Title: Corrective eyeglasses

Topics: Corrective eyeglasses	**Time**: 90 minutes (2 lessons)	**Age**: 10 class 15 – 16 years old pupils

Differentiation:

- More able pupils may be asked to calculate error of one measurement and to evaluate measurement accuracy.
- For most able and talented a discussion about eye structure and eyesight physiology is carried out.
- Students who complete the work quickly are asked to work on the extension tasks provided.

Guidelines, ICT support etc.:

- Students are presented with a consistent workflow and with a list of equipment needed for this activity.
- Analysis of results and discussion effective when the work is done in groups of 2-3 students.
- In case class does not contain the necessary equipment, the teacher demonstrates experiment.

Equipment needed for this activity:

- Corrective glasses with converging lenses,
- Corrective glasses with diverging lenses,
- Optical bench,
- An arrow as an object,
- Converging lens,
- Light source,
- A ruler,
- A screen,
- textbooks;
- activity sheet.

Required knowledge:

- Concepts of eyesight anomalies, thin lens, lens focus, refractive power, magnification;
- Fractions, calculation of measurement bias.

Health and Safety:

Safe handling of experimental equipment.

Learning outcomes for this activity:

<u>All</u>

- Will know eyesight anomalies and their correction ways.
- Will be able to experimentally ascertain, which of the research eyeglasses are for correction of far-sightedness, and which – for near-sightedness.
- Will be able to define the road of rays through lenses.

<u>Most</u>

- Will understand, why short-sighted wear glasses with diverging lenses, and long-sighted – with converging ones.
- Will be able to explain the work mechanism of corrective glasses.
- Will be able to describe the main contact lens' parameters.
- Will be able to draw and describe the image of the thing formed by converging and diverging lenses.

<u>Some</u>

- Will be able to evaluate, how the image of the thing changes depending on its distance to the lens.
- Will be able to evaluate the measurement bias.

Lesson description

Starter Activity

Pupils enter the classroom put away coats and bags.
Pupils are asked to recall from mathematics: fractions calculation, expression of unknown number, calculation of measurement bias.
Discuss these issues with students:

Are there any students carrying glasses?
Do these students have problems seeing close or distant objects?
What kind of lenses are designed to correct their vision?
Who of the students are with the highest diopter glasses?
What is the physical meaning of the diopter?

Pupils are asked to recollect, what eyesight anomalies are, to explain thin lens formula, lens focus, refractive power, magnification concepts.
For most able and talented a discussion about eye structure and eyesight physiology.

Main Activity

Pupils begin work on **Corrective eyeglasses** worksheet.
An explanation of practical is given.
Students in groups of 2-3 carry out experimental tasks.
In case class does not contain the necessary equipment, the teacher demonstrates experiment.

Experiment tasks:

I. To experimentally ascertain, which of the research eyeglasses are for correction of far-sightedness, and which – for near-sightedness.
II. To measure refractive power and focal length of eyeglass lenses (converging lens) for correction of far-sightedness.
III. To measure refractive power and focal length of eyeglass lenses (diverging lens) for correction of near-sightedness.

I.

1. Arrange the instruments on the optical bench in the following order: light source, an object, research lens (research corrective glasses) and a screen are placed so that the straight line going through the centre of a lens and through the centre of light source would be vertical to the screen.
2. Focus a research lens on the screen as long as you get a clear object (arrow) image. A real object image is rendered only with converging lenses, which are for far-sightedness correction.
3. If focusing a research lens a distinct image of an object is not produced on the screen, thus, it is a diverging lens. It is for near-sightedness correction.

II.

1. Make use of the optical bench, designed in the first part of the experiment.
2. Focus the eyeglasses for far-sightedness (converging lens) as long as you get a distinct, two, three times magnified object (arrow) image on the screen.
3. Measure the distance by a ruler between an object and a lens d and the distance between a lens and a screen f.
4. According to a thin lens formula, calculate research lens focal length F.
5. Repeat the experiment three times, changing the object distance from the lens and getting a magnified or a decreased object image.
6. Enter the measurement results in a table.

7. Calculate the average value of the focal length $F_{m.}$ and according to it, calculate lens refractive power *D*.

III.

