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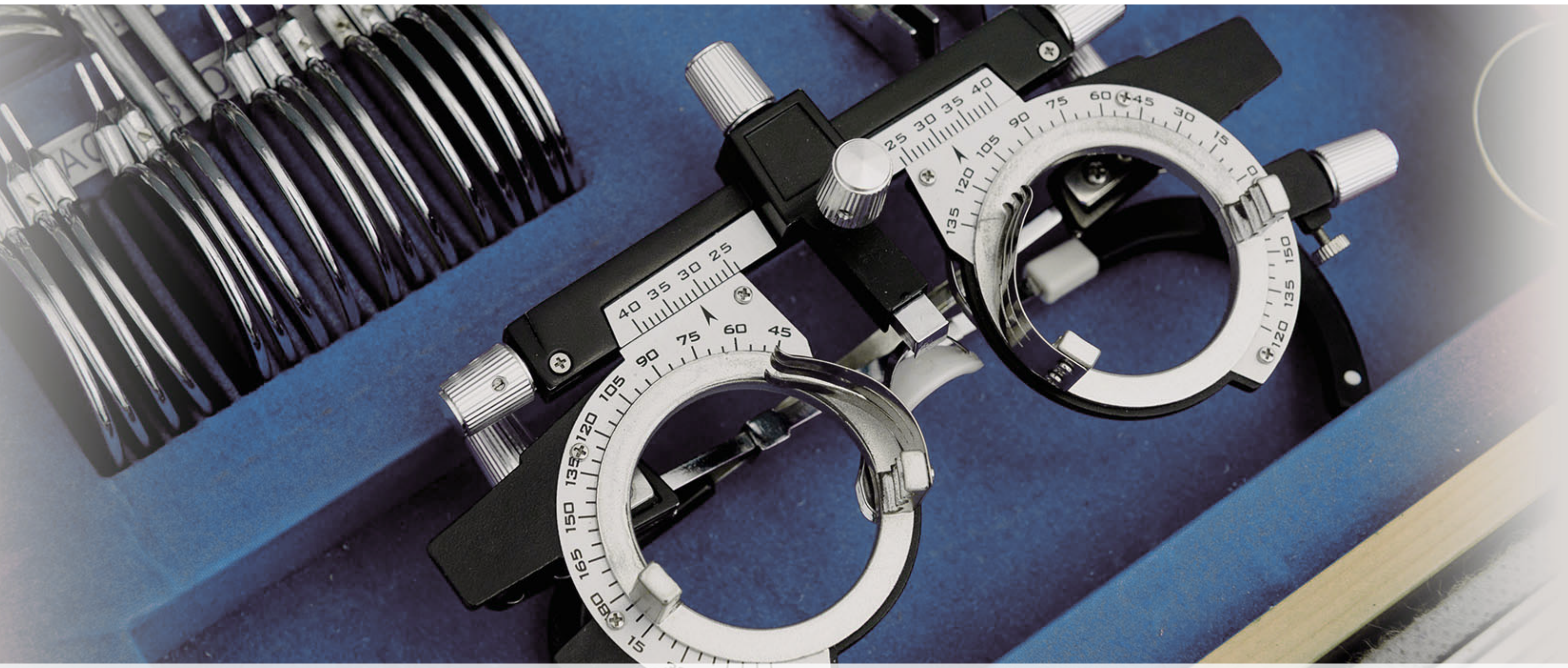


Print version

Spectacle technology I

Protocols for practical education

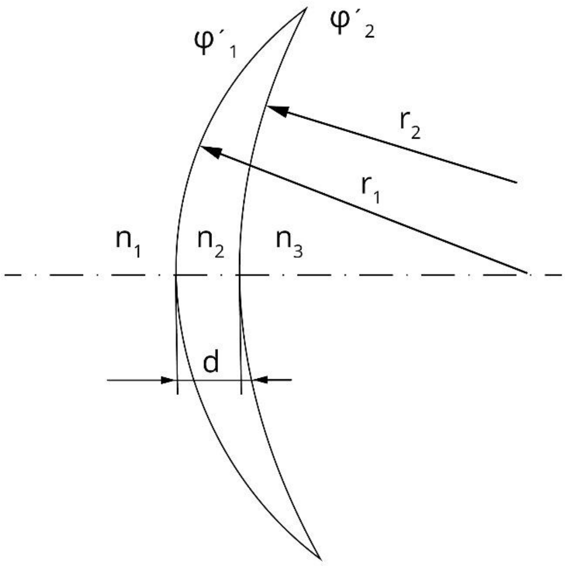
MASARYK UNIVERSITY

Table of Contents

1 Imaging with plus spectacle lens

1.1 Introduction

Spectacle lens is special optical device which transmits and refracts the light. The lens consists of two optical surfaces which surround the basic material. Basic material is formed from glass or plastic. As basic spectacle lens we distinguish plus and minus lenses. Plus lenses are lenses with a positive image focal length. Biconvex, plano-convex, periscope and meniscus lenses are basic types of plus lenses. Periscope lenses have basic surface value +/-1.25 D. Meniscus lenses can be divided into semi-shell (base surface value +/-6 D) and shell (base surface value +/-8 D).



Picture 1.1: Meniscus plus lens (**φ**´ – optical power, $\boldsymbol{\varphi}_1$´ – front optical power $\boldsymbol{\varphi}_2$´ – back optical power, r_1 – front radius, r_2 – back radius, $n_{1,3}$ – refractive index of the air, n_2 – lens refractive index, d – central thickness, Rutrle 2001).

1.2 Goals

- Draw biconvex spectacle lens and its rays transfer schematically.
- Calculate optical power of the plus meniscus semi-shell lens according the Gullstrand formula. Front side optical power is +7 D, thickness is 2.5 mm and refractive index is 1.5. Draw this lens schematically.

1.3 Equipment

Drawing equipment, ruler.

1.4 Methods

Draw biconvex spectacle lens and its rays transfer schematically.

Draw schematically biconvex lens. Object is placed in objective plane in distance which is twice bigger than is the focus distance of the lens. Draw all important points – focus, principal points etc. How will look the final image (e.g. inverted, smaller, real)?

Calculate optical power of the plus meniscus semi-shell lens according the Gullstrand formula. Front side optical power is +7 D, thickness is 2.5 mm and refractive index is 1.5. Draw this lens schematically.

Use Gullstrand formula:

$$\varphi'_c = \varphi'_1 + \varphi'_2 - \frac{d}{n}\varphi'_1 . \varphi'_2$$ **φ´** [D], d [m] (1)

1.5 Results

Draw biconvex spectacle lens and its rays transfer schematically.

Calculate optical power of the plus meniscus semi-shell lens according the Gullstrand formula. Front side optical power is +7 D, thickness is 2.5 mm and refractive index is 1.5. Draw this lens schematically.

$\boldsymbol{\varphi}'_c$ =

Drawn figure:

1.6 Discussion

Plus lenses are used for correction of hyperopia. Currently we use so called point focal lenses. These lenses replace meniscus spectacle lenses. These lenses have adapted curvatures of both sides to decrease astigmatism in peripheral view. This calculation is real for vertex powers from +8 to -25 D. If we need higher values we have to use aspheric lenses.

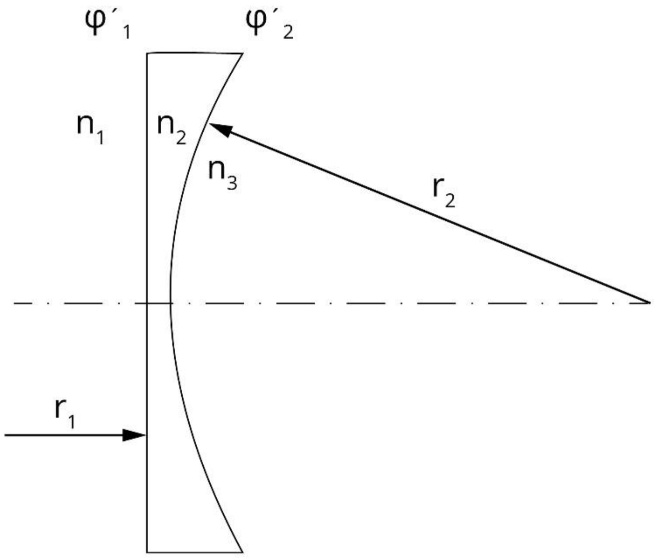
1.7 Conclusion, notes, comments

In which distance should be placed object form plus lens if we want to use this lens as a magnification device. Draw schematically this lens and imaging rays with object.

