# Determination of the magnification of a microscope

## Task and equipment

## Information for teachers

## Additional Information

Although this experiment can be performed directly following an experiment on the construction and mode of operation of a microscope, it is recommended that it be performed separately; otherwise students might feel overly challanged.

## Suggestions

To avoid fading of the image which is seen through the ocular the intermediate image was left on the transparent paper screen. This screen can also be removed and the power supply voltage reduced to decrease fading.

## Remarks

The second task and the required measurements of the variables $b'$ and $B'$ form an interesting supplement to the treatment of the magnification of a microscope, but they may be omitted if they seems too difficult for students.
If the teacher wants to discuss the equation $M = M_1 \times M_2$, the following derivation of the equation can be used:
The total magnification is $M = B/G$ where $G$ = size of the image formed by the objective, and $B$ = size of the image seen through the ocular.
$B'$ the size of the intermediate image. Therefore: $M = B/G = (B/B') = M_1 \times M_2$.

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### Task

### How can the magnification of a microscope be determined?

Construct a model of a microscope and determine its achievable magnification.

# Student's Sheet

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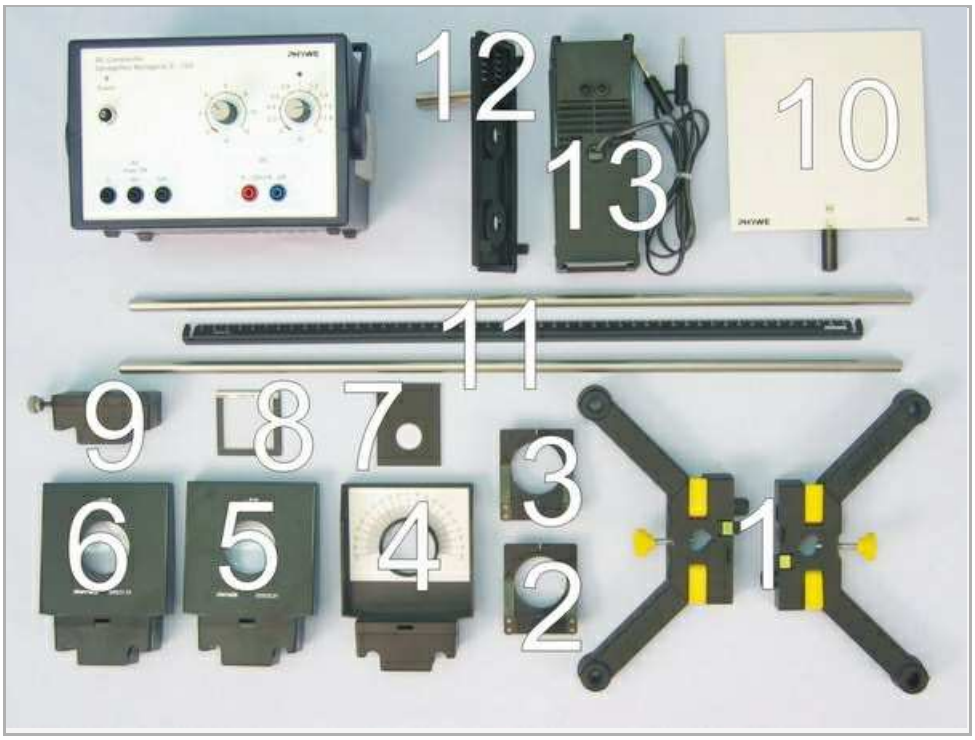
## Equipment




| Position No. | Material | Order No. | Quantity |
|---|---|---|---|
| 1 | Support base, variable | 02001-00 | 1 |
| 2/3 | Diaphragm holder, attachable | 11604-09 | 2 |
| 4 | Mount with scale on slide mount | 09823-00 | 1 |
| 5 | Lens on slide mount, f=+50mm | 09820-01 | 1 |
| 6 | Lens on slide mount, f=+100mm | 09820-02 | 1 |
| 7 | Diaphragm with hole, d=20mm | 09816-01 | 1 |
| 8 | Ground glass screen,50x50x2 mm | 08136-01 | 1 |
| 9 | Slide mount for optical bench | 09822-00 | 1 |
| 10 | Screen, white, 150x150mm | 09826-00 | 1 |
| 11 | Support rod, stainless steel, l = 600 mm, d = 10 mm | 02037-00 | 2 |
| 11 | Meter scale for optical bench | 09800-00 | 1 |
| 12 | Bottom with stem for light box | 09802-10 | 1 |
| 13 | Light box, halogen 12V/20 W | 09801-00 | 1 |
| | PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A | 13506-93 | 1 |
| Additional material | | | |
| | Transparent scale (millimetre) paper, 50 mm x 50 mm | | 1 |
| | White paper (DIN A4) | | 1 |
| | Paper clips | | 4 |
| | Ruler, transparent (approx. 30 cm) | | 1 |

# Set-up and procedure

## Set-up

Prepare the transparent millimetre paper with two lines as shown in Fig. 1.

