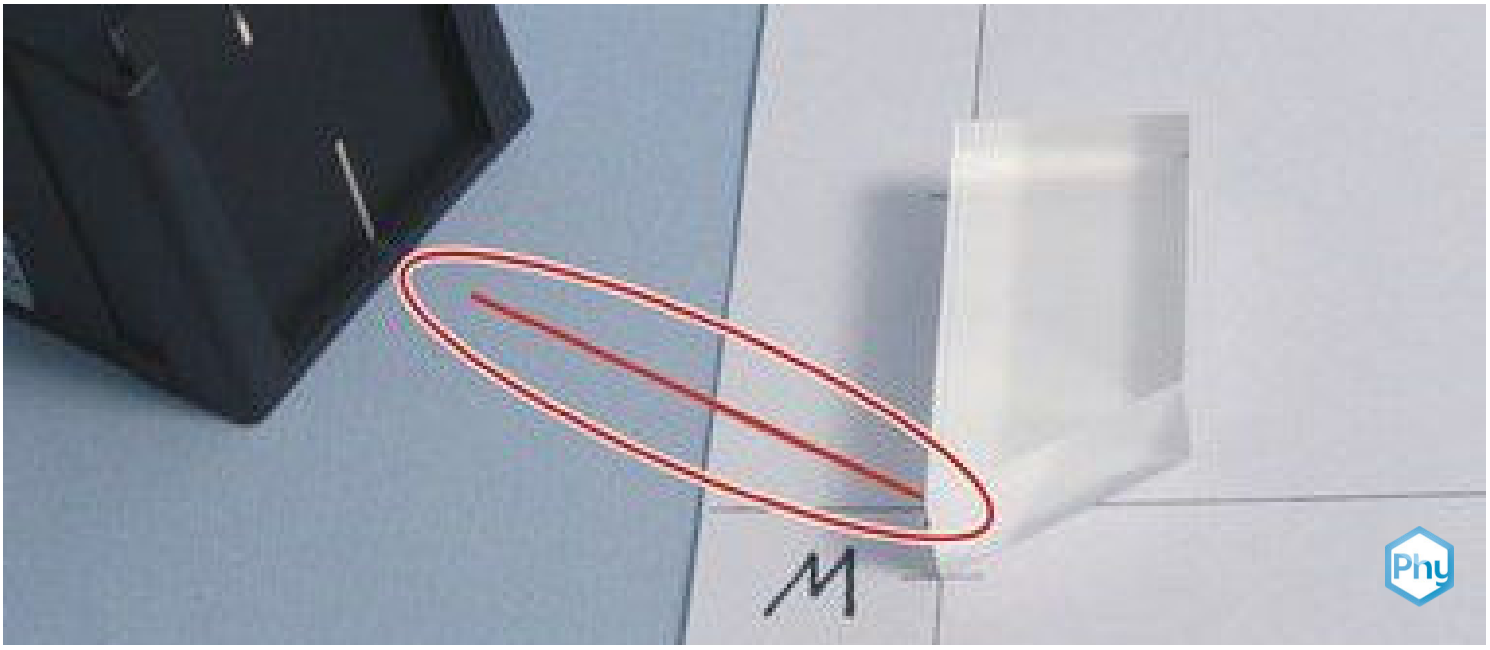
Complementary colors



The main focus of the study is to observe the resulting mixed colors when spectral colors are masked out of the spectrum.