2 Imaging with minus spectacle lens

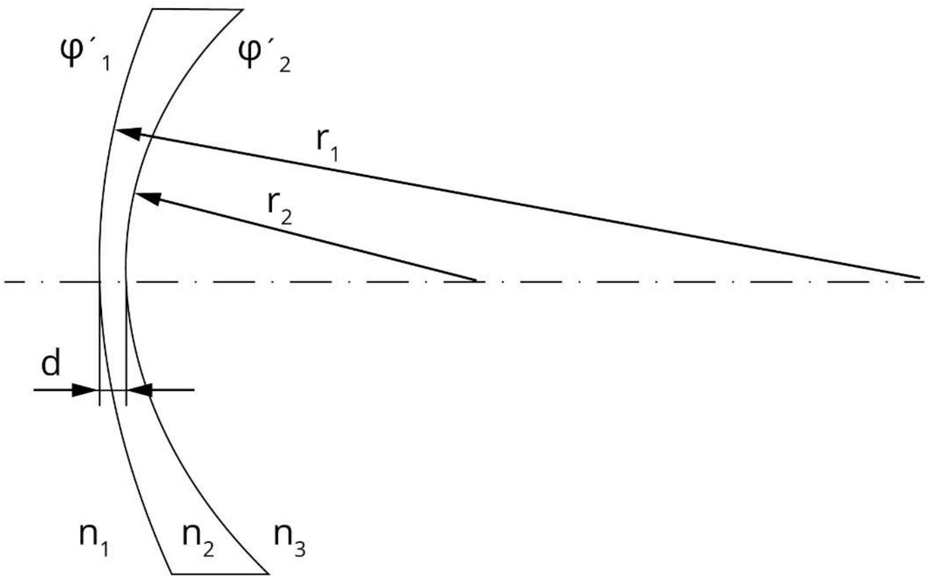
2.1 Introduction

Minus spectacle lenses can be biconcave, plan-concave, periscope, meniscus and point-focal imaging. In biconcave lenses the total optical power is formed with count of front and rear surface (both are minus). Currently these lenses where replaced by new types because of bad image quality (oblique rays astigmatism, visual field distortion). Plano-concave lens has one surface plan. Total optical power is formed by rear surface.



Picture 2.1: Plan-concave lens (φ' – optical power, φ_1' – front optical power φ_2' – back optical power, r_1 – front radius, r_2 – back radius, $n_{1,3}$ – refractive index of the air, n_2 – lens refractive index, d – central thickness, Rutrle 2001).

In minus periscope lenses is used front surface with power +1.25 D. So, the value of the back side should be -1.5 D and smaller. These lenses better deal with oblique ray's astigmatism and enables free movement of eyelids with eye-brushes behind the glasses.



Picture 2.2: Periscope minus lens (**φ**´ – optical power, r –radius, n – refractive index, d – central thickness, Rutrle 1993).

Concept of periscope lens enables to develop meniscus lens – semi-shell and shell. Further development goes to so called point-focal lenses.

2.2 Goals

- Schematically draw biconcave spectacle lens and its imaging rays
- Calculate optical power of the minus meniscus semi-shell lens according the Gullstrand formula. Back side optical power is -10 D, thickness is 1.5 mm and refractive index is 1.5. Draw this lens schematically.

2.3 Equipment

Drawing equipment, ruler.

2.4 Methods

Schematically draw biconcave spectacle lens and its imaging rays

Draw schematic picture with biconcave spectacle lens. Object is placed in objective plane in distance which is twice bigger than is focus distance. On the picture draw all important points – focus points, main points etc. How will look the final image?

Calculate optical power of the minus meniscus semi-shell lens according the Gullstrand formula. Back side optical power is -10 D, thickness is 1.5 mm and refractive index is 1.5. Draw this lens schematically.

$\varphi'_c = \varphi'_1 + \varphi'_2 - \frac{d}{n}\varphi'_1 . \varphi'_2$ **φ**´ [D], d [m] (1)

2.5 Results

Draw biconcave spectacle lens and its rays transfer schematically.

Calculate optical power of the minus meniscus semi-shell lens according the Gullstrand formula. Back side optical power is -10 D, thickness is 1.5 mm and refractive index is 1.5. Draw this lens schematically.

$\boldsymbol{\varphi}'_c$ =

Drawn figure:

2.6 Discussion

Minus lenses are thicker in periphery in contrary to plus lenses. With minus lenses we correct myopia. Minus lens shifts rays from space in front of retina right to the retina. If we correct myopia we use weakest lens to avoid of accommodation.

2.7 Conclusion, notes, comments

How looks the image formed by minus spectacle lens if the object is placed in distance which is bigger than focus distance? Draw the schematic picture.

3 Total optical power of the spectacle lens calculation with Gullstrand formula

3.1 Introduction

Gullstrand formula we can use for spectacle lens optical power calculation. Total lens optical power can be calculated as addition of front and rear lens surface optical power. We need to know also lens thickness and refraction index. Surface lens optical power is calculated from these values: radius and refractive index in front of the lens and in the lens. Optical power can be calculated according to lower formula:

$\varphi' = \frac{n' - n}{r}$ $\boldsymbol{\varphi}'$ [D], r [m] (2)

Description:

φ'	optical power
n	refraction index in front of the lens
n'	refraction index behind the lens
r	lens curvature

3.2 Goals

- Measure radius front and rear spectacle lens surface
- Measure central thickness of the lens
- Calculate total optical power of the lens

3.3 Equipment

Spectacle lens, sphere-meter, thickness-meter, writing staff

3.4 Methods

Measure radius front and rear spectacle lens surface

With help of hand sphere-meter measure front and rear lens surface. From the sphere-meter display read the values and approximate it to 0.25 D.

Picture 3.1: Hand sphere-meter (BS Optik 2013).

Measure central thickness of the lens

With help of hand thickness meter measure central thickness of the spectacle lens. Please approximate on 0.1 mm.

Picture 3.2: Hand thickness-meter (BS Optik 2013)

Calculate total optical power of the lens

On the base of knowledge of Gullstrand formula, front and rear spectacle lens optical power, lens thickness and refraction index calculate total optical power of the lens ($\boldsymbol{\varphi}'_c$).

3.5 Results

Measure radius front and rear spectacle lens surface

φ'_F = (front)

φ'_R = (rear)

Measure central thickness of the lens

tc = (central thickness)

Calculate total optical power of the lens

φ'_c =

3.6 Discussion

Optical power of the particular lens surfaces defines the type of lens. In case of spherical lens, the curvature is equal over whole lens surface. In cylinder lenses we usually measure two perpendicular radii – one is strongest and another weakest. So, we can measure two different optical powers on one lens surface.

In case of aspheric lenses (not only single-focus but also progressive) which has surfaces formed by 2^{nd} order curves (ellipse, parabola, hyperbola) we can measure different curvatures and finally of course different optical power of the optical surface.

3.7 Conclusion, notes, comments

How is differentiated optical power and vertex power of the spectacle lens?

What can we measure using lensmeter – optical power or vertex power?

What it means own magnification of the lens?

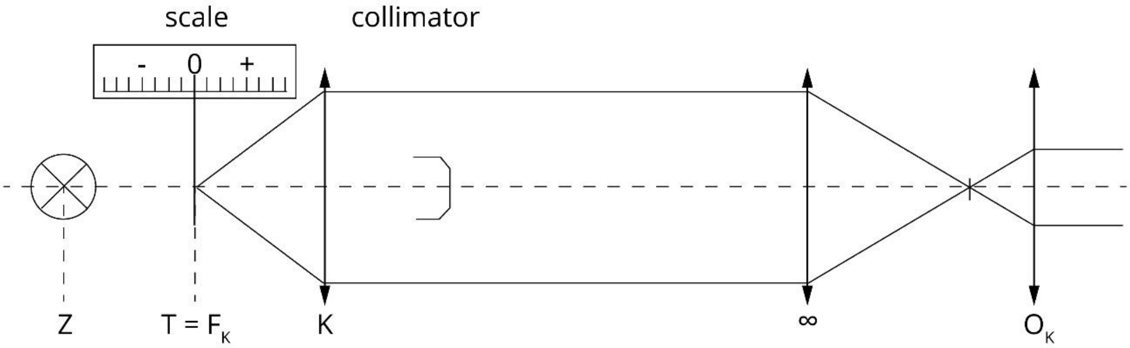
4 Sphere and cylindrical lens vertex power measurement with eyepiece lensmeter

4.1 Introduction

Vertex power of the lens is usually measured in lensmeter. We distinguish some different types of lensmeters. Basic type is mechanical lensmeter with an eyepiece (eyepiece). Further we can use projection lensmeter or automated digital lensmeter.

Picture 4.1: Mechanical eyepiece lensmeter (Beneš et al. 2010).

Mechanical lensmeter contains light source, collimator, rest peace for lens, holder for lens, marking device, objective and eyepiece with TABO-scheme.



Picture 4.2: Mechanical lensmeter in schematic view (Z – light source, T – scale, K – Collimator, Ob – objective, Ok – eyepiece, Kopáčová 2007).