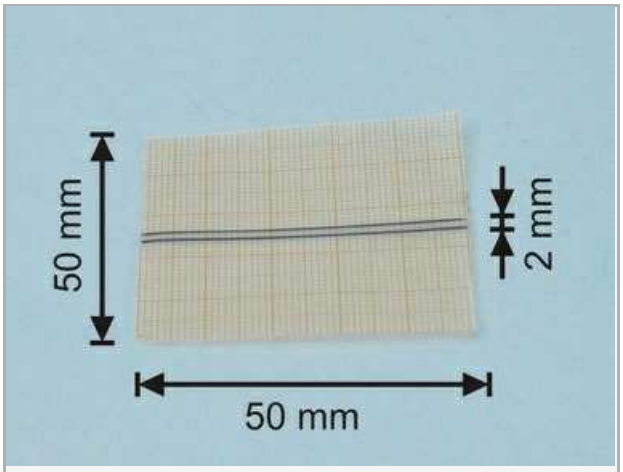



Fig. 1

Get the support base variable, meter scale for optical bench and the two support rods as shown in Fig. 2 and assemble the optical bench as shown in Fig. 3.

Fig. 2

Fig. 3

Place the base with rod under the light box as shown in Fig. 4 and Fig. 5.

Fig. 4

Fig. 5

Clamp it onto the left part of the support base so that the lens end points away from the optical bench. (Fig. 6)

Fig. 6

Insert an opaque cover in front of the lens and slide the transparency into the slot at the other end of the light box. (Fig. 7)

Fig. 7

Position the lens with $f$ = +50 mm (the objective) at the 9.5 cm mark on the optical bench (Fig. 8), place the diaphragm holder on the mount of this lens, and insert the diaphragm with hole into the diaphragm holder.
Now place the mount with scale at the 40 cm mark on the optical bench (Fig. 8), fix the second diaphragm holder to the mount of this lens, and insert the ground glass screen into it, which will serve as projection screen for the intermediate image.
Position the lens with $f$ = +100 mm (the ocular) at about 49 cm on the optical bench as shown in Fig. 8.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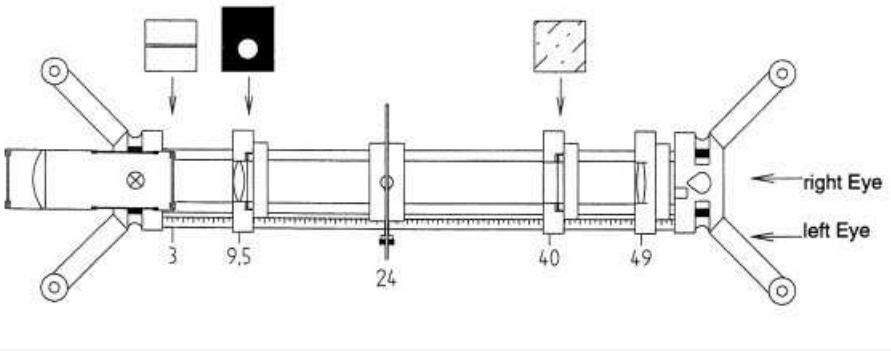


Fig. 8

## Procedure

Connect the light box to the power supply (12 V~) and switch it on.
Ensure that the intermediate image of the two lines (object) is in focus on the ground glass screen. If necessary, readjust the focus by moving the objective slightly (Fig 9).

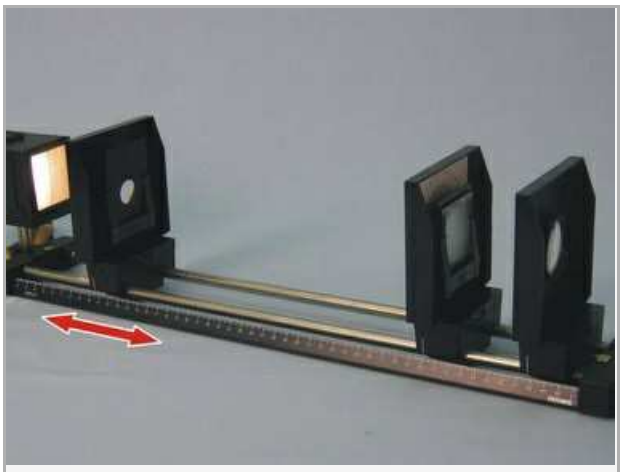

Fig. 9

Look through the ocular at the intermediate image and move the ocular until the projection of the intermediate image is in focus.
Attach the sheet of white paper tightly to the screen using the paper clips. Place the screen with mount in front of the optical bench, 25 cm from the ocular (Fig. 10).

