CoreBOX

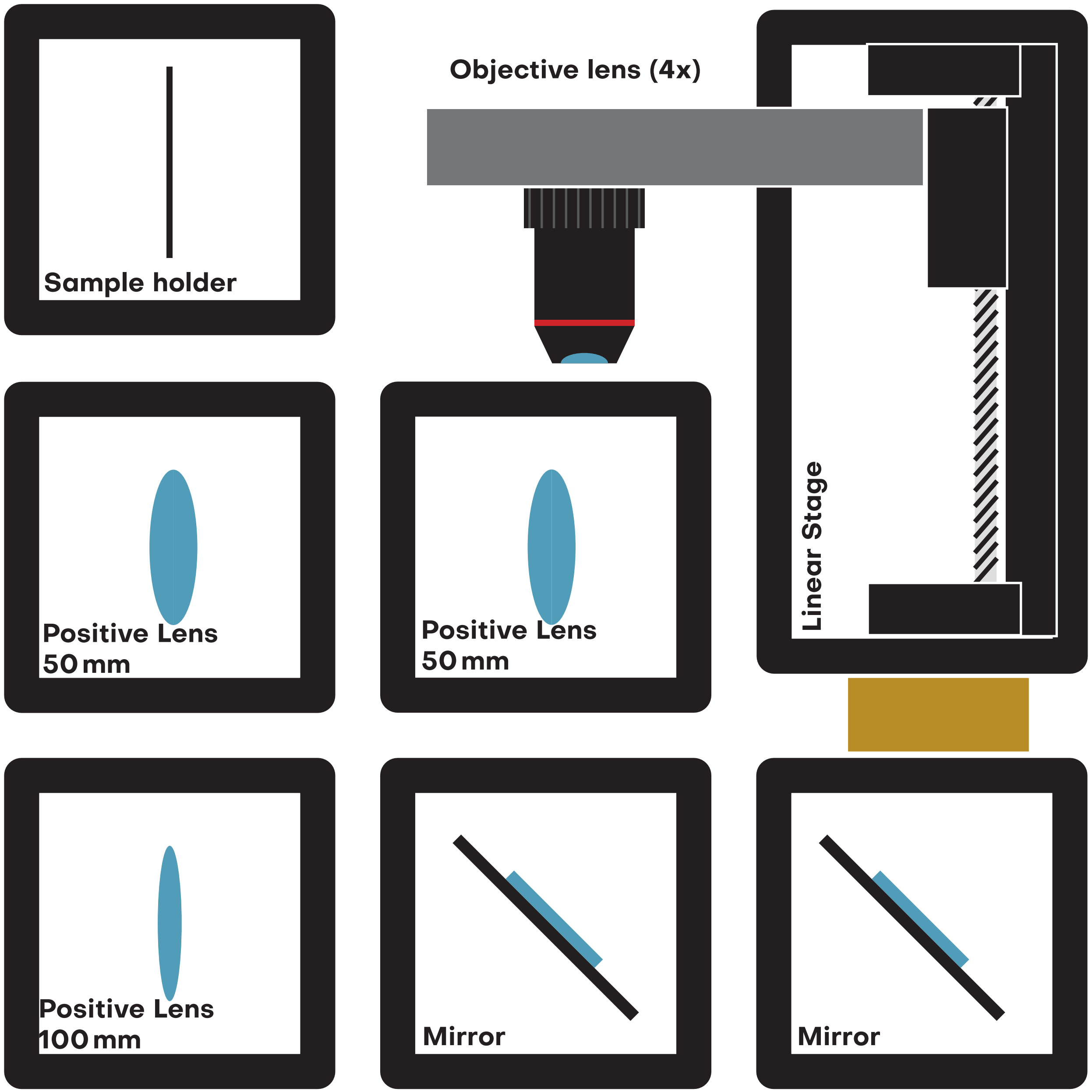
What‘s inside?

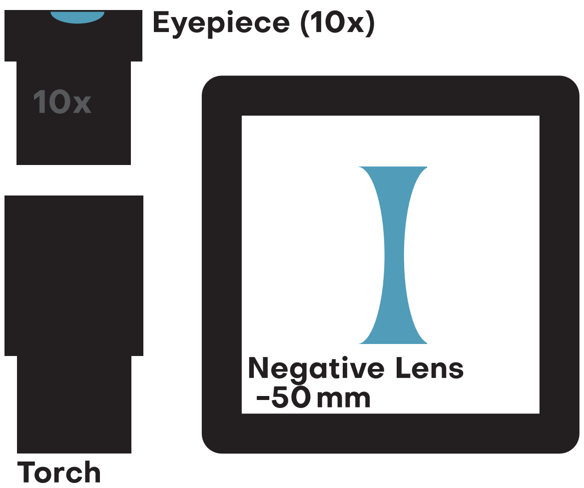
Specimen holder and linear stage:
Holds the specimen and moves the objective

Mirror, lens, eyepiece and objective:
Focuses and reflects

Attention:
Please do not touch the glass!

Cleaning the lenses:
Use a lens cleaning cloth





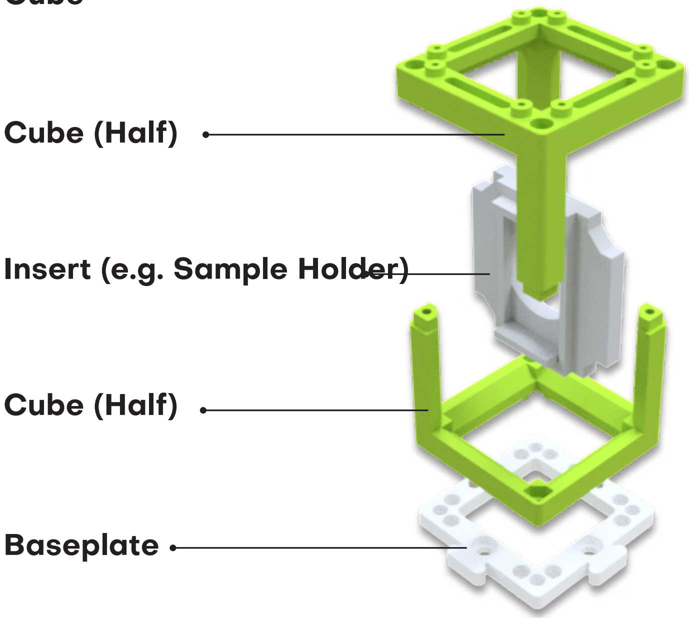
You.See.Too.? UC2!

The core element of the UC2 project is a simple cube. The cube consists of two halves and houses a sliding insert. The insert can hold different optical components (e.g. lenses, mirrors), which means that different functions can be realised with each cube. The cubes, as well as the base plates in puzzle format, which can be extended in all directions, are injection moulded and therefore have a high precision. The parts are held in place by a positive fit, which eliminates the need for magnets and screws. The inserts in stop plate format can be quickly adapted to new components and find space in the cube.

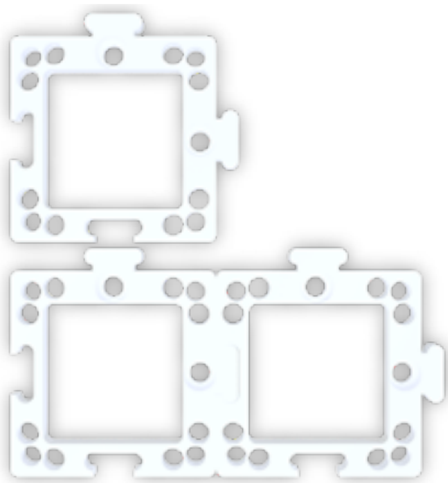
Cube Type 1

Injection Molded with Formfit

Cube



Baseplate



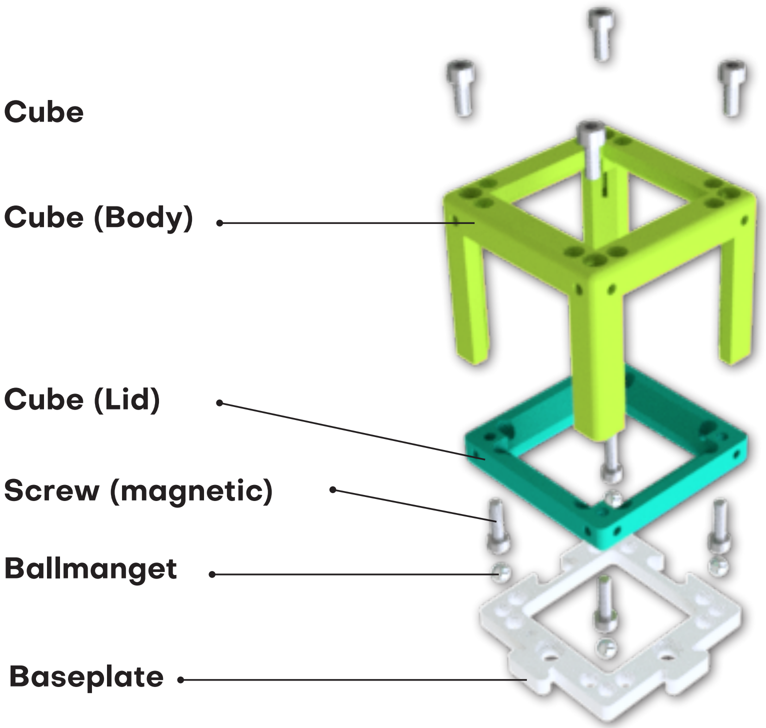
The cube can be mounted on a base plate. The base plate modules can be put together like a jigsaw puzzle.

UC2 for DIY 3D printing

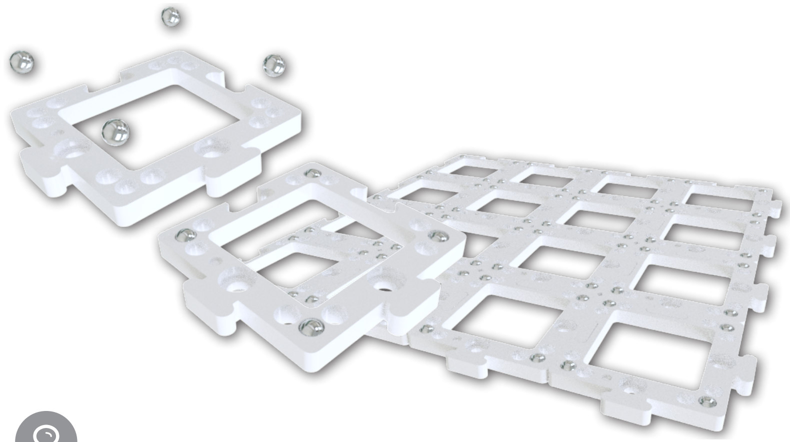
In addition to the injection-mouldable design, the cube also comes in a printable version. Both cubes are compatible with each other, but the cube consisting of lid and body is easier to print. The magnetic screws are used to connect with the spherical magnets on the plate. By combining different cube modules, it is very easy to assemble different optical structures. A new function can be added with each cube. There are no limits to your creativity.

Cube Type: 2

3D printed with magnetic connection

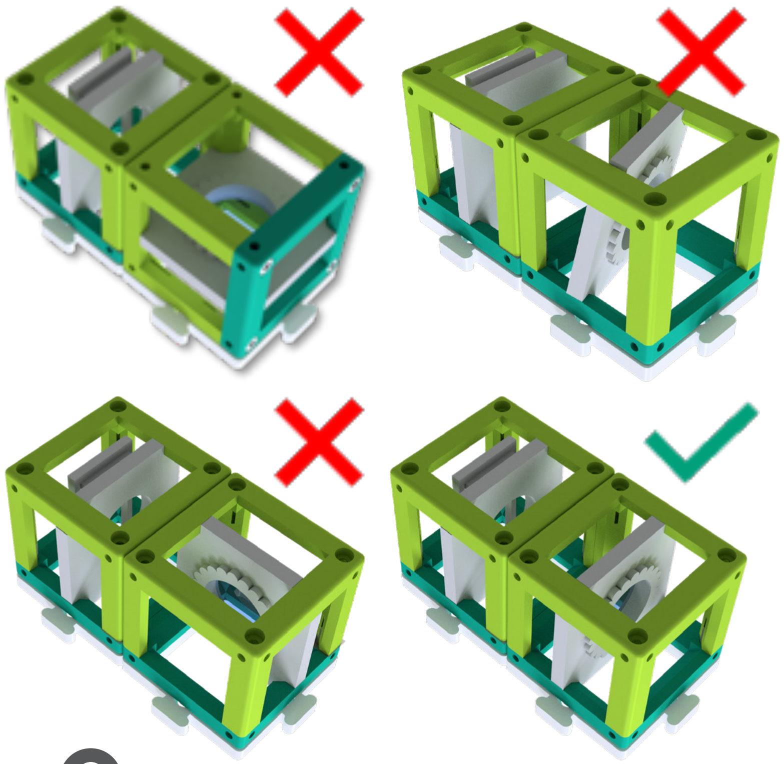


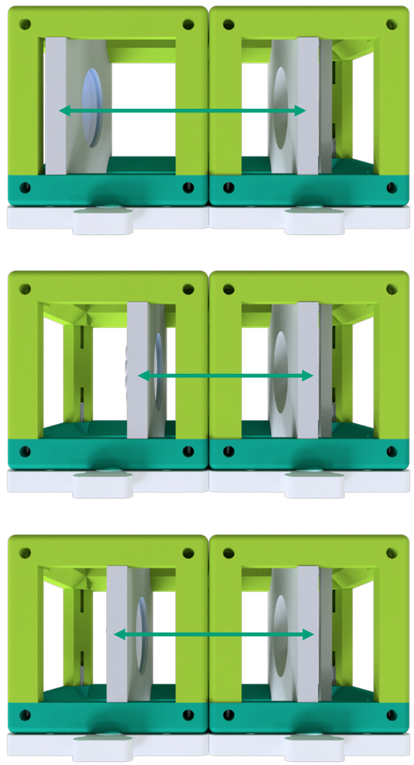
Baseplate with magnets



Small spherical magnets are embedded in the 3D-printed base plate, onto which the cubes are attached. Then you can build them yourself. You can find everything here.a

How the cubes fit together





Make sure the cubes are properly stuck on the plate and not tilted.

