

Worksheet 1: Rainbows

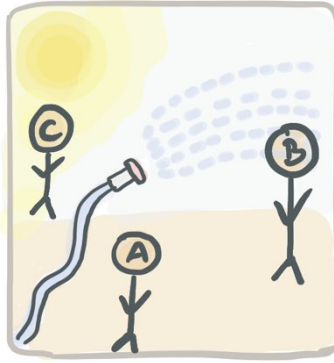
1st Experiment: Inspecting an artificial rainbow

Task 1.1



Make a guess about the place where you can see a rainbow.

- A
- B
- C



Task 1.2



Now walk around the fountain. Check your assumption from task 1.1

Result:

Task 1.3: Observations



Watch the rainbow very closely!
Where do its colors come from?

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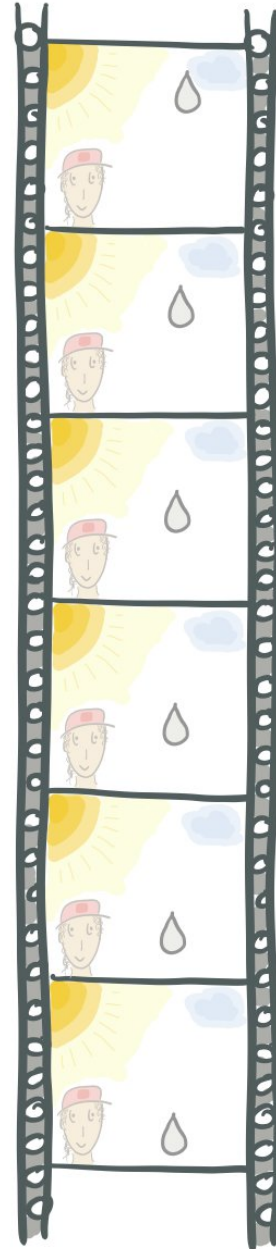
Worksheet 2: Rainbows

Task 2.1



On the right you see the same falling raindrop in several images of a fast sequence.

Color this drop in the observed order of colors.



Task 2.2



Write down your research question(s).

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Worksheet 3: Rainbows



Using the photo below, describe what a rainbow looks like.

Note the order in which the spectral colors appear from top to bottom.

Distinguish between the (weak) upper and the (strong) lower arc.



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Scaffsheet 1 provides words and phrases you can use for your description.

Scaffsheet 1 

Scaffsheet 1: Rainbows



Here you find words and phrases that you may use to describe the rainbow ...

green yellow

Between the arcs ...

violet red orange blue

For the first ... the order of colors is:

secondary rainbow main rainbow

is darker than is brighter as

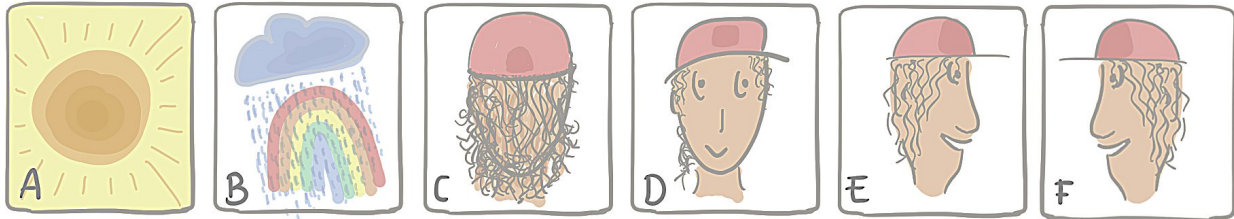
Worksheet 4: Rainbows

At the fountain on the schoolyard, you have noticed: Observers see the rainbow only if the sun, the rain area and the observers are arranged correctly.

Task 4.1



Use the following pictures to depict this arrangement. Choose pictures appropriately and put them in the right order. (Several solutions are possible)



Appropriate arrangement(s):

Task 4.2



Describe this arrangement in words!

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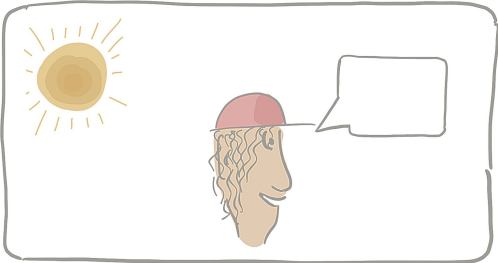
Scaffsheets 2 & 3 might help you to write correctly!

