**Practical No 5**

# DETERMINATION OF FOCAL LENGTH AND RADIUS OF CURVATURE OF THE EYE MODEL AND FOCAL LENGTH OF CORRECTING LENS

## Equipment:

1 - optical spectrometer,
2 - eye lens model,
3 - two correcting lenses.

## Course of measurements:

1. Determination of radius of curvature of the eye lens model.

a) Measure the distance between the object (letter Y or E) x and the principal plane of the lens model (located in the middle of the lens model) and the distance y between the image plane and the principal plane. The ring on the syringe piston must be placed in the position l. Perform the measurements of the x and y twice to obtain two pairs of x and y values. The thickness of the lens in the position l – $d_1$ = 1.7 cm.

b) Change the position of the piston ring to ll. The thickness of the lens is now $d_2$ = 1.9 cm. Perform the measurements of the x and y as it was done in point 1a.

c) Change the position of the piston ring to Ill. The thickness of the lens is now $d_3$ = 2.1 cm. Perform the measurements of the x and y as in point 1a and 1b.

Write down the results to the Table 1 and calculate the focal length f applying the formula:

$$\frac{1}{f} = \frac{1}{x} + \frac{1}{y} \qquad (1)$$

Calculate the f for each pair of the x and y obtained in points 1a-1c. For each position of the piston ring calculate the average value of focal length ($f_{av}$).

The general formula for the refractive power (Z) of a thick lens:

$$Z = \frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + \frac{d(n-1)^2}{R_1 R_2 n_1} \qquad (2)$$

where:
n - refractive index of the lens,
$n_1$ - refractive index of the external environment (in this case – air, so $n_1$ = 1),
d - thickness of the lens,
$R_1$, $R_2$ - radii of curvature of refractory planes of the lens.

Assuming $R_1 = R_2 = R$ and n = 4/3 (refractive index of water) we can rearrange the equation (2) to the form of a quadratic equation:

$$9R^2 - 6f_{av} - f_{av}d = 0 \tag{3}$$

which we can apply to calculate the R:

$$R = \frac{1}{3}\left(f_{av} + \sqrt{f_{av}^2 + df_{av}}\right) \tag{4}$$

Put the calculated R values to the Table 1.

<u>2. Determination of focal lengths of the correcting lenses.</u>

For the 3rd position of the piston ring (III) calculate f values for two correction lenses. Assume that correction lenses are thin (d = 0).

To calculate the focal length of correction lenses ($f_k$) apply the formula for the refracting power of a two-Iens assembly:

$$\frac{1}{f_u} = \frac{1}{f} + \frac{1}{f_k} - \frac{l}{f \cdot f_k} \tag{5}$$

where:
$f_u$ - focal lens of the assembly,
l – the distance between the lenses.

Focal lens of the assembly can be calculated applying the formula:

$$\frac{1}{f_u} = \frac{1}{x_u} + \frac{1}{y_u} \tag{6}$$

where:
$x_u$ - distance between the object and a correction lens,
$y_u$ - distance between the image and the eye lens model. Rearranging the equation (5) we obtain finally:

$$f_k = f_u \frac{f - l}{f - f_u} \tag{7}$$

Write down the values of focal length calculated for both correcting lenses with the use of the equation (7) to the Table 2.

<u>3. Determination of the refracting angle of the prism.</u>

**Preform measurements for both prisms (2 and 4)**

a. Turn the sodium lamp on and wait for 3 minutes.
b. Place the ocular of the spectrometer in a position opposite to the collimator to obtain a focused image of the slit in the absence of the prism.
c. Place the prism on the object stage of the spectrometer. The angle must be pointed towards the collimator, and the black wall must be perpendicular to the ocular.
d. Measure the angle of reflection from the left refractory plane of the prism - $A_L$ and the angle of reflection from the right plane - $A_R$ by rotating the collimator left and right, respectively, until you see the slit again. Read the angle (its absolute value) from the scale on the ocular's stage and put the values to the Table 3.
e. Determine the refracting angle (φ) from the following formula:

$$\varphi = 0.5(A_L + A_R) \quad (8)$$

4. Determination of the refractive index of the prism.

**Preform measurements for both prisms (2 and 4)**

a) Place the prism on the object stage of the spectrometer. The angle opposite the black wall must point towards the angle between 280° and 290° (at the protractor). Find the image of the slit.
b) Slowly rotate the prism counterclockwise observing the slit all the time. Find the position of the prism in which the image of slit stops moving in spite of the rotation of the prism.
c) Read off the angle of minimal deviation ($E_{min}$) from the scale on the stage.
d) Calculate the refractive index of the prism ($n_1$) applying the formula (9):

$$n_1 = \frac{\sin\frac{\varphi + E_{\min}}{2}}{\sin\frac{\varphi}{2}} \quad (9)$$

Write down the calculated value to the Table 3.

## Required theoretical knowledge:

1. Structure of human eye and optical scheme of image formation.
2. Resolving power of the eye.
3. Eye accomodation.
4. Defects of vision and correction methods.
5. Elementary formulas for lenses.
6. Relationship between the refractive index and the angle of minimal refraction in the prism.
7. Scheme of an optical spectrometer.

| Wroclaw Medical University Department of Biophysics and Neuroscience | Practical No 5<br>Determination of focal length and radius of curvature of the eye model and focal length of correcting lens |
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| Grade: | Tutorial signature |

1. Determiantion of the focal length and radius of curvature of eye model lens.

| Position of syringe piston | $x_1$ [cm] | $x_2$ [cm] | $y_1$ [cm] | $y_2$ [cm] | $f_1$ [cm] | $f_2$ [cm] | $f_{av}$ [cm] | R [cm] |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| II | | | | | | | | |
| III | | | | | | | | |

2. Determination of the focal length of correction lenses.

| Correction lens | $x_u$ [cm] | $y_u$ [cm] | $f_u$ [cm] | f [cm] | $f_k$ [cm] |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |

3. Determination of refractive index of the glass prism.

| Prism number | Right angle $A_R$ | Left angle $A_L$ | Refracting angle of the prism $\varphi$ | Angle of minimal refraction $E_{min}$ | Refractive index $n_1$ |
|---|---|---|---|---|---|
| 2 | | | | | |
| 4 | | | | | |