# The astronomical telescope

Physics > Light & Optics > Optical devices & lenses

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| easy | 1 | 10 minutes | 10 minutes |

This content can also be found online at:

http://localhost:1337/c/62dd796b318b270003e217b8

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# Teacher information

## Application

Experimental setup

Astronomical telescopes allow the viewing of distant objects that appear closer and magnified by the optical instrument. The magnification is created with the help of several lenses.



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## Other teacher information (1/3)

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### Principle

An astronomical telescope (Kepler telescope) consists of two components: a converging lens as objective, which produces a real intermediate image, and another converging lens as eyepiece, which magnifies the intermediate image like a magnifying glass.

### Learning objective

Students should learn about the construction and function of a telescope and observe its optical effect.



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## Other teacher information (2/3)

### Task

- Students should build a model of an astronomical telescope and investigate how its parts work together.

## Other teacher information (3/3)

- In the second part of the experiment, when the students adjust the telescope model to a relatively distant object, it is recommended that they hold the optical bench with one hand and use the other hand to adjust the focus.
- To avoid damage to the lenses, the teacher should ask the students to connect the parts of the optical bench as tightly as possible beforehand and to handle the lenses with care.
- The use of an aperture to limit the field of view was avoided in order to make the model and the experiment as simple as possible.
- **Remark:** The astronomical telescope was first described by Kepler. That is why it is also called Kepler's telescope.



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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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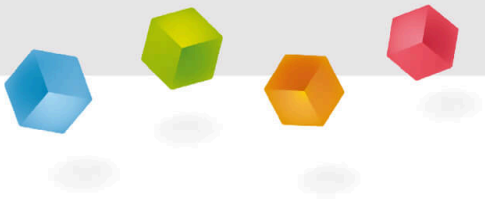

# Student information



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# Motivation

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Observatory telescope

An astronomical telescope allows the viewing of distant objects to appear closer and magnified by the optical instrument. The magnification is created with the help of several lenses.

**How is the astronomical telescope constructed and how does it work?**



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Optical profile-bench for student experiments, l = 600 mm | 08376-00 | 1 |
| 2 | Lens on slide mount, f=+50mm | 09820-01 | 1 |
| 3 | Lens on slide mount, f=+100mm | 09820-02 | 1 |
| 4 | Slide mount for optical bench | 09822-00 | 1 |
| 5 | Table with stem | 09824-00 | 1 |
| 6 | Screen, white, 150x150 mm | 09826-00 | 1 |
| 7 | Stearin candles, d 13mm, 20 pcs | 09901-02 | 1 |



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| 7 | Stearin candles, d 13mm, 20 pcs | 09901-02 | 1 |

# Structure (1/2)

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- Set up the optical bench with the two tripod rods and the variable tripod foot.
- Place the scale on the front tripod rod.



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## Structure (2/2)

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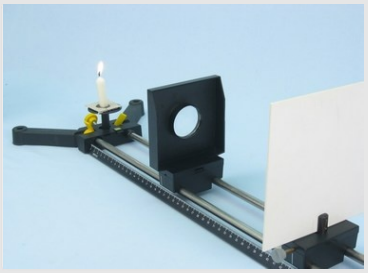

- Using the left part of the tripod base, attach the table with stem, place the candle on it and light it.
- Set the screen at 43 cm and the lens $f = +100\,\mathrm{mm}$ at about 10 cm onto the optical bench.

## Procedure (1/3)

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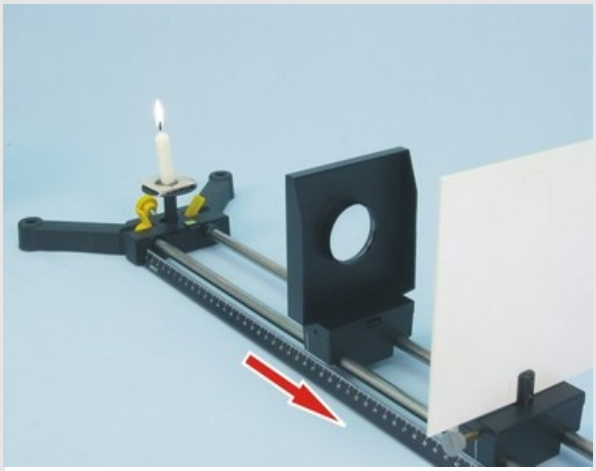

Displacement of the lens

- Move the lens, which is the objective of the telescope, to the right until a sharp image of the candle flame appears on the screen.
- Adjust a little if the candle flame is not in the optical axis.
- Write down the characteristics of the image called the intermediate image.