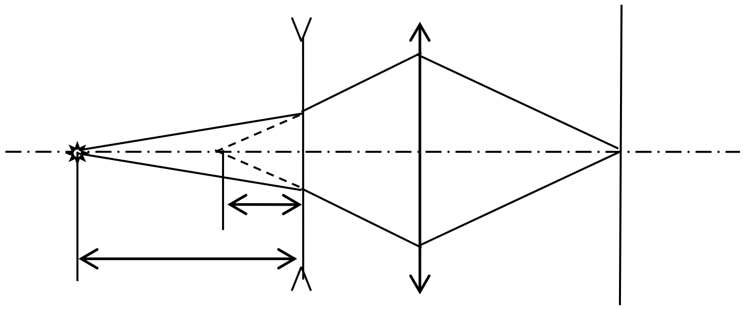


Figure 1

1. Arrange the instruments in the following order: an object (arrow), diverging lens, converging lens and a screen. It has to be set up so, that a straight line, going through the lens centres and the light source centre, would be vertical to the screen (Figure 1).
2. Move the converging lens as long as you get a distinct object image on the screen. Measure the distance between the object and the diverging lens *d*.
3. Mark the place, where the diverging lens stands (point A), and take it away. Do not move the converging lens and the screen. The image on the screen, after elimination of the diverging lens, becomes indistinct.
4. Without moving the converging lens and the screen, move the object closer to the converging lens as long as a distinct object image appears on the screen. It means that the object now is in that place, where earlier was its virtual image obtained by the diverging lens S_1.
5. Calculate the distance from the new object place to the place where earlier diverging lens stood. This will be virtual image distance from the lens *f*.
6. Using lens formulas, calculate diverging lens focal length *F*. Do not forget, that the distance between the lens and the virtual image is negative.
7. Repeat the experiment three times, changing the object distance from the lenses.
8. Insert the measurement results in the table.
9. Calculate the average value of the focal length $F_{m.}$ and according to it, calculate lens refractive power *D*.

<u>Work sheet activity</u>

Pupils are asked to complete the activity work sheets individually: pupils are asked to answer, how to experimentally tell apart converging lenses from diverging ones, to fill in the data table, to draw conclusions.

More able pupils may be asked to calculate error of one measurement and to evaluate measurement accuracy.

Pupils who complete the work quickly are asked to work on the extension tasks provided (**Drawing images obtained by lenses).**

<u>Plenary</u>

Pupils are asked about the procedure carried out; they are asked to consider the reason for any odd results.

The pupils are asked to make a conclusion about how to experimentally determine what sight anomaly the eyeglasses are for, and how the image changes, changing the object‘s distance to the lens.

For most able and talented a discussion about calculation of one measurement bias result accuracy.

Corrective eyeglasses

Thin lens focal length can be calculated according to the formula:

$$\frac{1}{F}=\frac{1}{d}+\frac{1}{f}.$$

Where, F – lens focal length, d – distance of the object from the lens, f – distance of the image from the lens. It has not to be forgotten that, if the object‘s image or focal length (for the diverging lens) is virtual, the sign “-“is written in the formula, in front of this unit. The lens refractive power is calculated according to the formula:

$$D=\frac{1}{F}.$$

Where, D – lens refractive power (in dioptres or m^{-1}), F - lens focal length (in metres). Linear lens magnification Γ shows, how many times the object image is bigger than the object itself.

$$\Gamma=\frac{f}{d}=\frac{h}{H}.$$

Where, h - image magnitude, H – object’s magnitude.

By diverging lens virtual object images are formed, which cannot be observed directly on the screen. Therefore, in order to determine diverging lens’ focal length, lens system is used, consisting of diverging L_1 and converging L_2 lenses, by which virtual light source S image S' is obtained (its position from the point of view of lens cannot be determined, and by converging lens L_2 it is projected onto the screen E (Figure 1).

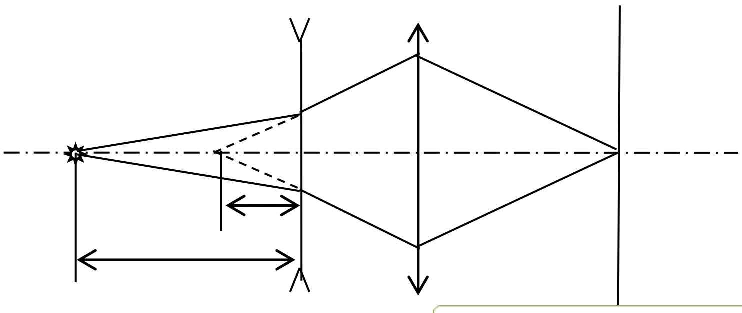
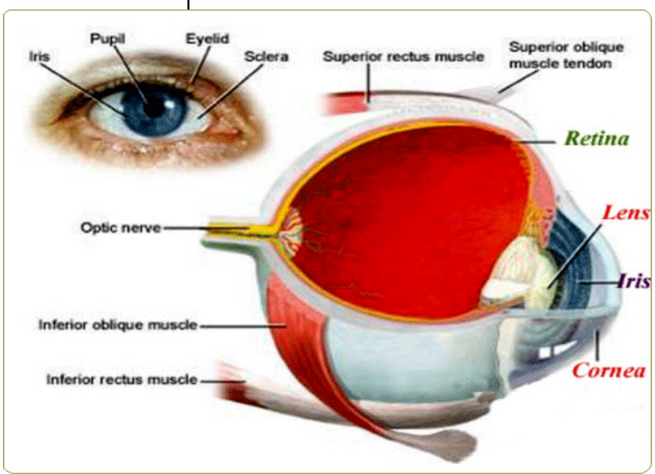