Physics > Light & Optics > Light & Colour

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/616d4c32aeb0ac0003430abd

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Teacher information

Application

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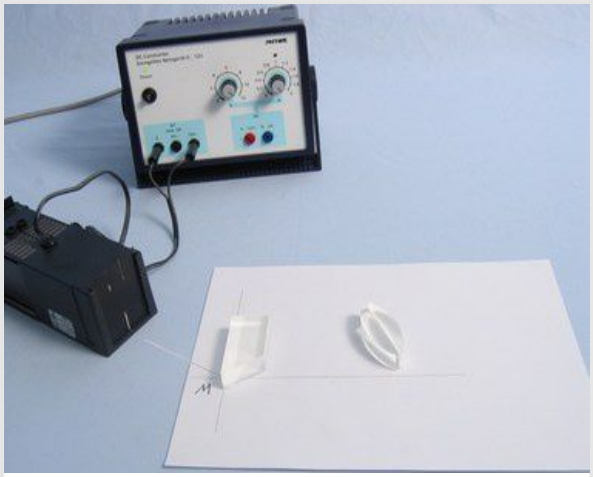

Complementary colors

The term complementary colors comes from color theory. In additive and also subtractive color mixing, two colors are considered complementary if their mixture results in white or black.

Complementary colours are often used in everyday life, be it by adding blue substances to detergents to reduce the yellow cast or in green surgical clothing, which is complementary to red blood to avoid afterimages.

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Other teacher information (1/6)

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Previous

The wavelength-dependent refraction (dispersion) at a prism, as well as the optical path of a converging lens should be known.

Principle

Complementary colors always overlap to form white, so if one color is missing from the spectrum, the overlay of the remaining spectrum will not produce white, but another color.

Other teacher information (2/6)

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Learning

In this experiment, the pupils first repeat their knowledge of the dispersion of light on a prism and of the unification of spectral colours with the aid of a converging lens. They then gain the knowledge that a complementary colour and a suppressed spectral colour together produce white again. As an aid to remembering complementary colours, a simple scheme is given which corresponds sufficiently to the observed phenomena.

Tasks

The main focus of the study is to observe the resulting mixed colors when spectral colors are masked out of the spectrum.

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Other teacher information (3/6)

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Additional information

The complete Newtonian color wheel and Helmholtz's findings on the systematics of complementary colors will not be discussed here.

This experiment can also be seen as another foundation stone for the understanding of additive and subtractive color mixing.

One way to characterize the color wheel with only 6 colors is common in experiments on additive and subtractive color mixing. There the colors red, green, blue, yellow, cyan and purple are used.

The complementary colours observed in this experiment are always mixed colours because of the way they are formed. Helmholtz, however, has shown that (except for purple) there is always a spectral color that has the same hue.

Other teacher information (4/6)

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Notes on structure and implementation 1

This experiment requires a narrow beam of light to strike the prism. Thus, after passing through the prism and lens combination, a distinct gathering point (image point) is created where the colors reunite to form white.

The auxiliary line is used for adjustment in order to achieve reproducible test setups that are as error-free as possible.

The spectrum is particularly broadly spread with this setting. However, care must be taken to ensure that the violet component also exits the prism completely.

The converging lens should be placed at a distance of about 10 cm from the vertical line so that the spectrum is sufficiently broadened to mask out spectral colors.

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Other teacher information (5/6)

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Notes on structure and implementation 2

It is also important to ensure that the light beam passes through the lens in the centre and symmetrically to the optical axis of the lens in order to avoid colour aberrations caused by imaging.

The observation of the collection point is subjective and the color impression depends on a good adjustment and blanking of a spectral color. Therefore, in the implementation, the paper strip is first slowly and continuously pushed through the spectrum and the type of change in the color impression is observed. Then, three colors whose complementary colors are clearly different are specifically blanked out.

Other teacher information (6/6)

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Comment on the results

Hiding a particular colour requires great care, and the subjective assessment of the colour in the collection point may vary. However, students should generally name one of the two colours given in the table on the right.

According to Newton's circle of colours, the colour purple is missing from this list. It is not a spectral color, but arises from the mixture of red and violet and thus closes the circle of spectral colors, in which a total of 12 colors are arranged.

