■ Task 1:

The lines are of equal length, the arrows at the ends of the lines create the impression of different lengths.

■ Task 2:

The central circles are the same size, the difference in the sizes of the surrounding circles creates the impression of a difference.

■ Task 3:

1st image: saxophonist – young woman

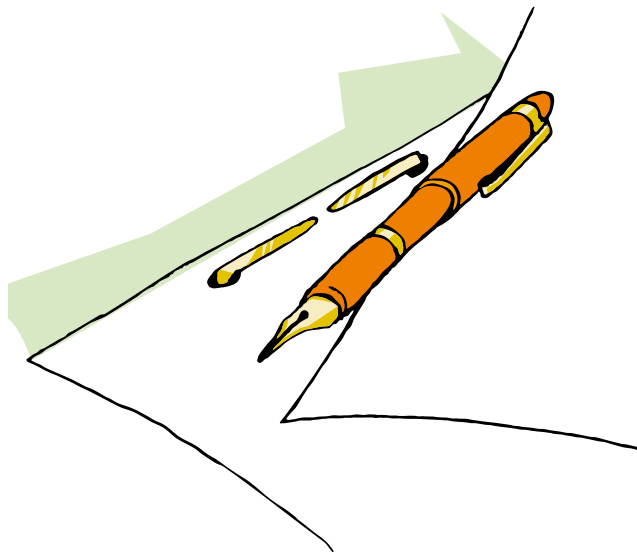
2nd image: vase – 2 faces

■ Task 4:

Drawing

List of Materials

The students only require the task sheet, their file and something to write with.



Dispersion – Spectrum – Rainbow

■ Games with the rainbow



A rainbow is always a beautiful natural phenomenon.



■ Task 1:

Perform as many as possible of the following experiments in a darkened room.

Make a note of your observations. You will need your notes at the end of the station for completing your work sheet.

- a) Look at a burning candle through the glass prism.
Hold the prism right up to your eye, and experiment with the prism in different positions.
- b) Make the experiment as shown in the photo.
Test the composite prism as well.



Then hold the lens between the prism and the projection surface.
Move the lens until the spot of light is as small as possible.
What has changed?

- c) Place a cylindrical glass containing water on the writing pad of an overhead projector.
When the projector is switched on, you will see something interesting on the wall or ceiling.

Dispersion – Spectrum – Rainbow



■ Games with the rainbow

- d) Place a mirror at an angle in a dish full of water.
Point a lamp at the surface of the water so that the beam of light strikes the part of the mirror that is under water.
Hold a sheet of white paper in front of the mirror to catch the image of the reflected light.
- e) Hold a CD at an angle above a white sheet of paper, and illuminate it from below with a flashlight.
When you move the CD slowly, you can see pretty colored patterns on the bright underlay.
- f) Stand at the window and look at the daylight through the hand spectroscope.
- g) If you are conducting your experiments on a sunny day, you can also try the following experiment:



■ Task 2:

You have certainly noticed that all the experiments involved rainbows.
Create a meaningful sentence from the words and phrases (see envelope) and make a note of it on the work sheet.
Then solve the other tasks.

Dispersion – Spectrum – Rainbow

■ Games with the rainbow



**A prism,
for example,
can split
white light
or sunlight
into colored
light.**

Work Sheet

■ Games with the rainbow



■ Task 1:

The sentence reads:

.....

.....

.....

■ Task 2:

When white light strikes a prism, a colored spectrum is created. The spectrum is the result of **dispersion**, a separation of colors. What is a continuous spectrum?

Which light sources cast a continuous spectrum? (Paetec textbook, bottom of page 94 and page 96)

.....

.....

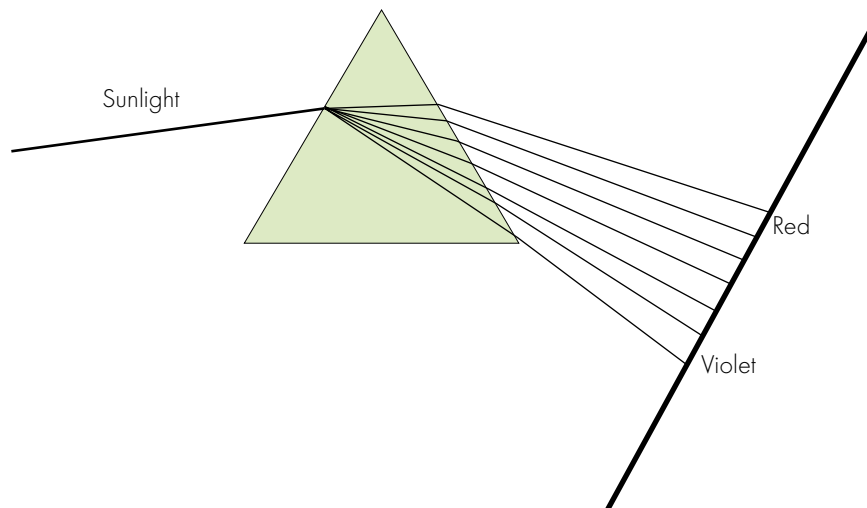
.....