Scaffsheets 2 & 3

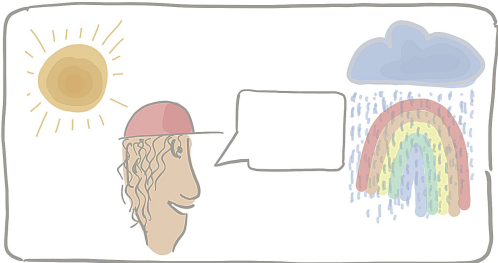
Scaffsheet 2: Rainbows



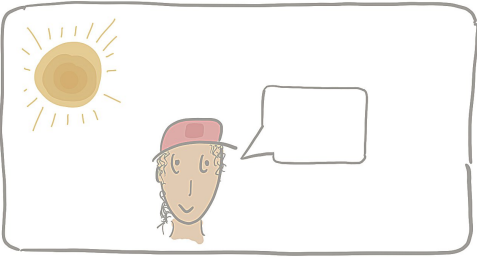
Here you practice how to describe an arrangement of items. Build suitable sentence for each speech bubble. Use the parts of the sentence given in the grey box.



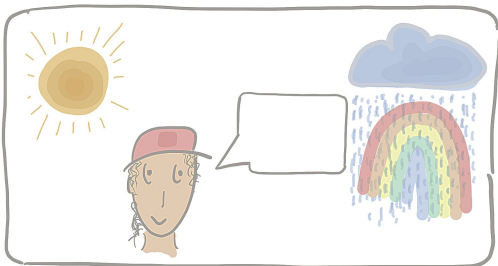
Picture 1



Picture 2



Picture 3



Picture 4

The sun	is	behind me.
The rain area	is located	on my right side.
		to my right.
		in front of me.
		to my left.
		on my left.

- 1:.....
- 2:.....
- 3:.....
- 4:.....

Scaffsheet 3: Rainbows



Formulating conditions

Conditions are expressed with if-then sentences (conditional sentences).

Example:

When the rain stops, I go to the playground.

Sometimes there are also two conditions for something to happen:

Example:

If you feed the dog and do your homework, you can go to the tennis court.

Worksheet 5a: Rainbow angles

Assign a matching speech bubble to each of the seven pictures A up to G.

There is no picture for four speech bubbles.

1 Attention: The rainbow angles are not angles between the horizontal and the light rays from the arc to the observer!

2 Accurate measurements show: In the secondary rainbow the angle for violet is 52.7° and for red 49.7° .

3 Accurate measurements show: In the main rainbow the angle for red is 42.7° and for violet 41.1° .

4 Between the light beams is an angle of about 42° .

5 The angles 42° and 51° are characteristic for all rainbows. They are called "rainbow angles".

6 Between the light beams is an angle of about 51° .

7 Sunlight hits the main rainbow. Colored light reaches the observer from this point.

8 The center C of the rainbow lies on the dashed line. The dashed line is the central perpendicular of the rainbow circle.

9 Sunlight hits the secondary rainbow. From there, colored light reaches the observer.

10 An observer sees a main rainbow M and a secondary rainbow S.

11 The image shows a beam of light from the sun to the observer. The beam is extended in the ground with a dashed line.

Worksheet 5b: Rainbow angles



Worksheet 6: In the rainbow laboratory

2nd Experiment: Investigations with a waterdrop model

Task 6.1



Write down our set of research questions.

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Task 6.2

Describe the experiments we will use to answer our research questions.

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Task 6.3



Conduct the experiment. Note your observations.

Color sequence of the secondary rainbow observed? YES / NO

Color sequence of the main rainbow observed? YES / NO

	rainbow angles	angles measured in the experiment
secondary rainbow		
main rainbow		

Task 6.4



Make a reasoned judgment as to whether the round bottom flask is a suitable model for a water droplet.

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Worksheet 7: In the rainbow laboratory

3rd Experiment: waterdrop-model-rainbow

Task 7.1



Write down our research question.

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So far we only have considered a flask (respectively a raindrop) in front of the observer. But we also have to take those to the right and to the left into account. How do the raindrops create a curved arc?

Anyone from your group can try this outdoors! You can find out how in Task 7.1.

Task 7.2



Hold the water filled flask in front of you, the sun behind you.

Raise and lower the piston until you see the two lights again.

Now hold your position and turn the flask only by moving your arm to the right (about 40 cm). Raise and lower again ...

Repeat this once or twice more, each time further out.



Do not look directly into the sun. If it is too bright for you, do not look into the water filled flask.

Task 7.3



Describe your observations.