4.2 Goals

- Individual adjustment of the lensmeter
- Measure total vertex power of the spherical lens
- Measure total vertex power of the cylindrical lens

4.3 Equipment

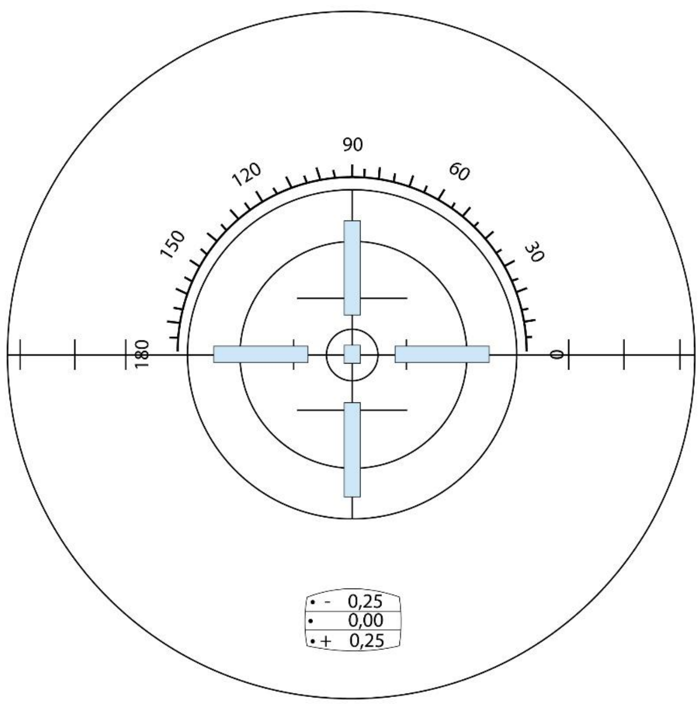
Mechanical lensmeter, spherical and cylindrical spectacle lens

4.4 Methods

Individual adjustment of the lensmeter

Before measurement of mechanical lensmeter you should adapt the eyepiece according the refraction status of the examiner. At first turn eyepiece counterclockwise as far as possible. After that turn with eyepiece clockwise until the TABO-scheme is clear. Further you should clear the green test mark. It should be clear when you can see zero on the scale.

Further you should check the exactness of the marking device of the lensmeter. At first draw two perpendicular lines on the lens. After that put the lens in lensmeter and mark it in 180 and 90 degrees. If these marks correspond with manual marking is the marking device correct.



Picture 4.3: Black TABO-scheme mark and green mark (Beneš et al. 2010).

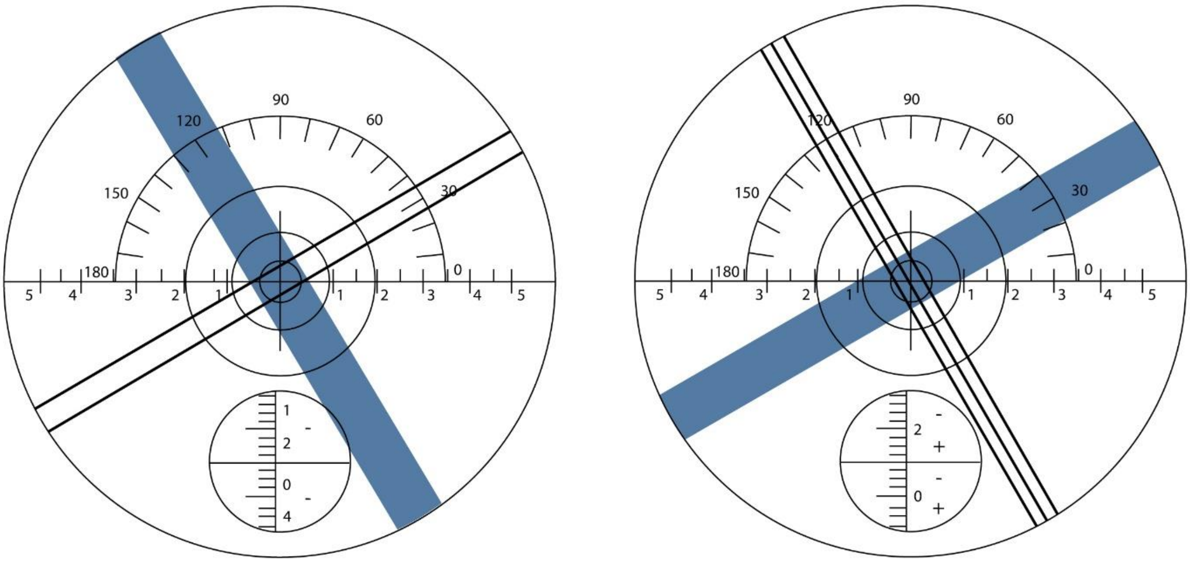
Measure total vertex power of the spherical lens

Place the spherical lens in lensmeter. Concave side is down on the rest peace. With measuring screw turn into both sides to see the green test mark clearly. Finally write down the vertex power value rounded to 0.25 D.

Measure total vertex power of the cylindrical lens

Place the cylinder lens into lensmeter. Turn with measuring screw until the first principal meridian direction is clearly focused. Write down this cylindrical value rounded on 0.25 D and axis of this principal meridian with degrees (from 1 to 180).

Further we should measure second principal meridian which should differ in diopters and axis is rotated with 90 degrees.



Picture 4.4: Principal meridians on cylindrical lenses (Alibaba.com 2013)

4.5 Results

Individual adjustment of the lensmeter

Write down the number from eyepiece which you found during eyepiece adjustment. It can show you your eye refractive error.

Measure total vertex power of the spherical lens

S_S =

Measure total vertex power of the cylindrical lens

S_{C1} =

Ax_1 =

S_{C2} =

Ax_2 =

Write sphero-cylindrical notation of cylindrical lens:

x sph comb. –y cyl ax. z deg.

x sph comb. +y cyl ax. z deg.

4.6 Discussion

Measurement on mechanical lensmeter needs examiner’s experience and practical skills. Firstly we start with lensmeter adjustment according refractive state of our eye. Here we can meet artificial accommodation (instrumental myopia) which can negatively influence measurement.

In practice there are many types of lensmeters. So, optician should meet the lensmeter and learn how the measure the lens. Majority of lensmeters have black TABO-scheme and green measuring mark. TABO-scheme is important for measuring axis of cylinder.

4.7 Conclusion, notes, comments

What is the refractive state after measurement on mechanical lensmeter?

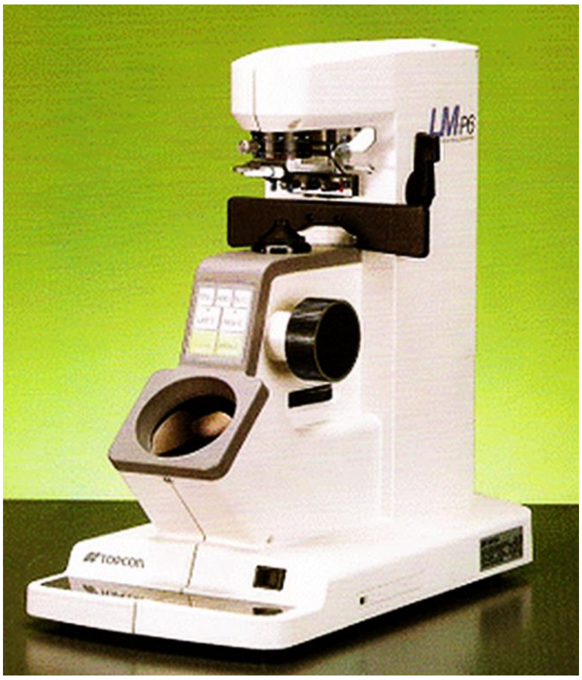
Which eye is the leading eye?

What is the difference between cylindrical - cylindrical and sphero-cylindrical notation in spectacle lens?

5 Sphere and cylindrical lens vertex power measurement with projection lensmeter

5.1 Introduction

Main advantage in measuring with projection lensmeter is that we can miss individualization of the instrument. Green test mark is projected on the transparent screen with the black TABO-scheme. Image of the green test mark can be magnified and we can observe it from middle distance.



Picture 5.1: Projection lensmeter (Benes et al. 2010).

Projection lensmeter can contain prismatic compensator which is suitable for measurement spectacle lenses with prismatic. We can use it for prismatic higher than 5 pD.

5.2 Goals

- Measure and write down vertex power value of cylindrical lens on projection lensmeter.
- Measure and write down vertex power value of spherical lens on projection lensmeter.

5.3 Equipment

Projection lensmeter, spherical and cylindrical spectacle lens.

5.4 Methods

Measure and write down vertex power value of cylindrical lens on projection lensmeter.

Meet the projection lensmeter. Find the button switch on, measuring screw and shifting rest place for the lens. Check the instrument calibration. Green test mark without lens should be focused in 0 dioptres.

Insert the spherical lens and measure its vertex power and write down values in diopters. You can round on 0.25 D.

Measure and write down vertex power value of spherical lens on projection lensmeter.

Insert cylindrical lens on rest place of the instrument. With the measuring screw focus test green mark in first principal meridian of the lens. Read the vertex power value on the instrument's scale. This procedure you should repeat in second principal meridian of the cylindrical lens. Finally cylindrical-cylindrical notation convert into sphere-cylindrical notation with plus and minus value of the cylinder.

5.5 Results

Measure and write down vertex power value of cylindrical lens on projection lensmeter.

S_s =

Measure and write down vertex power value of spherical lens on projection lensmeter.

S_1 =

ax_1 =

S_2 =

ax_2 =

x sph comb. –y cyl ax. z deg.

x sph comb. +y cyl ax. z deg.

5.6 Discussion

Projection lensmeter is appropriate for workplace where alternate different professionals during working. It is not need to adjust the eyepiece for each person. But you should be careful about the surrounding light. If the surrounding luminance is to high you can see bad contrast on instrument's display.