Spektralfarbe	Komplementärfarbe
Rot	Grünblau
Orange	Eisblau
Goldgelb	Blau
Gelb	Ultramarinblau
Grüngelb	Violett
Grün	Purpur
Grünblau	Rot
Eisblau	Orange
Blau	Goldgelb
Ultramarinblau	Gelb
Violett	Grüngelb
(Purpur)	Grün

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Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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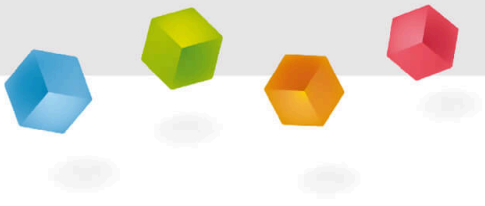

Student Information

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Motivation

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Complementary colours are often used in everyday life, whether by adding blue substances to detergent to reduce the yellow tint and thus make the laundry look whiter, or in the green colour of surgical clothing, which is complementary to the colour of blood, to reduce after-images.

Task

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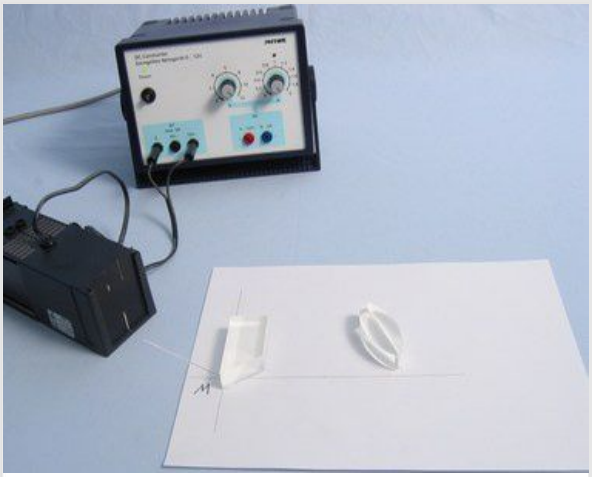

Test setup

What are complementary colors?

- Blend out individual spectral colours from the spectrum of white light and investigate which mixed colour is produced.

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Equipment

Position	Material	Item No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Block, trapezoidal	09810-02	1
3	Block,planoconvex lens,fl+100mm	09810-04	2
4	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Additional material

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Position	Material	Quantity
1	Ruler (approx. 30cm)	1
2	White paper (DIN A4)	1
3	Protractor	1

Structure (1/2)

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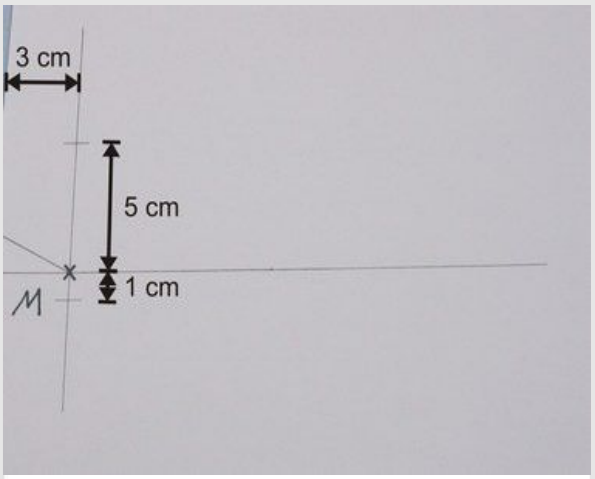
Attention!

Make sure that the light and the model bodies do not change their position when you fade out individual colors from the spectrum with a strip of paper.

- Place the sheet of paper crosswise in front of you on the table. Draw a right-angled line cross at the bottom left and mark the intersection point with M.
- Mark 1 cm below and 5 cm above $M$the vertical line.
- Stretcher in the crossing point $M$the angle 28° and draw an auxiliary line.