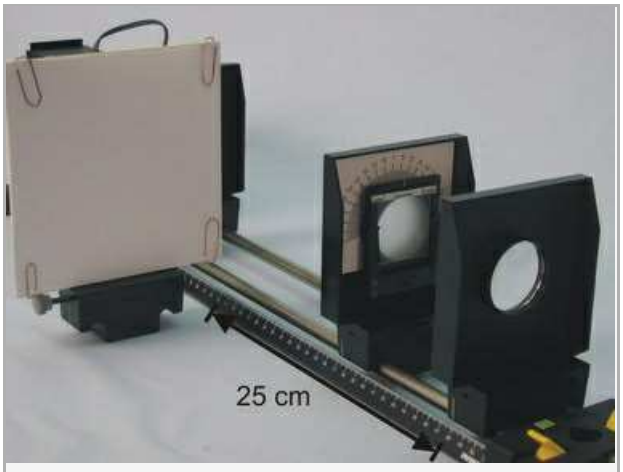


Fig. 10

Now look through the ocular at the image with your right eye. With your left eye look past the ocular at the paper on the screen (Fig. 11). With a pencil or felt-tip pen mark the distance on this paper which appears to equal the distance of the two image lines in the ocular (Fig. 11).


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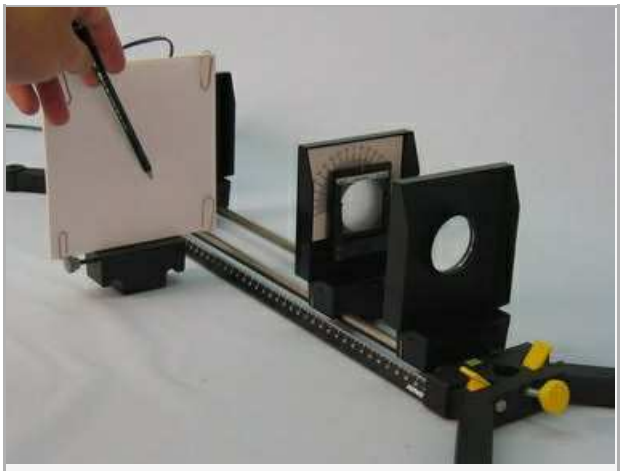

Fig. 11

Measure the distance *B* between the two marks on the paper of the screen (image size) as shown in Fig. 12.

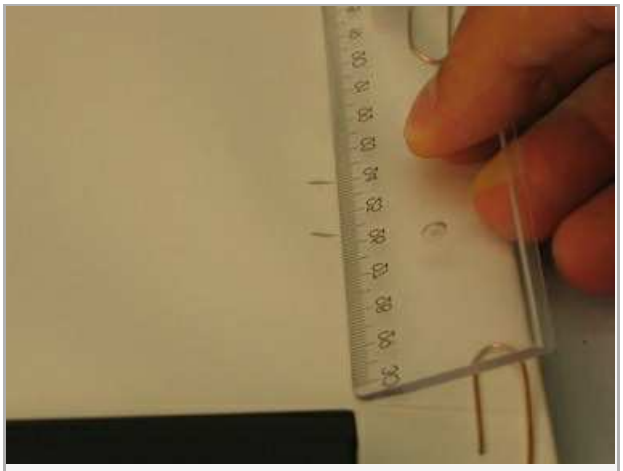

Fig. 12

Measure the size of the intermediate image *B*', that is the distance between the two lines on the ground glass screen (Fig. 13).

Fig. 13

Measure the object distance *g* and the image distance *b*' for the intermediate image. Note all of your measuring results n the report.
Switch off the power supply.


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# Report: Determination of the magnification of a microscope

## Result – Observations

*Distance between the lines:*

Object $G$ = 2 mm

Image (white screen) $B$ = ..... mm

Intermediate image (ground glass screen) B' = ..... mm

*Image through the objective:*

Object distance g = ..... cm

Image distance (intermediate image) b' = ..... cm

## Evaluation – Question 1

What magnification was achieved by the microscope model? ? $M = B/G$ =

.....

.....

.....

.....

## Evaluation – Question 2

Since $B'$ as well as $g$ and $b'$ can be measured for the intermediate image from the microscope model, the magnification can also be determined by a second method.

For the total magnification of a microscope the following is true: $M = M_1 \times M_2$ where $M_1$ and $M_2$ are the respective magnifications of the objective and the ocular individually. Calculate the magnification of a microscope model using this method and compare this result with that which you obtained in Question 1.

For the objective: $M_1 = b'/g$ or $M_1 = B'/G$;
$M_1 =$

For the ocular: $M_2 = 25\ \text{cm} / f$ ($f$ = the focal length of the ocular)
$M_2 =$

Magnification of the microscope:
$M =$