Tip: The cubes hold best in „sandwich“ format, with the plates holding the cubes at the top and bottom

If you do not see a sharp image, move the inserts (e.g. lens) until you see it clearly.

The green arrow in the picture shows you how to do this.

What a lens can do

Take one or more of the cubes that have a lens in them and look at the UC2 symbol shown here through it. Hold the cube in your hand and change the distance between the lens and the image.

What does the picture look like?

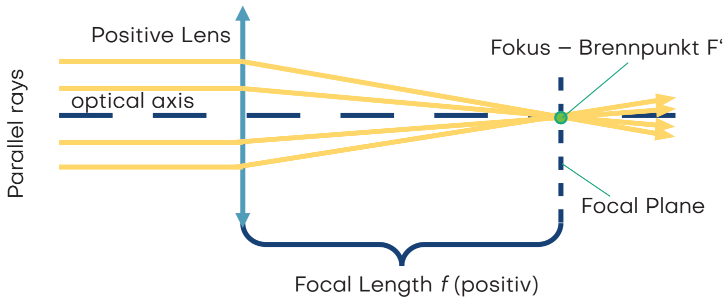
Different lenses have different capabilities. What difference do you observe between the different lenses?

Lenses

In ray optics, light is represented as a bundle of rays (arrows), which entails a simplification of the physical properties of light. A beam has a direction and is therefore drawn with an arrow. A lens „refracts“ the beam and thus changes its direction.

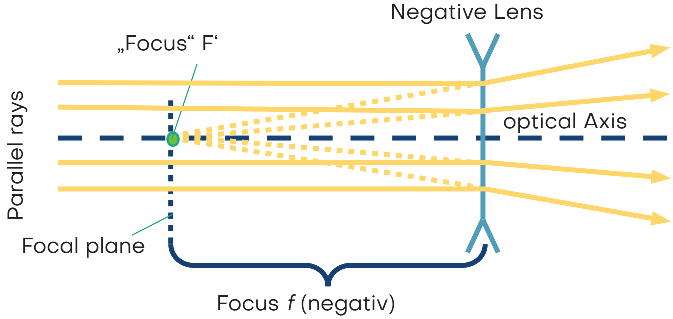
Positive Lens

In the „real“ world | On Paper



Negative Lens

In the „real“ world | On Paper



Collective lenses refract the light rays that run parallel to the optical axis at a point called the focal point.

Diverging lenses refract the light rays that run parallel to the optical axis as if they were originating from a point called the „virtual“ focal point.

The focal length of a lens here corresponds to the distance from the lens to the focal plane on which the focal point lies. It is given in millimetres (f = mm).

Lenses „refract“ the light rays

You will find the focal length of the lens as a printed number on the lens holders. The CoreBOX contains one 100 mm converging lens, two 50 mm converging lenses and one -50 mm diverging lens. The numbers indicate the focal length.

The converging lens is also called a positive or convex lens. The middle part of the lens is always thicker than the edge.

The image can be magnified with the converging lens. The magnification is different for the 50 mm lens and the 100 mm lens. The image can be upright or inverted.

The diverging lens (negative lens) is sometimes also called a negative or concave lens. The middle part of the lens is always thinner than the edge.

With the diverging lens (f = - 50 mm) the image is always reduced and always upright.

We assume that our lenses are so-called „thin lenses“. This means that we can look at them as a plane and not worry about their thickness. This makes explanations and calculations much easier.

Have the answers raised any more questions? Then go on to find out how exactly the lenses work...

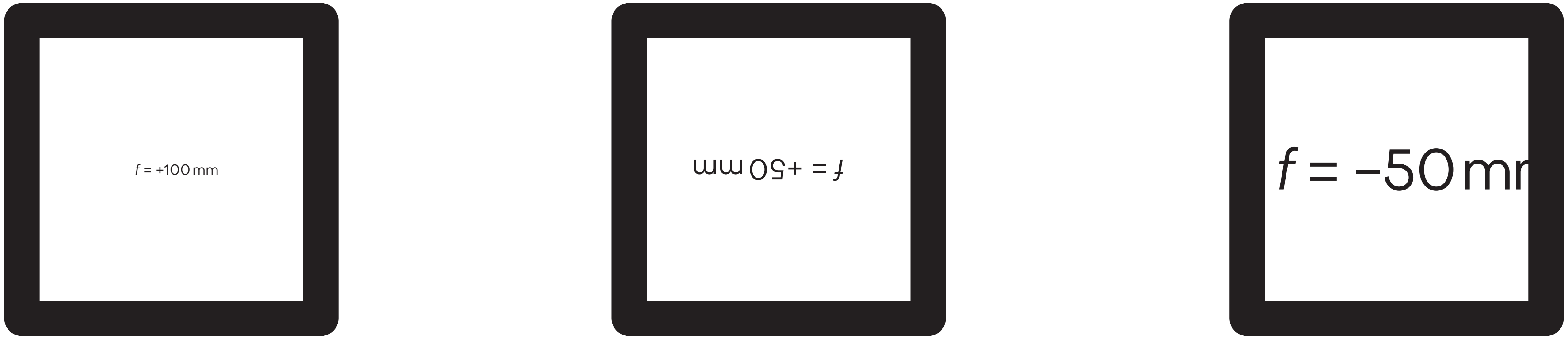
Imaging using a lens

Now take the lens cubes. Try to decipher the respective information about the focal length in the illustrated cubes with the matching lens. Move the lens over the writing until it is the same size as the text „UC2“ in the middle.

Can you see the text the same size and orientation as the „UC2“? What happens when you change the distance between the lens and the image?

What happens if you get a lens with the wrong focal length?

UC2



Imaging an object through a positive lens

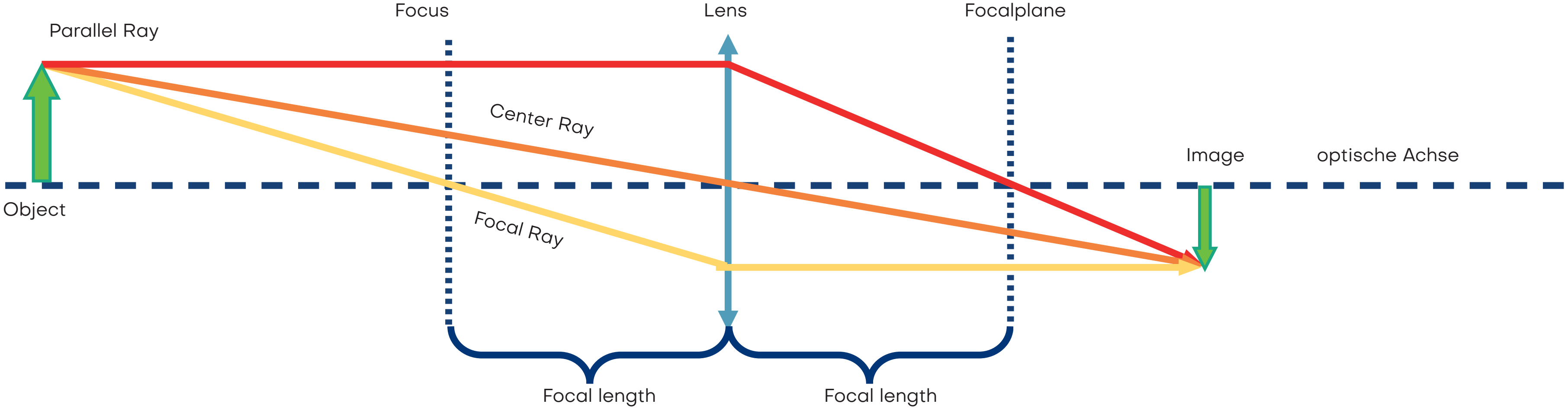
Let‘s take the converging lens as an example. We start with an object (green arrow) and see what happens to the rays that start from the top. There are infinitely many rays in all directions, but for drawing the figure the following three rays will suffice:

1. The center ray (orange) passes undisturbed through the center of the lens.

2. The focal beam (yellow) also starts from the tip of the arrow, but goes through the object-side focal point at focal length f. After the lens, it continues at the same height, but now parallel to the optical axis.

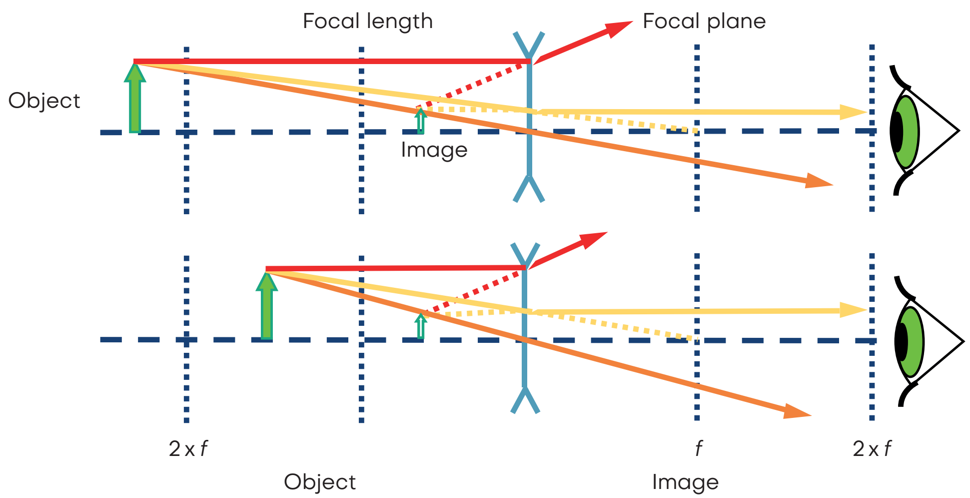
3. The parallel beam (red) initially runs parallel to the optical axis, but is then refracted at the lens in such a way that it runs through the focal point on the image side at focal length f.

The image is formed where all the rays intersect. The principle is the same for all points or the rays of an object emanating from them. Depending on which lens is used and depending on the position of the object, the properties of the image change, such as size, orientation and position.



Imaging an object through a negative lens

In the case of the negative lens, we use the same method to image the ray path. Unlike the case of the converging lens, the image is always reduced and virtual. Magnification depends on the position of the object in front of the lens. Unlike the converging lens, the image is created on the object side and is therefore called a virtual image. You can see it directly with your eyes but not project it onto a screen.



The way a lens creates an image is predictable by kno-wing the focal length of that lens. Therefore, a certain distance must be maintained so that you can see the writing with the specified lens on the previous sheet.

With the diverging lens (f = -50 mm) you always see a reduced virtual image. A virtual image can only be viewed with the eye. So far we have only seen virtual images.

The magnification and the location where the image is formed depend on the focal length of the lens and the distance between the lens and the object.

The Positive lens as a magnifying glass

Take the UC2 lens cube with focal length f = 50 mm and use it as a magnifying glass.

The magnifying glass..

... is a simple converging lens with a small focal length.

Put the lens cube on the sheet and move the lens to a height

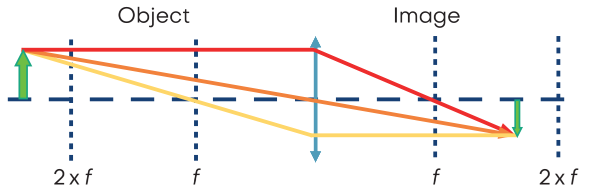
until you can read the text written here.

The magnifying glass is the simplest optical device!

Can you read the small letters through the converging lens? What is written there?

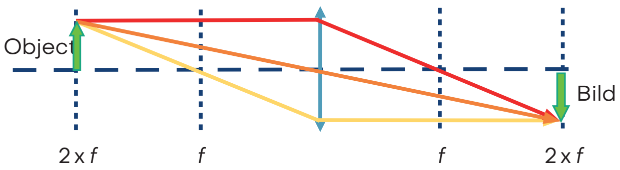
The Positive Lens

The magnification and position of the object depend on the converging lenses.