Preparation

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Structure (2/2)

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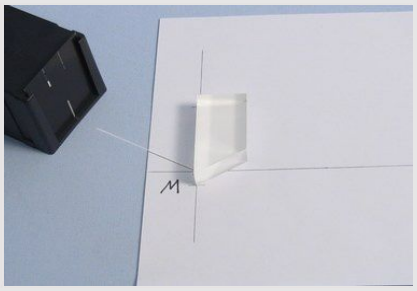
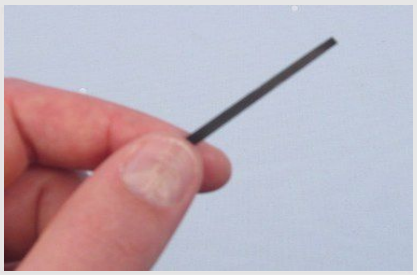
- Place the trapezoidal model body between the two marks on the vertical line.
- Insert the slit diaphragm on the lens side into the light box and place it on the edge of the sheet according to the illustration.
- Cut a small strip of paper about 1 mm wide and lay it out ready.





Procedure (1/3)

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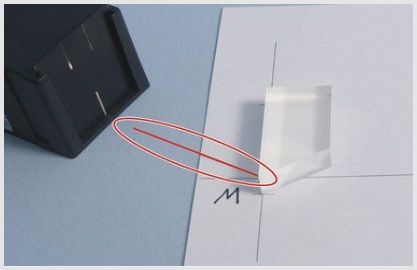
- Connect the light box to the power supply (12 V ~).
- Let the light beam fall exactly along the auxiliary line onto the prism.
- Observe the refracted light beam that leaves the prism grazing.
- The position of the light box is correct if the refracted light beam appears completely coloured and the violet part can also be seen.



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Procedure (2/3)

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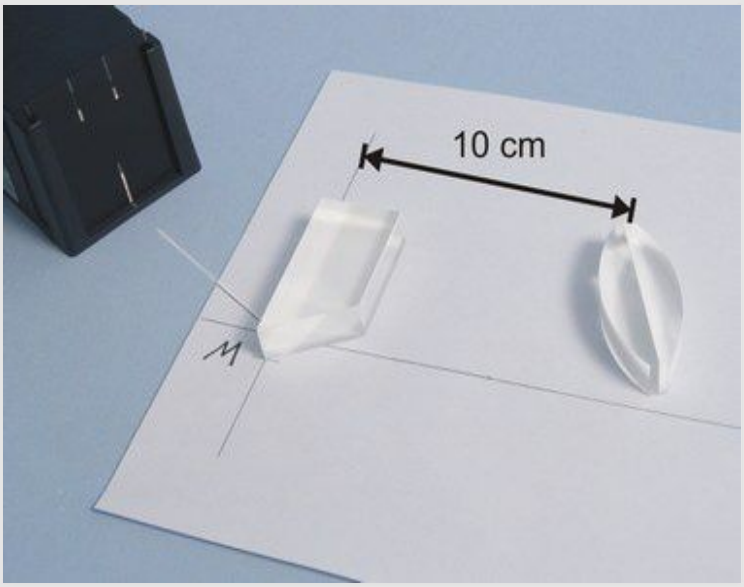

- Bring the two convex lenses placed next to each other into the coloured fanned out light beam.
- The distance of this lens combination from the vertical line should be approx. 10 cm. Make sure that the light beam passes through the centre of the lenses as far as possible.
- Describe the path of the light beam and the colors observed after passing through the lenses.

Procedure (3/3)