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## Procedure (2/3)

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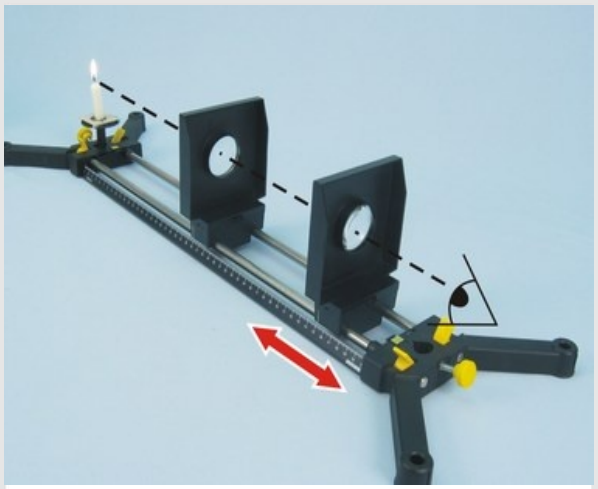

Displacement of the eyepiece

- Remove the screen and set the lens $f = +50\,\mathrm{mm}$ at about 45 cm onto the optical bench.
- Move it until the image from the intermediate image can be seen sharply with the eye. This lens forms the eyepiece of the telescope.
- Describe the properties of the image seen through the eyepiece. What is the effect of the eyepiece?

## Procedure (3/3)

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Experimental setup

- Now extinguish the candle and take it off the optical bench. Now point the telescope model at an object several metres away that is bright enough (window cross, curtain, etc.) and move the lenses against each other until the image is sharp. Because of the lens errors that lead to distortion of the image, you should concentrate on sections of the image that are close to the optical axis.
- Measure and note the distance $l$, that the lenses (the objective and the eyepiece) have when the image of the distant object is in focus.
- Also note the focal lengths of the lens and eyepiece in the report.



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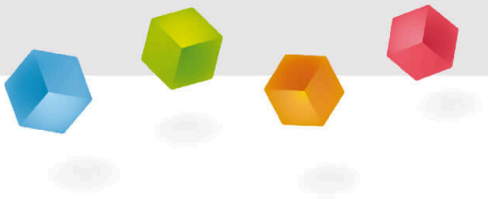

# Report

## Table 1

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Write down your measurement results in the table.

| Sizes | Measured values |
|---|---|
| Distance between objective and eyepiece [cm] | |
| Focal length of the lens $f_1$ [mm] | |
| Eyepiece focal length $f_2$ [mm] | |



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## Task 1

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What are the properties of the intermediate image?

- ○ inverted, reduced, virtual
- ○ inverted, enlarged, real
- ○ inverted, reduced, real

Check

What effect does the eyepiece have on the intermediate image?

- ☐ It acts as a magnifying glass.
- ☐ It creates a reduced (upright) image of the intermediate image.
- ☐ It creates an enlarged (upright) image of the intermediate image.

Check

## Task 2

PHYWE

What is the relationship between the distance $l$ of the lenses and the focal lengths $f_1$, $f_2$?

- ○ The distance between the two lenses is about the same as the focal length of the eyepiece: $l = f_2$.
- ○ The distance between the two lenses $l$ is about the same as the focal length of the lens: $l = f_1$.
- ○ The distance between the two lenses is about the same as the sum of the two focal lengths: $l = f_1 + f_2$.

Check



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## Task 3

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In the practical version of an astronomical telescope, the objective and the eyepiece are mounted at the ends of a tube of adjustable length. The tube ensures that no light from the side makes observation of the intermediate image difficult or impossible.

The text below now describes the construction and functioning of an astronomical telescope. Fill in the missing words.

An astronomical telescope consists of a converging lens with a long focal length, the [ ], and a [ ] with a short focal length, the eyepiece, mounted on the [ ] of a tube of adjustable length. The lens produces an inverted, reduced, [ ] image of the distant object, called the [ ]. The eyepiece, which acts as a [ ], produces a magnified, [ ] image of the intermediate image.

Check

## Task 4

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Perhaps you have seen films about seafarers, for example, from the past with telescopes that could be used with one eye. The sailors had to change the length of the tube in order to clearly see the distant object, e.g. a ship.

What was the minimum length of these telescopes?

- ○ The minimum length is $l = 2\,f_1 + f_2$ .
- ○ The minimum length is $l = f_1 + 2\,f_2$ .
- ○ The minimum length is $l = f_1 + f_2$ .

Check



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# Task 5

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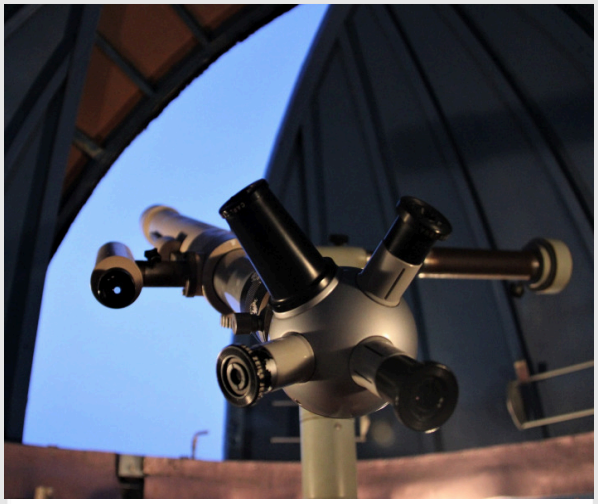
Why do you think the astronomical telescope has this name?

- ○ It is called an astronomical telescope because it is (was) preferably used for astronomical observations.
- ○ It is called an astronomical telescope because it is (was) preferably used for microscopic observations.

Check



Astronomical telescope



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