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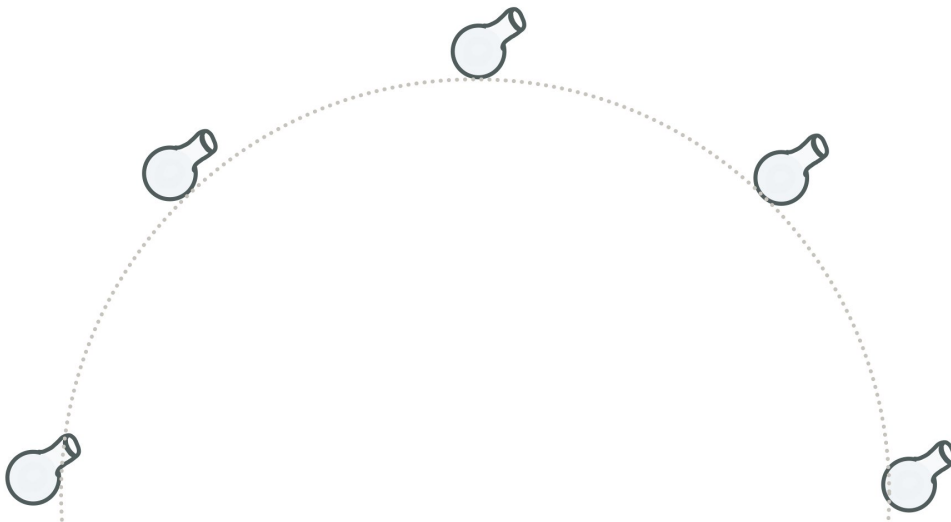
Task 7.4



Let us now focus on the lower luminous phenomenon, which belongs to the main rainbow.

Examine where exactly the glow occurs in the round-bottom flask.

Enter the positions into the sketch.



Task 7.5



How is it possible that the piston lights up from different positions in different directions?

One of you holds the flask in a fixed position in the sunlight and the others look at it from all sides

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Task 7.6

Explain what this experiment tells you about the formation of the rainbow.



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Worksheet 8a: In the rainbow laboratory

Learning task 1: What happens in a raindrop?

Task 8.1



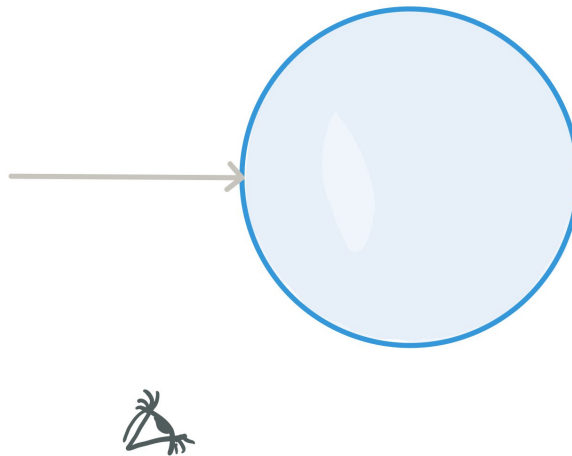
Write down the questions we now want to clarify.

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Task 8.2

We first look at the sunlight moving towards the center of a drop.

- a) Make a guess as to what happens to this light. Draw the course of the light that you suspect. (The gray arrow represents the sunlight)



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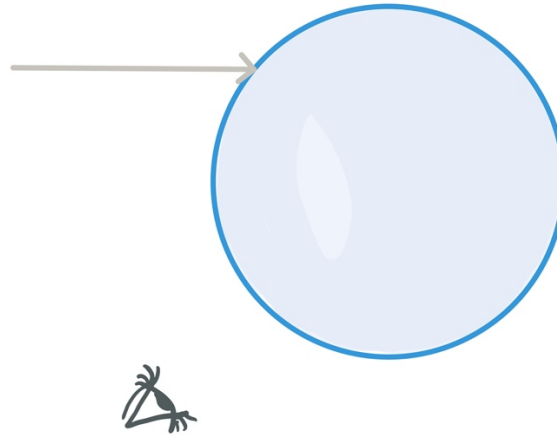
- b) Evaluate whether this light can contribute to the formation of the rainbow.

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Task 8.3

We now look at sunlight entering in a droplet in the upper half.

- a) Make a guess as to what happens to this light. Draw the course of the light that you have guessed.



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- b) Evaluate whether this light can contribute to the formation of the rainbow.

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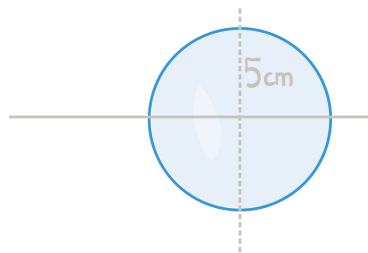
Worksheet 8b: In the rainbow laboratory

Task 8.4 Construction task

Now we have a guess what happens to the light in the drop.
In optics, we can even predict by construction!

1. Take a sheet of squared paper across and draw a circle with a radius of 5 cm on the right half. Mark the center and draw a straight line (called axis) across the center.

Your drawing should look like this:



2. Draw a beam of light falling horizontally 4 cm above the axis from and coming from the left onto the drop.
3. Now construct the path of the light beam in the drop and how he leaves it.