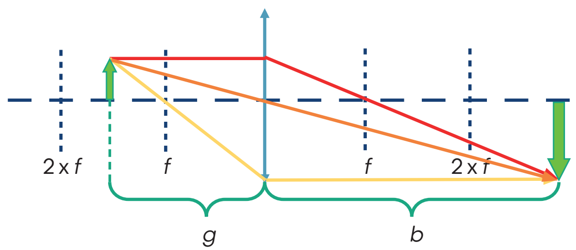
If the distance between the object and the lens is more than twice the focal length of the lens, then the image is...

- **the opposite**
- **swapped sides**
- **scaled down**
- **real**



If the distance between the object and the lens is exactly twice the focal length of the lens, then the image is...

- **the opposite**
- **swapped sides**
- **same size**
- **real**



If the distance between the object and the lens is more than the focal length and less than twice the focal length of the lens, then the image is...

- **the opposite**
- **swapped sides**
- **enlarged**
- **real**

Image width (b)

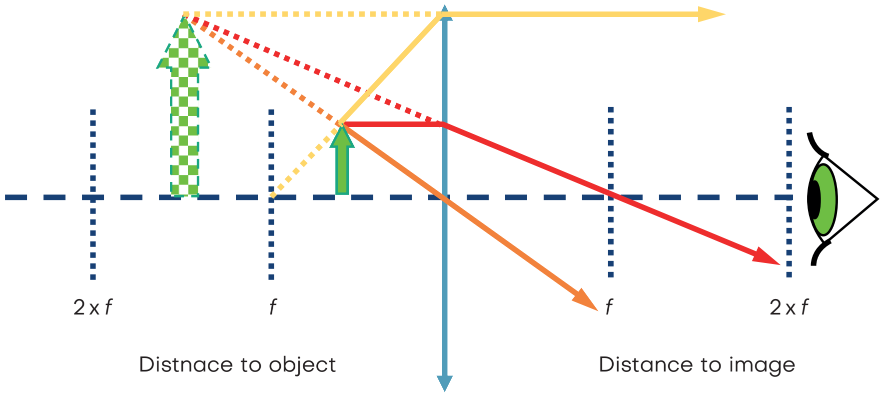
The distance between the lens plane and the image formed by the lens is de-noted as b.

Object distance (g)

The distance between the object and the lens plane is called g.

The converging lens can produce a real image. The real image can then be seen on a screen.

Why the positive lens magnifies



Lupeneffekt

If the distance between the object and the lens is less than the focal length of the lens, then the image is...

- **upright**
- **right orientation**
- **magnified**
- **virtual**

Calculate the mangification of a lens using the following lens:

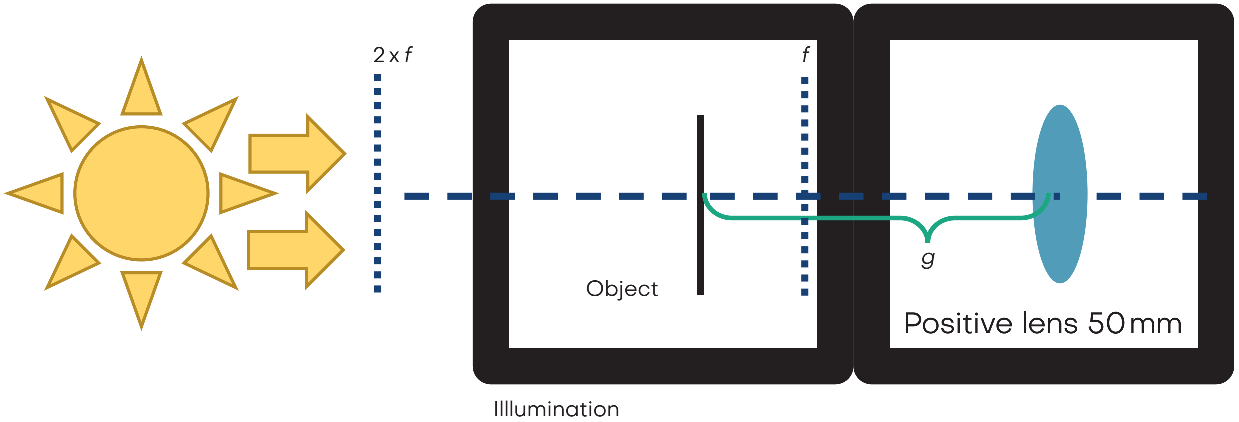
$$V = \frac{250\ \text{mm}}{f}$$

250 mm is the distance of clear visual range – i.e. the distance between the object and the eye at which most people can read well. More on this later in the “accommodation” of the eye.

The magnifying glass is the simplest of all optical devices, because it consists only of a simple converging lens with a suitable focal length. Why does the cube with the 50 mm enlarge the small text? If the object is in front of the focal length of the lens – i.e. less than 50 mm in front of the lens – the lens creates a virtual image which is behind the actual object. The eye perceives it enlarged. Check out the diagram above.

How does a movie projector work?

Take the UC2 lens cube with a focal length of f = 50 mm and place it behind the sample holder cube. The distance between the object and the lens (i.e. the object distance g) should be approx. 60 mm. If you now illuminate the object with the flashlight, you will see it sharply at a distance of approx. 300 mm on the wall. A cinema projector has a film strip instead of the object and of course a much stronger light source.

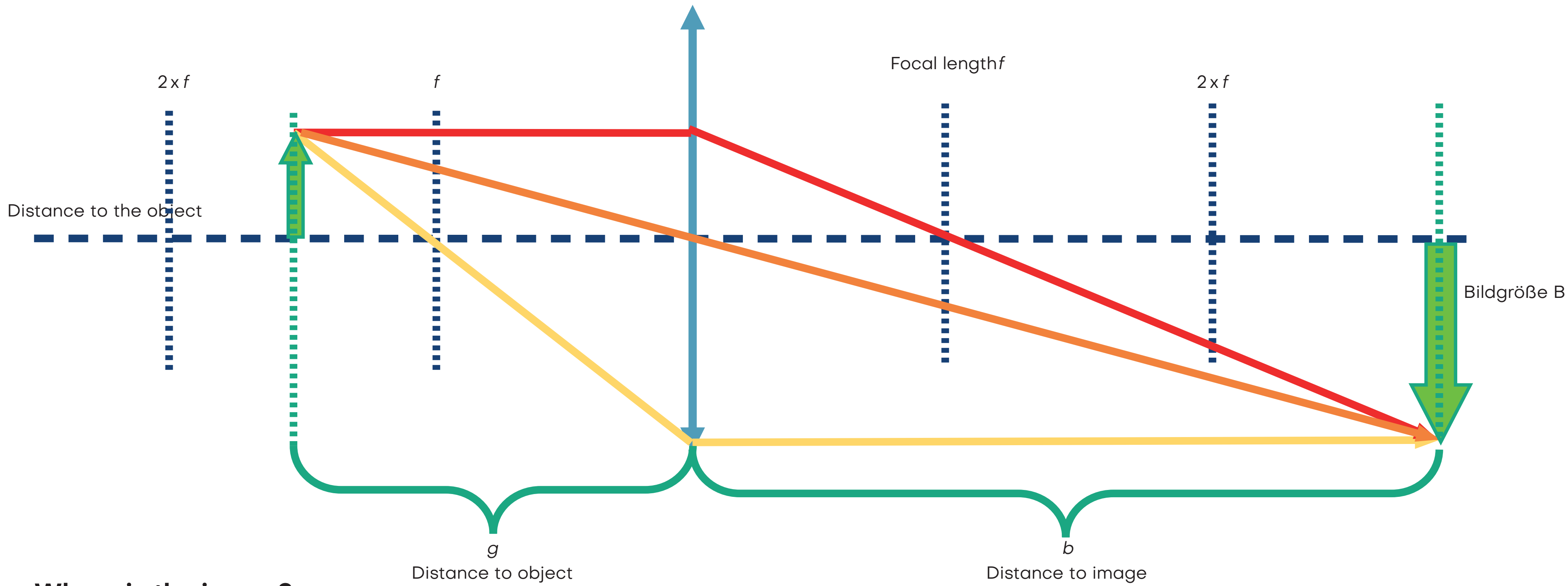


Use a flashlight (e.g. from your mobile phone) as a light source and hold it in front of the object.

How is the image oriented?

Slide the lens back and forth in the cube and see when the image is in focus. Find the image for g = 60 mm, 65 mm, 70 mm and measure the distance between the lens and the image.

How does a movie projector work?



Where is the iamge?

When an object is imaged through a converging lens, the position and size of the image depend on the distance (g) of the object to the lens and its focal length (f).

The lens equation describes the relationship between image distance (b) and object distance (g): $$\frac{1}{f} = \frac{1}{g} + \frac{1}{b}$$

How big is the image?

The magnification of the object on the screen can easily be calculated using the following formula: $$V = \frac{b}{g} = \frac{B}{G}$$

How does a movie projector work?

Check whether your observation agrees with the calculation.

$$\frac{1}{f} = \frac{1}{g} + \frac{1}{b}$$

Calculate the magnification of the projector for the different values g and b.

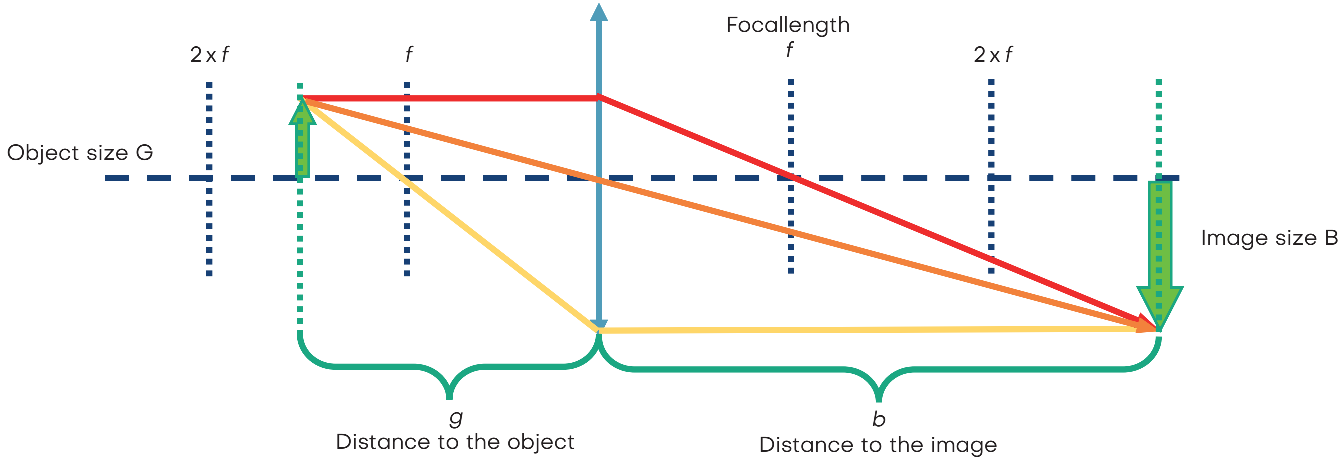
$$V = \frac{b}{g} = \frac{B}{G}$$

Our lens has a focal length of f = 50 mm.

for g = 60 mm => b = 300 mm

for g = 65 mm => b = 217 mm

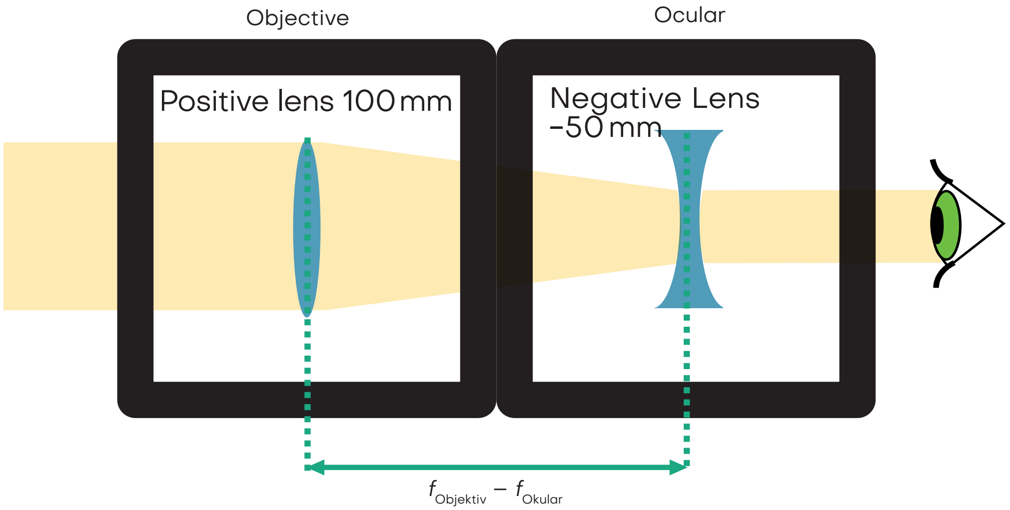
for g = 70 mm => b = 175 mm



The projector always produces an enlarged, inverted (reversed) image. The position of the image and its magnification depend on the position and size of the object.

