PHYS 708

Lab 1

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Experiment O601

Total internal reflection inside a prism

Purpose

To understand how a simple camera works.

Equipment

- 1 Optical lamp
- 1 Lens, $f = 100mm$
- Inclined bench and screen
- 1 Tea candle

Procedure

1. Set up experiment like O601 Fig. 1.
2. Light the tea candle.
3. Align screen till the image of the flame can be seen in good focus on it.
4. Observe the image of the candle flame and write a description of it in the table.
5. Determine the object distance g and the image distance b, then enter both values into the table.
6. Now set the object distance to $g = 350mm$ and move the screen until the candle flame is well focused.
7. Determine the object distance b and enter the value into the table.

g in mm	b in mm	Image properties
300	149.2	Inverted, smaller
350	139.5	Inverted, smaller

Evaluation

Additional Exercises

1. A camera is focused by adjusting the highly sensitive distance between the lens and the imaging mechanism/the film.

2. Arrow 1 is in focus.

Complete the following

The brighter the object to be photographed, the shorter the exposure times need to be.

The higher the f-stop value, the smaller the aperture.

Answer the following questions:

Read some books so that you can explain the term depth of field as it relates to the f-stop setting

The depth of field is very shallow for a wider apertures or smaller f-stops, and the depth of the field is deeper for a smaller aperture or higher f-stop.

What does the ISO value represent?

The ISO value is some gauge of the sensitivity of the film to light. The higher the ISO value, the more sensitive it is to light.

Experiment O602

Model Slide Projector

Purpose

To Investigate how a slide projector works.

Equipment

- 1 Optical lamp
- 1 Optical bench
- 1 Lens, $f = +100mm$
- 2 Lenses, $f = +50mm$
- 1 Inclined bench and screen
- 1 Slide holder
- 1 Object (slide)

Procedure

1. Set up the experiment as in Fig. 1, initially using the lens with focal length f = + 100 mm.
2. Place the screen as far away as space allows.
3. Connect the optical lamp to its power supply.
4. Move the condenser lens (f = + 50 mm) in such a way that the slide in the slide holder is as well illuminated as possible.
5. Move the screen till the image of the slide is well focused on the screen.
6. Determine the object distance g and image distance b, then enter the values into the table.
7. Swap the lens with focal length f = + 100 mm with the other lens of focal length $f = +50mm$.
8. Now move the lens ($f = +50mm$) until the image of the slide is once again well focused on the screen.

9. Determine the object distance g and image distance b, then enter the values into the table.

10. Determine the magnification V using the formula $V = \frac{b}{g}$ and enter the value into the table.

Evaluation

f in mm	g in mm	b in mm	V
100	130	750	5.8
50	60	830	13.8

Complete the following

1. A slide projector has a converging lens called a condenser and another movable converging lens called the objective.

2. In a slide projector, the slide is positioned between the focal point and another point that is twice as far.

3. The image is formed after the point that is double the focal length.

4. The image is a real image that is upside down, flipped from left to right, and magnified.

5. In order to obtain an image the correct way up and correct way round, the slide needs to be inserted into the slide holder upside down and switched from left to right.

6. For large rooms, projectors are used which have a greater focal length.

7. In order to produce large images in small rooms, projector lenses of shorter focal length are used.

Additional Exercises

Draw the path of rays through a slide projector

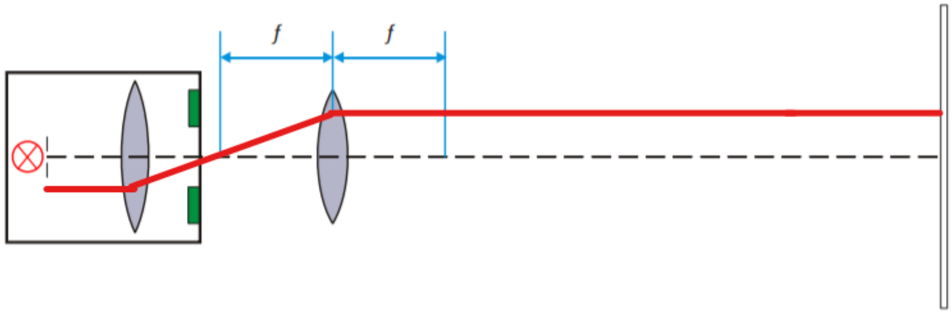

Figure 1: Ray path through slide projector

Experiment O603

Model Microscope

Purpose

To understand how a microscope works.