5.7 Conclusion, notes, comments

What are advantages and disadvantages of the projection lensmeter?

Is it possible to measure progressive lens on projection lensmeter?

6 Sphere and cylindrical lens vertex power measurement with digital lensmeter

6.1 Introduction

Currently we use so called digital or automated lensmeters for measuring vertex power of spectacle lens. Devices contain the same mechanical parts like the previous ones (light source, collimator, lens holder etc.) but also digital display (LCD) which can show us all important parameters of the measured lens.

The spectacle lens measuring in digital lensmeter is very rapid and automatic. We can control the instrument's function with buttons bellow display. Here we can change measuring with plus to minus cylinder, define rounding or switch on automatic measuring of the progressive lenses.

Picture 6.1: Digital automated lensmeter (Benes et al. 2010).

The most modern instruments contain so called Shack-Hartmann sensor which enables to measure high order aberration. This aberration can be generated by progressive spectacle lenses. Further we can show graphically on instrument's display increasing of the lens' addition. Some digital lensmeters are able to measure lens absorption and transmission.

6.2 Goals

- Measure and write down vertex power value of cylindrical lens on digital lensmeter.
- Measure and write down vertex power value of spherical lens on digital lensmeter.

6.3 Equipment

Digital automated lensmeter, sphere and cylindrical spectacle lens

6.4 Methods

Measure and write down vertex power value of cylindrical lens on digital lensmeter.

At first familiarize yourself with the device. Find the switch on button and rest place for the lens. Try to use marking device. In software menu meet the basic setting. It is usually rounding of measuring 0.25 D, changing the cylindrical value (plus/minus). Further place the spherical lens into instrument and user the lens holders. Finally, you can read vertex power values from to instrument's display.

Measure and write down vertex power value of spherical lens on digital lensmeter.

Be sure that all values on instrument's display are cleared. Put the cylindrical lens in the instrument's rest place. On instrument's display you can read sphero-cylindrical notation of lens' vertex power. This notation converts to cylindrical-cylindrical notation.

6.5 Results

Measure and write down vertex power value of spherical lens on digital lensmeter.

S_s =

Measure and write down vertex power value of cylindrical lens on digital lensmeter.

x sph comb. –y cyl ax. z deg.

x sph comb. +y cyl ax. z deg.

S_1 =

ax_1 =

S_2 =

ax_2 =

6.6 Discussion

Measuring with digital lensmeter is very rapid and exact. It is important to have proper measuring conditions. Spectacle lens should be placed into instrument with concave surface down. If we measure all spectacles it is important to place these spectacles in lensmeter with lower part down. Both spectacle eyes should be rested on the instrument's rest place.

Picture 6.2: Right spectacles' position in the lensmeter (Benes et al. 2010).

6.7 Conclusion, notes, comments

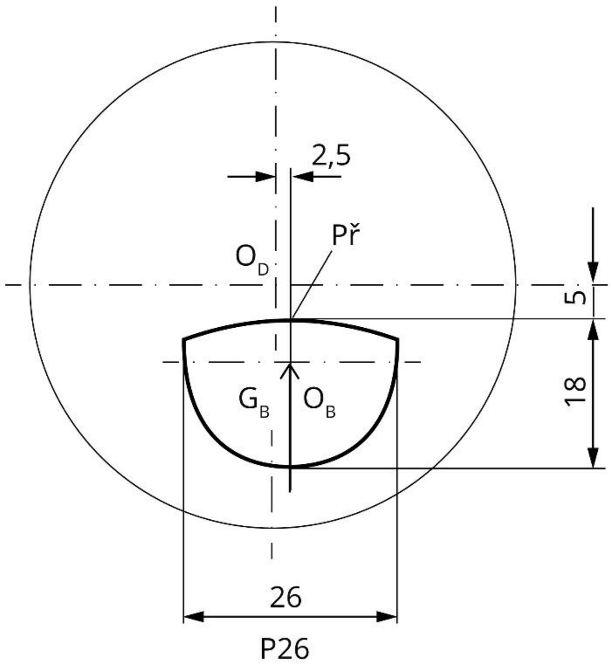
How can we determine prismatic in the lensmeter?

Is it important to measure lens' vertex power with 0.01 D? Why?

7 Bifocal lens vertex power measurement with eyepiece lensmeter

7.1 Introduction

Bifocal lenses are used for correction of ametropia and presbyopia. Older mineral bifocal lenses contain segment for near with higher refraction index than is refractive index of basic lens. Newer plastic bifocal lenses contain segment for near with higher curvature than basic lens has. These lenses have on the front surface small touchable step. Sometimes we need special bifocal lenses for correction of accommodative strabismus called E-lines.



Picture 7.1: Plastic bifocal lens type C (O_o – distance optical center, G_B – near geometric center, O_B – near optical center, Pr – step, Rutrle 2001).

7.2 Goals

- Measure vertex power of the lens’ distance part
- Measure vertex power of the near segment and mark its optical center
- Draw the measured lens and mark its important points

7.3 Equipment

Hand mechanical lensmeter with eyepiece, bifocal lens

7.4 Methods

Measure vertex power of the lens' distance part

Put the bifocal lens in the lensmeter's rest place with concave surface down. Firstly, measure and note the vertex power of the distance part of the lens above the step. Finally mark the distance optical center with the instrument's marking device.

Measure vertex power of the near segment and mark its optical center

Shift with the bifocal lens so you will place near segment in the instrument's measuring axis. Find the near optical center, measure its vertex power and finally mark it with the marking device.

Draw the measured lens and mark its important points

Draw the picture of bifocal lens in ration 1:1. Draw exact diameter, shape and near segment position. Further measure distance between distance and near optical center, size of the near segment etc. Measure nasal decentration of the near segment.

7.5 Results

Measure vertex power of the lens' distance part

S_D =

Measure vertex power of the near segment and mark its optical center

S_N =

Draw the measured lens and mark its important points

7.6 Discussion

Bifocal lenses are still very popular and often used. Its main advantage is wide visual field for distance and middle distance based on the rest of accommodation amplitude. Near segment reduce near visual field but help to rest of accommodation amplitude to focus near objects. In comparing with progressive lenses, it is interesting possibility how to correct presbyopia. But some patients complain on narrow visual field and jump in the visual field which is produced by different vertex power of the distance and near part.

7.7 Conclusion, notes, comments

Can it be negative addition?

How is near segment decentered?

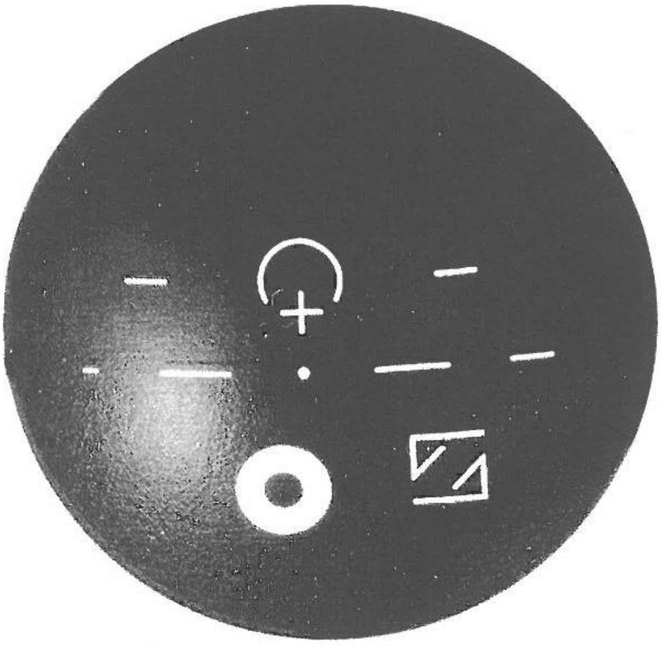
Define minimal grinding high of the bifocal’s near segment?

8 Progressive lens vertex power measurement with digital lensmeter

8.1 Introduction

Currently we can order progressive spectacle lens with vertex power calculated for measurement in lensmeter. Paper bag for these lenses contain two notations – one for ordered values and one with values for lensmeter. Opticians control these values on lensmeter to test the lens. Each progressive lens contains micro-signs burned by laser or cut by diamond knife and prints.

We should measure back vertex power for distance viewing segment of the lens in place of centration distance cross. In place of near circle, we should measure near vertex power values. Difference between distance and near vertex refractive power defines addition. Addition is also marked with the micro-sign in the lens body.



Picture 8.1: General marks on progressive lens (Rutrle 2001).

8.2 Goals

- Measure vertex power of the distance point
- Define addition of the progressive lens
- Draw progressive lens with iso-astigmatic and iso-spherical lines

8.3 Equipment

Digital lensmeter, progressive lens.

8.4 Methods

Measure vertex power of the distance point

At first choose the right program for progressive lens measurement from display's menu of the lensmeter. Further move with the lens placed in lensmeter's rest place until you will see control cross on the lensmeter's display. Now press button to freeze these values.

Define addition of the progressive lens

Move with the lens placed in the lensmeter's rest place to bottom printed circle. In this circle you should measure near vertex power values. Difference between far and near vertex power values shows the addition.