This is a Galileo telescope

Place the lens cubes on the sheet as shown in the diagram and then use the telescope to look into the distance.

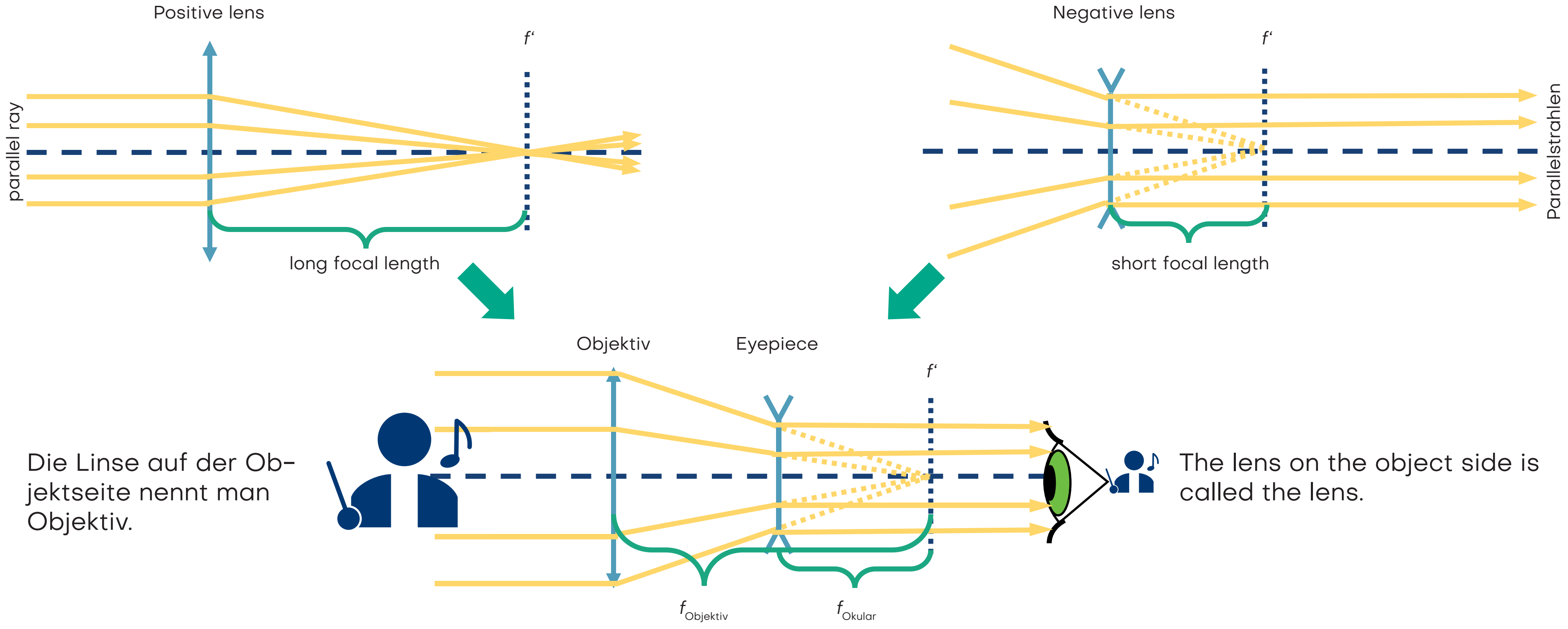


What does the picture look like?
How is the image oriented?

As you look through the telescope, adjust the distances between the components to see a sharp image!x

How does the Galileo telescope work?

A telescope is an optical instrument that makes distant objects appear many times closer or larger.

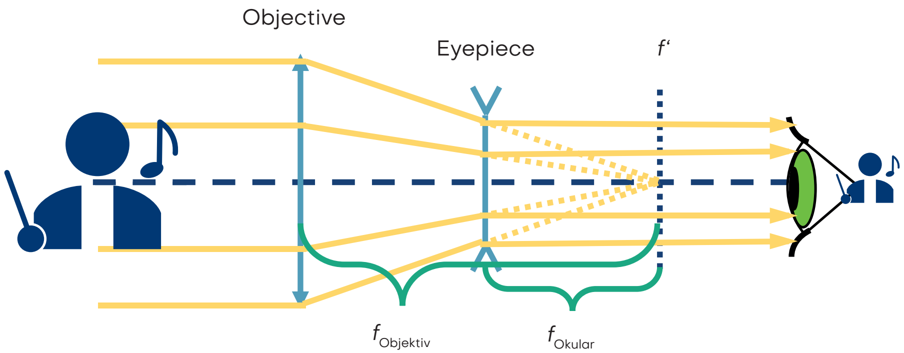


Die Linse auf der Objektseite nennt man Objektiv.

The lens on the object side is called the lens.

The Galileo telescope is also used in opera glasses.

How does the Galileo telescope work?



What is the magnification of this Galileo telescope?
Formula for calculating magnification

$$V = \frac{-f_{Objektiv}}{f_{Okular}}$$

Field of view designates the area in the field of view of an optical device within which objects can be recorded.

It is not possible to achieve very high magnification with this telescope. But it is very compact.

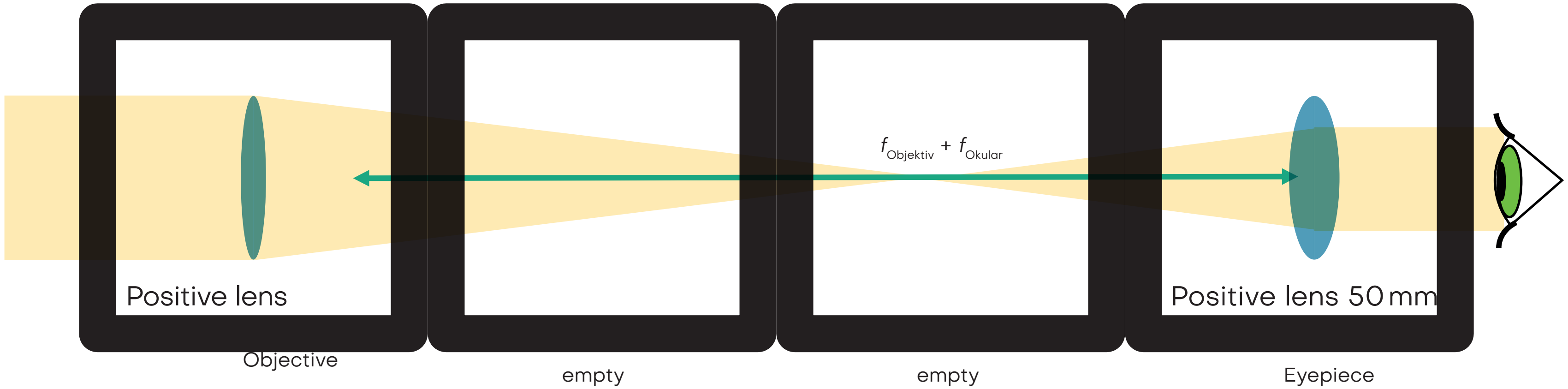
The image is always

- magnified with the magnification from the formula above
- upright
- true to side

The field of view is small.

What is the Kepler-Telescope?

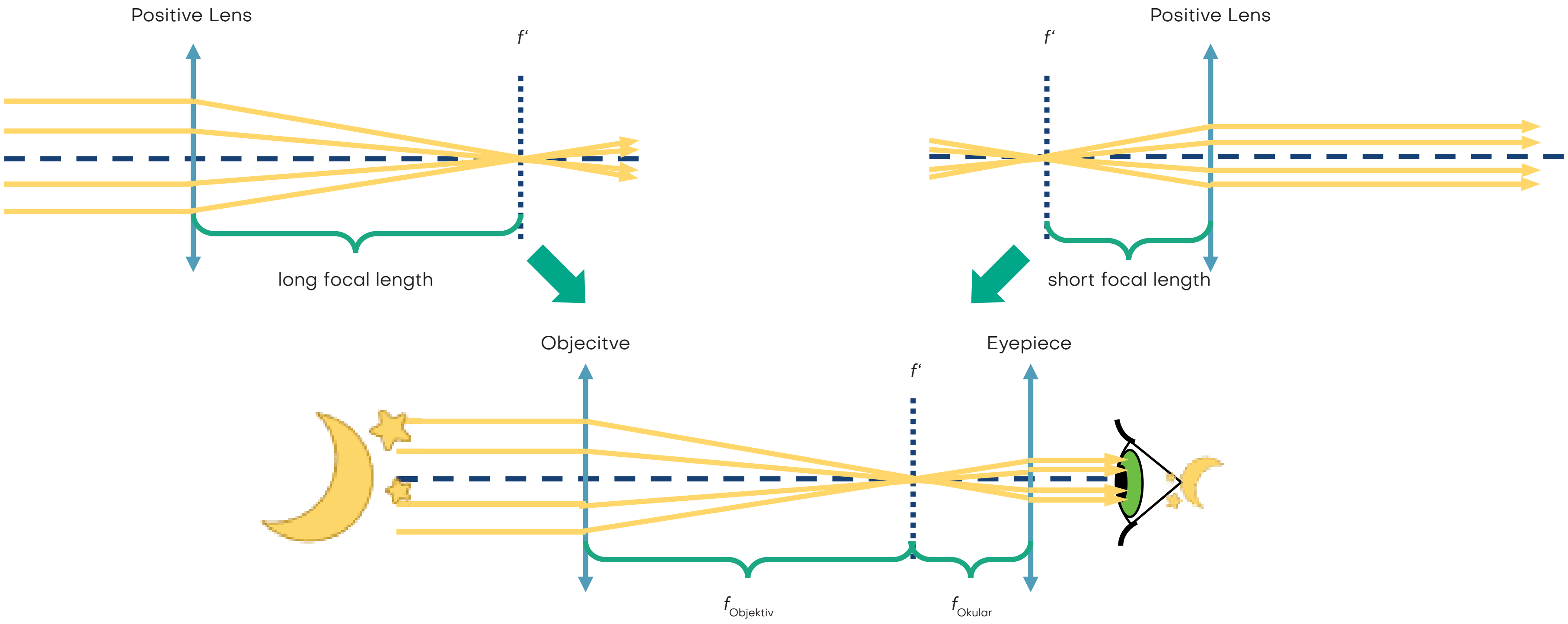
put the lenses in the right position as shown in the diagram. Then look through the telescope into the distance.



What does the picture look like?
How is the image oriented?

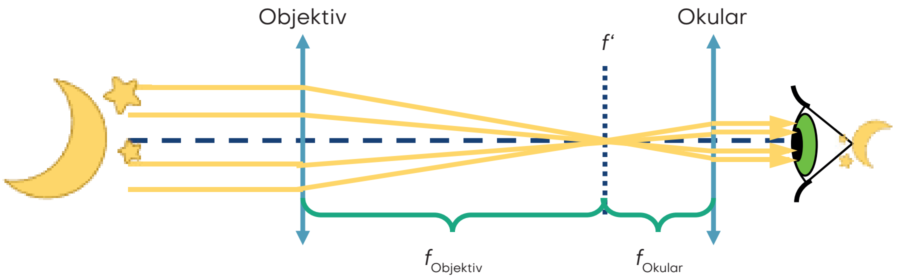
As you look through the telescope, adjust the distances between the components to see a sharp image!

How does the Kepler-Telescope work?



This type of telescope is often used in astronomy.

This is how the Kepler telescope works



What is the magnification of this Kepler telescope?
Formula for calculating magnification

$$V = \frac{f_{Objektiv}}{f_{Okular}}$$

This telescope can achieve a higher magnification than the Galilean telescope. But it creates the opposite picture. However, this is not a problem for observing the stars.

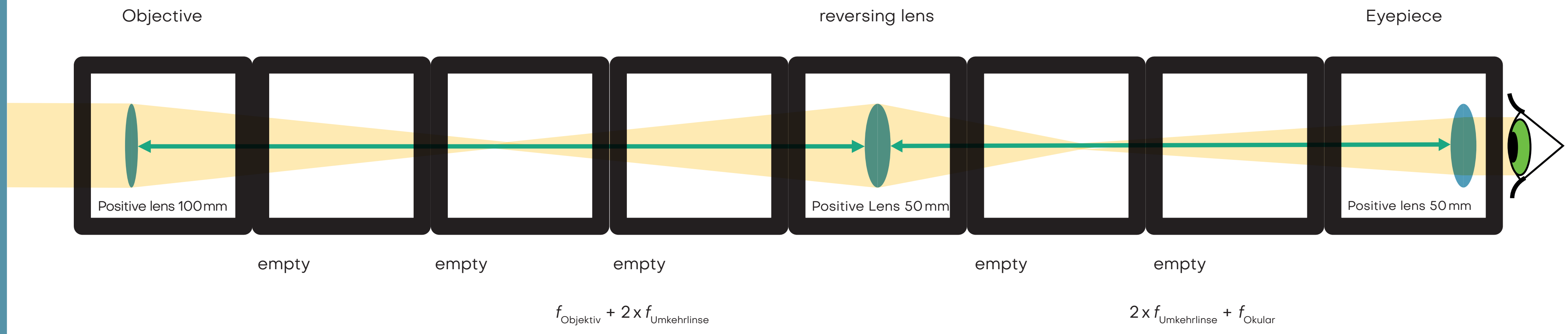
The picture is always

- magnified with the magnification from the formula above
- the opposite
- swapped sides

The field of view is larger than that of the Galileo telescope.