Equipment

- 1 Optical lamp
- 1 Optical bench
- 1 Lens, $f = 100mm$
- 1 Lens, $f = 50mm$
- Inclined bench and screen
- 1 Tea candle
- 1 Object (slide)

Procedure

1. Place the optical lamp like in O603 Fig. 1.
2. Connect the lamp to its power supply.
3. Align screen till the image of the slide is well focused on the screen.

4. Cut off a piece of paper with some scissors that fits nicely in front of the light aperture.
5. Make sure to completely cover the aperture with the paper and remove the screen.
6. Place a lens of focal length $f = 100mm$ at the end of the optical bench and look through it at the image of the slide which was previously on the screen (see O603 Fig. 2).

Evaluation

Answer the following questions:

1) What do you observe on the screen?

There is a magnified image of the object which is upside-down and reversed from left to right.

2) What does the image look like when you look at it through the lens?

The image is even more magnified than it was on the screen.

Complete the following:

1) The movable lens is called the objective and the fixed lens is called the ocular.
2) The objective creates an intermediate image which is magnified again by the ocular.

Name some applications of microscopes in medicine, research and production: In medicine, microscopes are used to investigate the causes of illness, in research they are used to investigate the structure of organic matter and in production they are used for checking the quality of products.

Experiment O604

Model of a Galileo Telescope

Purpose

To investigate if it possible to create a model of a Galileo telescope

Equipment

- 1 Optical bench
- 1 Lens, $f = +300mm$
- 1 Lens, $f = -100mm$

Procedure

1. Place the lens with focal length $f = -100$ mm at the 0-cm mark on the optical bench and the lens of focal length $f = +300$ mm at the 20-cm mark (see Fig. 1).
2. First look at the object with your naked eye from about 10 cm away.
3. Now hold the optical bench with the -100 mm lens in front of your eye in such a way that you can see the object through both lenses.
4. Move the lens with focal length f = + 300 mm back and forth to focus the image as best you can.
5. Now determine how far the diverging lens is from the converging lens and compare this with the focal length of the converging lens.
6. Think about what the relationship between the separation and the focal lengths of the two lenses might be and write down your conclusion under Relationship.

Evaluation

- The separation between the converging lens and the diverging lens is: 19 cm.
- The separation between the lenses is given by the following equation to within the error tolerances for the two focal lengths: $f_1 + f_2 = 300mm - 100mm = 200mm$.

Complete the following

1. The diverging lens (ocular) is within the focal length of the converging lens (objective).
2. This means that a real image of the object is not formed at the focal point.
3. The image seen through a Galileo telescope is the correctly upward and magnified.

Additional Exercises

Name some applications in which a Galileo telescope is used:
Binoculars and simple telescopes that can be used to observe the sky.

Experiment O605

Model Kepler Telescope

Purpose

To understand how a microscope works.

Equipment

- 1 Optical bench
- 1 Lens, $f = 100mm$
- 1 Lens, $f = 50mm$

Procedure

1. Place the lenses like in O605 Fig. 1.
2. Look at the object from $10m$ away.
3. Hold optical bench with $f = 50mm$ lens in front of your eye in such a way that you can the object through both lenses.
4. Now determine how far apart the two converging lenses are and compare this with the focal length of the $300mm$ lens.
5. Think about what the relationship between the separation and the focal lengths of the two lenses, and write down your conclusion under relationship.