Use this law of refraction to calculate the angles of refraction:

$$\frac{\sin \alpha}{\sin \beta} = \frac{n_{\beta}}{n_{\alpha}}$$

a: angle of incidence
b: angle of refraction

n_{α} : Refractive index for the medium in which the light is incident
 n_{β} : Refractive index for the medium into which the light is refracted

$n_{\text{Air}} = 1,00$
 $n_{\text{Water}} = 1,33$

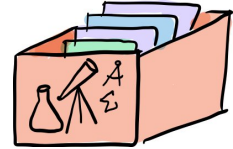
4. Describe also what happens with the light.

Check your results comparing it with the proposed solution on Scaffsheet 4.

Scaffsheet 4

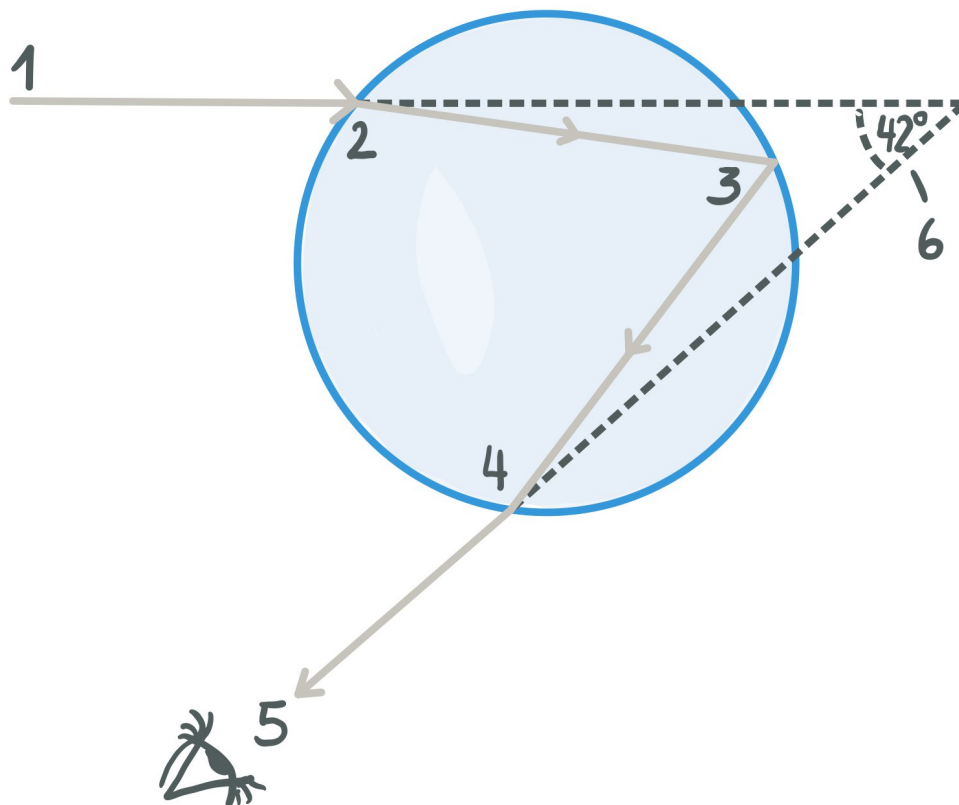


Scaffsheet 4: proposed solution for the optical construction



Angle of incidence into the drop: 53°

Total deflection angle: 42° .



Description:

1. Sunlight enters in the raindrop.
2. This light is refracted for the first time.
3. The light is reflected (angle of incidence equals angle of refraction).
4. The light is refracted for the second time
5. The light moves towards the earth - at an angle of 42° to the direction of incidence (eventually towards an observer)

Worksheet 9: In the rainbow laboratory

4th Experiment: experimental test

So far, we have used theoretical considerations to investigate what might happen to the light in a raindrop. You have applied your knowledge of refraction and reflection.

In physics, however, you are only convinced when your theoretical considerations pass an experimental test.

A suitable experiment will now be demonstrated to you: It shows a beam of light entering a circular bowl filled with water. This water bowl represents a raindrop.

Task 9.1: experimental demonstration

Write down our expectations.

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Task 9.2: Conclusions

Evaluate whether our theoretical considerations (see Worksheet 8) pass the experimental test!