.....

■ Task 3:

Enter the missing colored components of the spectrum in the drawing.

Explain how it is created with the aid of page 139 of the physics book (Cornelsen).



.....

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Work Sheet

■ Games with the rainbow



■ Task 4:

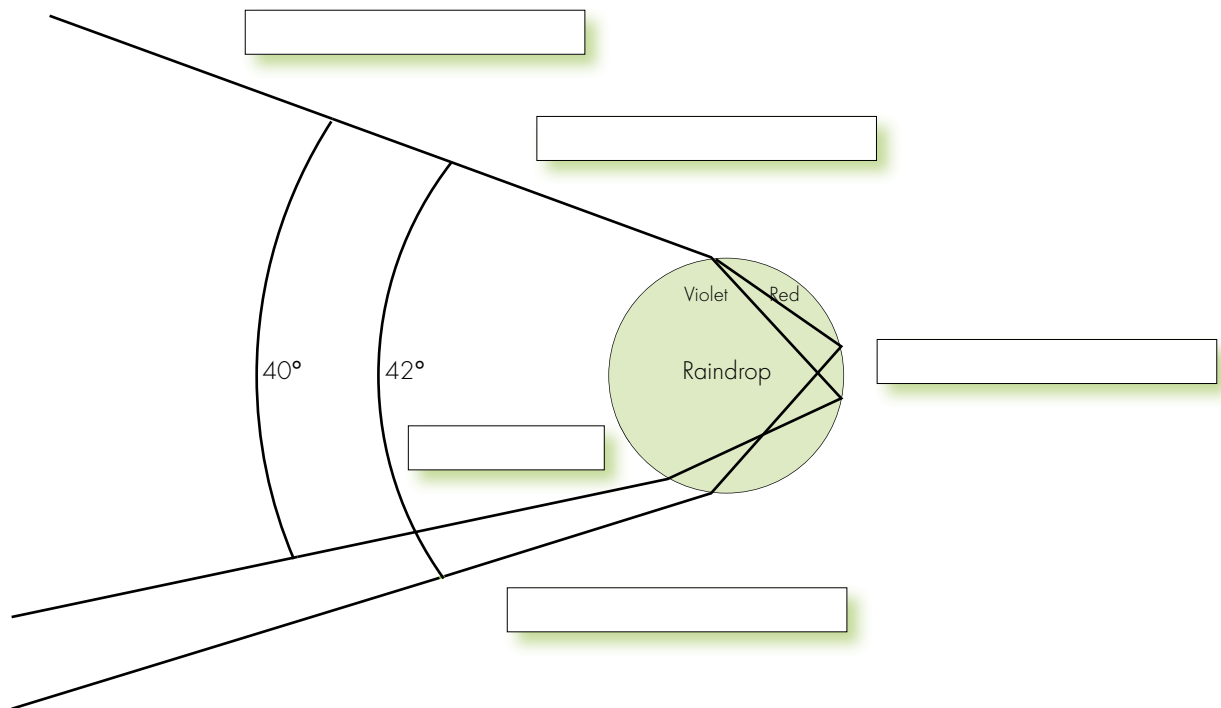
Fill in the gaps in the text and the boxes in the diagram with the aid of the book (Paetec, page 99).

You can see a rainbow when in the air,
and you stand

White light is when it enters a raindrop. Part of the light is reflected from the back
of the raindrop onto its front. This phenomenon is called

At the front, the light is again and enters your

You can only see the colors at a certain angle to the direction of the sunlight.



Answer Sheet

■ Games with the rainbow



■ Task 1:

The sentence reads:

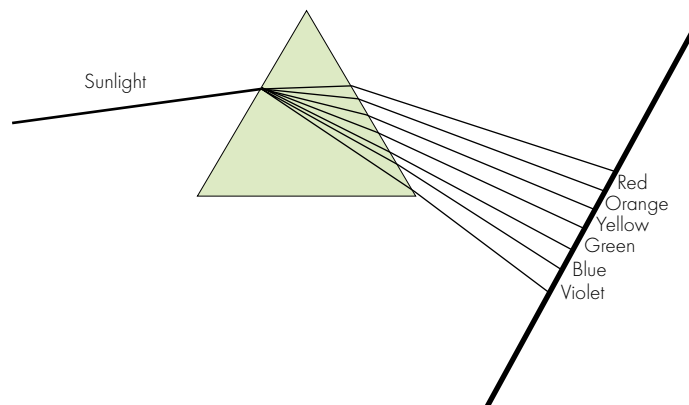
A prism, for example, can split white light or sunlight into colored light.

■ Task 2:

A continuous spectrum is a band of colors of the spectrum. It is created when light is radiated by glowing solid objects, fluids or gases under high pressure (e.g. light bulb, sun).

■ Task 3:

According to the law of refraction, the angle of refraction in glass depends on the speed of propagation. Because different colors travel at different speeds in glass, they are refracted at different angles. That is why we see the spectral colors.