Evaluation

Conclusion:

The separation between the two converging lenses: $348mm = 34.8cm$

Relationship:

$$s = f_1 + f_2 \tag{1}$$

$$348mm \approx 50mm + 300mm = 350mm \tag{2}$$

Complete the following:

1) The object is a long way beyond twice the focal length of the objective.
2) The image of the object is close to the focal point of the objective.
3) An intermediate image of the object is close to the focal length of the ocular. It is as if it were being viewed through a magnifying glass.
4) The view through an astronomical is of a real image, upside-down, reversed from left to right and reduced in size.

Additional exercises:

1) Explain why astronomical telescopes are not used for terrestrial applications. Although the magnification provided by telescopes can be very large the image seen by the viewer is rotated by 180°.
2)Find out a way of correcting the orientation of the image through a Kepler telescope so that it could be used as a terrestrial telescope. One can insert two prisms which both exhibit total internal reflection, but this this also increases the field of vision.
3) Name some applications where Kepler telescopes are used:
For observation of astronomical bodies/events.

Experiment O606

Model of a terrestrial telescope

Purpose

Make a model of a terrestrial telescope

Equipment

- 1 Optical bench
- 2 Lenses, $f = +50mm$
- 1 Lens, $f = +100mm$

Procedure

1. Place one lens ($f = +50mm$) (ocular) on the optical bench at the 0-cm mark, a second lens ($f = +50mm$) at the 18-cm mark and a third lens ($f = +100mm$) (objective) at the 35-cm mark (see Fig. 1).
2. First look at an object about 5 m away with your naked eye.
3. Now hold the optical bench with the +50-mm lens in front of your eye in such a way that that you can look through all the lenses to see the object.
4. Move the lens in the middle ($f = +50mm$) back and forth to make the image as sharp as possible.

Evaluation

1. The image through a terrestrial telescope is a real image, correctly upward and the correct way round.
2. The objective produces an intermediate image which is real, reduced in size and inverted (upside-down and reversed from left to right).
3. The intermediate image is between one and two times the focal length of the middle lens. This results in the emergence of a real image which is inverted again, but this time magnified, and which is located within the focal length of the ocular. This is then viewed as if through a magnifying glass.

Additional Exercises

Name one advantage of a Galileo telescope over a terrestrial telescope:
A Galileo telescope is smaller which allows it to be more portable, easier to use, etc. This is because it uses two lenses that are not very far apart.

Experiment O701

Dispersion of light into colors using a prism

Purpose

To investigate how a prism disperses visible light into its separate colors.

Equipment

- 1 Optical lamp
- 1 Optical bench
- 1 Lens, $f = 100mm$
- 1 Slide holder
- 1 Slide with a single slit
- Inclined bench and screen
- 1 Prism
- 1 Rectangular glass block
- 1 Red filter

Sub-Experiment 1

Procedure

1. Follow O701 Fig. 1
2. Place the screen $50cm$ beyond the end of the optical bench.
3. Align screen till the image of the slide is well focused on the screen.
4. Put rectangular glass block about $9cm$ behind the $f = 100mm$ lens, and put the prism on top of it.
5. Place the screen at an angle to the optical bench, maintaining the same distance.
6. Move the screen until the spectrum shows up.

Evaluation

Complete the following:

1) A prism disperses light into a spectrum of colours.
2) The band of all these colours is called a spectrum. Colours in a spectrum cannot be dispersed any further.
3) Because the spectrum is formed by a prism, it is sometimes called a prismatic spectrum.
4) The colour red is least diverted from the straight path and the colour violet is refracted the most.
5) The correct order of the colours is red, orange, yellow, green, blue and violet.

Sub-Experiment 2

Procedure

1. Now slot the red filter into the slide holder and position it directly in front of the optical lamp (see Fig. 3).

2. Observe the spectrum on the screen and write down what you see.

Evaluation

The spectrum as seen now only contains red light. The red light is not comprised of any substituent colors.

Additional exercises:

A rainbow is created by refraction and reflection of sunlight by water droplets when the sun is shining through them from behind the observer. The reason for the emergence of the colours is dispersion by the droplets, which act similarly to a prism and refract the components of white light to differing degrees.

Exercise O702

Recombining spectral colours

Purpose

Recombine the spectral colours with the help of a cylindrical lens.