This is a spotting scope

The spotting scope is long, so the scheme here is not as big as in reality. Set the lenses in the correct position as shown here and look into the distance through the telescope.

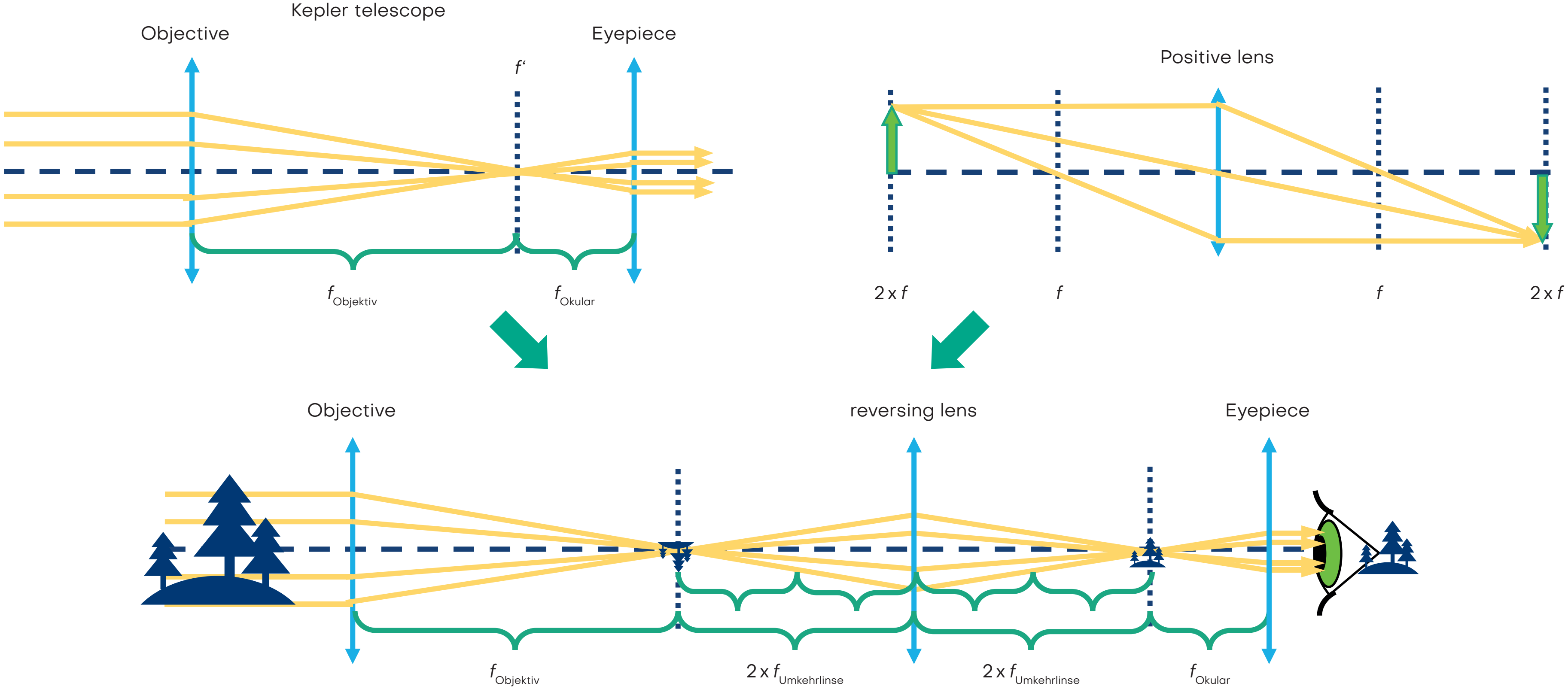


How does the image here compare to the Kepler telescope?

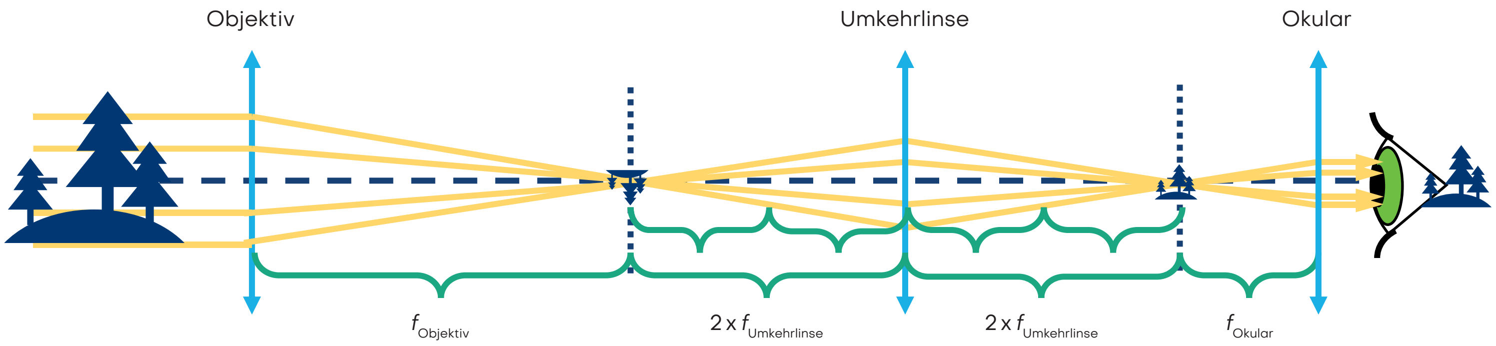
As you look through the telescope, adjust the distances between the components to see a sharp image!

This is how the spotting scope works

This is the simplest spotting scope. The image is inverted compared to the Kepler telescope because that is better for terrestrial observation. Once you understand the concept of the Keppler telescope and converging lens imaging, you can easily combine them as shown here:



This is how the spotting scope works



The magnification is the same as that of the Kepler telescope. The erecting lens only changes the orientation (the image is reversed), not the magnification.

$$V = \frac{f_{Objektiv}}{f_{Okular}}$$

An upright image is necessary for terrestrial observations. True terrestrial telescopes use prism systems to rotate the image and keep it compact.

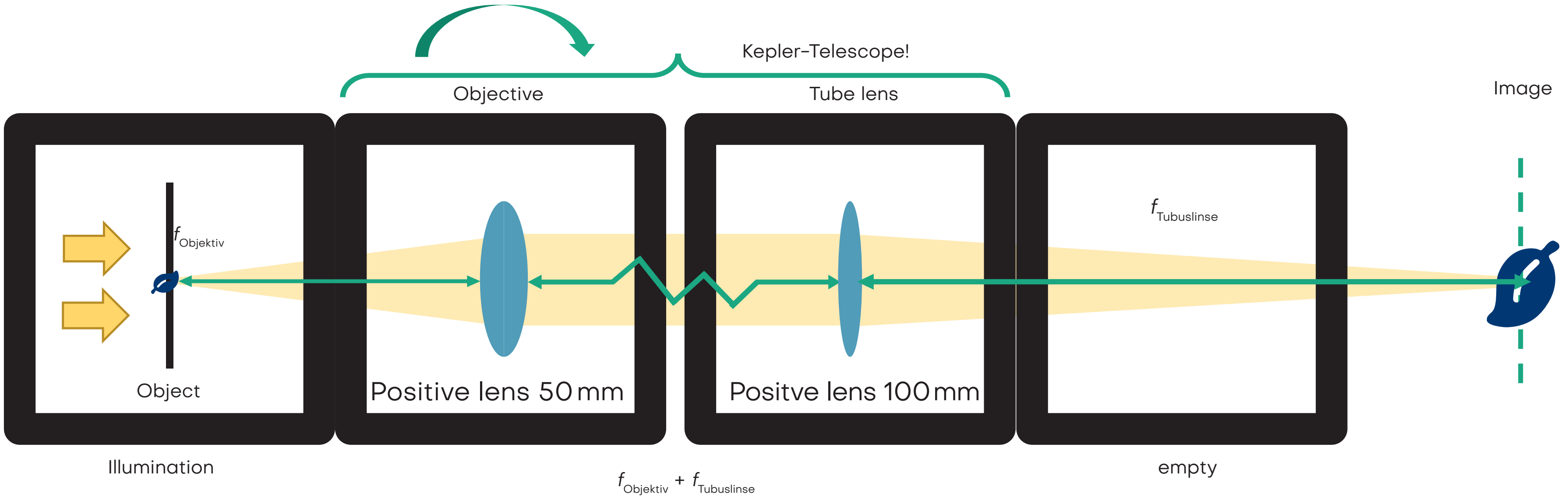
The picture is

- enlarged with the same magnification as with the Keppler telescope
- upright
- true to side

Light microscope with „infinity optics“

Place the object about 50mm in front of the lens and find the image about 100mm behind the tube lens (using a paper or the wall as a screen) as shown in the diagram. Move the lenses to get a sharp image.

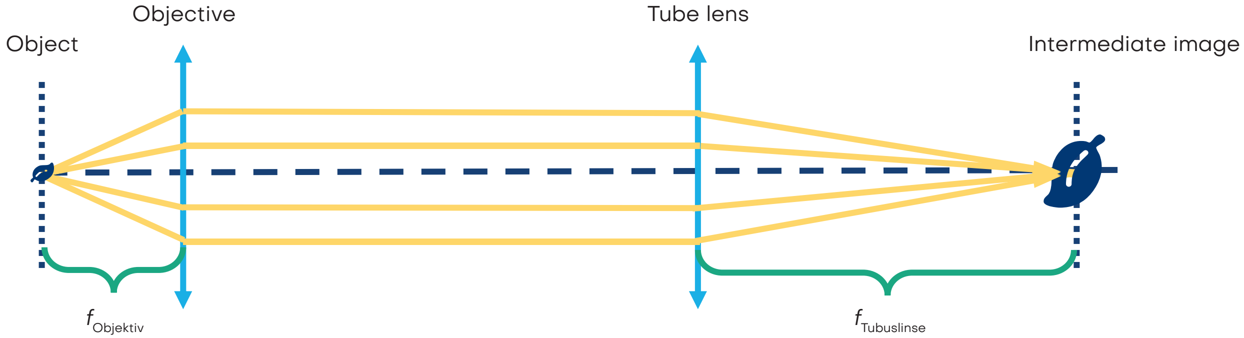
What happens if you turn the Kepler telescope upside down?



Place the object with the lens together as one unit on the paper. Set up the tube lens at a distance of 100 mm from your screen. Change the distance between the lenses – does the image change?

What means „infinity optics“?

A microscope is a device that allows objects to be viewed or imaged at high magnification.



The image is called an intermediate image because it is often further enlarged with an eyepiece.

The object is approximately in the object-side focal plane of the lens. Thus, all incident rays are converted into a parallel bundle of rays behind the lens. The lens has a short focal length.

The tube lens creates a real image by collecting parallel rays that strike the tube lens in its focal plane. If we place them behind the lens, the object will be imaged from the focal plane of the lens. The tube lens has a longer focal length than the objective.

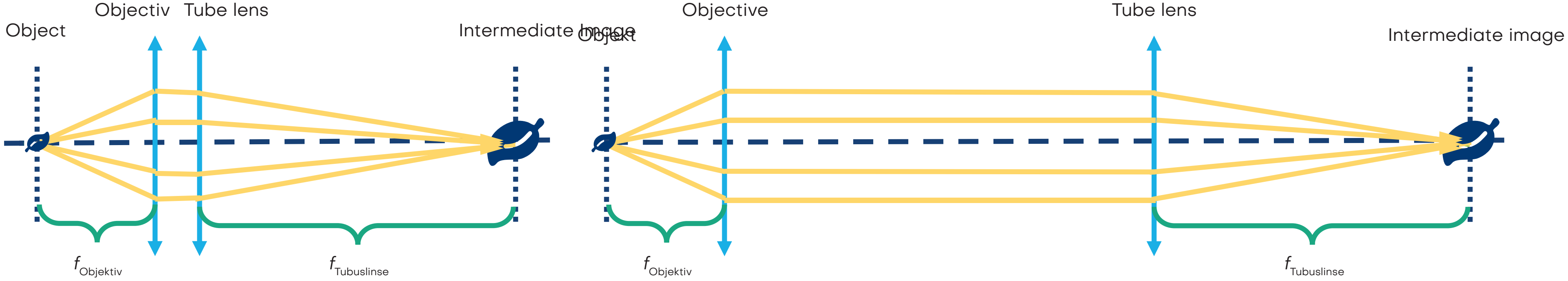
The image in the plane of the intermediate image is reversed, flipped, enlarged and real. The real image can be seen on a screen.