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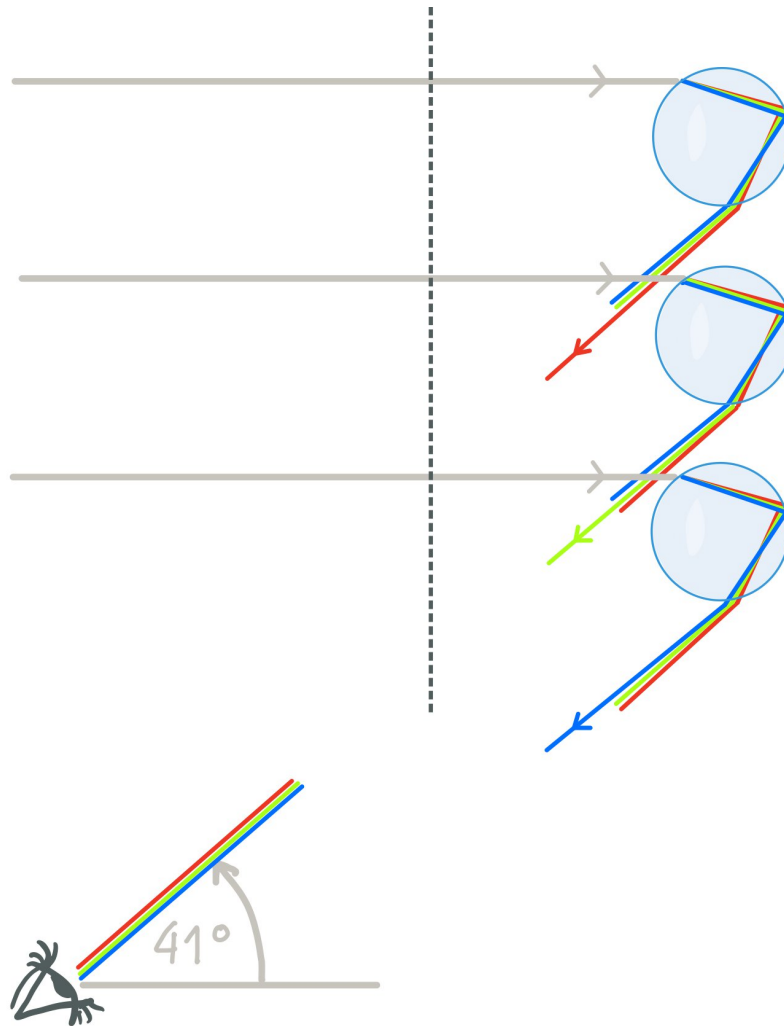
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Worksheet 10: In the rainbow laboratory

Task 10.1: Close to an explanation ...

Think back to task 2.1: You have colored a raindrop in the order in which it shines in the main rainbow. With our results from experiment 2 we are close to an explanation!

The following picture should help you explain. There you see the same drop three times as it falls. You also see the eye of the observer. Of course, it is much farther away from the drop than it is shown in the picture. This is illustrated by the dashed line.



Write an explanation of why the raindrop appears first red, later green, then blue to the observer.

Scaffsheet 5 supports you in formulating!

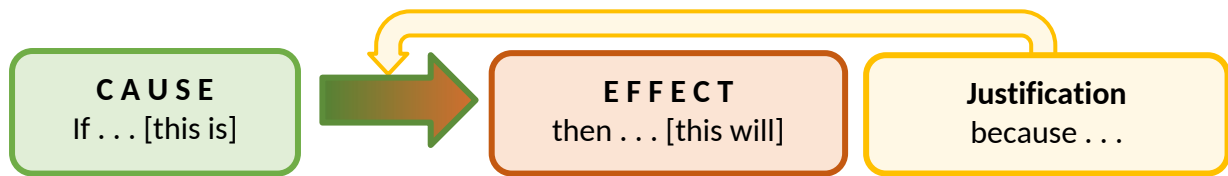
Scaffsheet 5



Scaffsheet 5: How to write a good explanation

An explanation is an answer to a scientific question based on facts, concepts, or rules. It explains why things happen, what they are made up of or how they work.

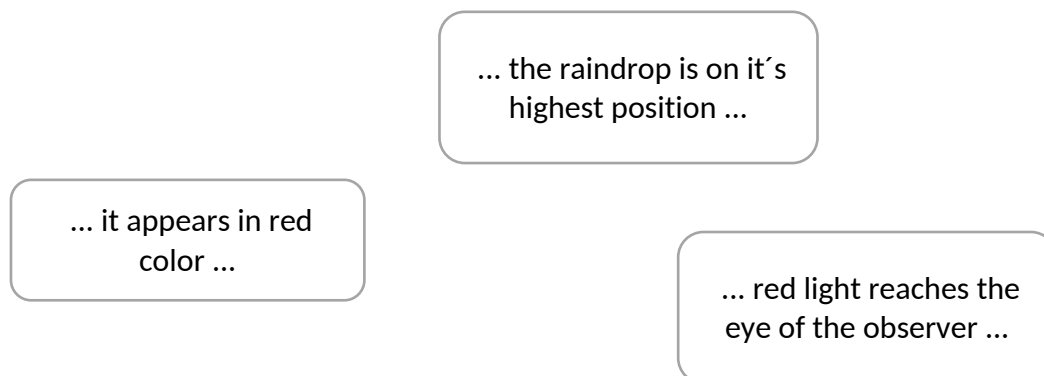
In general, a **causal explanation** has the following structure:



Example: **if** I eat too much chocolate, **then** I will get fat **because** chocolate contains lots of unhealthy ingredients responsible for weight gain.