Another way how to define addition is read micro-sign in the lens' body.

Draw progressive lens with iso-astigmatic and iso-spherical lines

Each progressive lens contains progressive corridor which is surrounded by astigmatisms. Draw pictures with iso-astigmatic and iso-spherical lines. One picture for astigmatism and second for sphere lines.

8.5 Results

Measure vertex power of the distance point

S_D =

Define addition of the progressive lens

add_1 (difference distance and near vertex power) =

add_2 (micro-sign reading) =

difference (add_1 and add_2) =

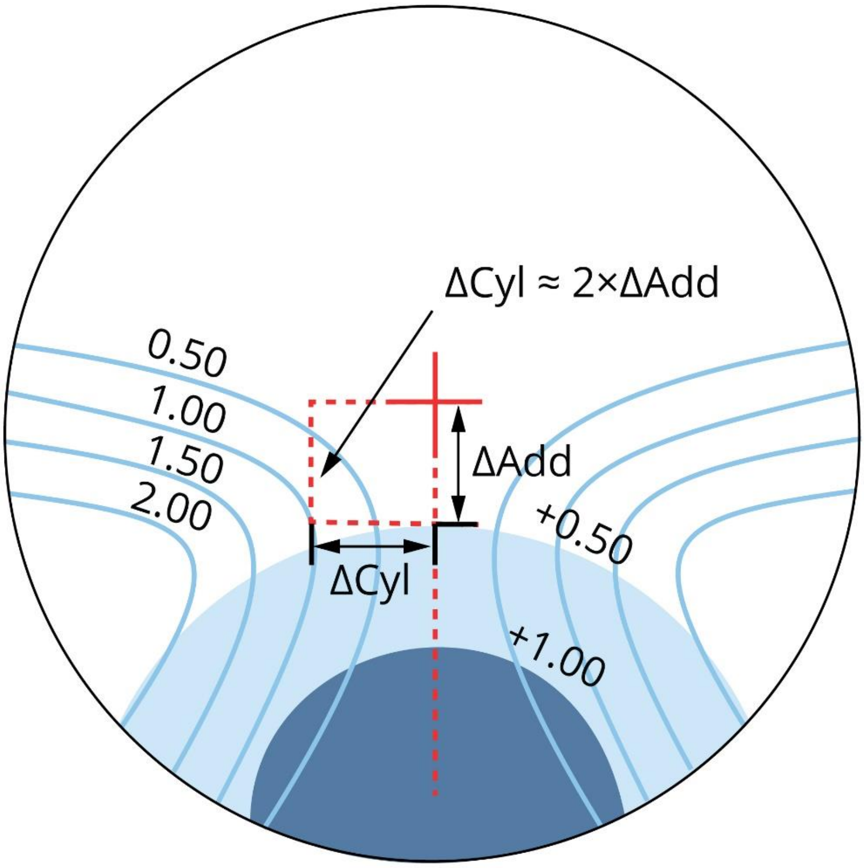
Draw progressive lens with iso-astigmatic and iso-spherical lines

Picture with iso-astigmatism lines

Picture with iso-spherical lines

8.6 Discussion

According Minkwitz's theorem the size of peripheral astigmatism is directly proportional to addition and indirectly proportional to progressive corridor length.



Picture 8.2: Minkwitz's theorem (Opticampus.com 2013)

For this reason, is better to start with progressive lenses with standard corridor length (20 mm) and start with wearing as soon as possible due to small addition. In other cases, we can expect increase of peripheral astigmatism.

8.7 Conclusion, notes, comments

Is it possible to measure near vertex power on progressive lens?

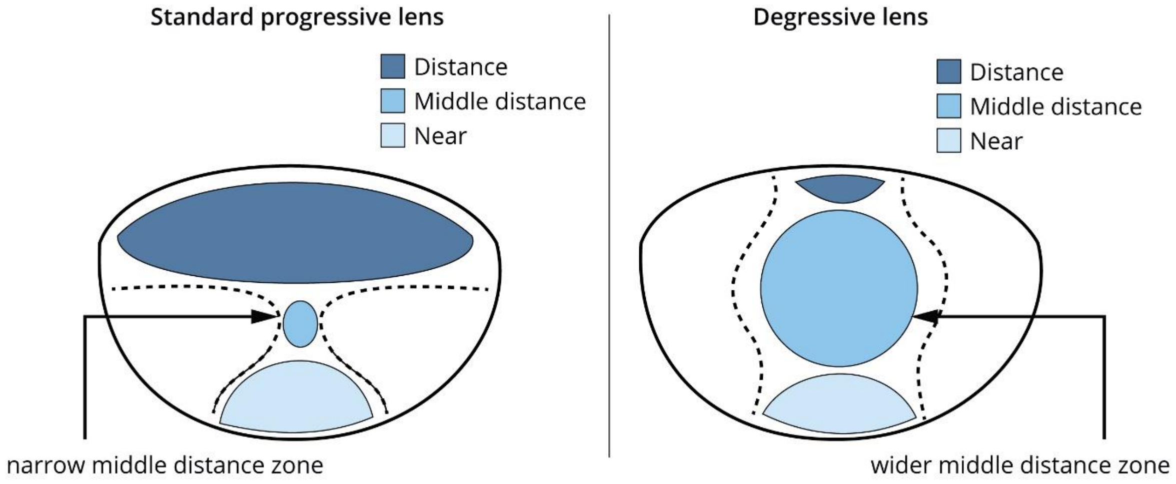
Which method of addition definition is the most suitable for you practice?

Try by yourself effect of peripheral astigmatism by gazing through the progressive lens.

9 Degressive lens vertex power measurement with digital lensmeter

9.1 Introduction

Degressive lenses are special type of progressive lenses optimized for using in rooms from 3 to 4 meters. Main advantage of these lenses is wide visual field for middle and near distance. But these lenses usually missed distance visual field. That is why we cannot recommend using these lenses for driving.



Picture 9.1: Difference between standard progressive lens and degressive lens (Youreyeoptcalalabama.com 2013)

Currently we can order different types of degressive lenses. It is very important to correctly center and order this type of spectacle lens. In practice we can basically distinguish two types of degressive lenses. First is ordered according the near vertex power. Manufacturer enables to us to choose type of so called degression, e.g. type A with degression 1.5 D and type B with degression 2 D. Second type of degressive lens is ordered as typical progressive lens, i.e. distance vertex power and addition. Manufacturer adds 0.5 D to distance vertex power so patient can see clearly to 2 m distance.

9.2 Goals

- Find and measure middle distance vertex power value of the degressive lens
- Find and measure near vertex power value of the degressive lens
- Define degression of this degressive lens
- Draw some type of degressive lens and its important points

9.3 Equipment

Digital lensmeter, degressive spectacle lens

9.4 Methods

Find and measure middle distance vertex power value of the degressive lens

With help of digital lensmeter try to find and measure vertex power of the middle-distance point.

Find and measure near vertex power value of the degressive lens

With help of digital lensmeter try to find and measure vertex power of the near distance point.

Define degression of this degressive lens

Degression can be calculated if you subtract power of middle-distance vertex power from near vertex power.

Draw some type of degressive lens and its important points

Choose one type of degressive lens and draw it schematically. Mark the middle-distance centration point and near point and type of degressive corridor.

9.5 Results

Find and measure middle distance vertex power value of the degressive lens

S_M =

Find and measure near vertex power value of the degressive lens

S_N =

Define degression of this degressive lens

Degression =

Draw some type of degressive lens and its important points

Try to draw micro-signs and prints.

9.6 Discussion

Degressive lenses are still more and more popular these days. The main reason is probably more comfortable vision in near and middle distance. These distances are in standard progressive lenses very reduced. Degressive lenses enable clear view in near and middle distance. If the bigger is degression the bigger is peripheral astigmatism. Important fact is minimal centration height for degressive lenses, i.e. approximately 23 mm.

9.7 Conclusion, notes, comments

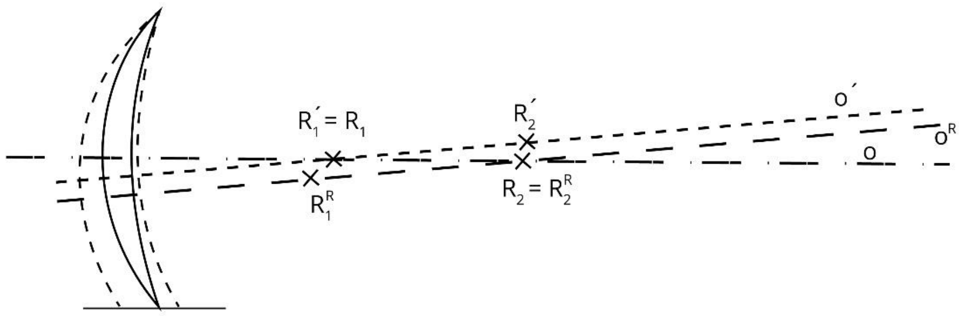
How far can you use degressive lens?

Can you recommend degressive lens? In which conditions?