What means „infinity optics“?

A microscope is a device that allows objects to be viewed or imaged at high magnification.

What is the magnification of the image?

Magnification $V = \frac{f_{Tubuslinse}}{f_{Objektiv}}$



The lenses of the Kepler telescope can also be used for a microscope, but in a different order. As long as the object is in the focal plane of the lens and the screen is in the focal plane of the tube lens, the distance between the lens and the tube lens doesn‘t matter because the light rays are parallel.

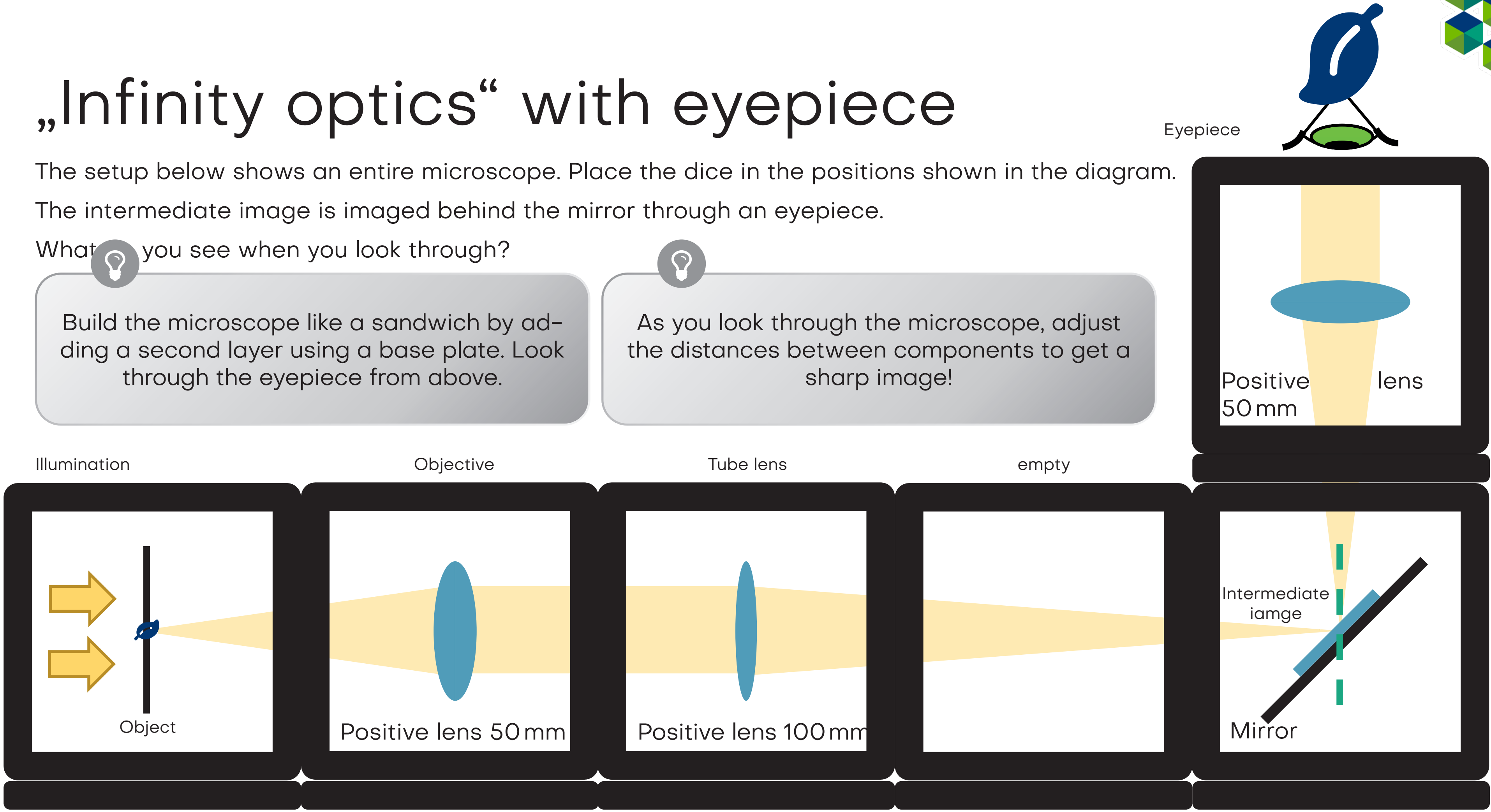
„Infinity optics“ with eyepiece

The setup below shows an entire microscope. Place the dice in the positions shown in the diagram. The intermediate image is imaged behind the mirror through an eyepiece.

What do you see when you look through?

Build the microscope like a sandwich by adding a second layer using a base plate. Look through the eyepiece from above.

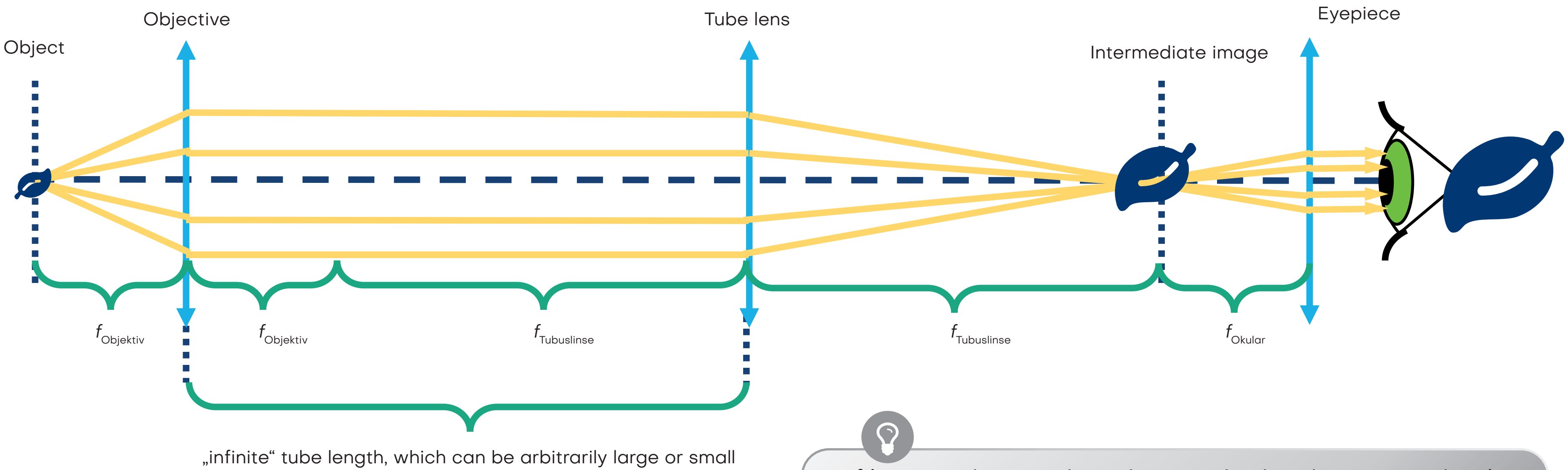
As you look through the microscope, adjust the distances between components to get a sharp image!



Can you see the microscopic image through the eyepiece lens with your eyes? What effect does the mirror have? Set up the microscope without the mirror. Make sure you still have two empty spaces between the tube lens and the eyepiece.

The eyepiece is used for...

Newer microscopes are equipped with so-called „infinity optics". In this case, the lens does not produce a real intermediate image. The light exits the lens as infinite parallel rays. At the end of the „infinite" tube is a tube lens. This creates an intermediate image, which is then enlarged again through the eyepiece.



A filter can be used to change the brightness and color of the image.

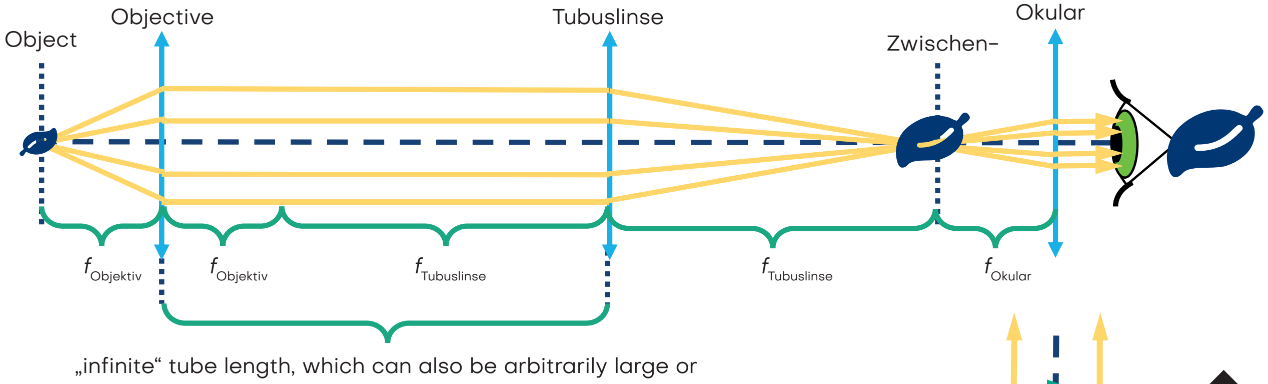
The image behind the eyepiece is reversed, reversed, enlarged and virtual. The virtual image can be seen with the eye.

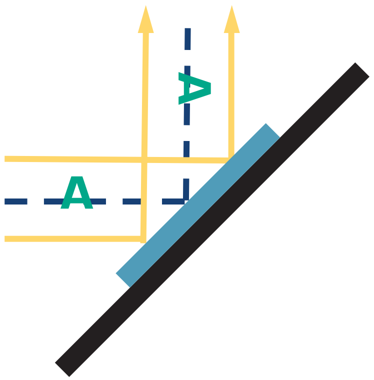
This configuration is very useful in modern microscopes as it allows additional components such as filters to be placed between the objective and tube lens without affecting the optical path.

The eyepiece is used for...

Newer microscopes are equipped with so-called „infinity optics“. In this case, the lens does not produce a real intermediate image. The light exits the lens as infinite parallel rays. At the end of the „infinite“ tube is a tube lens. This creates an intermediate image, which is then enlarged again through the eyepiece.

What is the magnification after the eyepiece?





Overall magnification

$$V = \frac{f_{Tubuslinse}}{f_{Objektiv}} \times \frac{250\ mm}{f_{Okular}}$$

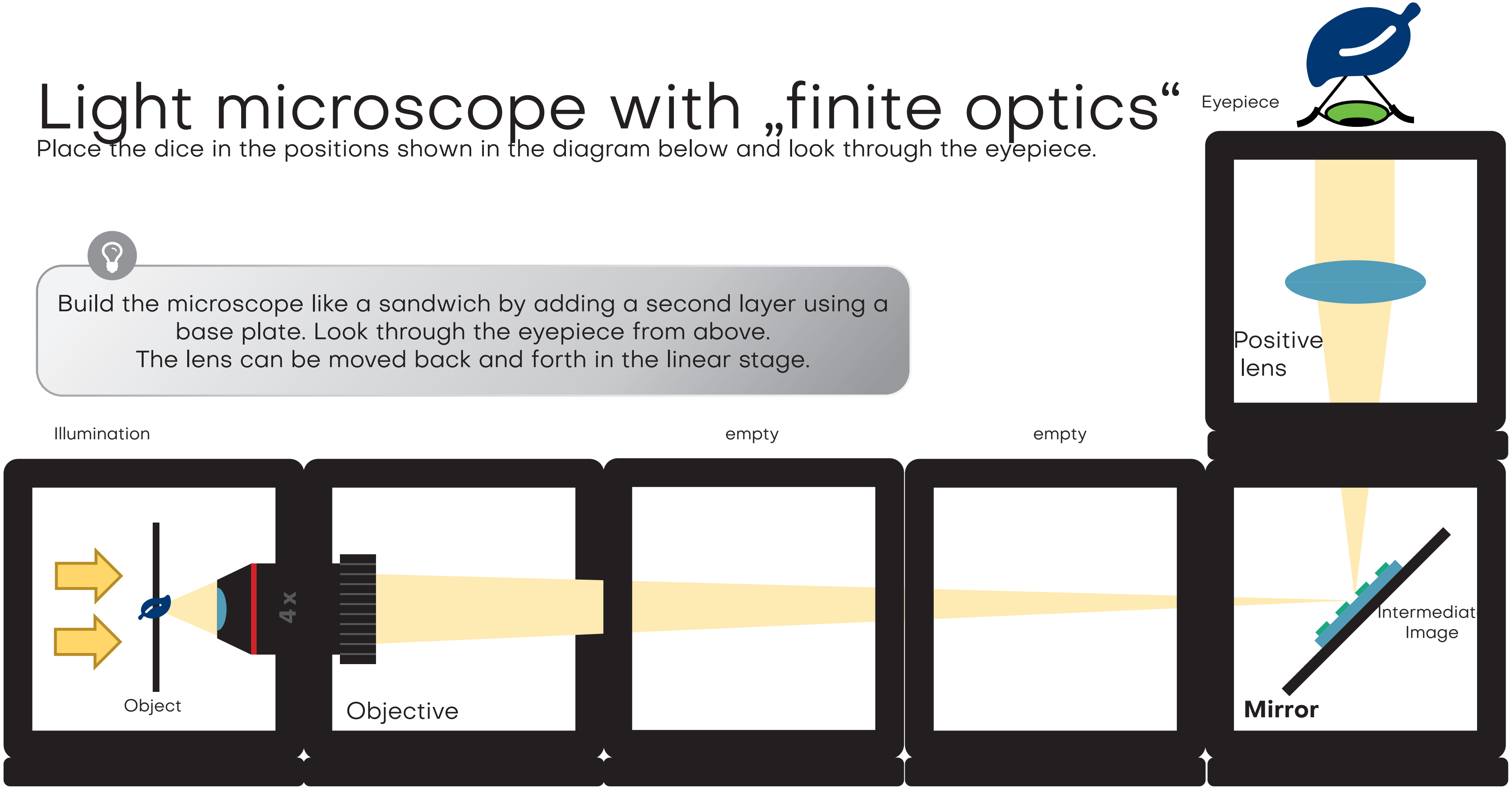
An eyepiece is actually just a lens that enlarges the intermediate image. It maps the virtual image in such a way that you can see it with your eyes.