Figure 1

An eye – optical system.



The eye‘s optical system is a converging lens of a changing focal length. The eye‘s optical system consists of cornea, clear fluid, lens, vitreous humour. Light rays, entering the eye, bend on the surface of cornea. Further on, they are additionally bent by a lens and vitreous humour. Passing through the lens, the rays intersect in the retina (Figure 2a) and form a real, decreased and turned upside down image of an object. This one irritates the endings of the optic nerve, by which the signal is transferred to the brain. Here, the image is overturned and a real image is seen. The eye‘s optical system‘s optical centre is at a distance of 5 mm from the cornea. When the muscle of an eye is in a relaxed position, optical system‘s refractive power is 59 D, when it is maximally tensed - 70 D. A very important feature of an eye as an optical instrument is – the ability to automatically change the parameters of the optical system depending on what the eye sees. This feature is called **accommodation.** Accommodation sphere is determined by the position of two points:

- **The farthest accommodation point** is defined by a position of a thing, the image of which is focused on the retina, without straining the muscle. The farthest accommodation point of a normal eye is at infinity.

- **The nearest accommodation point.** Bringing the object closer, the muscle straining itself reflexively presses the lens and its focal length decreases so, that an object is projected on the retina again. In order to discern the object in great detail, one can bring it only to the nearest accommodation point. Then the eye muscle is maximally tensed. For a normal eye this point is 10-20 cm from the eye. The nearest accommodation point increases with the age. Besides these two points, the state of an eye is also defined by **the best viewing distance**. This distance is the smallest distance at which an eye, without any special muscle tension, can discern the object details. This distance for a normal eye is 25cm. .

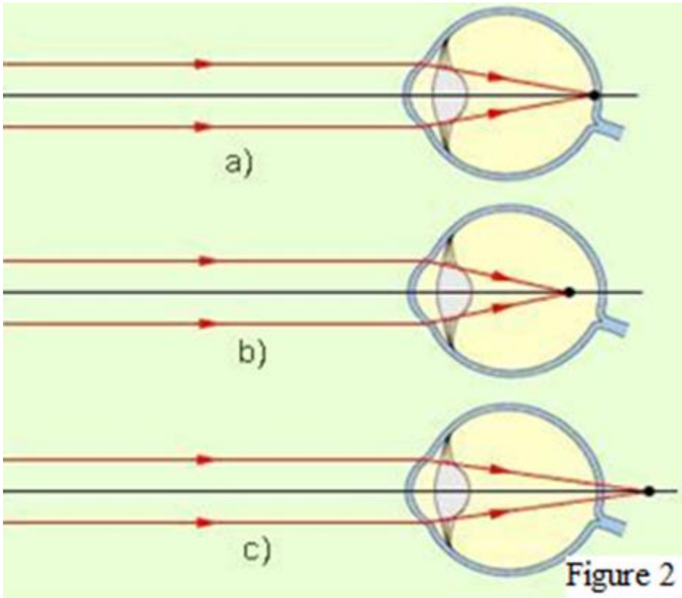


Figure 2

Near-sightedness and far-sightedness.
When accommodation points do not get in the far and near accommodation point limit, a man is called **near sighted** or **far sighted**. In the eye of a near sighted person, the images of far objects form not on the retina, but in front of it (Figure 2b). Such people see far images as blurred. The farthest accommodation point is not very far, and the best viewing distance is also closer. In the farsighted person's eye, the image of the far object forms behind the retina (Figure 2c). Seeing the close up objects, the eye still accommodates, when the distance to the object is more than 25 cm.

Eyeglasses.

