The microscope (Item No.: P1436203)

Curricular Relevance

Area of Expertise: Physics

Education Level: Age 14 - 16

Topic: Optics

Subtopic: Optical devices

Experiment:

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

microscope, magnification, intermediate image, objective, ocular

Task and Material

Introduction

A microscope is used to enlarge small objects that cannot be seen with the naked eye.
It is comprised of two converging lenses, the objective and the eyepiece.

In order to be able to measure the magnification of the microscope, a “model eye” will also be placed on the optical profile bench.
It consists of a screen, the “retina”, and a 50 mm lens, the “eye lens”.

In the second experiment the interim image is captured behind the objective and the magnification of the objective measured.

Task

1. Look at the object with the 'model-eye'.
2. Determine the size of the interim image.
3. Enlarge the image with the complete microscope setup.

Material

Position No.	Material	Order No.	Quantity
1	experimental lamp hex 1	08130-99	1
2	Optical profile-bench, l = 1000 mm	08370-00	1
3	Lens on slide mount, f=+100mm	09820-02	1
4	Lens on slide mount, f=+50mm	09820-01	2
5	Slide mount for optical bench	09822-00	2
6	Mount with scale on slide mount	09823-00	1
7	Diaphragm with hole, d=20mm	09816-01	1
8	Screen, white, 150x150 mm	09826-00	1
9	Screen, metal, 300 x 300 mm	08062-00	1
10	Diaphragm holder, attachable	11604-09	2
11	Ruler, plastic, 200 mm	09937-01	1
12	Slide -Emperor Maximilian-	82140-00	1

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Setup and Procedure

Setup

The general setup is shown in fig. 1a:

- Fasten the experimental lamp to a mount and position it at 2.0 cm on the optical bench.
- Place a mount with scale on slide mount directly in front of the light (white mark at 15.0 cm), attach a diaphragm holder and insert the “Emperor Maximilian” slide as the object. This slide should be an example of a finely structured microscopic object that is going to be magnified severly.
- Plug in the power plug of the lamp to turn it on. Use the horizontal slider to move the lamp inside the case in order to fully illuminate the Emperor-slide.
- Mount the screen to the optical bench by attaching it to a mount for the optical profile-bench.
- The position of the lenses will be discussed in the next section.

Procedure

Experiment 1: Look at the object with the eye model (Fig. 1a)

- Place the 50-mm (eye) lens at 29 cm and the screen (retina) about 10 cm behind it.
- Attach the 20-mm diaphragm onto the eye lens by inserting it into the diaphragm holder and mounting it onto the lens.
- Move the “Emperor Maximilian” object so that it is projected as a sharp image on the retina (turn the slide in the holder until the image is upright and on the right side).
- Write down the position of the slide.
- To determine the magnification e.g. measure the object size O by measuring from the lower edge of the photo up to the line of the header as well as the corresponding image size I.

Fig. 1a: Setup with the eye model

Experiment 2: Demonstrate the interim image (Fig. 2a)

- Remove the eye model from the optical profile bench but do not move the slide of Emperor Maximilian.
- Instead place the screen at 70 cm on the optical bench.
- Place a diaphragm holder with an inserted 20-mm diaphragm on a f = 50 mm - lens (now the objective lens of the microscope) and place this at approximatly 23 cm on the optical profile bench.
- Move the lens until a sharp image of the Emperore-slide is displayed.
- Write down the position of the lens.

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- To determine the magnification e.g. measure the size of the face, i.e. the distance between the chin (separation line between the neck and clothing) and the line of the header.

Fig. 2a: Setup for demonstration of the interim image

Experiment 3: Complete microscope (Fig. 3a)

- Remove the screen of the optical bench and leave the rest of the setup unchanged. Place an additional lens (eyepiece) with f = 100 mm at approximately 77 cm.
- Mount the eye model behind it, so that the eye lens (diaphragm not necessary) is at position 87 cm and the screen at 97 cm.
- Create a sharp image by moving the eyepiece lens which projects a chosen section of the object magnified and sharp onto the screen.
- Locate and look at fine structures by moving the slide in the diaphragm holder. To determine the magnification, i.e. select both lines that frame the header and measure the distance.