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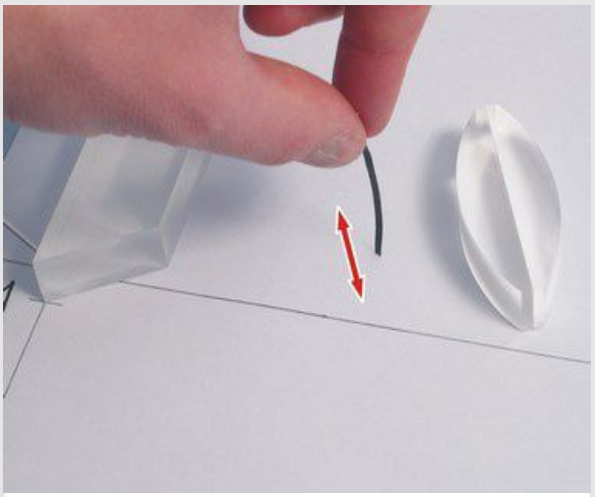
- Push the narrow strip of paper in front of the lenses through the coloured light beam so that individual colours are faded out one after the other. Start at the red edge of the light beam and slide the strip **slow**to the purple rim.
- Observe the narrowest point of the light beam (collection point) behind the lens combination and note the change.
- Now selectively blend out the colours red, green and blue and note the colour of the collection point in each case.
- Turn off the power supply and remove the model bodies from the paper.



Moving the Paper Strip

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Report

Task 1

10° PHYWE

Give an explanation for the observed color of the light beam in the collection point of the lens combination when no color is faded out.

- Each color has its own focal point and therefore there is no overlapping.
- In the collection point of the lens combination all colors of the spectrum overlap and result in red.
- At the collection point of the lens combination, all colors of the spectrum overlap and result in white.

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Task 2

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10°

How does the color of the collection point change when a color is faded out in the spectrum?

Drag the words into the correct boxes!

If a color is missing from the spectrum, the superposition of the _____ no longer gives _____, but a different color. If the hidden color changes from _____ to violet, then the color of the _____ also changes in the order of the spectral color, but starting with green-blue.

red

collecting point

residual spectrum

white

Check

Task 3

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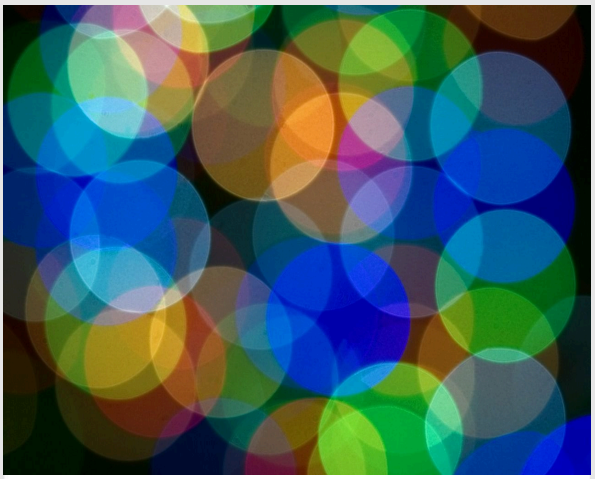
The hidden spectral color and the color visible in the collection point are called complementary colors. Consider what color results when two complementary colors are superimposed.

There is no general answer to this question.

Complementary colors always overlap to white.

Complementary colors always overlap to form red.

Complementary colors always overlap to form blue.



Overlay of different colors

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Task 4

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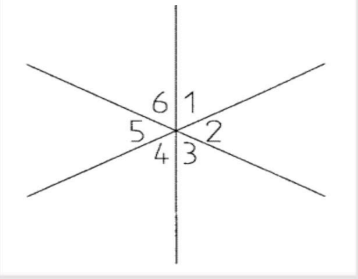

Match each color with the correct complementary color.

Red - ; Orange - ,
yellow - ; Green - ,
blue - ; Purple - .

red | orange | purple | green | yellow | blue

Check

Make a sketch on a sheet of paper as shown in the illustration and enter the colours of the spectrum (red, orange, yellow, green, blue and violet) consecutively in this illustration for the numbers 1 to 6. Opposite colours are complementary colours.

Then fill in the cloze with this knowledge.

Slide	Score / Total
Slide 21: Superposition of the colors of the spectrum	0/1
Slide 22: Color of the collection point	0/4
Slide 23: overlay	0/1
Slide 24: Assignment of the complementary colors	0/6

Total 0 / 12

Solutions | Repeat

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