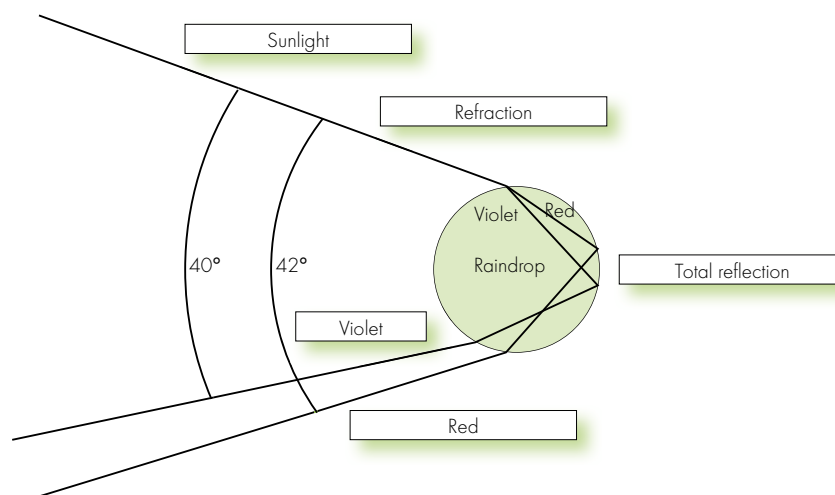
■ Task 4:

You can see a rainbow when there are **drops of water** in the air, and you stand **with your back to the sun**.

White light is **refracted** when it enters a raindrop. Part of the light is reflected from the back of the raindrop onto its front.

This phenomenon is called **total reflection**. At the front, the light is **refracted** again and enters your **eye**.

You can only see the colors at a certain angle to the direction of the sunlight.

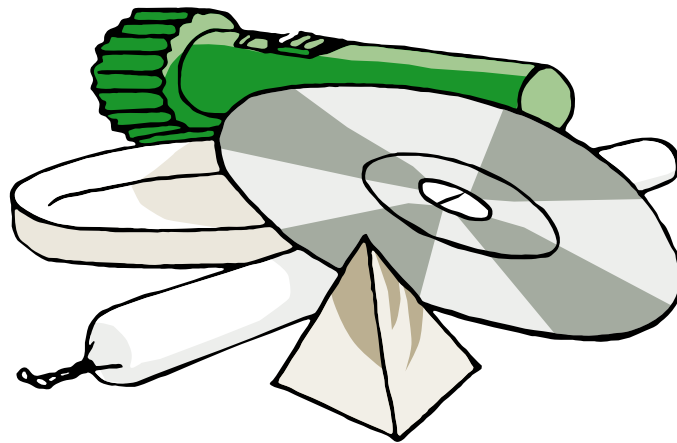


Equipment and Aids

■ Games with the rainbow



- Candle
- Glass prism
- Overhead projector
- Lens (optical bench +120)
- Rectangular dish
- Water
- Mirror, e.g. mirror tile
- White paper as a projection surface
- Hand spectroscope
- Flat cylindrical glass vessel with a large diameter
- Flashlight
- CD



Appendix: Light and Colors

■ Tips and notes for teachers

■ Idea:

- Encourage students to work on their own initiative.
- Do this by having diverse tasks with various methods.
- Construction kit system, because individual building blocks can be selected from it.
- Building blocks can be used in different ways.
- It is possible to combine demonstration with self knowledge.
- Additional tasks can be added to the construction kit at any time.

■ Implementation:

- Work meeting of teachers from 3 different schools, and personal working time for preparation.
- Store all the materials in a large box, so that it is all kept together.
- Craft tasks for the preparation of the material were solved together. This allowed for a lively exchange of experience, as on their own the project took longer to complete..
- The experiments were carried out several times before the descriptions were written.
Improve the description if there is any ambiguity.
- Mathematics, physics, biology, chemistry and astronomy teachers can help.
- Symbols for recognizing tasks at the top right-hand corner of task, work and information sheets.
- Paper of different colors.
- Laminated for frequent use.

■ Help from the teacher:

Provide catalogs, old magazines for cutting up (letter boxes are full of them).
Provide scissors and glue for making collages.

■ Pitfalls:

- Additive color mixing – use the box as a darkened room, try out the play of light in advance, possibly set it up yourself, so less time will be required for the experiment.
- For the »hole in the hand« experiment, hold the tube so that it touches the hand.
- Subtractive/additive color mixing: Take into account the time required for the paint to dry.
- Appropriate literature should be provided for the examples of color mixing and the topic »vision«.

■ Reference (Light and Colors Construction Kit)

Bibliography:

- Naturwissenschaften »Farben«, Volk und Wissen – Mensch Natur Technik, Band 4;
Paetec – Was ist was: Licht und Farbe; Band 17 – [de.wikipedia.org/wiki/Adaptation_\(Auge\)](https://de.wikipedia.org/wiki/Adaptation_(Auge))
- www.medizininfo.de/augenheilkunde/fehlsichtigkeit/normalsicht.htm
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