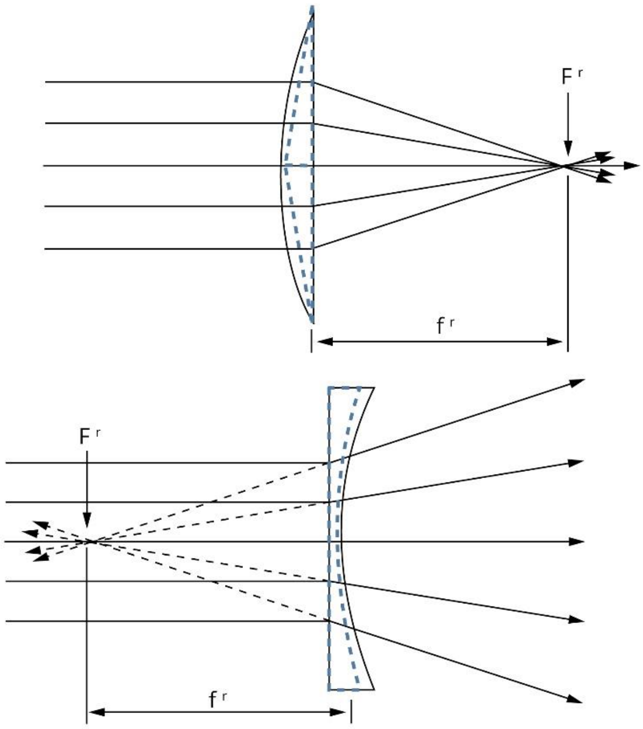
10 Prismatic effect of spherical and cylindrical lens inducement on lensmeter

10.1 Introduction

Prismatic effect of the spectacle lens can be induced by lens decentration and during lens manufacturing. Currently it is preferred prismatic effect manufacturing. De-centered lens with prismatic has different place for optical and geometric point. Contrarily manufactured prismatic lens has optical and geometrical point in one place. This lens could be centered according the basic point imaging rules.



Picture 10.1: Manufacturing of prismatic lens (Rutrle 1993).



Picture 10.2: Plus and minus lens with optic prismatic inside (F – focus, f – focusing distance, 2020mag.com 2013, adapted)

10.2 Goals

- Induce prismatic effect in spherical spectacle lens
- Induce prismatic effect in cylindrical spectacle lens

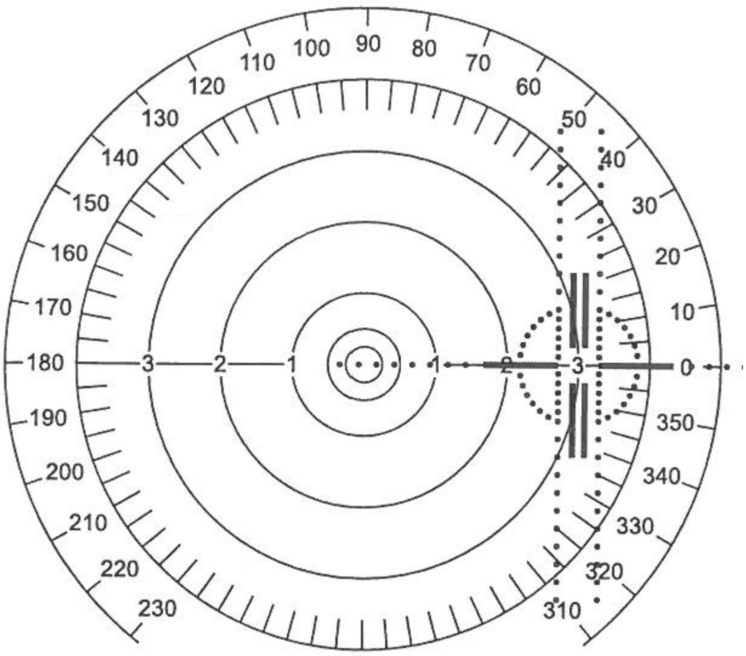
10.3 Equipment

Lensmeter, spherical and cylindrical lens.

10.4 Methods

Induce prismatic effect in spherical spectacle lens

Let's induce prismatic effect 1 prism diopter BI (OD). Use mechanical eyepiece lensmeter. Every circle in lensmeter means 1 prismatic. At first put the lens in the lensmeter's rest device. Further according to TABO-scheme de-center lens to induce 1 prismatic BI (OD). Finally with the lensmeter's marking device mark the lens' important points. After removing the lens from lensmeter mark the lens' base position.



Picture 10.3: Inducing of prismatic in spherical lens with de-centration (Rutrle 2001)

Induce prismatic effect in cylindrical spectacle lens

Rotate cylindrical lens in higher cut to axis 180 and shift the lens to induce 1 prismatic in base 270 degrees. With help of marking device mark centering important point on the lens. You need to know base of the prismatic and value of the prismatic.

10.5 Results

Induce prismatic effect in spherical spectacle lens

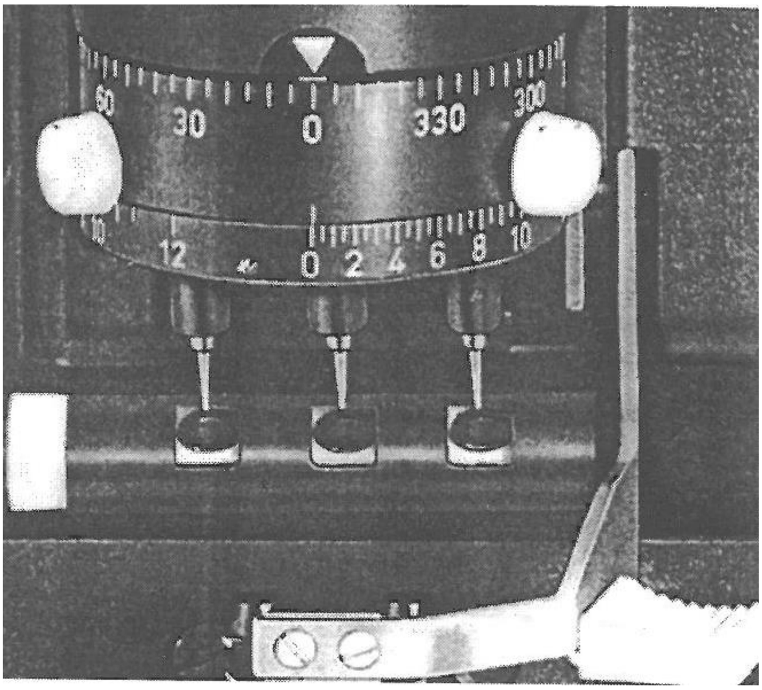
Draw schematically de-centration of spherical lens like you did it in lensmeter. Draw black TABO-scheme, green test mark and lens with de-centration

Induce prismatic effect in cylindrical spectacle lens

Draw schematically de-centration of spherical lens like you did it in lensmeter. Draw black TABO-scheme, green test mark and lens with de-centration

10.6 Discussion

Prismatic lens are used for correction of heterophoria and heterotropia. Prismatic lens helps to eye muscle to keep single eyepiece vision without diplopia. If we de-center plus lens we shift centering point against the basis and if we de-center minus lens we shift centering point to the basis. The size of de-centration is showed on lensmeter's circles or we can calculate de-centration with help of Prentice formula. If we have high prismatic effect we can use prismatic compensator from the lensmeter. If we use digital lensmeters we can read decentration in millimeters or prismatic diopters right from the display.



Picture 10.4: Prismatic compensator on projecting lensmeter (Rutrle 2001).

10.7 Conclusion, notes, comments

Which aberration does you know appear in lenses with high prism?

If we correct esophoria where we place the prismatic basis?

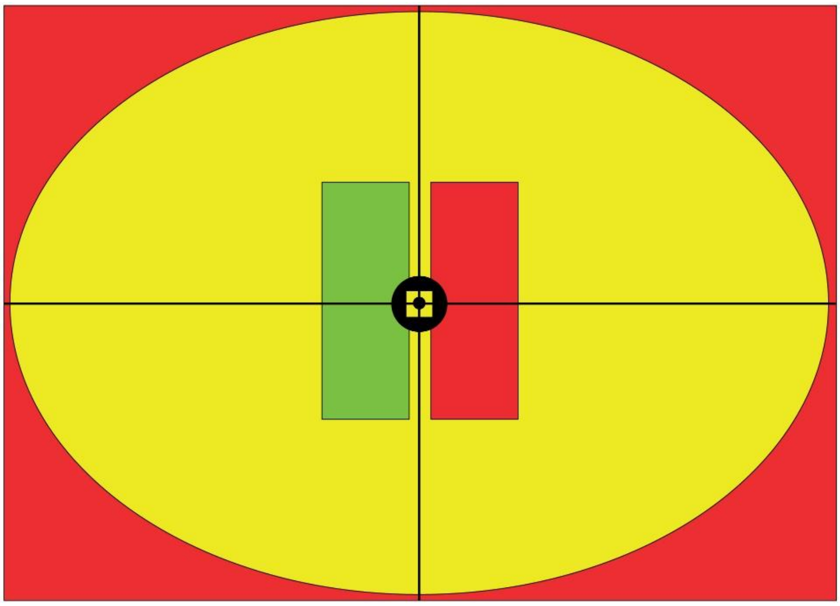
11 Calculation of the lens magnification

11.1 Introduction

Each spectacle lens contains own magnification (so called shape factor). This magnification we can calculate according to following formula. We need to know lens' front surface's optical power ($\boldsymbol{\varphi}'_1$), central thickness of the lens (t) and refractive index (n) of the lens and vertex distance (d).

$$M = Mp.Ms = \frac{1}{1-\varphi' d} . \frac{1}{1-\varphi'_1 . t/n} \qquad \text{M [\%]}, \boldsymbol{\varphi}'_1 \text{ [D], d [m], t [m]} \qquad (3)$$

Spectacle's own magnification we can use for correction aniseikonia. Size of the aniseikonia can be measured with instruments called eikonometers or with the help of collection of so-called size lenses. Measured magnification difference between eyes should be added to sphero-cylindrical correction. The spectacle lens manufacturers are able to produce lenses with own magnification. Usually they provide it with change of lens base curvature or lens thickness.