Remarks

The students should not look through the microscope without the eye model. The lamp is to bright for such an experiment.

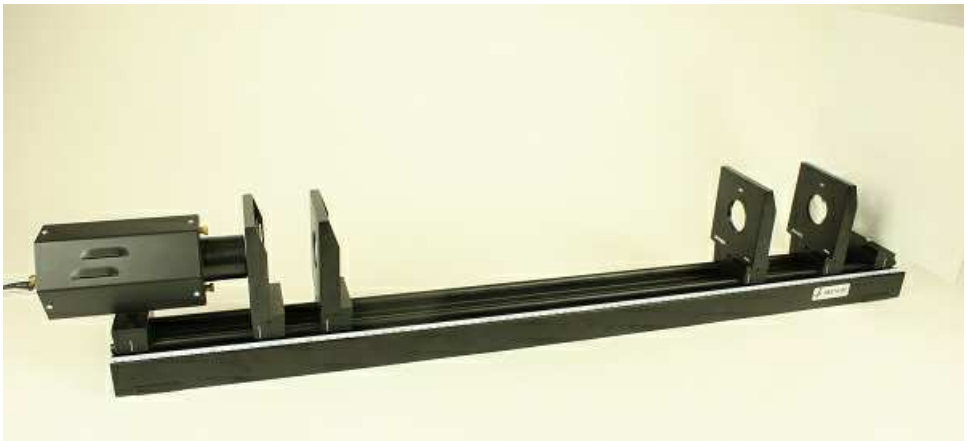

Fig. 3a: Setup of the complete microscope with included eye model

Results and Evaluation

Results

Viewed Images:

Fig. 1b: Image with eye model

Fig. 3b: Image viewed with the complete microscope

Fig. 2b: Interim image

Results of the measurement:

Table 1: Magnification

Experiment 2	Object	$\frac{O}{\mathrm{cm}}$	$\frac{I}{\mathrm{cm}}$	Magnification	Factor
1	Picture without header	2.7	2.8	naked eye	1.0
2	Face	1.2	10.0	Objective	8.3
3	Header	0.3	4.2	Total	14.0

Experiment 1
Position of the slide after adjusting: 15.5 ... 16.5 cm.
In this part of the experiment, the image is just as large as the object.
The fine structures, e.g. on the coat and hair, are not easily recognizable to the naked eye.

Experiment 2
Position of the lens, f = 50 mm, after adjusting: ca. 22.5 ... 23.5 cm.
The image is much larger than the object, the fine structures are clearly visible everywhere.

Experiment 3
Position of second lens, f = 100 mm, after adjusting: ca. 77.3 cm.
The image section is now very small, the slide must be moved in order to find the chosen area.
However, the structures are now strongly magnified.

Evaluation

The microscope is comprised of an objective lens and an eyepiece lens, the distance from each other is much larger than the sum of the focal lengths of the two.
The object lies close in front of the anterior focal point of the objective.

This creates an upside down, enlarged and real image (the interim image) that can be directly captured on a screen.
It is located inside of the anterior focal length of the eyepiece so that this can work like a magnifier.
It creates an upright virtual image that can be viewed with the eye.

The magnification of the microscope is measured by the size of the image created on the retina of the eye (see remarks).
The magnification of the objective can be calculated by measuring a section in the interim image.

The factors for the magnification of the objective and the total magnification of the setup microscope are contained in Table 1.
The total magnification of the microscope $V_{Micr.}$ can be calculated from the magnifications of the objective $V_{Obj.}$ and the eyepiece $V_{Eye.}$

$$V_{Micr.} = V_{Obj.} \cdot V_{Eye.} \tag{1}$$

From Table 1 an eyepiece magnification of $V_{Eye.} = 1,7$.

Remarks

The positions for the slide, lens or screen indicated are intended as an aid to help setup the experiment.
A microscope is used to magnify the visual angle under which objects are viewed.

The total magnification is the ratio of the image size, which appears when viewing an object in the microscope to the size which the object would have under the “conventional visual range” of 25 cm.
The comparison of the retina images corresponds to this definition.

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