Now it's your turn:

1. Select which box contains cause, effect, and justification.
2. Then arrange them accordingly.
3. Add **if**, **then** and **because**. Write down the complete sentence.



4. You have formed the first sentence of your explanation. Continue your explanation!

Worksheet 11: Your Wikipedia article about the main rainbow



11.1 Create a draft for a Wikipedia article about the main rainbow.

The article should be addressed to people of the same age - understandable for them and with everything you have learned about the rainbow so far.

Follow the usual Wikipedia structure!

As you can see down below, a Wikipedia article usually consists of the following four parts, which are always arranged in the same way:

The screenshot shows a Wikipedia article page for 'Rainbow'. The page layout includes a sidebar on the left with navigation links, a top navigation bar with 'Article' and 'Talk' tabs, and a search bar. The main content area is on a grid background and contains several instructional boxes:


- abstract**: In a few sentences you give an overview of what follows.
- table of contents**: Shows the headings of the main section.
- main section**: It contains all informations, you want to provide. It should be divided into sections and these should have headings.
- hard facts**: Key facts at a glance, mostly numbers.

There is also a photograph of a rainbow in a landscape.

Use the following blank Wikipedia page

Print it in a large format and complete your article on it.

Blank Wikipedia page



WIKIPEDIA
The Free Encyclopedia

- Main page
- Contents
- Current events
- Random article
- About Wikipedia
- Contact us
- Donate

Contribute

- Help
- Learn to edit
- Community portal
- Recent changes
- Upload file

Tools


- What links here
- Related changes
- Special pages
- Permanent link
- Page information
- Cite this page
- Wikidata item

Print/export

- Download as PDF
- Printable version

In other projects

- Wikimedia Commons
- Wikiquote
- Wikisource

Languages 

Boarisch

 Not logged in [Talk](#) [Contributions](#) [Create account](#) [Log in](#)

Article [Talk](#)

Read

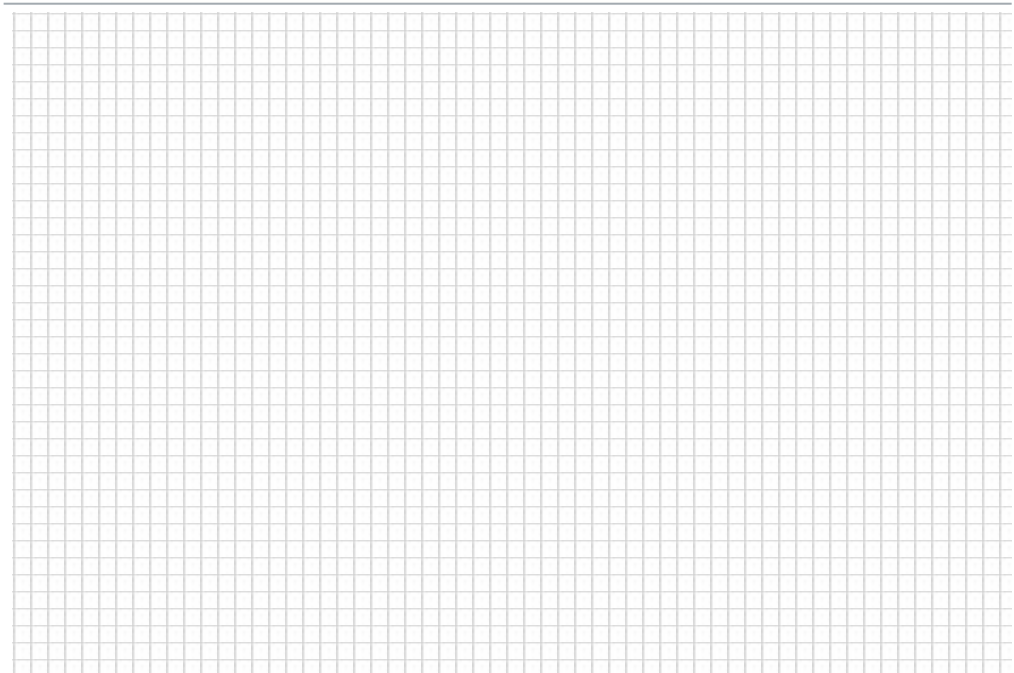
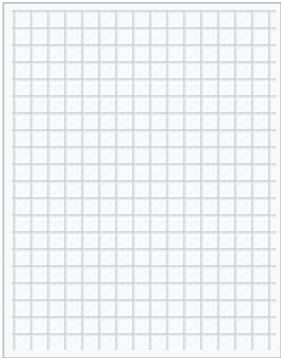
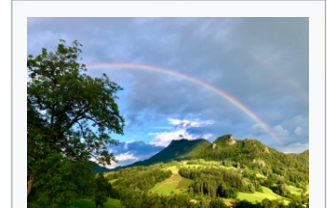
[Edit](#)