Picture 11.1: Anaglyph eikonometer (Opticaldiagnostic.com 2013)

11.2 Goals

- Calculate own magnification of spectacle lens with front surface's optical power +8 D and thickness 3 mm
- Calculate own magnification of the given lens

11.3 Equipment

Writing equipment, sphere-meter, calculator and spectacle lens.

11.4 Methods

Calculate own magnification of spectacle lens with front surface's optical power +8 D and thickness 3 mm

According above placed formula calculate own magnification of the spectacle lens

Calculate own magnification of the given lens

For calculation you need to know optical power of the front surface which you can measure with sphere-meter. Further you need to know central thickness of the lens which could be measured with thickness-meter. We suppose refractive index of the lens is 1.5.

11.5 Results

Calculate own magnification of spectacle lens with front surface's optical power +8 D and thickness 3 mm

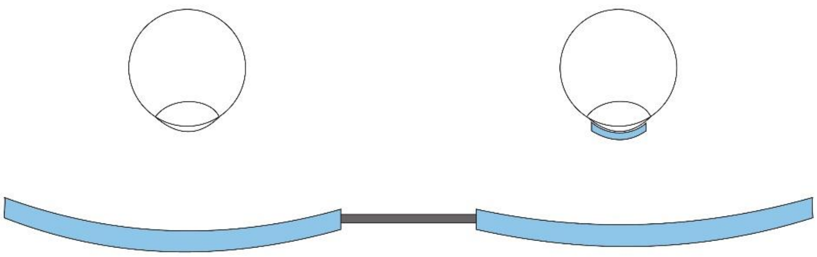
M_1 =

Calculate own magnification of the given lens

M_2 =

11.6 Discussion

We can use many corrections of the aniseikonia in the practice. For example, in case of eyepiece aphakia we can use contact lens to reducing difference between the image sizes of the both eyes. In another case we can use correction with spectacle lenses but the size of images of both eyes can be nearly 20 % which is usually non-tolerated. Third possibility is use combination spectacle lens – contact lens. This combination can change the size of the image.



Picture 11.2: Correction of aniseikonia with combination contact lens and glasses (Opticaldiagnostic.com 2013)

11.7 Conclusion, notes, comments

Which type of aniseikonia correction could you recommend?

What are the causes of the aniseikonia?

12 The proper spectacle lens base choosing

12.1 Introduction

Before starting grinding the spectacle lens we have to choose the right semi-finish lens. Semi-finish can differ with type, refractive index, thickness, diameter and curvature of the front surface (basis). Usually all semi-finishes are supplied with finished front surface. This lens has already finished front surface and we have to grind rear surface to produce thinner lens (Vesely et. al 2012).

Picture 12.1: Difference between semi-finish and finished thin lens on the left side (Vesely et. al 2012).

Semi-finishes have to fulfil norm 0.02 D for front surface's front surface, further quality of the front surface, diameter and thickness. Minus lenses are usually produced from semi-finished lenses with base from +0.5 to 4 D. Plus lenses are produced from semi-finished lens with base from +5 to +14 D. The higher base is, the higher should be lens front curvature (smaller radius). For choosing the right semi-finish basis we usually use this formula:

$$\varphi'_{BBAZ} = \frac{\frac{sph+cyl}{2}}{2} + 6$$ $\boldsymbol{\varphi}'_{BBAZ}$ [D], sph, cyl [D] (4)

φ'_{BBAZ} … *basis optical power*

12.2 Goals

- Choose suitable base of the semi-finished lens
- Base choosing confirm with sphere-meter measuring

12.3 Equipment

Calculator, spectacle lens, sphere-meter.

12.4 Methods

Choose suitable base of the semi-finished lens

Given spectacle lens measure in mechanical lensmeter. Measure its sphero-cylindrical value. According to upper showed formula calculate appropriate lens base (φ'_{BBAZ}).

Base choosing confirm with sphere-meter measuring

With help of sphere-meter measure front lens optical power (basis) and check if there was the appropriate choose of the semi-finish during manufacturing process.

12.5 Results

Choose suitable base of the semi-finished lens (φ'_{BBAC}... calculated basis)

φ'_{BBAZC} =

Base choosing confirm with sphere-meter measuring (φ'_{BBAM}... measured basis)

φ'_{BBAZM} =

12.6 Discussion

The choosing of proper lens base is very important. We can influence e.g. own lens magnification which can correct patient's aniseikonia. Further right choice of the lens base influence image quality according the Tscherning calculation. For sunglasses with curved spectacle eye we usually choose bigger base power (e.g. +6 or +8 D).

12.7 Conclusion, notes, comments

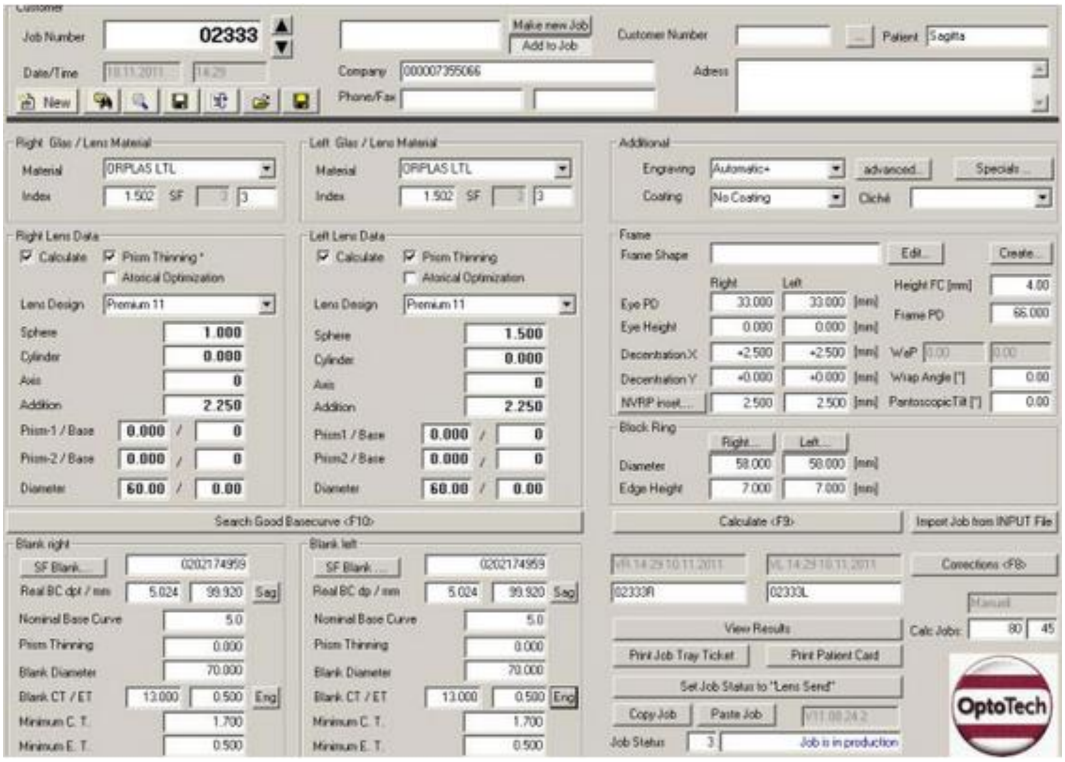
What difference in basis is between plus and minus lenses?

Which lenses needs to have largest storage of the semi-finished lenses with different basis?

13 Central and edge thickness of the spectacle lens calculation during manufacturing

13.1 Introduction

Central thickness of the spectacle lens is not only influenced by proper base chose but also with rear curvature calculation. Currently we use software programs for these calculations. Every lens producer uses their own software. We write down in software sphere and cylindrical power, axis, addition, prismatic and lens diameter. Further we can choose appropriate refractive index of the material, lens diameter and basis of the semi-finish. The software enables to calculate appropriate lens decentration and peripheral lens thickness (Vesely et al. 2012).



Picture 13.1: View of one of the calculation programs for spectacle lens producing (Vesely et. al 2012).