Equipment

- 1 Optical lamp
- 1 Optical bench
- 1 Lens, $f = +100mm$
- 1 Slide holder
- 1 Slide with single slit
- 1 Inclined bench and screen
- 1 Prism
- 1 Rectangular glass block
- 1 Plastic jar with lid
- Water
- 1 Sheet of a paper

Sub-experiment 1: Procedure

1. Position the optical lamp on the optical bench.
2. Place the screen about 50 cm beyond the end of the optical bench.
3. Insert the slide with a single slit into the slot on the optical lamp.
4. Connect the lamp to its power supply.
5. Position the lens with focal length $f = +100mm$ at the 25-cm mark and move both lens and screen until the slit is well focused on the screen.
6. Put the rectangular glass block about 9 cm behind the lens ($f = +100mm$) on the optical bench.

7. Put the prism on top of the block.
8. Place the screen at an angle to the optical bench and about 15 cm away from it (see Fig. 1).
9. Move the prism into the beam and turn it in such a way that a spectrum can be seen on the screen.
10. Fill the plastic jar with water and close the lid.
11. Place the jar in the beam between the prism and the screen (see Fig. 2).
12. Move the screen towards the jar, observe the spectrum on the screen and write down what you see.

Sub-experiment 1: Evaluation

1. A prism disperses light into its spectral colours.
2. The light emerging from the jar of water is white in colour.
3. The spectral colours overlap at the focal point resulting in a white beam.
4. The plastic jar of water acts like a converging lens.

Sub-experiment 2: Procedure

1. Put a sheet of paper in front of the plastic jar to block off the red part of the spectrum and observe what happens to the spectrum on the screen.
2. Now block off the violet part of the spectrum and observe the spectrum on the screen again.
3. Write down both observations.

Sub-experiment 2: Evaluation

Observations

If you block the red light of the spectrum, the spectrum on the screen is green. Similarly if you block the violet part of the spectrum, the spectrum on the screen is yellow.

Experiment O703

Addition of colors- Complementary colors

Purpose

To investigate the possibilities for the addition of colors.

Equipment

- 1 Optical lamp
- 1 Optical bench
- 1 Lens, $f = 100mm$
- 1 Slide holder
- 1 Slide with a single slit
- Inclined bench and screen
- 1 Prism
- 1 Semi-circular body
- 1 Parallel block
- 1 Plastic jar with lid
- 1 strip of paper $20 \times 20mm$
- 1 strip of paper $20 \times 300mm$
- 1 Rod, $2mm$
- Adhesive tape
- Water

Setup

1. Follow O703 Fig. 1
2. Place screen $60cm$ away from the optical bench at an angle which accentuates the spectrum.
3. File the plastic far with water and close the lid.

Blocked-out spectral color	Complementary color
Red	Green
Orange	Blue
Yellow	Violet
Green	Red
Blue	Orange
Violet	Yellow

4. Use the semi-circular body to place under the jar of water and place the jar in the beam between the prism and the screen, so that it is about $5cm$ in front of the screen.

5. If necessary, move the plastic jar and the semi-circular body so that that the white slit can be seen on the screen next to the spectrum.

6. Attach a paper strip to the plastic jar in such a way that the spectrum is visible on the strip and the white slit is visible on the screen.

Procedure

1. Use the rod to block off the red light in the spectrum, observe the white strip on the screen and enter the color that results into the table.

2. do the same with the other spectral colors and enter into the table the color that can be seen on the screen in each case.

3. Now block off multiple colors with the paper strip and observe the resulting color on the screen.

Complementary colour Red Green Orange Blue Yellow Violet Green Red Blue Orange Violet Yellow

Answer the following:

1) Is it possible to find out what happens when the blocked-off colours and the complementary colours are added? Yes, by removing the rod or paper strip again.
2) What colour results when the colours are mixed? The mixed colour is white.

Complete the following:

1) When colors are added together a mixed color results where the spectral colors overlap.
2) In the case of subtractive color mixing, the mixed color is the result of absorption of certain colors from white light.

3) The colors that are obtained by mixing paints arise due to subtractive mixing of colors.