[View history](#)



Rainbow

From Wikipedia, the free encyclopedia

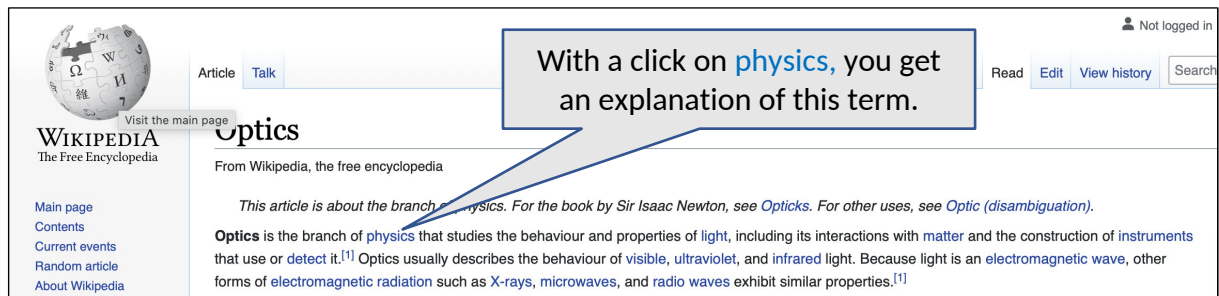


Drawings say more than a thousand words!

A good main section consists of an understandable text und matching drawings. Select some of the following drawings or make your own drawing if you like.

Your text should also contain blue links!

A useful feature of Wikipedia is the so-called "hyperlink structure": Terms that may be unfamiliar to readers are shown with a blue link. Below you can see an example. If a reader clicks on this link, he will get an explanation of this term.



Create a table of links and add it to your Wikipedia article.

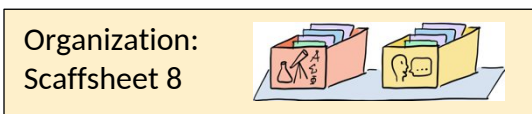


What else?

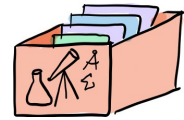
You don't know how to start and organize your work?
Scaffsheet 7 gives you clues.



You are unsure about the claims that your explanations in the article should meet?
Scaffsheet 8 gives you clues.



Scaffsheet 6: Hyper-Links



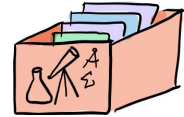
Here are some terms that might appear in your text and are explained with blue links.

Look for more terms when your main section is ready and complete the table with it.

Formulate definitions of these terms last. List these definitions in your document in an appendix.

Link-Term	Explanation
reflection	...
dispersion	...
refraction	...

Scaffsheet 7: Clues for organized work



First step: A review ...

A review of all, you have learned about the main rainbow, might be a good start. During the review you can decide:

- What content should the article have?
- In what order do we present this content?

By the way you can make a first draft for your table of contents.

Not only a retelling - making choices ...

Your article is not meant to be a pure retelling of what and how you learnt about the main rainbow. You have to make choices, what might be important for the addressees and what not.

Scaffsheet 8: Claims your explanations should meet

Hier würden wir in etwa ein ähnliches Arrangement für den Regenbogen entwickeln, wie es Teresa Conolly für die Leitfähigkeit zusammenstellt, falls das gewünscht ist – es wäre dann aber sehr ähnlich und unsere Materialien sind sowieso schon sehr lang e- vielleicht ist das auch entbehrlich ?????

Beispiel Teresa:

A GOOD CAUSAL EXPLANATION HAS:

ideas connected with causal links

incorrect	correct
If I get in the pool, <u>then</u> I will get wet and <u>then</u> I will get cold. L This is just a chronological order of steps.	If I get in the pool, I will get cold because water has a higher thermal conductivity than air. As a result , I lose heat much quicker and consequently feel cold.

ideas ordered chronologically and linked by sequential connectives

incorrect	correct
<u>At the end</u> , I got in the pool <u>before</u> I got cold.	First , I got in the pool, then I got wet, after that I got cooler, in the end I was freezing.

reasons based on relevant rules, concepts and definitions

incorrect	correct
If water is heated up to 100°C, it boils <u>because I say so</u> .	If water is heated up to 100°C, it boils because it has reached its boiling point.

experimental data like observations and measurements as back up

incorrect	correct
... because <u>my father once told me so</u>	The experiment showed that water boils at exactly 100°C.

present tense

incorrect	correct
Heat <u>caused</u> the water to boil.	Heat <u>causes</u> water to boil.

scientific terms

incorrect	correct
bubbling point, burning, glass mug	boiling point, combustion, beaker

Worksheet 12: Feedback for your classmates!