Earlier was the calculation of the rear optical power (**φ´**$_2$) made manually. According to lower placed formula where **φ´**$_1$ is front surface optical power (basis), **φ´**$_c$ is total lens optical power, n is refractive index of the material and d smallest thickness of the lens (for plus lenses it is usually 0,5 mm, for minus lenses it is usually in center 1,7 mm).

$$\varphi'_2 = \frac{n\,(\varphi'_C - \varphi'_1)}{n - d.\varphi'_1} \qquad \boldsymbol{\varphi}'\ [D],\ d\ [m] \qquad (5)$$

Further we need to calculate front and back lens curvature. If we know optical surfaces of both sides (**φ´**$_1$ a **φ´**$_2$) and refractive index we can use lower formulas:

$$r_1[mm] = \frac{(n-1)1000}{\varphi'_1}$$ **φ´** [D], r [mm] (6)

$$r_2\,[mm] = \frac{(1-n)1000}{\varphi'_2}$$ **φ´** [D], r [mm] (7)

Further we need to calculate height of the lens sagitta according lower formulas:

$$s_1 = r_1 - \sqrt{r_1^2 - \left(\frac{d}{2}\right)^2}$$ s, r, d [mm] (8)

$$s_2 = r_2 - \sqrt{r_2^2 - \left(\frac{d}{2}\right)^2}$$ s, r, d [mm] (9)

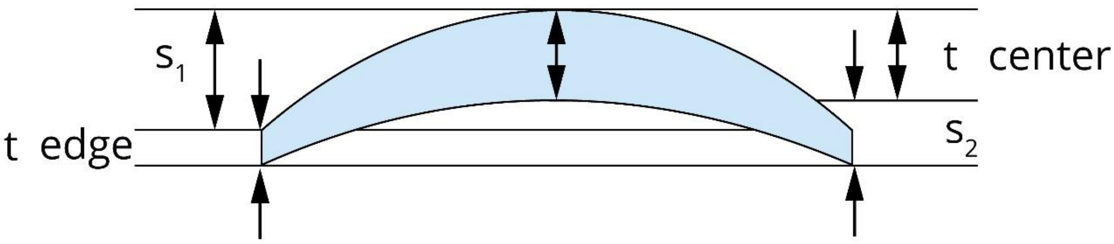
Now we can calculate final central (for plus) and peripheral (for minus) thickness according lower formula:

$e = s_2 - s_1 + t$ e, s, t [mm] (10)

(e – peripheral thickness for minus lens, t is substituted with 1.7 mm)

$t = s_1 - s_2 + e$ e, s, t [mm] (11)

(t – central lens thickness for plus lens, e is substituted with 0.5 mm)



Picture 13.2: Spectacle lens parameters – s = sagitta, t = thickness (Vesely et. al 2012).

13.2 Goals

- Calculate central thickness of the plus lens
- Confirm the calculation with schematic drawing
- Calculate edge thickness of the minus lens
- Confirm the calculation with schematic drawing

13.3 Equipment

Spectacle lens, sphere-meter, calculator.

13.4 Methods

Calculate central thickness of the plus lens

With help of sphere-meter measure given lens basis. After that calculate rear lens optical power. Peripheral edge thickness substituted with 0.5 mm. Further calculate radius and sagitta of the front and rear surface. Finally, we can calculate central lens thickness.

Confirm the calculation with schematic drawing

Draw the plus lens. With sphere-meter and thickness-meter measure back surface and lens thickness of given lens a check if the measurements refer to previous calculations.

Calculate edge thickness of the minus lens

With help of sphere-meter measure given lens basis. After that calculate rear lens optical power. Central thickness substituted with 1.7 mm. Further calculate radius and sagitta of the front and rear surface. Finally, we can calculate peripheral lens thickness.

Confirm the calculation with schematic drawing

Draw the plus lens. With sphere-meter and thickness-meter measure back surface and thickness of given lens a check if the measurements refer to previous calculations.

13.5 Results

Calculate central thickness of the plus lens

$\boldsymbol{\varphi}'_2$ =

r_1 =

r_2 =

s_1 =

s_2 =

t =

Confirm the calculation with schematic drawing

Calculate edge thickness of the minus lens

φ'_2 =

r_1 =

r_2 =

s_1 =

s_2 =

t =

Confirm the calculation with schematic drawing

13.6 Discussion

During final lens parameters calculation is central and peripheral thickness very important. Peripheral lens thickness influences lens cutting for frames with nylon or for drilled frames. Central thickness influences consistence and stability of the minus lens. We can say that if we have higher central lens thickness we have more stable lens, but this lens will have higher peripheral lens thickness which is unaesthetic.

13.7 Conclusion, notes, comments

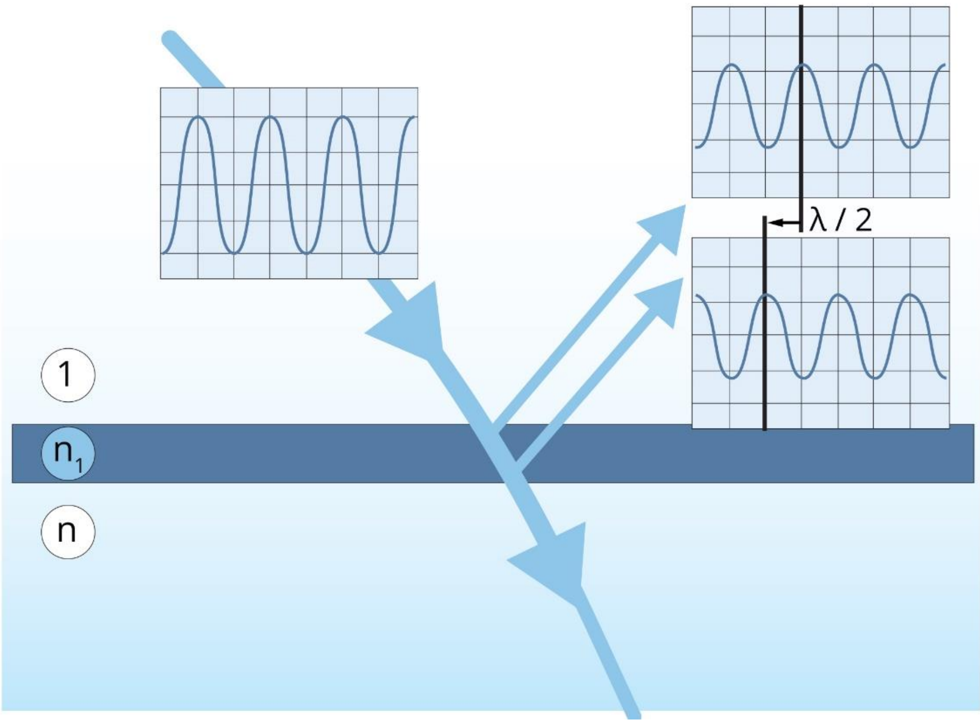
Does the lens diameter play the role for central lens thickness? In which case?

14 Phase and amplitude condition of the spectacle lens anti-reflex

14.1 Introduction

Antireflex layer is used for purpose to increase reflection on front and rear lens' surface. Antireflex layer use wave origin of the light and phenomenon called interference. Antireflex is multiple layer working on destructive interference. Antireflex divides reflected light into optical waves which undergo destructive interference and are neutralized. If we want to enable this physical phenomenon we have to maintain phase and amplitude condition.

According the phase condition the two light waves have opposite phase. According to amplitude condition the size of the two waves' amplitudes should be equal. The amplitude size depends on lens and antireflex refractive index.



Picture 14.1: Phase and amplitude condition for antireflex (Vesely et al. 2012).

14.2 Goals

- Calculate thickness of the single antireflex layer
- Calculate appropriate refractive index for single antireflex layer

14.3 Equipment

Calculator, writing equipment.

14.4 Methods

Calculate thickness of the single antireflex layer

We suppose that we have single layer antireflex. At the base of the rest light color assess the wavelength of antireflex. If you know wavelength of antireflex and refraction index of the lens you can calculate the thickness of the antireflex according lower formula:

$$d = \frac{\lambda}{4n} \qquad d, \lambda \text{ [m]} \qquad (12)$$

Calculate appropriate refractive index for single antireflex layer

According to index of given spectacle lens try to calculate refractive index of the antireflex to fulfil the amplitude condition. Again, suppose one-layer antireflex.

$$n_{AR} = \sqrt{n_{SL}} \qquad (13)$$

n_{AR} refractive index of the antireflex

n_{SL} refractive index of the lens

14.5 Results

Calculate thickness of the single antireflex layer

d =

Calculate appropriate refractive index for single antireflex layer

n_{AR} =

14.6 Discussion

For producing of antireflex we can use different types of material. We can use oxide of titan, silicon or chromium. These materials are connected to lens surface by method called physical vapor deposition (PVD). Firstly, during this process this material is going to sublimate at after that is settled on the lens surface. Currently we can use three types of vacuum deposition – temperature, plasmatic and ionic (Vesely et al. 2012).

14.7 Conclusion, notes, comments

Why is important multi-layer antireflex?

How is produced rest color of the antireflex layer?

Why we don’t use antireflex on sunglasses?

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Spectacle technology I

Practical exercises

Mgr. Petr Veselý, DiS., Ph.D.

Department of Optometry and Orthoptics,
Faculty of Medicine, Masaryk University

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