For the person to see normally, i.e., the images to be focused on the retina, optional lenses are used – **eyeglasses.** For the near sighted, the eyeglasses decreasing optical power are of great help, therefore diverging lenses are used. (Figure 3b). Passing through such a lens, parallel rays are sensed by the eye as though coming from the far accommodation point. Then a near sighted person can see distant things. The refractive power of the near sighted glasses is negative. The glasses, increasing optical power, help the farsighted. In this case, converging lenses are used (Figure 3a). Passing through such a lens, parallel rays, having been bent in the lens, will diverge less and will intersect on the retina. The refractive power of the farsighted glasses is positive.

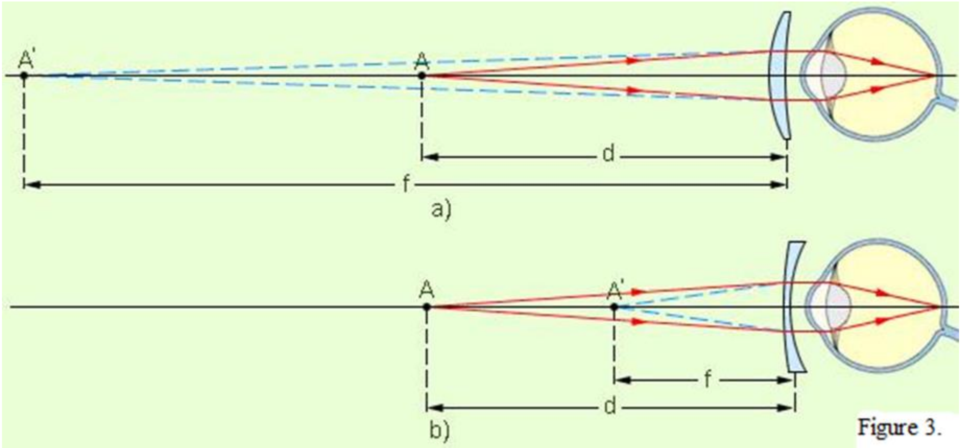


Figure 3.

Questions	Answers
1. What do we call lens focal length? 2. What do we call lens optical power? 3. How to understand the statement: "The magnification of lens is equal to 0,5? 4. Can a virtual image be projected on the screen? 5. When and what glasses do farsighted and near sighted have to wear? 6. Linear equation is given: 1/2 - 3x/4 = 5/8. Find x. 7. Thin lens formula is given: $\frac{1}{F}=\frac{1}{d}+\frac{1}{f}$. Find *d*. 8. Thin lens formula is given: $\frac{1}{F}=\frac{1}{d}+\frac{1}{f}$. d = 24 cm, f = 0,4 m Find *F*. 9. Thin lens formula is given: $\frac{1}{F}=\frac{1}{d}+\frac{1}{f}$. F = 20 cm, d = 30 cm Find *f*.	.

Corrective glasses

Answer sheet

I. Which of the research eyeglass lenses are for correction of far-sightedness, and which – for near-sightedness:

- If, with the research lens, a distinct image of an object is obtained on the screen –

The lens .... is for... correction.

- If, with the research lens, indistinct image of a thing is formed on the screen –

The lens .... is for .... correction.

II and III.

Fill in the data table:

Task	Experiment No	d, m	f, m	Image description	F, m	F_m, m	D, D
II	1						
	2						
	3						
III	1						
	2						
	3						

- **Extra. Calculate the bias of one measurement:**

d = ………± …….. m, f = ………± ……. m,

$$F = \frac{f \cdot d}{d - f}, \quad \Delta F = \varepsilon \cdot F \qquad \varepsilon = \varepsilon_1 + \varepsilon_2 + \varepsilon_3$$

$$\varepsilon = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = \frac{\Delta f}{f} + \frac{\Delta d}{d} + \frac{\Delta f + \Delta d}{d - f} =$$

$\varepsilon =$

$\Delta F = \varepsilon \cdot F =$

The unit obtained is F = ………± …… m, or ……..≤ F ≤ ………

Conclusions:

- Make a conclusion about how to experimentally determine what sight anomaly the eyeglasses are for.

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- From the experiment results make a conclusion, how the image changes, changing the object distance to the lens.

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Drawing of the images, obtained by lenses

- Draw the process of rays, when an object is placed at a distance $2F_m$ from the **converging** lens. Describe the obtained image. What is the distance from the lens to the object image?

- Draw the process of rays, when an object is placed at a distance $2F_m$ from **diverging** lens. Describe the obtained image. What is the distance from the lens to the object image?

- The far accommodation point of a near sighted eye is 80 cm. Calculate, what refractive power glasses are necessary for a man, using a thin lens formula.

- If the near sighted sees best at a distance of 16 cm, but not at 25 cm, then the refractive power of his glasses has to be