With the mirror you can not only see yourself, but also reflect the incoming light in any direction. So you can fold the optical path and make it more comfortable to work with. The mirror doesn‘t affect the magnification, but it does rotate the image in one direction.

Light microscope with „finite optics“

Place the dice in the positions shown in the diagram below and look through the eyepiece.

Build the microscope like a sandwich by adding a second layer using a base plate. Look through the eyepiece from above.
The lens can be moved back and forth in the linear stage.

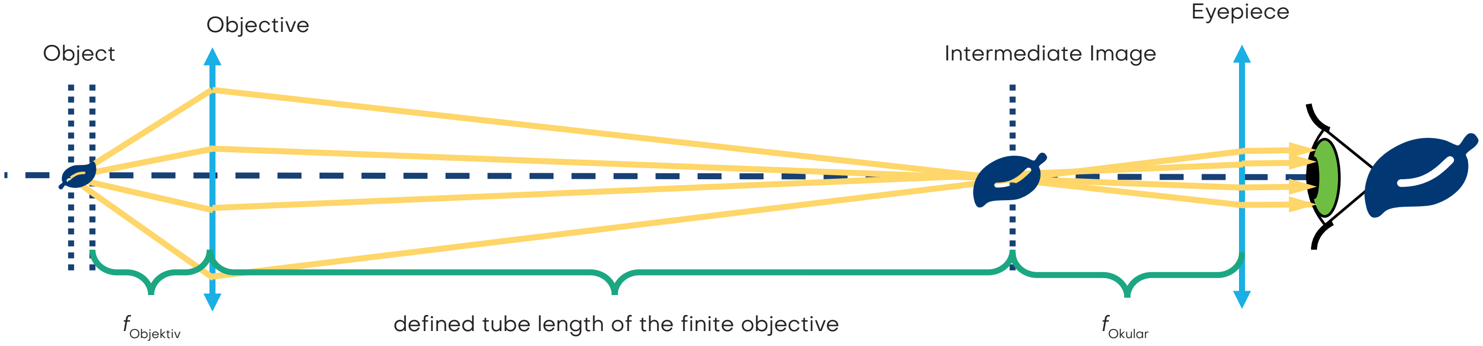


Do you see the image through the eyepiece as before? Can you find the real intermediate image with a sheet of paper?

Turn the small gear on the lens holder. This is how you move or focus the lens. If you can‘t go any further, you can also move the lens in the holder.

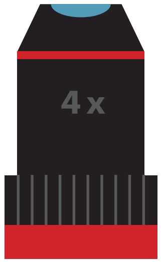
„Finite optics“ versus „Infinite optics“

The lenses of older or smaller microscopes are often so-called finite lenses. They behave like a lens with an extremely short focal length and create an intermediate image behind the lens with an image distance that is defined by the tube length. The tube length is printed and corresponds to 160 mm for our lens. The real intermediate image is created there and is enlarged by the eyepiece optics.



Microscopes have the ability to focus or sharpen the object either by moving the object or the lens.

Here we simply move the lens holder by hand. We adjust the distances between the components to see a sharp image.



„Finite optics“ versus „Infinite optics“

What is the magnification of the intermediate image? And what is the magnification after the eyepiece?

lens magnification

$$V = 4$$

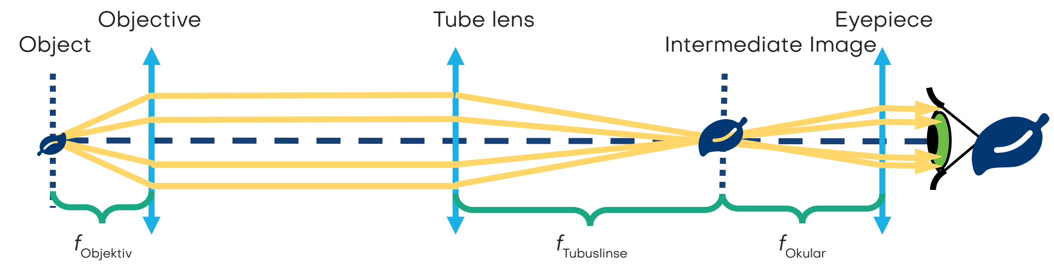
as written on it

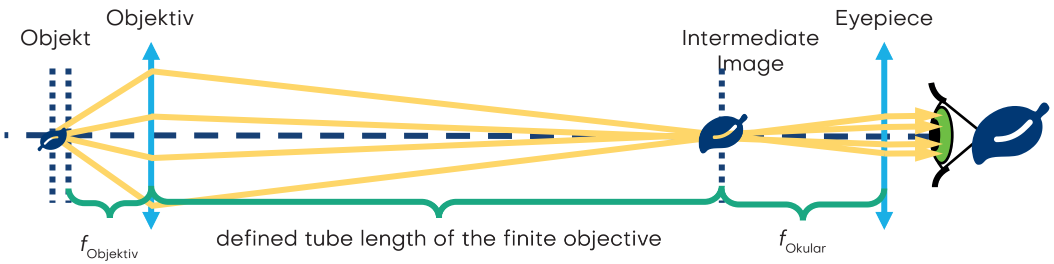
eyepiece magnification

$$V = \frac{250\ mm}{f_{Okular}}$$

overall magnification

$$V = V_{Objektiv} \times V_{Okular}$$





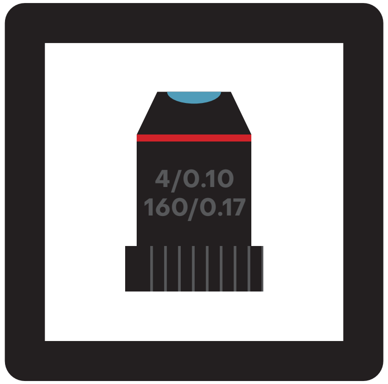
The image is larger than with the infinity microscope. The magnification of the lens here is 4x. If you calculated the magnification with the previous microscope, this certainly doesn‘t surprise you.

The intermediate image is now only formed by the lens and is 160 mm behind it. We‘ll find out why in the next step.

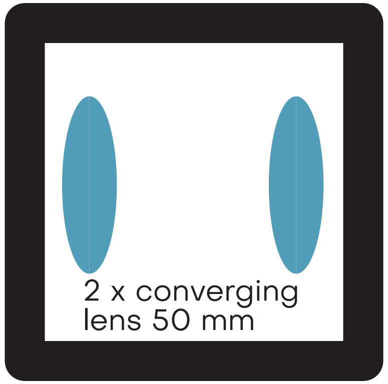
Objective and eyepiece

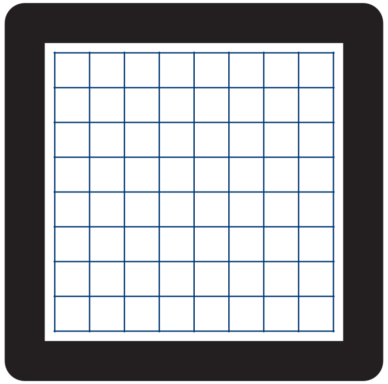
Look at the lens! What‘s in there? what is written on it

Open the cubes with the 50mm lenses. Now place both 50mm lenses in a cube so that the „bellies“ of the len-ses are pointing at each other.



Das Objektiv ist auch eine Sammellinse mit kurze Brennweite.





Look through the 50mm lens and then look through the lens at the small text.

Which of the lenses magnifies more? what stands written there?

Look through the single 50mm lens and then through the dual lens at the grid.

How does the magnification and field of view change?

This is the objective lens

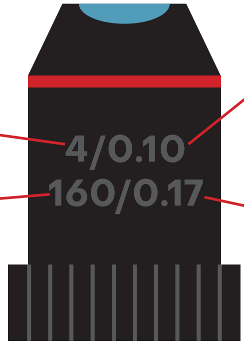
Ein Objektiv ist ein optisches System, das eine vergrößerte Abbildung eines Gegenstands erzeugt. Die verschiedenen auf dem Objektiv abgedruckten Zahlen haben verschiedene Bedeutungen:

Magnification:

Common magnifications are 4x, 10x, 40x, 100x.

Tube length:

∞ stands for infinity, 160 stands for 160 mm and is the most commonly used tube length according to DIN

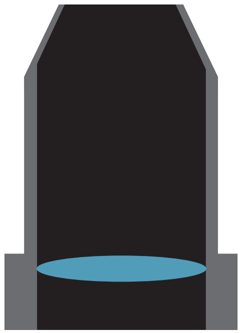


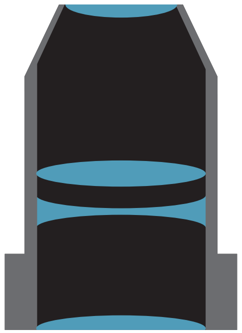
Numerical Aperture:

It determines the ability to collect light and thus the optical resolution.

Coverslip correction :

A coverslip is sometimes used to seal the sample. A lens must be corrected for this thickness (0.17 mm).





The 4x objective has only one lens in it. The higher magnification lenses are complete lens systems.

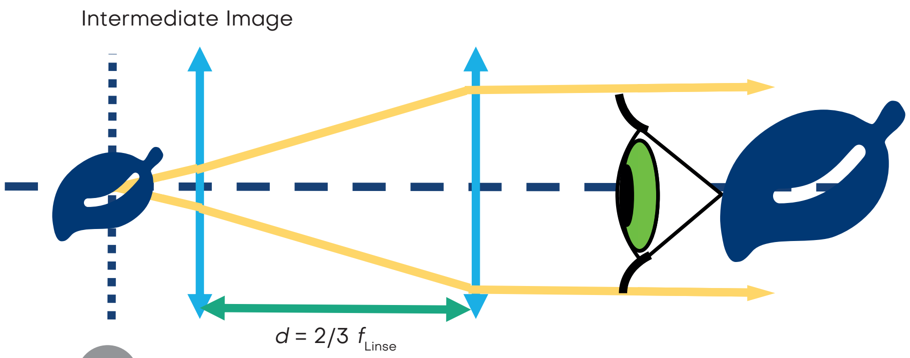
The lens is also a converging lens with a short focal length. The 4 x lens has a focal length of f = 32 mm. When used as a magnifying glass, it has a higher magnification than the 50mm lens. The field of view is sharp but small.

This is the eyepiece

An eyepiece is actually a magnifying glass because it enlarges the intermediate image. The eyepiece we use here is a so-called Ramsden eyepiece.