WANTED: your feedback!

Wikipedia's strength is its users, who keep the articles up to date with illustrations and topics and improve them.

Therefore, correct the article of another group!

Pay attention to ...

- completeness,
- correctness of content,
- suitable for the addressees
- ...

Give your feedback in a comprehensive way!

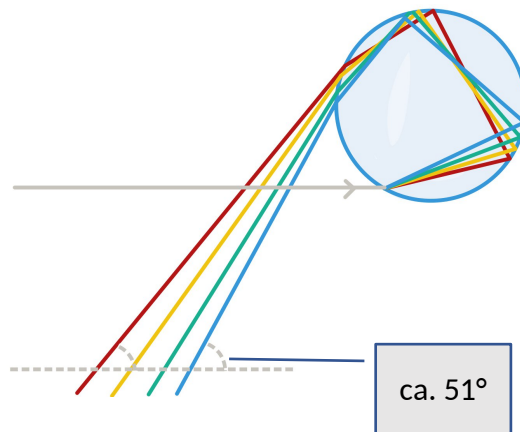
Worksheet 13: There is more about rainbows!

You have now explored and explained the main rainbow. But more phenomena are still missing, e. g. secondary rainbow and the dark band between the arcs. The following tasks will guide you to explain these phenomena as well.

Task 10.1: The secondary bow

The following drawing shows you the path of light through a drop of water that enters in it below the center of the drop.

- Describe the course of the light.
- Explain the secondary rainbow with the help of this course.



Task 10.2: Alexander's dark zone

Between the main and the secondary rainbow is a zone darker than the arcs and the rest of the sky. This is Alexander's Dark Zone - named after Alexander of Aphrodisias, a Greek philosopher.

Make a guess as to why this zone between the arches is so dark!

(Hint: Think beyond the visible spectrum!)

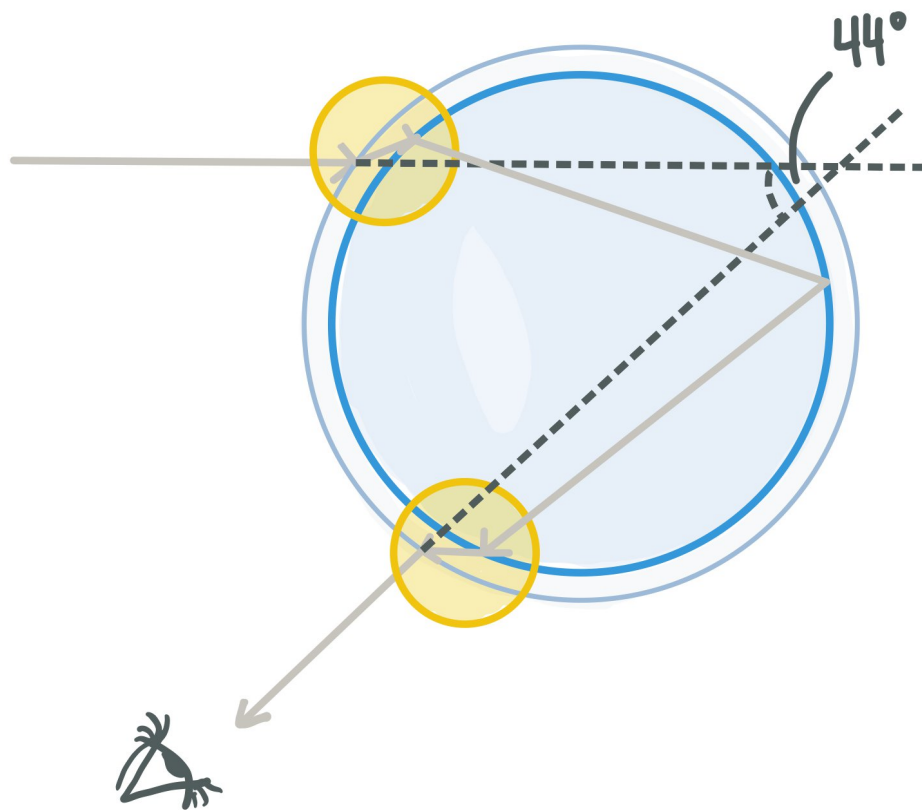
Task 10.3

Add to your Wikipedia article!

It should necessarily cover the secondary rainbow - and even something more, if you like ...

Appendix

Information on the influence of the glass envelope on the exit angle



5.