A single lens can also be used as an eyepiece. However, with the Ramsden eyepiece, which consists of a lens system, the field of view is better because it produces fewer errors at the edge of the field of view. The Ramsden eyepiece consists of two lenses with the same focal length. Its focal length is $f_{Ramsden\text{-}Okular} = 3/4\ f_{Linse}$

What is the magnification of the Ramsden eyepiece? $V = \dfrac{250\ mm}{\frac{3}{4} f_{Linse}}$



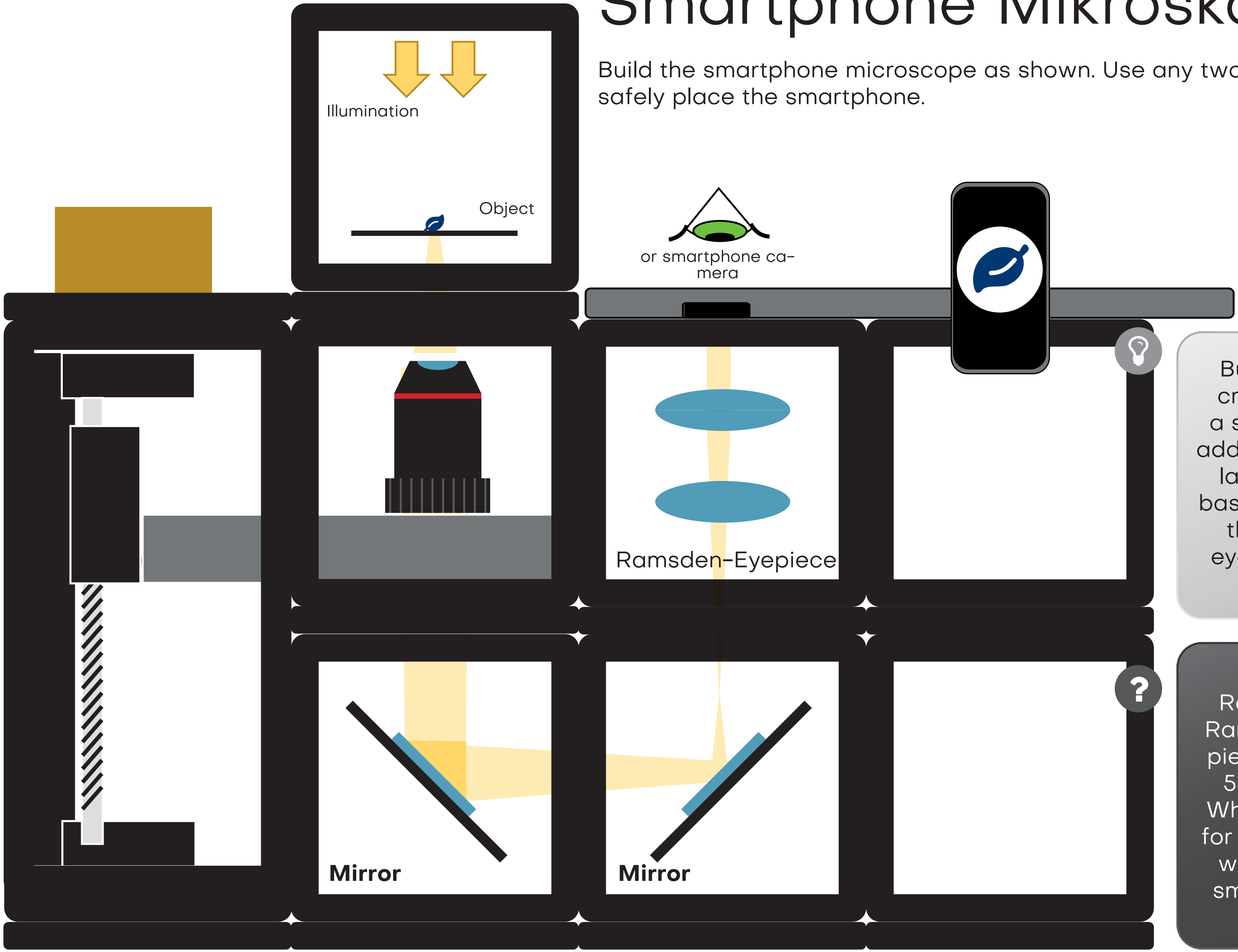
Each eyepiece has a so-called Ramsden disk, which is the smallest diameter of the light beam that exits the microscope through the eyepiece.

The image scale is higher at short object distances than with a single 50 mm lens.

The field of view is larger and the image looks clearer with the Ramsden eyepiece.

Smartphone Mikroskop

Build the smartphone microscope as shown. Use any two cubes to safely place the smartphone.



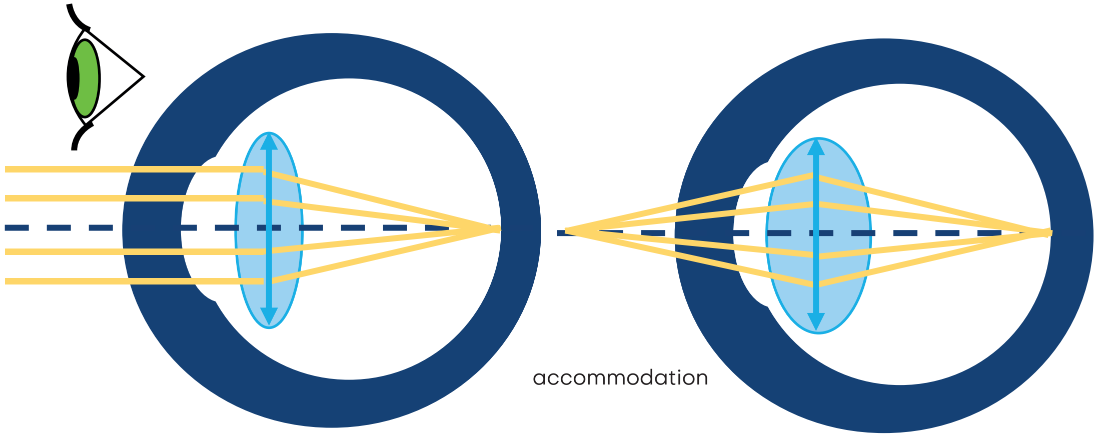
Build the mi-croscope like a sandwich by adding a second layer using a base plate. Look through the eyepiece from above.

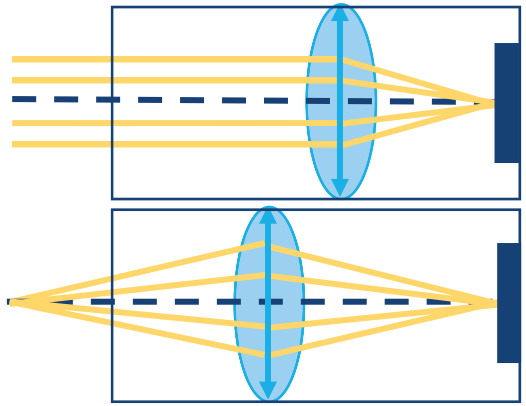
Replace the Ramsden eye-piece with the 50mm lens. What is better for the eye and what for the smartphone?

Better with smartphone or eye?

The smartphone camera has a lens with a very short focal length because it has to fit into the thin smartphone. The lens then creates an image on the camera sensor whose properties are similar to the human eye.

The eye can depict objects both from a distance and from close up. This property is called accommodation. The smartphone camera can also do this, but it is called autofocus. It describes the ability to move objects into different distances sharply on the sensor.

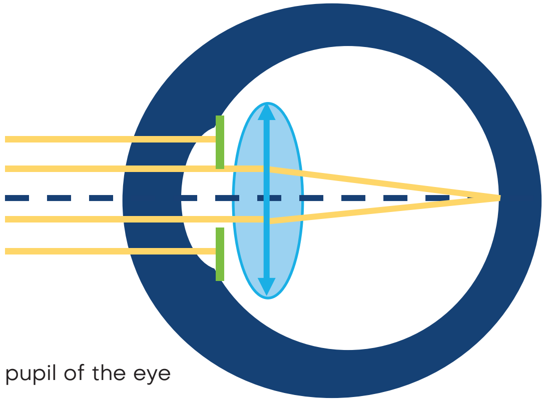




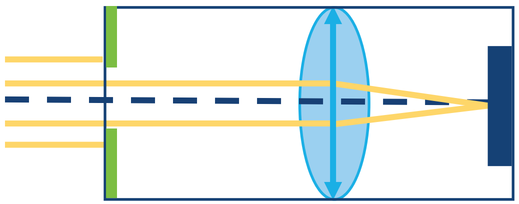
The image from the eyepiece comes in parallel rays, as if coming from infinity. It was observed with a relaxed eye (looking into the distance) or with a camera focused at infinity.

Better with smartphone or eye?

In order to be able to see the image of the microscope, the pupil – i.e. the „aperture“ that limits the incidence of light – must match the Ramsden disc of the eyepiece. The pupil of the eye is fixed inside and cannot be brought closer to the eyepiece. The pupil of the smartphone camera, on the other hand, is very close to the surface of the cell phone. Because of this difference, you need a different distance to the eyepiece for the eye and the camera.



pupil of the eye



pupil of the camera

What is the magnification of this microscope?
Formula for calculating magnification

$$V = V_{Objektiv} \times V_{Ramsden-Okular}$$

With the Ramsden eyepiece, the Ramsden disc is closer to the cube and has a smaller diameter, which works well for the smartphone camera.

The Ramsden disk of the single 50mm lens has a larger diameter, making it more convenient for observing the sample with the eye. Through the eyepiece it looks as if the image is on the mirror underneath. The 50mm lenses have a large diameter, so when using a single lens as an eyepiece, the field of view is limited by the size of the mirrors.

Calculation results

Lupe

$$V_L = \frac{250\ \text{mm}}{50\ \text{mm}} = 5$$

Projektor

$$V_1 = \frac{300\ \text{mm}}{60\ \text{mm}} = 5$$

$$V_2 = \frac{217\ \text{mm}}{65\ \text{mm}} = 3{,}33$$

$$V_3 = \frac{175\ \text{mm}}{70\ \text{mm}} = 2{,}5$$

Galilei-Fernrohr

$$V_{GF} = \frac{100\ \text{mm}}{50\ \text{mm}} = 2$$

Kepler-Fernrohr

$$V_{KF} = \frac{100\ \text{mm}}{50\ \text{mm}} = 2$$

„Unendlich"-Mikroskop

$$V_{UM} = \frac{100\ \text{mm}}{50\ \text{mm}} = 2$$

„Unendlich"-Mikroskop mit Okular

$$V_{UMO} = \frac{100\ \text{mm}}{50\ \text{mm}} \cdot \frac{250\ \text{mm}}{50\ \text{mm}} = 10$$

„Endlich"-Mikroskop - Zwischenbild

$$V_{EMZ} = 4$$

„Endlich"-Mikroskop - Gesamtvergrößerung

$$V_{EMG} = 4 \cdot \frac{250\ \text{mm}}{50\ \text{mm}} = 20$$

Ramsden-Okular

$$V_{RO} = \frac{250\ \text{mm}}{\frac{3}{4} 50\ \text{mm}} = 6{,}66$$

Smartphone Mikroskop mit Ramsden-Okular

$$V_{SM} = 4 \cdot \frac{250\ \text{mm}}{\frac{3}{4} 50\ \text{mm}} = 26{,}66$$

Glossary

Beam of light
An arrow or line showing the direction of the light; Unless otherwise stated, the light in the schemes always comes from the left.

Lens
A transparent refractive body z. B. made of glass or plastic

Thin lens
A model of a lens that assumes it has no volume

Converging lens
A lens that converges (collects) the incoming light

Diverging lens
A lens that fans out the incoming light

Focus F (object focus), F‘ (image focus)
A point where light is focused (collecting lens) or from which it appears to diverge (diverting lens)

Focal length f
The distance between the focal point & the thin lens

Focal plane
A plane parallel to the thin lens that passes through the focal point

Optical axis
The basic framework for every optical sketch; it passes through the center of the lens and is perpendicular to the plane of the lens

virtual image
An image produced by a lens or optical system that can be viewed by a human eye through the system

real picture
An image produced by a lens or optical system that can be viewed on a screen behind the system

Magnification
A ratio of the image size and the object size (for a real image); a ratio of the observed image and the object size (for a virtual image)

Object
An object that we want to image with the lens; the size of the object is G

Distance g of the object
The distance between the object and the thin lens

Image
An image of the item; Size of the picture is B.

Distance (b) of the image
The distance between the image (real or virtual) and the thin lens

Object page
side in relation to the lens on which the object (item) is located; left in the schemes

Image side
side relative to the lens on which the real image is formed; The virtual image is on the same side as the object.

Center ray
Center rays pass through the thin lens unchanged.

Parallel rays
All rays that run parallel to the optical axis are refracted by the lens in such a way that they meet at the focal point. As the brightest point directly behind the lens, this is only found in converging lenses.

Focal rays
All rays that pass through a focal point or come out of the focal point are refracted by the lens in such a way that they pass parallel to the optical axis behind the lens.

Illumination
In microscopy, you need an illumination source to be able to see the object. This can e.g. B. a flashlight or the reflection from the sun.

Magnifying glass (also magnifying glass or burning glass)
The simplest optical device that magnifies the object for the human eye

Telescope (also lens telescope or refractor)
An optical instrument that, when used, makes distant objects appear many times closer or larger

Lens
An optical system that creates a real optical image of an object

Eyepiece
The eye-side part of an optical system

Light microscope
A microscope that uses light to produce highly magnified images of small structures or objects

Tube lens
A lens that creates a real intermediate image from the parallel rays of light after the infinity optics lens

Intermediate image
Magnifying image of the object produced by the lens

Mirror
A reflective surface smooth enough for light reflected off it to create an image

Accommodation of the eye
A dynamic adjustment of the refractive power of the eye; It means that objects at different distances can be imaged sharply on the retina.

Autofocus
Unlike accommodation, in most cases of autofocus, the focal length remains constant and the distance between the lens and the screen is varied.

Impressum

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Layout: Katrin Uhlig, Benedict Diederich

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